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PJ.05-W2-DTT

DIGITAL TECHNOLOGIES FOR TOWER

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Abstract

The Remote Tower concept is changing the provision of Air Traffic Services (ATS) in a way that it is more service tailored, dynamically positioned and available when needed, enabled by digital solutions replacing the need of controllers and tower buildings at aerodromes.

Remotely Provided Air Traffic Service for Multiple Aerodromes and development of the Remote Tower Centre are part of this development which started with Single Remote Towers.

This document is part I of the Validation Report relating to solution PJ05-W2-35 – “Multiple Remote Tower and Remote Tower Centre” targeting at V3 maturity.

Five exercises in total were organised and performed at different locations based on different prototypes. The validations were conducted as both real-time simulation and as passive shadow mode trials.

The OI step addressed in this Validation Report is:

- **SDM-0210: Highly Flexible Allocation of Aerodromes to Remote Tower Modules**

‘The provision of remote ATS service to the remote aerodromes can be dynamically assigned (over time) to any other Remote Tower Module (RTM) within a Remote Tower Centre (RTC). RTC planning tools supporting the RTC supervisor enable an efficient usage of all RTMs and staff in an RTC.’

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1 Executive summary

This document describes the Validation Report for PJ05-Solution 35 ‘Multiple Remote Tower and Remote Tower Centre’. The Operational Improvement Step addressed in this solution is SDM-0210 “Highly Flexible Allocation of Aerodromes to Remote Tower Modules”.

‘The provision of remote ATS service to the remote aerodromes can be dynamically assigned (over time) to any other Remote Tower Module (RTM) within a Remote Tower Centre (RTC). RTC planning tools supporting the RTC supervisor enable an efficient usage of all RTMs and staff in an RTC.’

As the main driver for the solution is increased cost efficiency by an increase of ATCO productivity, which cannot directly be validated in the exercises, the validations addressed the prerequisites of the concept, i.e. safety and human performance.

ATCOs productivity will be increased by balancing the workload between different MRTMs accommodated within an RTC. Balanced workload will be achieved by a flexible allocation of airports to dedicated MRTMs, supported by RTC Supervisor and Supervisor Planning Tool or by the extended automation support tools.

Compared to previous Multiple Remote Tower solutions flexible allocation could now lead to the situation that aerodromes are not always placed in the same position within the MRTM.

Flexible allocation of aerodromes allows balancing tolerable ATCO workload and high traffic levels. While some situations might result in small delays, aerodrome capacity will not be reduced by introducing multiple remote tower concept (if more capacity is required, flexible allocation needs to be adjusted or another MRTM to be opened)

Five exercises in total were organised and performed at different locations based on different prototypes. The validations were conducted as both real-time simulation and as passive shadow mode trials. Workshops were held as an addition to the validation activities to obtain more data for the Safety and Human Performance report.

The following exercises were executed in order to reach V3 maturity for Solution 35:

| Exercise | Method | Platform | ANSP |
|-------------------------|--------------------|-------------------------|----------------|
| EXE-PJ05-W2-35-V3-2.1.1 | RTS (ATCO and SUP) | DLR / FRQ | ON / PANSO |
| EXE-PJ05-W2-35-V3-2.1. | PSM (ATCO) | DLR / FRQ Comsoft | |
| EXE-PJ05-W2-35-V3-2.2 | RTS (ATCO) | NATMIG | COOPANS |
| EXE-PJ05-W2-35-V3-2.3.1 | RTS (ATCO and SUP) | INDRA | AVINOR |
| EXE-PJ05-W2-35-V3-2.3.2 | PSM (ATCO) | INDRA | HUNGAROCONTROL |
| EXE-PJ05-W2-35-V3-2.3.3 | RTS (ATCO and SUP) | INDRA | HUNGAROCONTROL |
| EXE-PJ05-W2-35-V3-2.4 | RTS (ATCO and SUP) | ENAV / IDS / TECHNO SKY | ENAV |

| | | | |
|-----------------------|------------|--------------------|-----|
| EXE-PJ05-W2-35-V3-2.5 | RTS (ATCO) | DFS / FRQ / THALES | DFS |
|-----------------------|------------|--------------------|-----|

Conclusions on concept clarification

ATCOs could work with a flexible allocation of aerodromes to MRTMs that was either initiated by a handover to or from another MRTM or by manually switching the position of aerodromes within a MRTM. ATCOs were always aware which aerodrome was displayed in which position within the MRTM.

The flexible allocation and transfer was in some exercises initiated by the ATCOs assessing the situation either based on the electronic flight strips or using the ATCO planning tool in other exercises. The ATCO contacted the ATCO at the other MRTM (only two MRTMs were validated) and agreed on the possibility to hand over an aerodrome and on the best time to do the handover. The point in time for a handover procedure is best selected by the ATCO with the most traffic at his MRTM.

In other exercises the flexible allocation and transfer was initiated by the SUP who assessed the situation based on the SUP planning tool. The exact timing of the handover was then defined by the ATCOs taking into consideration the current and forecasted traffic and other relevant circumstances like the weather conditions.

Both approaches worked well and it might be chosen based on the specific local situation in the RTC which one to implement. If the ATCOs are responsible for the flexible allocation, higher buffers need to be provided, as some workload was associated to the handover procedure. Managing a higher number of aerodromes in an RTC should be supported by a SUP role.

Transfer of aerodromes should happen in lower traffic periods, when the ATCOs have spare capacity for the handover process and to build up the situational awareness. In case of an emergency, the other aerodrome(s) should be handed over to make sure that the ATCO can fully focus on the non-nominal situation. It is better to split as soon as possible, and not to wait for additional information on the emergency to predict the expected workload, because such a situation can quickly escalate, which would make the handover process more challenging.

In the validations the supervisors were able to flexibly allocate the aerodromes to MRTMs in the simulated environment. While the ATCO is assumed to be able to hold up to 4 endorsements, the SUP will probably have less (if any) full endorsements.

Conclusion on technical feasibility

The validation results confirm the technical feasibility of the flexible allocation of aerodromes to MRTMs and the supervision of multiple MRTMs/aerodromes.

The MRTM must be designed to display up to 3 aerodromes at a time with the possibility of a flexible allocation. The ATCO should be able to flexibly position aerodromes within one MRTM (move the position of displayed aerodromes manually in order to arrange them according to his/her needs and/or preferences).

During a handover procedure all information of the aerodrome that is being handed over must be displayed on both MRTMs.

Conclusion on performance assessments

Situation awareness was at a satisfactory to acceptable level when providing ATS to three aerodromes at a time and using flexible allocation of aerodromes. Nevertheless, ATCOs stated they needed a generally higher level of attention to keep their SA for all three aerodromes compared to controlling just one aerodrome. Flexible allocation of aerodromes had almost no effect on situation awareness and ATCOs stated that they easily could get used to it.

Nevertheless, situation awareness decreased rapidly when traffic levels became too high, or the situation became very complex (which occurred mainly when ATCOs controlled three aerodromes at a time or when unforeseen traffic popped up). Therefore flexible allocation of aerodromes requires that sufficient buffers are foreseen in order to avoid ATCO overload to consider e.g. unforeseen traffic like police or rescue helicopters or various incoming calls. ATCOs need to be trained to avoid complex situations with increasing traffic levels (e.g. by applying conservative separations)

Recommendations

During deployment phase it needs to be considered how local availability of real data (e.g. flightplans for VFR flights) might affect integrated SUP and ATCO planning tools.

Based on the specific locally defined roles, the ATCO and SUP planning tools need further optimisation regarding HMI design in order to allow to more intuitively assess the situation.

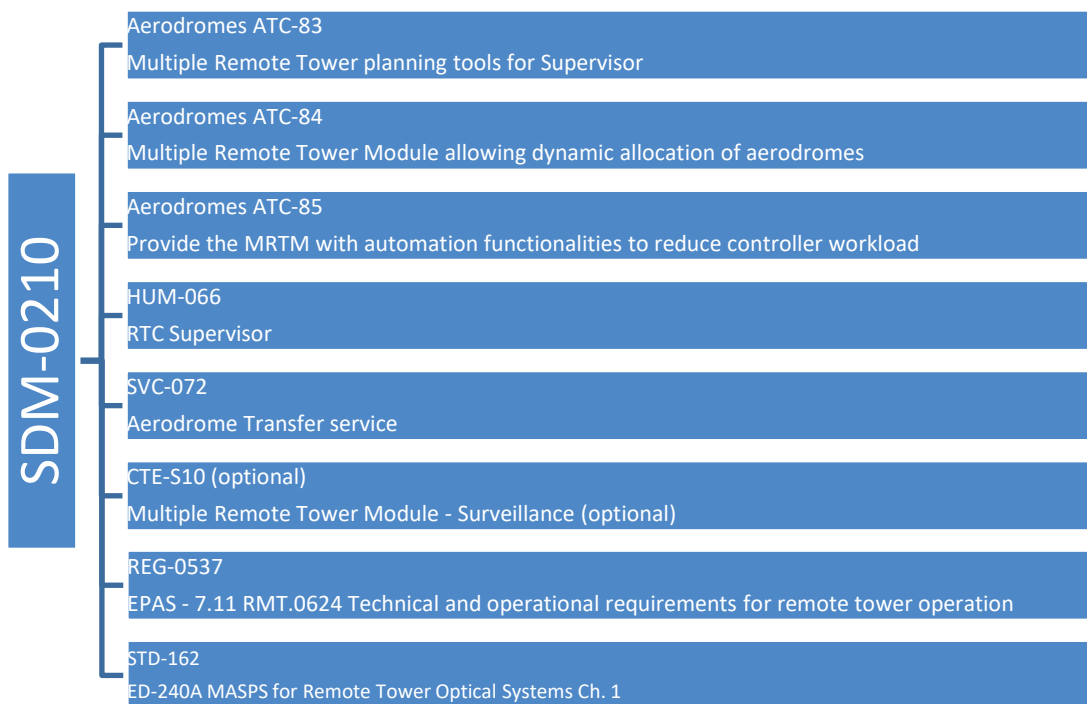
Depending on the complexity of the SUP planning task and the SUP workload, the SUP planning tool needs to be extended by weather information and information on ATCO endorsements and ATCO availability (alternatively it might be sufficient to retrieve this information from existing other systems).

The supervisor role might be allocated different tasks depending on the specific local implementation. During the deployment phase, the supervisor role should reflect those locally defined tasks for the supervisor.

The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors.

Conclusions on SESAR Solution maturity

The validation exercises have shown that solution 35 (SDM-210: 'Highly Flexible Allocation of Aerodromes to Remote Tower Modules') has reached V3 maturity. All operational Enablers for solution 35 were positively evaluated.



2 Introduction

2.1 Purpose of the document

This document provides the Validation Report for PJ05-W2-35 for V3. It describes the results of validation exercises defined and how they have been conducted and provides a set of relevant conclusions and recommendations.

This document (VALR) covers the main body of the Validation Report: validation approach and context, the validation objectives, scenarios and validation exercises. It is complemented by the following documents:

- PJ05-03 SPR-INTEROP/OSD Part II Safety Assessment Report
- PJ05-03 SPR-INTEROP/OSD Part III Security Assessment Report
- PJ05-03 SPR-INTEROP/OSD Part IV Human Performance Assessment Report
- PJ05-03 SPR-INTEROP/OSD Part IV Performance Assessment Report

2.2 Intended readership

The intended audience for this document are primarily all the partners involved in SESAR 2020, PJ05 addressing Solution 35.

The intended readerships for this document are:

- PJ05 Partners addressing PJ05-W2-35.

External to the SESAR project, other stakeholders are to be found among:

- ANS providers
- ATM infrastructure and equipment suppliers
- Airspace users
- Airport owners/providers
- Affected NSA
- Affected PSOs

SESAR 2020 Projects/Solutions:

- PJ.14 (EECNS) CNS

Founding Members

(Solution PJ.14-W2-84 — New use and evolution of Cooperative and Non-Cooperative Surveillance)

SESAR 2020 Transversal Projects:

- PJ.19 W2 (CI) Content Integration PJ.20 W2 (AMPLE) Master Plan Maintenance

2.3 Background

The work done for single remote tower and contingency remote tower are the baseline for multiple remote tower concepts.

Validations in SESAR 1 were conducted within the frame of the three different Operational Improvements:

- SDM-0201 - Remotely Provided Air Traffic Service for Single Aerodrome
- SDM-0204 - Remotely Provided Air Traffic Service for Contingency Situations at Small to Medium Aerodromes (with a Single Main Runway)
- SDM-0205 - Remotely Provided Air Traffic Services for Two Low-density Aerodromes

All detailed information related to previous work done in SESAR 1, can be found in the data packs for the following solutions:

- Solution #71: "ATC and AFIS service in a single low density aerodrome from a remote CWP"
- Solution #52: "Remote Tower Services for two low-density aerodromes"
- Solution #12: "Single remote tower operations for medium traffic volumes"
- Solution #13: "Remotely provided air traffic service for contingency situations at aerodromes"

Validations within SESAR 2020, wave 1 were performed at V2 and V3 maturity level for the following operational improvements:

- SDM-0207 – Remotely Provided Air Traffic Service for Multiple Aerodromes (up to 3 aerodromes) – V3 level
- SDM-0210 – Highly Flexible Allocation of Aerodromes to Remote Tower Modules – V2 level

All above mentioned solutions regarding Remote Tower concept developed and validated under SESAR programme projects (SESAR 1, SESAR 2020 wave1), have delivered results determining the solution PJ05-02-V3 as reference for Solution 35 regarding Multiple Remote Tower Modules.

2.4 Structure of the document

The structure of the document is as follows:

§1 Contains the executive summary of the document

§2 This section provides an introduction to the document

§3 Describes the context of the validation

§4 Contains the SESAR Solution 35 Validation Results for the ATCOs

§5 Contains the SESAR Solution 35 Validation Results for the Supervisors

§6 Provides the conclusions and recommendations

§7 List of the References applicable to this document

Appendix A to E provide the validation results per exercise

2.5 Glossary of terms

| Term | Definition | Source of the definition |
|---------------------------------|--|--------------------------|
| ATS (Air Traffic Service) | A generic term meaning variously, Flight Information Service (FIS), Alerting Service (ALRS) and Air Traffic Control Service (ATC) (area control service, approach control service or aerodrome control service). In this document, when the term ATS is used, it is usually referring to TWR or AFIS. | ICAO, Annex 11 |
| Aerodrome ATS | Aerodrome ATS means air traffic service for aerodrome traffic, in the form of 'aerodrome control service (ATC) or 'aerodrome flight information service' (AFIS). | EASA |
| Aerodrome Control Service (TWR) | The air traffic control (ATC) service provided by the Air Traffic Control Officer (ATCO) for aerodrome traffic. Air traffic control service is a service provided for the purpose of: <ul style="list-style-type: none"> • preventing collisions: • between aircraft, and • on the manoeuvring area between aircraft and obstructions; and expediting and maintaining an orderly flow of air traffic. | ICAO, Annex 11 |
| APP (Approach control service) | APP (Approach control service) is the service for Arrival and Departing traffic (before and after they will be/have been under the TWR control. APP is provided by a single ATCO for one or more airports, either separate or in combination with TWR (TWR & APP from the Tower). | ICAO |
| APW | APW (Area Proximity Warning) warns the controller about unauthorised penetration of an airspace volume by generating, in a timely manner, an alert of a potential or actual infringement of the required spacing to that airspace volume. | SKYbrary |
| ATCO | ATCO (Air Traffic control Officer) is the person trained to maintain the safe, orderly, and expeditious flow of air traffic in the global air traffic control system. | NATCA |
| Conventional Tower | Conventional Tower means a facility located at an aerodrome from which aerodrome ATS is provided principally through direct out-of-the-window observation of the aerodrome and its vicinity. | EASA |
| Multiple mode of operation | Multiple mode of operation means the provision of ATS from one remote tower/remote tower module for two or more aerodromes at the same time (i.e. simultaneously). | EASA |

| | | |
|---|--|------------------------|
| Multiple Remote Tower Module (MRTM) | Multiple Remote Tower Module (MRTM) is a term used by project PJ.05 and in this document to specifically indicate a Remote Tower Module (RTM) which enables the possibility to provide ATS to two or more aerodromes at the same time (i.e. simultaneously). | PJ.05 definition |
| Out-of-the-window (OTW) view | 'Out-of-the-window (OTW) view means a view of the area of responsibility of the aerodrome ATS unit from a conventional tower, obtained via direct visual observation. | EASA |
| Remote Tower | Remote Tower means a geographically independent facility from which aerodrome ATS is provided principally through indirect observation of the aerodrome and its vicinity, by means of a visual surveillance system. (It is to be seen as a generic term, equivalent in level to a conventional tower). | EASA |
| Remote Tower Centre (RTC) | A Remote Tower Centre (RTC) means a facility housing one or more remote tower modules. | EASA |
| Remote Tower Module (RTM) | Remote Tower Module (RTM) means a combination of systems and constituents from where remote aerodrome ATS can be provided, including one or more ATCO/AFISO workstation(s) and the visual presentation. (It can be compared with the tower cabin of an aerodrome conventional tower.) | EASA |
| Remote Tower Centre Supervisor (RTC supervisor) | Remote Tower Centre Supervisor (RTC supervisor) The role of an RTC supervisor may be established in order to provide an efficient set up at all times and guarantee a flexible system by means of; maintaining overall supervision of all aerodromes within the RTC; managing the allocation of staff and Modules (MRTMs/RTMs); performing planning, administration, allocation of tasks and supervision of technical systems. | PJ.05 definition |
| Simultaneous movements | Simultaneous movements are all aircraft and vehicle movements under the control of the ATCO, or on the frequency at the same time. | PJ.05 definition |
| Single mode of operation | Single mode of operation means the provision of ATS from one remote tower/remote tower module for one aerodrome at a time. | EASA |
| Technical Enablers | Technical Enablers refer to additional features and functions within a single or a multiple module that enable the provision of ATS using the concept. These technical features will assist in the areas of visualisation and operational performance. Further information on the requirement status of the Technical Enablers is given within this document. | EASA |
| Visual Presentation | Visual Presentation means a view of the area(s) of responsibility of the aerodrome ATS unit, provided by a visual display. | EASA |
| Visual Surveillance System | Visual Surveillance System means of a number of integrated elements, normally consisting of optical sensor(s), data transmission links, data processing systems and situation displays providing an electronic visual presentation of traffic and any | ICAO, Doc 4444 EASA |

other information necessary to maintain situational awareness at an aerodrome and its vicinity.

Note: EUROCAE ED-240/ED-240A is using the term 'remote tower optical system' for the same purpose.

Table 1: Glossary of terms

2.6 Acronyms and Terminology

| Acronym | Definition |
|---------|--|
| AC | Aircraft |
| ACC | Area Control Centre |
| ADS-B | Automatic Dependent Surveillance - Broadcast |
| AFIS | Aerodrome Flight Information Service |
| AFISO | AFIS Officer |
| AIM | Automation Impact on Mental Workload |
| AIP | Aeronautical Information Publication |
| AN | Availability Note |
| ANSP | Air Navigation Service Provider |
| ALRS | Alerting Service |
| APP | Approach Control |
| APT | Airport |
| ARR | Arrival |
| ASM | Assumption |
| ATC | Air Traffic Control |
| ATCO | Air Traffic Control Officer |
| ATM | Air Traffic Management |
| ATS | Air Traffic Service |
| CA | Capacity |
| CARS | Controller Acceptance Rating Scale |
| CEF | Cost Efficiency |
| CFTO | Cleared For Take Off |
| CNS | Communication Navigation and Surveillance |

| | |
|-------------------|--|
| CR | Change Request |
| CRT | Criteria |
| CTR | Control Zone |
| CWP | Controller Working Position |
| DEP | Departure |
| DFS | DFS – German Air Navigation Services |
| DLR | Deutsches Zentrum für Luft und Raumfahrt |
| EASA | European Aviation Safety Agency |
| EATMA | European ATM Architecture |
| EFPS | Electronic Flight Progress Strip |
| EFS | Electronic Flight Strip |
| EXE | Exercise |
| FATO | Final approach and take-off area |
| FDPS | Flight Data Processing System |
| FIS | Flight Information Service |
| GA | General Aviation |
| HC | Hungarocontrol |
| HDD | Head Down Display |
| HPAR | Human Performance Assessment Report |
| IBP | Industry Based Platform |
| ID | Identifier |
| IFR | Instrument Flight Rules |
| IDS AIRNAV | Company Name |
| ILS | Instrument Landing System |
| INTEROP | Interoperability Requirements |
| IR | Infrared |
| KPA | Key Performance Area |
| KVM | Keyboard Video Mouse |
| LND | Landing |
| LVO | Low Visibility Operations |
| LVP | Low Visibility Procedures |
| MET | Meteorology, meteorological |

| | |
|--------------|--|
| METAR | Meteorological Aerodrome Routine Report |
| MLAT | Multilateration |
| MRTC | Multiple Remote Tower Center |
| MRTM | Multiple Remote Tower Module |
| MSDF | Multi Sensor Data Fusion |
| NLR | Research Center |
| NSA | National Safety Agency |
| OBJ | Objective |
| OI | Operational Improvement |
| OSD | Operational Service and Environment Definition |
| OTW | Out-The-Window |
| PAR | Performance Assessment Report |
| PJ | Project |
| PSM | Passive Shadow Mode |
| PSO | Staff Organisation |
| PTT | Push To Talk |
| PTZ | Pan-Tilt-Zoom |
| PU | Punctuality |
| QNH | QNH Air Pressure |
| RDP | Radar Data Processing |
| RTS | Real Time Simulation |
| RTC | Remote Tower Centre |
| RTM | Remote Tower Module |
| RTO | Remote Tower Operations |
| RTWR | Remote Tower |
| RVR | Runway Visual Range |
| SAF | Safety |
| SAR | Safety Assessment Report |
| SASHA | Situational Awareness for SHAPE |
| SATI | SHAPE Automation Trust Index |
| SHAPE | SHAPE Automation Trust Index |
| SMGCS | Surface Movement Guidance and Control System |

| | |
|-------------|--|
| SOL | Solution |
| SPR | Safety and Performance Requirement |
| SUS | System Usability Scale |
| SUP | Supervisor |
| SVMC | Special Visual Meteorological Conditions |
| VP | Visual Presentation |

Table 2: Acronyms and terminology

3 Context of the Validation

3.1 SESAR Solution 35: a summary

This VALR document provides descriptions for several validation exercises that were performed in order to deliver results for achievement of the targeted V3 maturity level for Solution 35 – Multiple Remote Tower and Remote Tower Centre. Each validation applied to a particularly selected small operating environment for airports located across seven different European countries. Validations were performed utilizing different validation platforms.

Note: Results from this solution will also be valid for airports within category Other Environment Airport

The objective of solution 35 is to increase ATCO productivity (i.e. reduce the number of ATCOs required) through a better balance of workload between different MRTMs within a Remote Tower Centre, supported by a Remote Tower Centre Supervisor role (RTC supervisor) and a Supervisor Planning Tool.

This will be achieved by a flexible allocation of grouped aerodromes to dedicated MRTMs. Such a flexible allocation of aerodromes in the MRTM implies that one aerodrome can take different positions within MRTMs. It is expected that this will increase the complexity as it will be more difficult to maintain situation awareness on the controlled aerodromes compared to a fixed allocation with dedicated aerodromes to a specific MRTM.

Depending on the complexity of the flexible allocation, the task of allocating the grouped aerodromes to MRTMs can be assigned to a specific role with particular expertise – (e.g. the RTC supervisor). In order to enable an efficient allocation, it is assumed that the RTC Supervisor will be supported by a Supervisor Planning Tool that incorporates data like traffic volume/complexity and weather conditions at the different airports, as well as ATCO endorsements and availability.

Note: The RTC Supervisor role can, within an RTC with a limited number of connected airports, be carried out by one of the ATCOs available in the RTC.

All issues that could impact the ATCOs ability to provide simultaneous ATS in a safe and efficient manner should be taken into consideration, including the following possibilities:

1. The traffic load should be kept at a certain amount defined in the scope of Solution 35 by taking into account traffic complexity and required controller workload for providing simultaneous ATC services. Such workload is generally caused by aerodrome complexity regarding layout or traffic patterns, e.g. backtracking vs. use of parallel taxiways, or ILS for just one RWY.
2. The workload could be balanced on an appropriate level by extended automation support.

The validations were based on the assumption that an ATCO can hold endorsements for up to 4 aerodromes, which can be grouped together and flexibly allocated to MRTMs. This requires harmonisation of MRTM-systems in the RTC and a harmonisation of procedures to support the ATCOs maintenance of 4 endorsements. Nevertheless, the concept is also valid for a higher number of grouped aerodromes, if the ATCO can hold endorsements for more aerodromes.

The Real Time Simulations address in general a setup with two MRTMs, each providing the capability to allocate 3 aerodromes at a time within each MRTM. The validations were focusing on evaluation of human performance and safety aspects.

Solution PJ.05.35 addresses the concept of 4 different aerodromes handled within an RTC, with up to 3 aerodromes per MRTM. Exercises addressing this aspect will use a minimum of 2 MRTMs to distribute 4 aerodromes to a limit of 3 in one MRTM.

| SESAR Solution ID | SESAR Description | Solution | Master or Contributing | Contribution to the SESAR Solution | OI Steps ref. (from EATMA) | Enablers ref. (from EATMA) |
|-------------------|--|----------|------------------------|---|--|------------------------------------|
| PJ05-W2-35 | Remotely Provided Air Traffic Services from a Remote Tower Centre with a flexible allocation of aerodromes to Remote Tower Modules | M | | Increased effectiveness on providing simultaneous ATS from an RTC to a large number of airports flexibly allocated to specific MRTMs. | SDM-0210 Highly Flexible Allocation of Aerodromes to Remote Tower Modules | AERODROME-ATC-83 |
| | | | | | | AERODROME-ATC-84 |
| | | | | | | AERODROME-ATC-85 |
| | | | | | | HUM-066 RTC Supervisor |
| | | | | | | SVC-072 Aerodrome Transfer service |
| | | | | | | CE-S10 (Optional) |
| | | | | | | STD-162 |
| | | | | | | REG - 0537 |

Table 3: SESAR Solution(s) addressed in the Validation Report

NOTE: MET requirements valid for PJ05-W2-35 are validated in SDM-0201, Single Remote Tower, and are valid for any Remote Tower Service.

CTE-S10 is linked to PJ.14-W2-84b.

3.2 Summary of the Validation Plan

3.2.1 Validation Plan Purpose

The objective for PJ.05-W2-35 is to develop and validate (compare OSED and VALP):

- MRTMs which allow ATCOs to provide ATS service to remote aerodromes while maintaining situational awareness for 3 small airports at a time.
- The RTC and the consequent dynamic allocation of airports between MRTMs.

The following traffic characteristics are just providing an **indication of the traffic volumes** regarding simultaneous movements (mix of IFR and VFR):

- 3 airports with up to 6 simultaneous movements
- 20 to 30 movements (air and ground) per hour in total for all airports

As the main driver for the solution is increased cost efficiency, which cannot directly be validated in the exercises, the validations addressed the prerequisites of the concept, i.e. safety and human performance.

The main validation method used were real-time simulations (RTS) as this allows variation of independent variables (e.g. traffic volumes, weather and operating conditions) in a repetitive way. RTS is the way to safely cover normal and abnormal scenarios needed for increased maturity of the concept. Several passive shadow mode validations were also conducted. In addition to this, expert groups and workshops helped to analyse the validation results and propose new designs (HMI, architecture). Safety assessment and risk assessment were covered in workshops.

The flexible allocation of airports to RTMs within an RTC required the following items to be investigated:

- **Support of ATCO situational awareness**
The RTM needed to be designed in a way that it supports ATCO situational awareness integrating all the information from the different airports. HMI guidelines needed to be applied in order to find the balance between providing all information required at a certain moment while avoiding clutter of information.
The use of automation tools supporting ATCO situational awareness was validated.
- **Flexible allocation**
In addition to opening a new position when splitting an aerodrome, a more flexible allocation of aerodromes, i.e. transferring one aerodrome to an already active MRTM was investigated further. A flexible allocation where a transferred aerodrome can take any position within the MRTM was investigated at V3 level.
- **Communication**
Phraseology with airport name added was kept for V3 but it also was further investigated whether the airport name is required in all radio transmissions or mainly for the

transmissions related to the runway (e.g. take-off and landing clearances) in order to reduce communication workload.

The amount of communication and time on the frequency was seen as a bottleneck in situations with high task load at V2, rather than workload or situation awareness and was further evaluated at V3 level.

- **Traffic in Simulations**

The number of movements per hour did not exceed 30 with up to 6 simultaneous movements in the real time simulations, to reflect realistic deployment scenarios and validate scenarios in which situation awareness is given at all times.

Upcoming traffic outside of presentation/current view is very usual in real life, which was not tested at V2 level. This traffic situation was also tested.

VFR flight plans were available in all simulations in V2 validation. The effect on workload was validated if the ATCO needs to set up flight plans for VFR flights.

- **Automation Support**

Automation support providing conformance monitoring, prioritization and indicating actions that need to be taken by the ATCO ('events') was further detailed allowing the ATCO to work in parallel with flight plans and the events. Events for VFR traffic were further elaborated.

- **Supervisor Planning Tool**

For allocating airports and ATCOs to MRTMs, the supervisor planning tool considered (e.g.):

- traffic
- a rostering plan and shift constraints

The workload calculation was further investigated at V3 level, e.g. with respect to the following items:

- The total workload of the aerodromes being allocated to one MRTM is supposed to be more than the sum of the individual workloads. When airports are combined, the workload should increase a bit more than simply adding the workloads of both airports. The more airports are combined, the higher the extra workload should become.
- A threshold for maximum task load per aerodrome and the possibility to see the number of simultaneous movements was added.
- The workload calculation needs to be fully transparent to the users.

The what-if functionality of the supervisor planning tool was further elaborated.

Operating the tool should be easy and the interface should be intuitive.

- **Role of the RTC Supervisor**

The role for the supervisor was defined and validated.

3.2.2 Summary of Validation Objectives and success criteria

To increase the consistency within the Remote-Tower activities, harmonized validation objectives and success criteria have been developed for PJ0 solution 35. When applicable, the validation objectives are related to the KPAs that are addressed with the multiple remote tower concept.

Success criteria were measured using questionnaires, debriefs and workshops. Answering category acceptable (or similar) will indicate success based on the majority of answers for those objectives. In other cases it depends on the expert judgement of the feedback in questionnaires & debriefs. If a majority of the ATCOs and runs provide results of satisfactory level, or higher, results indicate success with respect to the objective. Feedback during debriefs will support expert judgement on the results.

The following list provides an overview of the generic validation objectives and validation criteria that were used for validating the multiple remote tower concept. More detailed information about objectives on Human Performance and Safety are to be found in the HP and Safety Assessment plan. Objectives covered in Real Time Simulations are found in the RTS column. Objectives covered in planned workshops are found in the WS column and results are presented in the HP and Safety reports.

3.2.2.1 Validation Objectives ATCO

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|---|---|------------------------------------|--|-----|----|-----|--|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3- VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3- VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | X | | | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3- VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | X | | X | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3- VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | X | X | X | COOPANS INDRA DLR |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|---|---|--------------------------------|---|-----|----|-----|--|
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | | COOPANS INDRA ENAV DLR |
| HUMAN PERFORMANCE – WORKLOAD | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | X | | | COOPANS ENAV INDRA DLR |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | X | COOPANS INDRA DFS ENAV DLR |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|---|---|--------------------------------|--|-----|----|-----|--|
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | | COOPANS INDRA ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | X | | | COOPANS ENAV INDRA DFS DLR |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | X | X | | COOPANS INDRA DFS ENAV DLR |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | X | X | X | COOPANS ENAV INDRA DLR |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|---|--------------------------------|---|-----|----|-----|--|
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | X | X | | COOPANS ENAV |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | X | X | X | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | X | X | X | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | X | | | COOPANS DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | X | X | X | COOPANS INDRA DFS |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|---|--------------------------------|---|-----|----|-----|--|
| | | | | | | | ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | X | X | X | COOPANS ENAV INDRA DFS DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | X | X | X | COOPANS ENAV INDRA DFS DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | X | X | X | COOPANS ENAV INDRA DLR |
| HUMAN PERFORMANCE – TRUST | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | X | | | DFS ENAV |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | X | | | DFS |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|--|---|--------------------------------|--|-----|----|-----|-----------------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | X | | | COOPANS DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | X | | x | COOPANS ENAV INDRA DLR |
| HUMAN PERFORMANCE – Transition Factors | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | X | X | | COOPANS INDRA ENAV INDRA |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | X | X | | COOPANS ENAV INDRA |
| SAFETY | | | | | | | |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|---|--------------------------------|---|-----|----|-----|--|
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | X | X | X | COOPANS INDRA DFS ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-S04.020 | ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.): <ul style="list-style-type: none"> Unstable approaches Bird strikes Aircraft not vacating RWY as expected | X | X | X | COOPANS INDRA DFS DLR |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | X | X | | COOPANS INDRA DLR ENAV |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | X | | | ENAV DLR |
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | X | | | COOPANS INDRA DLR |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|--|--------------------------------|---|-----|----|-----|--|
| | flexible allocation of aerodromes between MRTMs | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | <p>ATCO is able to identify and manage abnormal situations (e.g.):</p> <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | X | | | COOPANS INDRA ENAV DFS DLR |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g.):</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other airport systems / infrastructure | X | X | X | COOPANS INDRA |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g.):</p> <ul style="list-style-type: none"> • Communication | X | X | X | COOPANS INDRA ENAV |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|---|--------------------------------|---|-----|----|-----|--|
| | | | <ul style="list-style-type: none"> Visualisation system | | | | |
| CAPACITY | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | X | X | | COOPANS INDRA DFS DLR |
| COST EFFICIENCY | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | X | X | | COOPANS DFS ENAV INDRA DLR |

3.2.2.2 Validation Objectives Supervisor

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|---|---|--------------------------------|---|-----|----|-----|---------------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | | | COOPANS ENAV INDRA DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | X | | | COOPANS ENAV INDRA DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | X | | | COOPANS ENAV INDRA DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | X | | | INDRA DLR |
| HUMAN PERFORMANCE – WORKLOAD | | | | | | | |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|---|--|--------------------------------|--|-----|----|-----|---------------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | | COOPANS INDRA ENAV DLR |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | X | X | COOPANS INDRA ENAV DLR |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | X | X | X | COOPANS ENAV INDRA DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | X | X | | COOPANS ENAV INDRA DLR |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | | X | COOPANS INDRA |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|--|---|--------------------------------|--|-----|----|-----|---------------------------------|
| | provision of ATS to multiple aerodromes | | | | | | ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | X | | X | COOPANS INDRA ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | X | | X | COOPANS INDRA ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | X | | | ENAV DLR |
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | X | X | X | COOPANS INDRA ENAV DLR |
| HUMAN PERFORMANCE – TRUST | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | X | | X | COOPANS INDRA ENAV DLR |
| HUMAN PERFORMANCE – Transition Factors | | | | | | | |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|---|--------------------------------|--|-----|----|-----|-----------------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | X | X | | COOPANS INDRA ENAV INDRA |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | X | X | | COOPANS ENAV INDRA |
| SAFETY | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): <ul style="list-style-type: none">Crash on an airport or its vicinityFire on an airportUnplanned closure of an airportATCO overload in one or more MRTM of the RTC | X | X | | COOPANS INDRA ENAV DLR |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g): <ul style="list-style-type: none">CommunicationVisualisation systemOther systems in the MRTM | X | X | X | INDRA ENAV |

| | Validation Objective | Criteria ID | Validation Criteria | RTS | WS | PSM | Coverage |
|----------------------------|--|--------------------------------|--|-----|----|-----|---------------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | X | X | | COOPANS INDRA ENAV DLR |

3.2.3 Validation Assumptions

In the table below the validation assumptions are given.

| Identifier | Title | Description | Justification | Impact on Assessment |
|-------------------------|---------------------------------|---|---|----------------------|
| ASM-PJ05-V3-VALP-ALL.01 | Single remote tower | Remote Provision of ATS to a single Aerodrome | The concept was validated in SESAR1, no other validation is required | N/A |
| ASM-PJ05-V3-VALP-ALL.02 | Remote tower for two aerodromes | Remotely Provided Air Traffic Services for Two Low Density Aerodromes | The concept was validated in SESAR1, no other validation is required | N/A |
| ASM-PJ05-V3-VALP-ALL.03 | PTZ accuracy | Proper control of the PTZ | Due to the nature of simulated presentation, PTZ control will be accurate | N/A |
| ASM-PJ05-V3-VALP-ALL.04 | Object bounding | Following a moving object by bounding could be an issue in the real environment | Due to the nature of simulated presentation, object bounding will be accurate | N/A |
| ASM-PJ05-V3-VALP-ALL.06 | Training and competencies | All Controllers have appropriate training and competencies | In order to validate the MRTM concept it is important that the controllers are familiar with the operating environment and tools. | High |
| ASM-PJ05-V3-VALP-ALL.07 | ATCO licensing | The number of endorsements an ATCO can hold is limited | It is assumed that an ATCO can hold endorsements for up to 4 (single) different airports | N/A |

Table 4: Validation Assumptions overview

In addition to the common validation assumptions, DFS exercise assumed availability of ground surveillance. It should be highlighted that surveillance is optional for solution 35.

3.2.4 Validation Exercises List

| Trial | Training | Part | Start | End |
|---|------------------|--|----------------|----------------|
| EXE-PJ05-W2-35-V3-2.1 – DLR/FRQ/ON/PANSA | September 2021 | EXE-05-W2-35-V3-2.1 (including 2.1.1 and 2.1.2) | November 2021 | November 2021 |
| EXE-PJ05-W2-35-V3-2.2 – COOPANS | March-April 2022 | EXE-PJ05-W2-35-V3-2.2 | April 2022 | April 2022 |
| EXE-PJ05-W2-35-V3-2.3 – INDRA/AVINOR/ HUNGAROCNTR | September 2021 | EXE-2.3.1 Avinor RTS | September 2021 | September 2021 |
| | April 2022 | EXE-2.3.2 HungaroControl PSM | April 2022 | April 2022 |
| | November 2021 | EXE-2.3.3 HungaroControl RTS | November 2021 | December 2021 |
| EXE-PJ05-W2-35-V3-2.4 - ENAV | April 2022 | All | April 2022 | April 2022 |
| EXE-PJ05-W2-35-V3-2.5 - DFS | August 2021 | All | August 2021 | September 2021 |

The following list provides an overview on the exercises that were performed for solution 35:

- EXE-PJ05-W2-35-V3-2.1 – DLR/FRQ/ON/PANSA
 - EXE-PJ05-W2-35-V3-2.1.1 Real Time Simulation by DLR/FRQ/ON/PANSA
 - EXE-PJ05-W2-35-V3-2.1.2 Passive Shadow Mode by DLR/FRQ Comsoft
- EXE-PJ05-W2-35-V3-2.2 – COOPANS
- EXE-PJ05-W2-35-V3-2.3 – INDRA/AVINOR/HUNGAROCNTR
 - EXE-PJ05-W2-35-V3-2.3.1 INDRA/AVINOR RTS
 - EXE-PJ05-W2-35-V3-2.3.2 INDRA/HUNGAROCNTR PSM
 - EXE-PJ05-W2-35-V3-2.3.3 INDRA/HUNGAROCNTR RTS
- EXE-PJ05-W2-35-V3-2.4 - ENAV

- EXE-PJ05-W2-35-V3-2.5 - DFS

| | 2.1-DLR | 2.2-COOPANS | 2.3-INDRA | 2.4-ENAV | 2.5-DFS |
|--|---------|-------------|-----------|----------|---------|
|--|---------|-------------|-----------|----------|---------|

Airports

| | | | | | |
|--------------------|-----------------|--------------------|---|--------------|----------|
| Number of Airports | 15 | 4 | 4 | 3 | 3 |
| Traffic Volumes | ≈ 18 per MRTM/h | ≈ 25-30 per MRTM/h | | Max 30 per h | 18 - 24 |
| VFR Traffic | ≈ 50% | ≈ 10% | | ≈ 25% - 75% | 30 – 60% |

Panorama

| | | | | | |
|-------------------------------------|--|----------------------|---------------------------|---|--------------|
| Monitor alignment | Side-by-side & Top-bottom | Side-by-side & Top | Side-by-side & Top-bottom | On top of each other | Side by side |
| Viewing Angle (panning) | 180° | 360° | 180° | 120° & 180°. 360° available via control panel | 180° |
| Weather Information | Wind, variation, QNH, cross/tail wind, gusts | Wind, variation, QNH | Wind, QNH | Yes on Head down display of CWP | Wind, QNH |
| Labels (continuous position update) | No | Yes | No | Yes | N/A |
| Object Bounding | No | Yes (Optional) | No | No | Yes |

PTZ

| | | | | | |
|-----------|----|-------------|----|------------------------|------------------|
| Displayed | No | In MRTMs VP | No | Yes, dedicated display | Next to panorama |
| Hot Spots | No | No | No | Yes | Runway Check |

| | | | | | |
|-------------------------------------|----|----------------|----|-------------|-------------------|
| Automatic Tracking (based on Radar) | No | No | No | Yes | Yes |
| Control | No | Optical mouse | No | Touch Input | Touch Input / Pen |
| Usage | No | Yes (Optional) | No | regularly | regularly |

EFS

| | | | | | |
|----------------------------|-----|-------------|-----|-----|--|
| Integrated into one Screen | Yes | Yes (WACOM) | Yes | Yes | Yes |
| VFR Flightplans available | Yes | No | Yes | Yes | Most flightplans to be created by ATCO |

Radar

| | | | | | |
|---------------------|-------------|-----|-----|----------------------------|-----|
| Air Surveillance | Yes | Yes | Yes | Yes (2 of 3 airports only) | Yes |
| Ground Surveillance | (Partially) | No | No | No | Yes |

ATCO Planning tool

| | | | | | |
|-----------------|---------------------------|---------------|---------------------------|---|-----|
| look ahead time | 20min-2hrs | 30min-2hrs | 20min-4hrs | 20min-3hrs | N/A |
| Information | Call sign, IFR/VFR, times | Call sign IFR | Call sign, IFR/VFR, times | Call sign, IFR/VFR/Vehicles, times, workload forecast, weather forecast, Module configuration on What-if; Traffic timeline plot | N/A |

MRTM

| | | | | | |
|-------------------------------|-----|-----|----|-----|-----|
| Color coding for each airport | Yes | Yes | No | Yes | N/A |
|-------------------------------|-----|-----|----|-----|-----|

| | | | | | |
|-----------------------------------|---------|--------------------|---------|-------------------------|---------|
| Merge / Split | Yes | Yes | Yes | Yes | N/A |
| <u>Voice communication</u> | | | | | |
| Phraseology with Airport name | Yes | Yes | Yes | Yes | Yes |
| Air/Ground Frequencies | Coupled | Coupled | Coupled | Coupled Air Frequencies | Coupled |
| Ground Frequencies | N/A | Separate/Uncoupled | Coupled | Yes, not coupled | N/A |

3.2.4.1 EXE-PJ05-W2-35-V3-2.1 DLR/FRQ/ON/PANSA

Realtime Simulation

| | |
|----------------------|--|
| Identifier | EXE-PJ05-W2-35-V3-2.1.1 |
| Title | The evaluation of a supervisor workplace in connection to a planning tool that allows and supports the flexible allocation of multiple RTM. |
| Description | <p>Real time simulations of 15 airports with different traffic scenarios on each airport. The supervisor has to supervise each airport and change the ATCOs on each workplace according to the requirements and endorsements.</p> <p>The objective is to assess the possibility of the flexible allocation of different airports in a realistic environment and in normal and abnormal conditions.</p> <p>A system usability analysis as well as a human performance analysis will be conducted as part of the activities.</p> |
| Validation Technique | Real Time Simulation |

Shadow Mode Trial

| | |
|-------------|---|
| Identifier | EXE-PJ05-W2-35-V3-2.1.2 |
| Title | The evaluation of a video tracking technology to enhance the Safety Nets and support the flexible allocation of multiple RTM. |
| Description | Passive Shadow Mode for three selected airports with the enhanced video information. |

| | |
|----------------------|---|
| | <p>The objective is to assess the influence on the safety net and the application of the additional information into the context of the ATC task.</p> <p>A system usability analysis will be conducted as well as part of the activities.</p> |
| Validation Technique | Passive Shadow Mode |

3.2.4.2 EXE-PJ05-W2-35-V3-2.2 COOPANS

| | |
|----------------------|--|
| Identifier | EXE-PJ05-W2-35-V3-2.2 COOPANS |
| Title | Remote Tower Centre with Flexible Allocation of Aerodromes between and within MRTMs. |
| Description | <p>The validation focus was on provision of simultaneous ATS for up to three aerodromes at a time by one ATCO, where the aerodromes were flexibly allocated between the MRTMs, as well as within each MRTM.</p> <p>Four different aerodromes in total were allocated to two separate and independent MRTMs within the RTC, whereas each MRTM was managed by one ATCO. In order to balance and/or reduce the ATCOs workload, the aerodromes were transferred between the MRTMs. A short-time planning tool supported ATCOs assessment about the most suitable time to initiate and conduct the transfer.</p> <p>The validation objective was to assess ATCOs situational awareness (SA) when providing simultaneous ATS to three aerodromes at a time, which were flexibly allocated between the MRTMs. In order to maintain or potentially increase SA, the validation platform allowed ATCOs to allocate the presented aerodromes within their MRTM according to their preferences.</p> <p>It was assumed that ATCOs could hold endorsements for four aerodromes.</p> |
| Validation Technique | <Real Time Simulation> |

3.2.4.3 EXE-PJ05-W2-35-V3-2.3 INDRA/AVINOR/HUNGAROCONTROL

The INDRA/AVINOR/HUNGAROCONTROL validation exercise includes in total three sub-validations together with the ANSPs HungaroControl and Avinor. These validations are listed under the same exercise number with sub-numbering as follows:

- EXE-PJ05-W2-35-V3-2.3.1 INDRA/AVINOR RTS
- EXE-PJ05-W2-35-V3-2.3.2 INDRA/HUNGAROCONTROL PSM
- EXE-PJ05-W2-35-V3-2.3.3 INDRA/HUNGAROCONTROL RTS

Founding Members

The three validations are described separately in the sub-chapters below

Real time Simulation with Avinor

| | |
|----------------------|---|
| Identifier | EXE-PJ05-W2-35-V3-2.3.1 |
| Title | Real time Simulation with Avinor |
| Description | <p>Real Time Simulation utilizing four simulated Norwegian aerodromes and a Remote Tower Centre with two Multiple Remote Tower Modules (MRTM), an approach position and a supervisor position. The MRTMs may present up to three aerodromes simultaneously or a combination of one aerodrome and approach area.</p> <p>The objective is to assess dynamic allocation of aerodromes to MRTMs while maintaining operations as well as the supervisor tools to support the dynamic allocation and planning of aerodrome allocation.</p> <p>A Human Performance analysis will be conducted as well as part of the activities.</p> |
| Validation Technique | Real Time Simulation |

Passive Shadow Mode Trial with HungaroControl

| | |
|----------------------|--|
| Identifier | EXE-PJ05-W2-35-V3-2.3.2 |
| Title | Passive Shadow Mode with HungaroControl |
| Description | <p>Passive Shadow Mode for three selected airports with enhanced video information in a Remote Tower Centre with two Multiple Remote Tower Modules (MRTM) and a Supervisor position.</p> <p>The objective is to assess dynamic allocation of aerodromes to MRTMs while maintaining operations as well as analysing the system usability under normal and degraded conditions in a realistic environment.</p> |
| Validation Technique | Passive Shadow Mode |

Real time Simulation with Hungarocontrol

| | |
|-------------|---|
| Identifier | EXE-PJ05-W2-35-V3-2.3.3 |
| Title | Real time Simulation with HungaroControl |
| Description | Real Time Simulation utilizing four simulated Norwegian aerodromes and a Remote Tower Centre with two Multiple Remote Tower Modules (MRTM) and a supervisor position. The MRTMs may present up to three |

| | |
|-----------------------|--|
| | <p>aerodromes simultaneously or a combination of one aerodrome and approach area.</p> <p>The objective is to assess dynamic allocation of aerodromes to MRTMs while maintaining operations as well as the supervisor tools to support planning of aerodrome allocation.</p> <p>A Human Performance analysis will be conducted as well as part of the activities.</p> |
| Expected Achievements | Indicator on flexibility and transfer of aerodromes between MRTMs including procedures for the transfer. The ability for the RTC Supervisor to plan the dynamic allocation of MRTMs within the RTC based on available information, as well as the support to MRTM during operations and transfer. |
| Validation Technique | Real Time Simulation |

3.2.4.4 EXE-PJ05-W2-35-V3-2.4 ENAV

| | |
|----------------------|--|
| Identifier | EXE-05-W2-35-V3-2.4 ENAV |
| Title | RTC with dynamic allocation of aerodromes to MRTMs |
| Description | <p>Real Time Simulation addressing RTC with the Supervisor role supported by a planning tool for dynamic allocation of 3 small environment airports between two MRTMs. Validation platform is based on ENAV RTC Test Bed integrating IDS AIRNAV and TECHNO SKY systems.</p> <p>Human Performance, Safety and Cost Efficiency analysis has been conducted to evaluate the ATCOs ability to provide simultaneous ATS in a safe and efficient manner.</p> |
| Validation Technique | <Real Time Simulation> |

3.2.4.5 EXE-PJ05-W2-35-V3-2.5 DFS

| | |
|-------------|---|
| Identifier | EXE-PJ05-W2-35-V3-2.5 DFS |
| Title | Flexible Allocation of aerodromes to MRTMs in combination with automation tools (supported by basic ground surveillance) |
| Description | Real Time Simulation with an ATCO providing ATS to 3 small size aerodromes at a time with the aerodromes flexibly allocated to the MRTM. The ATCO will be supported by automation tools (e.g. conformance monitoring, attention guidance with event list) which are based on basic ground and airborne surveillance. The visual |

| | |
|----------------------|--|
| | <p>presentation will be reduced to a minimum with the surveillance being focussed on radar/MLAT/ADS-B and use of PTZ.</p> <p>The objective is to assess the ATCO situation awareness and human performance in different scenarios</p> <p>The shadow mode will validate the generation of alarms and alerts as well as indication of clearances that need to be provided based on the basic ground surveillance. The shadow mode validates the functionality for one aerodrome based on real data while the full functionality is validated in RTS based on simulated data.</p> |
| Validation Technique | Real Time Simulation and Shadow Mode |

3.3 Deviations

3.3.1 Deviations with respect to the SJU Project Handbook

There are no deviations from SJU Project Handbook

3.3.2 Deviations with respect to the Validation Plan

Specific deviations on exercise level are presented in the annexes

In the DLR exercise the baseline configuration without a SUP was removed from the experimental design due to time constraints and necessary training.

In the COOPANS exercise no supervisor planning tool was tested and no supervisor was involved in the validation. Instead the ATCOs used ATCO planning tool and planned transfers themselves.

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4 ATCO - SESAR Solution 35 Validation Results

4.1 ATCO - Summary of SESAR Solution 35 Validation Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---|---|--------------------------------|--|--|--|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>ATCO Situation Awareness was in general at an acceptable level with the flexible allocation of aerodromes and up to 6 simultaneous movements in the simulated environment.</p> <p>Nevertheless, situation awareness decreased rapidly when traffic levels became too high or the situation became very complex (which occurred mainly when ATCOs controlled three aerodromes at a time or when unforeseen traffic popped up).</p> <p>Flexible allocation of aerodromes requires that sufficient buffers are foreseen in order to avoid ATCO overload to consider e.g. unforeseen traffic like police or rescue helicopters or various incoming calls. ATCOs need to be trained to avoid complex situations with increasing traffic levels (e.g. by applying conservative separations)</p> | COOPANS INDRA DFS ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|-------------------------|----------------------------|--------------------------------|---|--|--|-----------------------------|
| | | | | <p>The ATCOS suggested that the number of simultaneous movements might be lowered if one or more of the following items apply:</p> <ul style="list-style-type: none"> - Number of aerodromes - Increased traffic complexity - Aerodrome complexity (e.g. backtracking, hot spots) - Weather conditions - Number of tasks (e.g. met reporting, coordination tasks) | | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs were in general ahead of traffic and thus able to prioritise tasks. The aerodrome with an emergency in general remained within the MRTM while other aerodrome(s) were handed over to another MRTM when possible. | COOPANS INDRA DFS ENAV DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>The user interface generally supported a sufficient level of situation awareness. All systems and system functionalities were well integrated which contributed to achieve this criterion</p> <p>The 'Column-wise' arrangement of information belonging to one aerodrome as</p> | COOPANS INDRA DFS ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|--------------------------|-----------------------------|
| | | | | <p>well as the staggered arrangement of the visual panoramas supported the ATCOs to differentiate between the different aerodromes.</p> <p>The ATCOs highlighted the possibility to decide by themselves at which position to allocate an aerodrome in the MRTM was a very important feature for maintaining situation awareness.</p> | | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | ATCOs could maintain an adequate level of situation awareness despite having to divide their attention to several airports with different procedures and characteristics – even if the allocation of the aerodromes was changing due to the flexible allocation | COOPANS INDRA DLR | OK |
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | The ATCOs HMI generally supported an acceptable level of team situation awareness. Nevertheless an improved alignment between ATCO and SUP HMI needs to be investigated. | COOPANS INDRA ENAV | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|------------------------------|--|--------------------------------|--|---|--|-----------------------------|
| HUMAN PERFORMANCE – WORKLOAD | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The ATCOs overall workload remained at a satisfactory or tolerable level in all the exercises during most of the time.</p> <p>Nevertheless, situation awareness decreased rapidly when traffic levels became too high or the situation became very complex (which occurred mainly when ATCOs controlled three aerodromes at a time or when unforeseen traffic popped up).</p> <p>Flexible allocation of aerodromes requires that sufficient buffers are foreseen in order to avoid ATCO overload to consider e.g. unforeseen traffic like police or rescue helicopters or various incoming calls. ATCOs need to be trained to avoid complex situations with increasing traffic levels (e.g. by applying conservative separations)</p> <p>During the handover process for the flexible allocation of aerodromes, the workload was reported to increase in DLR, COOPANS and INDRA/HC exercises. This requires a good</p> | COOPANS INDRA DFS ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---|---|--------------------------------|---|--|--|-----------------------------|
| | | | | timing for the handover process to be executed in phases with tolerable workload. | | |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The ATCOs confirmed that the amount of communication and time on the frequency were acceptable. The squelch indication was well received by the ATCOs. | COOPANS ENAV INDRA DLR DFS | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | ATCOs confirmed that operating methods (e.g. handover of aerodromes) were efficient under both normal and abnormal operating conditions when providing ATS to multiple aerodromes. During degraded mode, the operating methods required more effort to be accomplished. | COOPANS INDRA DFS ENAV DLR | OK |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when | ATCOs agreed that their roles and responsibilities when providing ATS to multiple aerodromes with flexible allocation were clear and acceptable. | COOPANS INDRA ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---|--|--------------------------------|--|---|--|-----------------------------|
| | | | working in an RTC with a flexible allocation of aerodromes between MRTMs | It was clear to the ATCOs who was responsible for monitoring of traffic and for initiating an aerodrome allocation. | | |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | ATCOs confirmed the feasibility and acceptability of providing ATS to the assigned number of aerodromes on condition that clear rules and procedures were established to prevent overload on the position. | COOPANS ENAV INDRA DFS DLR | OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | <p>ATCOs confirmed that the phraseology when providing ATS to multiple aerodromes was efficient under both normal and abnormal operating conditions as well as in degraded mode.</p> <p>The airport name should be used in all transmissions and at least in all critical transmissions. (e.g. it is essential if the same runway directions are used at different aerodromes).</p> | COOPANS INDRA DFS ENAV DLR | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|---|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The majority of the ATCOs agreed that the System / HMI supported the flexible transfer of an aerodrome. The HMIs could be improved to support ATCOs and SUP teamwork to ensure a common shared picture of the situation at the MRTMs | COOPANS ENAV INDRA DLR | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | No team errors were observed during the simulation | INDRA ENAV | OK |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs rated that the required information was easy to access and presented in an effective way and that they rarely needed to search for information. | COOPANS INDRA DFS ENAV DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | ATCOs confirm the usability of input devices and HMI controls in all exercises | COOPANS INDRA DFS ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|-------------------------|----------------------------|--------------------------------|---|--|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | The majority of the ATCOs confirm that the alarms and alerts were adequate. | COOPANS DFS ENAV DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The ATCOs did not see that the human machine interface will increase the potential for human error | COOPANS INDRA DFS ENAV DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | ATCOs could not always rely on the traffic forecast tool to anticipate the traffic sequence or assess the future traffic load | COOPANS ENAV INDRA DFS DLR | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | The majority of ATCOs were aware which aerodrome was placed to which positions of the MRTM. Even the flexible allocation of aerodromes did not lead to any confusion about which aerodrome was placed in which position. | COOPANS ENAV INDRA DFS DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which | The majority of the ATCOS were aware which airport will be transferred and under which conditions. | COOPANS ENAV | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|--------------|-----------------------------|
| | | | aerodrome will be transferred between the MRTMs. | During handover the respective aerodrome was displayed at both MRTMs which did not confuse the ATCOs. | INDRA DLR | |
| HUMAN PERFORMANCE – TRUST | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | <p>In the DFS exercise the ATCOs confirmed that they could trust the task prioritisation provided by the events (providing clearances which can be issued by the ATCO).</p> <p>ENAV ATCOs were provided with a task prioritisation tool to inform them about the next required clearance. The tool was integrated in the EFPS and highlighted the clearance in the strip of the aircraft that was expected to be cleared.</p> | DFS ENAV | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | <p>ATCOs trusted in the reliability of the conformance monitoring provided by the events in the DFS exercise</p> <p>In the DFS exercise ATCOs rated the trust in the automation support provided by the events as being quite helpful. Alarms and</p> | DFS | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------------|-----------------------------|
| | | | | alerts were provided for conflicting clearances as well as for non-conformances (as defined in the airport safety nets). | | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | ATCOs trusted in the reliability of the alarms and alerts. | COOPANS DFS ENAV DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | ATCOs trusted the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | COOPANS ENAV INDRA DLR | OK |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | For some specific implementations it might be new for the ATCOs to work in a team (which is a new skill requirement in these implementations). | COOPANS INDRA ENAV INDRA | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors | COOPANS ENAV INDRA | OK |
| SAFETY | | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|---------------------------------|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | <p>The majority of the ATCOs confirm that they were able to identify and solve potential conflicts in a timely manner</p> <p>Nevertheless, ATCO training is required to avoid potential conflicts as far as possible in high traffic levels and/or complex situations (e.g. by using conservative separations and limiting traffic numbers when needed)</p> | COOPANS INDRA DFS ENAV | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> Unstable approaches Bird strikes Aircraft not vacating RWY as expected | <p>ATCOs partially agreed that they were able to identify and solve potential hazardous situations in a timely manner. The criterion was validated with a limited number of hazardous situations only</p> | COOPANS INDRA DFS | POK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | <p>ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with</p> | <p>ATCOs were generally able to distinguish with which aircraft or vehicle at which aerodrome they were communicating with.</p> <p>ATCOs appreciated the indication of an incoming call on the visual panorama</p> | COOPANS INDRA DLR ENAV | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-------------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | The majority of ATCOs find that they were not inducing more conflicting situations than in the reference scenario | ENAV DLR INDRA | OK |
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | <p>The ATCOs were in general able to foresee traffic at his/her MRTM at short term in order to avoid overloads. It should be mentioned that unforeseen traffic (e.g. vehicles or police and rescue helicopters) can occur at any time.</p> <p>The ATCO planning tools did not always fully support foreseeing traffic (compare CRT-PJ05-W2-35-V3-VALP-H11.060).</p> | COOPANS INDRA DLR | POK |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | <p>ATCO is able to identify and manage abnormal situations (e.g.):</p> <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | The majority of ATCOs find that they are able to identify and manage abnormal situations (aircraft emergency) | INDRA ENAV DFS | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|--|--------------------------------|---|--|--------------------------------|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g): <ul style="list-style-type: none">• Communication• Visualisation system• Other airport systems / infrastructure | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure occurring at one of the aerodromes | COOPANS INDRA | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g): <ul style="list-style-type: none">• Communication• Visualisation system | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes | COOPANS INDRA ENAV | OK |
| CAPACITY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | The majority of ATCOs agree that providing ATS with up to 6 simultaneous movements is in general feasible and acceptable. It must be emphasised that spare capacity needs to | COOPANS INDRA DFS DLR | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|--|--------------------------------|--|--|--|-----------------------------|
| | | | | be considered for unforeseen events or other operational tasks | | |
| COST EFFICIENCY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | <p>ATCOs stated that they can provide ATS for up to three aerodromes applying flexible allocation of aerodromes. The required staff will depend on the need to have spare capacity and resources available to dynamically change the allocation of aerodromes.</p> <p>All exercises assumed that the ATCOs have up to 4 endorsements</p> | COOPANS DFS ENAV INDRA DLR | OK |

Table 5: ATCO - Summary of Validation Exercises Results

4.2 Detailed analysis of SESAR Solution Validation Results per Validation objective

Founding Members

The following chapters provides the summary of all the different validation exercises. For each criterion the bold text describes the common conclusion (considering the results from all exercises). In addition to this the information is given, when one or more exercises deviated from this common conclusion and might have lead to the status 'POK'. This additional information is given to be considered when developing specific local implementations with specific local needs.

If the majority of exercises showed the status 'OK', this status was also taken as the consolidated status. In case there were some exercise status 'POK' or 'NOK' there was discussion during the workshops (VALR as well as HP and SAF) on the severity on these statements compared to the 'OK' status, leading to the consolidated status.

4.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

4.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

| OBJ-PJ05-W2-35-V3-VALP-H02 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>ATCO Situation Awareness was in general at an acceptable level with the flexible allocation of aerodromes and up to 6 simultaneous movements in the simulated environment.</p> <p>Nevertheless, situation awareness decreased rapidly when traffic levels became too high or the situation became very complex (which occurred mainly when ATCOs controlled three aerodromes at a time or when unforeseen traffic popped up).</p> <p>Flexible allocation of aerodromes requires that sufficient buffers are foreseen in order to avoid ATCO overload to consider e.g. unforeseen traffic like police or rescue helicopters or various incoming calls. ATCOs</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H02 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | <p>need to be trained to avoid complex situations with increasing traffic levels (e.g. by applying conservative separations)</p> <p>The ATCOS suggested that the number of simultaneous movements might be lowered if one or more of the following items apply:</p> <ul style="list-style-type: none"> - Number of aerodromes - Increased traffic complexity - Aerodrome complexity (e.g. backtracking, hot spots) - Weather conditions - Number of tasks (e.g. met reporting, coordination tasks) <p>In the DLR exercise ATCOs highlighted that prior allocation plans (daily plans) would be helpful to raise the level of situational awareness. Allocation plans might just be coordinated via the supervisor.</p> <p>In the DFS exercise system support provided by reminder events (such as landing reminders) and safety alerts helped to maintain Situations Awareness.</p> | |
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | <p>ATCOs were in general ahead of traffic and thus able to prioritise tasks. The aerodrome with an emergency in general remained within the MRTM while other aerodrome(s) were handed over to another MRTM when possible.</p> <p>Nevertheless ATCOs in the DLR and INDRA/AVINOR exercise reported that they had difficulties prioritizing tasks mainly in high traffic / complex situations.</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H02 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | In the DLR exercise ATCOs stated that tasks could be done in more effective way if standardised by particular rules (e.g. conditions to handover aerodromes) | |
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>The user interface generally supported a sufficient level of situation awareness. All systems and system functionalities were well integrated which contributed to achieve this criterion</p> <p>The 'Column-wise' arrangement of information belonging to one aerodrome as well as the staggered arrangement of the visual panoramas supported the ATCOs to differentiate between the different aerodromes.</p> <p>The ATCOs highlighted the possibility to decide by themselves at which position to allocate an aerodrome in the MRTM was a very important feature for maintaining situation awareness.</p> <p>In the COOPANS exercise situation awareness was supported by assigning a coloured frame for each aerodrome for the respective displays.</p> <p>In the INDRA/HC exercises situation awareness was temporary reduced after a handover due to an unwanted change in the setup of the radar maps shifting to different places (while the MET displays remained in the previous position).</p> <p>The DLR user interface was rated as being good and supporting situational awareness, but there is plenty of space to even improve it before operational status (e.g. add additional information in the visual representation, easier interface for handover of aerodromes)</p> | OK |

| | | | |
|--------------------------------|--|--|----|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | <p>ATCOs could maintain an adequate level of situation awareness despite having to divide their attention to several airports with different procedures and characteristics – even if the allocation of the aerodromes was changing due to the flexible allocation.</p> <p>In the DLR exercise ATCOs stated that situational awareness would be even higher if they were more acquainted and experienced with the operational environment of all aerodromes.</p> <p>This criterion was not addressed in ENAV and DFS exercises.</p> | OK |
|--------------------------------|--|--|----|

4.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of | <p>The ATCOs HMI generally supported an acceptable level of team situation awareness. Nevertheless, an improved alignment between ATCO and SUP HMI needs to be investigated.</p> <p>In the COOPANS exercise team situation awareness was evaluated just between ATCOs working at the different MRTMs (leading to the exercise status 'POK' for this criteria).</p> <p>In the INDRA/AVINOR exercise the supervisors' HMI did not support an acceptable level of situational awareness of the ATCOs workload and traffic situation at the MRTMs.</p> | POK |

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--------------------------|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | aerodromes between MRTMs | This criterion was not addressed by DLR and DFS exercises. | |

4.2.2 HUMAN PERFORMANCE – WORKLOAD

4.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

| OBJ-PJ05-W2-35-V3-VALP-H04 Assess ATCO workload when providing ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The ATCOs overall workload remained at a satisfactory or tolerable level in all the exercises during most of the time.</p> <p>Nevertheless, situation awareness decreased rapidly when traffic levels became too high or the situation became very complex (which occurred mainly when ATCOs controlled three aerodromes at a time or when unforeseen traffic popped up).</p> <p>Flexible allocation of aerodromes requires that sufficient buffers are foreseen in order to avoid ATCO overload to consider e.g. unforeseen traffic like police or rescue helicopters or various incoming calls. ATCOs</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H04 Assess ATCO workload when providing ATS to multiple aerodromes | | | |
|--|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | <p>need to be trained to avoid complex situations with increasing traffic levels (e.g. by applying conservative separations)</p> <p>During the handover process for the flexible allocation of aerodromes, the workload was reported to increase in DLR, COOPANS and INDRA/HC exercises. This requires a good timing for the handover process to be executed in phases with tolerable workload.</p> | |
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | <p>The ATCOs confirmed that the amount of communication and time on the frequency were acceptable. The squelch indication was well received by the ATCOs.</p> <p>In the COOPANS and ENAV exercise air frequencies were coupled and transmitted via headphones, vehicle frequencies were separated and transmitted via dedicated loudspeakers. In the COOPANS exercise problems resulted from simultaneous incoming calls from air and vehicle frequency in terms of overlapping calls. A potential mitigation would be a call up button for the vehicles.</p> <p>In the COOPANS exercise the air and vehicle frequencies were addressed by the ATCO for an outgoing call via a specific PTT device with 4 Buttons (one air and 3 vehicle frequencies)</p> <p>In the INDRA exercises air frequencies were coupled and transmitted via headphones or a dedicated loudspeaker while vehicle frequencies were coupled separately and transmitted via a dedicated loudspeaker.</p> <p>In the DLR exercise all air and vehicle frequencies were coupled.</p> <p>In the DFS exercise all air frequencies were coupled (no dedicated vehicle frequency used).</p> | OK |

4.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

4.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

| OBJ-PJ05-W2-35-V3-VALP-H06 Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>ATCOs confirmed that operating methods (e.g. handover of aerodromes) were efficient under both normal and abnormal operating conditions when providing ATS to multiple aerodromes.</p> <p>During degraded mode, the operating methods required more effort to be accomplished.</p> <p>In the DFS exercise it was discussed during the debriefings that ATCOs need to be trained to work using conservative separations and not to try to speed up traffic as much as possible (as they are used to in today operations)</p> <p>In the DLR exercise the ATCOs indicated a general need for more training of the operational methods.</p> <p>In the COOPANS exercise no abnormal conditions were evaluated.</p> | OK |

4.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

| OBJ-PJ05-W2-35-V3-VALP-H07 Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>RESULT: ATCOs agreed that their roles and responsibilities when providing ATS to multiple aerodromes with flexible allocation were clear and acceptable.</p> <p>It was clear to the ATCOs who was responsible for monitoring of traffic and for initiating an aerodrome allocation.</p> <p>The criterion was not addressed by DFS exercise.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the | <p>ATCOs confirmed the feasibility and acceptability of providing ATS to the assigned number of aerodromes on condition that clear rules and procedures were established to prevent overload on the position.</p> <p>Attention must be paid to the number of simultaneous movements which was rated critical in the DFS exercise. Especially traffic that cannot be delayed (like rescue or police helicopters) and thus might increase the number of simultaneous movements must be considered.</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H07 Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | | | |
|--|-------------------------------|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | assigned number of aerodromes | | |

4.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | <p>ATCOs confirmed that the phraseology when providing ATS to multiple aerodromes was efficient under both normal and abnormal operating conditions as well as in degraded mode.</p> <p>The airport name should be used in all transmissions and shall be used in all runway related transmissions. (e.g. it is essential if the same runway directions are used at different aerodromes).</p> <p>In the DFS exercise the ATCOs highlighted that the pilots starting a call using the respective aerodrome name in the phraseology helped to maintain situation awareness.</p> <p>In the COOPANS exercise during the transfer, both ATCOs confirmed control of certain aerodrome using the aerodrome name (e.g. My control at Malmö airport – Your control at Malmö airport).</p> <p>In the COOPANS and DLR exercise abnormal situations were not part of the validation exercise.</p> | OK |

4.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

4.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

| OBJ-PJ05-W2-35-V3-VALP-H18 Assess that human-machine interface supports the team in carrying out their tasks | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | <p>The majority of the ATCOs agreed that the System / HMI supported the flexible transfer of an aerodrome. The HMIs could be improved to support ATCOs and SUP teamwork to ensure a common shared picture of the situation at the MRTMs.</p> <p>In the COOPANS exercise the SUP position was out of scope.</p> <p>The criterion was not addressed in DFS exercise.</p> | POK |
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | <p>No team errors were observed during the simulation</p> <p>This criterion was only addressed in the INDRA/HC and the ENAV exercises.</p> | OK |

4.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

| OBJ-PJ05-W2-35-V3-VALP-H11 Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | <p>ATCOs rated that the required information was easy to access and presented in an effective way and that they rarely needed to search for information.</p> <p>In the INDRA exercises the ATCOs saw the need for improvement of the timeline and cardinal presentation and presentation of the wind information in the visual representation.</p> <p>Situation Awareness was temporarily reduced with the INDRA System after a handover due to an unwanted change in the setup of the radar maps shifting to different places (while the MET displays remained in the previous position).</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | <p>ATCOs confirm the usability of input devices and HMI controls in all exercises</p> <p>In the INDRA/HC exercise the two-button design of the mic was unfamiliar and not intuitive (while it was appreciated in the INDRA/AVINOR exercise).</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | <p>The majority of the ATCOs confirm that the alarms and alerts were adequate.</p> <p>In the DLR exercise ATCOs stated that additional features for the proximity warnings might be helpful.</p> <p>In the DFS exercise ATCOs rated the usability and utility of the automation support provided by the events as being quite helpful. Alarms and alerts were provided for conflicting clearances as well as for non-conformances (as defined in the airport safety nets).</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H11 Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | The criterion was not addressed in the INDRA exercises. | |
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | <p>The ATCOs did not see that the human machine interface will increase the potential for human error</p> <p>In the COOPANS exercise ATCOs stated that the human machine interface could sometimes increase the potential for human error. There is a request to keep the layout in the WACOM screen the same for all modes.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | <p>ATCOs could not always rely on the traffic forecast tool to anticipate the traffic sequence or assess the future traffic load.</p> <p>In the DFS exercise the ATCOs highlighted the usability and utility of the task prioritisation provided by the events indicating clearances that could be issued as wells as alarms and alerts.</p> <p>In the DLR exercise ATCOs stated that functionalities or metrics could be changed to make the planning tool more useful (The tool had a fixed time horizon of 20 Minutes and ATCOS preferred it to be flexible)</p> <p>In the INDRA/HC exercise the ATCOs preferred the strips over the planning tool as they contained more detailed information and the timeline was not always accurate.</p> <p>In the INDRA/Avinor exercise ATCOs could not always rely on the traffic forecast tool to anticipate the traffic sequence or assess the future traffic load.</p> | POK |

| OBJ-PJ05-W2-35-V3-VALP-H11 Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | <p>In the COOPANS exercise the ATCOs stated that the ATCO planning tool was useful, it is however in need of further development (More reliable workload estimation are required. VFR and vehicle traffic was not part of the workload estimations, MET conditions etc.).</p> <p>In the ENAV exercise the prioritisation tool was easy to use. During the debriefing, the ATCOs judged it as useful but there was not so much interest in it. It has to be considered, that ATCOs involved in the exercise were not familiar with the EFPS system, so the HMI indication processed by the ATCO Prioritisation Tool algorithm was not always obvious as supporting information.</p> | |
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | The majority of ATCOs were aware which aerodrome was placed to which positions of the MRTM. Even the flexible allocation of aerodromes did not lead to any confusion about which aerodrome was placed in which position. | OK |

| | | | |
|--------------------------------|--|--|----|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | <p>The majority of the ATCOS were aware which airport will be transferred and under which conditions. During handover the respective aerodrome was displayed at both MRTMs which did not confuse the ATCOs.</p> <p>DLR: During the transfer procedure, both could listen, talk and see the airport on their workplace. They could also hear the other ATCOs talk. The frequencies were coupled when the visual representation of the airport was activated.</p> <p>COOPANS: When an initial communication between the involved ATCOs was established and transfer of the particular aerodrome was initiated, the traffic situation at that aerodrome was described between the ATCOs. After confirmation about who has the current control over the aerodrome, the ATCO in charge had to select the required frequencies presented in VCS while the other ATCO had to deselect/release them.</p> <p>ENAV: During the handover procedure, once initiated, the receiving ATCO started monitoring the frequency (of the airport that was going to be transferred) few seconds before the airport was displayed on both visual presentations; the frequency was manually (not automatically) taken over by the receiving module at the end of the handover procedure. Indeed, before the transfer, the receiving ATCO manually set audio module only for receiving (RX) communications related to the airport that was about to be acquired. After transfer, the receiving ATCO needed to manually set audio module for coupling the 'air' frequencies, by clicking TX related to the transferred airport. The sending ATCO manually set his audio module on RX to monitor transferred airport frequency until the acknowledgment of the successful completion of the handover procedure from the receiving ATCO in order to positively close the handover procedure. No issues were raised by ATCOs about the frequency during the handover.</p> <p>INDRA/Avinor and HungaroControl: During handover the receiving ATCO selected the frequency in monitoring mode to listen to gain a situational awareness of the receiving airport traffic. The visual picture as well as surveillance and flight plan information were also presented. At an agreed time, the actual handover was done and the receiving ATCO enabled the frequency for transmission and changed the heads-down environment to operating mode. At the same time the sending ATCO changed the airport frequencies and heads-down</p> | OK |
|--------------------------------|--|--|----|

| | | | |
|--|--|--|--|
| | | <p>environment to monitoring mode. When the sending ATCO assessed that the receiving ATCO was in control and did not need more assistance, the sending ATCO could deselect the airport and the associated frequencies.</p> <p>The criterion was not addressed in the DFS exercise.</p> | |
|--|--|--|--|

4.2.5 HUMAN PERFORMANCE – TRUST

4.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

| OBJ-PJ05-W2-35-V3-VALP-H13 Assess ATCO trust in support systems when providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | <p>In the DFS exercise the ATCOs confirmed that they could trust the task prioritisation provided by the events (providing clearances which can be issued by the ATCO).</p> <p>ENAV ATCOs were provided with a task prioritisation tool to inform them about the next required clearance for the module. The tool was integrated in the EFPS and highlighted the clearance in the strip of the aircraft that was expected to be cleared. No issues raised in relation to the trust of the functionality of the task prioritisation tool. The level of reliability was considered sufficient on the basis of a 7 points post-simulation question where most of the ATCOs somewhat agreed that the tool provided reliable suggestions.</p> <p>The criterion was not addressed in the DLR; COOPANS and INDRA exercises.</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H13 Assess ATCO trust in support systems when providing ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | <p>ATCOs trusted in the reliability of the conformance monitoring provided by the events in the DFS exercise</p> <p>In the DFS exercise ATCOs rated the trust in the automation support provided by the events as being quite helpful. Alarms and alerts were provided for conflicting clearances as well as for non-conformances (as defined in the airport safety nets).</p> <p>The criterion was only assessed in the DFS exercise.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | <p>ATCOs trusted in the reliability of the alarms and alerts.</p> <p>In the DFS exercise ATCOs appreciated the alarms and alerts provided by the events. Alarms and alerts were provided for conflicting clearances as well as for non-conformances (as defined in the airport safety nets).</p> <p>In the COOPANS exercise only the alerts were addressed.</p> <p>The criterion was not addressed in the INDRA exercises.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | <p>ATCOs trusted the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer</p> <p>For the DLR exercise ATCO stated that the transfers of aerodromes was quite manual at the platform the validation took place. It needs to be more automated or the procedures have to be clearer.</p> <p>The criterion was not addressed in the DFS exercise.</p> | OK |

4.2.6 HUMAN PERFORMANCE – Transition Factors

4.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

| OBJ-PJ05-W2-35-V3-VALP-H15 Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | <p>For some specific implementations it might be new for the ATCOs to work in a team (which is a new skill requirement in these implementations).</p> <p>More information on new requirements on knowledge, skills and experience are given in the HPAR.</p> <p>The status is set to OK referring to preliminary identification only.</p> <p>The criterion was not addressed in DLR and DFS exercises.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | <p>The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors.</p> <p>The criterion was not addressed in the DLR and DFS exercises.</p> | OK |

4.2.7 SAFETY

4.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

| OBJ-PJ05-W2-35-V3-VALP-S04 Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | <p>RESULT: The majority of the ATCOs confirm that they were able to identify and solve potential conflicts in a timely manner</p> <p>Nevertheless, ATCO training is required to avoid potential conflicts as far as possible in high traffic levels and/or complex situations (e.g. by using conservative separations and limiting traffic numbers when needed)</p> <p>In the DFS exercise ATCOs were supported by the system in identifying potential conflicts (by providing alarms and alerts via the events) which was well appreciated.</p> <p>In the ENAV exercise the ATCOs were even appreciating the conflicting clearances tool which supported the ATCOs in the overload cases in the early identification of clearances in conflict.</p> <p>The criterion was not addressed in the DLR exercise</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous</p> | <p>ATCOs partially agreed that they were able to identify and solve potential hazardous situations in a timely manner. It should be noted that the criterion was validated with a limited number of hazardous situations only.</p> | POK |

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| | <p>situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> • Unstable approaches • Bird strikes <p>Aircraft not vacating RWY as expected</p> | <p>In the INDRA/AVINOR exercise, ATCOs did not always timely detect runway incursions by unauthorized vehicles (However the analysis revealed contributing factors that were not directly related to multiple tower operations (cf. detailed results of CRT-PJ05-W2-35-V3-VALP-S04.020, in section C.4.2.7.1)</p> <p>In COOPANS exercise the system allowed ATCOs to choose a preferred mode of aerodrome presentation. Working in triple mode, regardless the number of presented aerodromes, the picture was more compressed resulting in a reduced resolution compared to single or double mode. Nevertheless, ATCOs could mitigate the reduced resolution by (temporarily) zooming the visual representation.</p> <p>In the DFS exercise ATCOs were supported by the system in identifying non-conformances (potentially leading to hazardous situations) which was well appreciated.</p> <p>The criterion was not addressed in DLR and ENAV exercises.</p> | |
| CRT-PJ05-W2-35-V3-VALP-S04.030 | <p>ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with</p> | <p>ATCOs were generally able to distinguish with which aircraft or vehicle at which aerodrome they were communicating with.</p> <p>ATCOs appreciated the indication of an incoming call on the visual panorama.</p> <p>In the COOPANS exercise ATCOs were support by the differentiated display of incoming calls for air and vehicle frequencies.</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-S04 Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | The criterion was not addressed in the DFS exercise. | |
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | <p>The majority of ATCOs find that they were not inducing more conflicting situations than in the reference scenario.</p> <p>In the INDRA/HC exercise this was confirmed also by over the shoulder observations.</p> <p>The criterion was not addressed in COOPANS, INDRA/AVINOR and DFS exercises.</p> | OK |

4.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

| OBJ-PJ05-W2-35-V3-VALP-S05 Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at | <p>The ATCOs were in general able to foresee traffic at his/her MRTM at short term in order to avoid overloads. It should be mentioned that unforeseen traffic (e.g. vehicles or police and rescue helicopters) can occur at any time.</p> | POK |

OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|--|---|--------|
| | short term in order to avoid overloads | <p>The ATCO planning tools did not always fully support foreseeing traffic (compare CRT-PJ05-W2-35-V3-VALP-H11.060).</p> <p>The criterion was not addressed in the ENAV and DFS exercises.</p> | |

4.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results**OBJ-PJ05-W2-35-V3-VALP-S06**

Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): | <p>The majority of ATCOs find that they are able to identify and manage abnormal situations (aircraft emergency)</p> <p>The criterion was not addressed in DLR and COOPANS exercises.</p> | OK |

OBJ-PJ05-W2-35-V3-VALP-S06

Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|--|-------------------|--------|
| | <ul style="list-style-type: none"> Aircraft emergency Crash on an airport or its vicinity Fire on an airport <p>Unplanned closure of an airport</p> | | |

4.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results**OBJ-PJ05-W2-35-V3-VALP-S07**

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|-----------------|---|--|--------|
| CRT-PJ05-W2-35- | ATCO is able to detect and recover from a technical | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure occurring at one of the aerodromes. | OK |

OBJ-PJ05-W2-35-V3-VALP-S07

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| V3-VALP-S07.010 | <p>failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system <p>Other airport systems / infrastructure</p> | The criterion was addressed only in the COOPANS exercises. | |
| CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> | <p>The majority of the ATCOs confirm that they were able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes.</p> <p>In the INDRA and ENAV exercises the ATCOs transferred the aerodrome to another active or spare MRTM and were supported by the supervisor.</p> <p>In the COOPANS exercise the ATCO transferred the aerodrome to another active MRTM (and was not supported by a supervisor)</p> | OK |

OBJ-PJ05-W2-35-V3-VALP-S07

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---|---|--------|
| | <ul style="list-style-type: none"> Communication <p>Visualisation system</p> | The criterion was not addressed in the DLR and DFS exercises. | |

4.2.8 CAPACITY**4.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results****OBJ-PJ05-W2-35-V3-VALP-CA1**

Assess capacity constraints when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided | <p>The majority of ATCOs agree that providing ATS with up to 6 simultaneous movements is in general feasible and acceptable. It must be emphasised that spare capacity needs to be considered for unforeseen events or other operational tasks.</p> <p>The criterion is rated 'POK' due to the results from the following both exercises:</p> | POK |

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---------------------------|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | to multiple remote towers | <p>In the COOPANS validation ATCOs stated that 6 simultaneous movements does not necessarily need to be the limit. It does however depend on what type of traffic situations the ATCO are working with. Other operational tasks that were not included in the validation also need to be considered.</p> <p>In the DFS exercise the ATCOs highlighted that attention must be paid to the number of simultaneous movements which was rated critical. Especially traffic that cannot be delayed (like rescue or police helicopters) and thus might increase the number of simultaneous movements must be considered.</p> <p>The criterion was not addressed in the ENAV exercise.</p> | |

4.2.9 COST EFFICIENCY

4.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35- | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on | ATCOs stated that they can provide ATS for up to three aerodromes applying flexible allocation of aerodromes. | OK |

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| V3-VALP-CE1.010 | endorsements out of a group of 4 aerodromes | <p>The required staff will depend on the need to have spare capacity and resources available to dynamically change the allocation of aerodromes.</p> <p>All exercises assumed that the ATCOs have up to 4 endorsements.</p> | |

4.3 Confidence in Validation Results

4.3.1 Limitations of Validation Results

4.3.1.1 Quality of Validation Results

All results in this validation exercises were subjectively assessed by the participants. Their opinions, estimations and evaluations have been collected by the means of questionnaires (including validated and tailored questions) after each simulation and after the exercise run; adapted scales during the runs and semi-directed interviews in the debriefing phase. All participants were active air traffic controllers and provided therefore reliable data from an expert point of view. An adequate briefing and training before starting the simulation was conducted to avoid motivational biases.

The standardized experimental conditions and the study design (repeated measures, within-subject) allowed each participant to realize all simulation runs. The scenario order was randomized in order to reduce a learning effect which could not fully be counterbalanced.

Taking into account that the results are independent, reliable and in addition to that as well valid for the respective profession, the validation exercise results can be considered of high quality.



4.3.1.2 Significance of Validation Results

The significance of the validation results is high as the solution was validated on five different platforms with a high number of ATCOs participating. Normal as well as non-nominal and degraded modes were considered.

However, the significance of the validation results is limited regarding the following aspects:

- the number of occurrences for degraded modes were limited
- In the planning tools the flightplans for all movements were available (including for all VFR traffic)
- not all ATCOs participating in the validations have a local endorsement at the aerodromes in the validations. therefore methods and procedures were simplified
- All validations, except one, were run as Real Time Simulations ensuring perfect conditions with respect to surveillance

5 Supervisor - SESAR Solution 35 Validation Results

The Supervisor part of solution 35 was covered by the ENAV, INDRA and DLR exercises.

5.1 Supervisor - Summary of SESAR Solution 35 Validation Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---|---|--------------------------------|---|---|----------------------|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants at the SUP workplace indicate a positive situation awareness. | ENAV INDRA DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | In general SUPs were able to prioritise tasks (e.g. between coordination task, planning aerodrome allocation to MRTMS and supporting the ATCO in an emergency). | ENAV INDRA DLR | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---|--|--------------------------------|--|--|---------------------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | The majority of the Supervisors agreed that the HMI supported their situational awareness and decision-making process | COOPANS ENAV INDRA DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | The majority of SUP confirmed that they could maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | INDRA DLR | OK |
| HUMAN PERFORMANCE – WORKLOAD | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of SUPs assessed that the workload was at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs. The exercises focussed mainly on the tasks related to the flexible allocation of aerodromes | INDRA ENAV DLR | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal | Supervisors reported that they were able to efficiently support ATCOs in non-nominal situations, and were also able to make | INDRA ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---|--|--------------------------------|---|---|----------------------|-----------------------------|
| | ATS to multiple aerodromes | | and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | decisions about the flexible transfer of aerodromes | | |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | The majority of supervisors assessed that the changes in roles and responsibilities were acceptable. | ENAV INDRA DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Majority of Supervisors confirmed the feasibility and acceptability of supervising the assigned number of clusters of aerodromes | ENAV INDRA DLR | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible | Supervisors assessed that they did not always have all required information available. In some cases this was due to the way the information was presented rather than the availability of the information. | INDRA ENAV DLR | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|---------------------------|----------------------------|--------------------------------|--|--|----------------------|-----------------------------|
| | ATS to multiple aerodromes | | allocation of aerodromes between MRTMs | | | |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | The majority of SUPs agreed that the input devices on the supervisor position were easy to use | INDRA ENAV DLR | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | In general the SUPs agreed that the planning tool was easy to use but there was some room for improvement (e.g. information on ATCOs availability and endorsements). | INDRA ENAV DLR | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | In the ENAV exercise the majority of Supervisors confirm adequate usability and utility of alarms for the SUP. The Supervisor was informed on an emergency when the ATCO pressed a respective button | ENAV | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | The supervisor HMI did not lead to human errors during the validation. Some HMI improvements are needed to reduce the potential of human errors. | INDRA ENAV DLR | OK |
| HUMAN PERFORMANCE – TRUST | | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|------------------------|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors could not always trust the planning tool to give them a correct picture of the situation at aerodromes/MRTMs. | INDRA ENAV DLR | POK |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | There are no new requirements on knowledge, skills and experience compared to the reference solution. The SUPs need to have sufficient knowledge on all of the aerodromes they are responsible for. SUPs might hold the endorsement for (some of) the aerodromes | INDRA ENAV INDRA | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors | ENAV INDRA | OK |
| SAFETY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): | Supervisors were able to support the ATCO in case of an emergency at one aerodrome by supervising the handover of aerodromes to another ATCO and offloading the ATCO from the coordination tasks. | INDRA ENAV DLR | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|------------------------------|---|--------------------------------|---|---|----------------------|-----------------------------|
| | flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | | | |
| OKOBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> Communication Visualisation system Other systems in the MRTM | Supervisors could manage the technical failure occurring in one MRTM by supporting the ATCO in the transfer of an aerodrome to a another MRTM | INDRA ENAV | OK |
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | Supervisors assessed that they did not always have all required information available. In some cases this was due to the way the information was presented rather than the availability of the information. | INDRA ENAV DLR | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Coverage | Validation Objective Status |
|-------------------------|----------------------------|----------------------|-------------------|--|----------|-----------------------------|
| | aerodromes between MRTMs | | | (compare CRT-PJ05-W2-35-V3-VALP-H12.010) | | |

Table 6: Supervisor - Summary of Validation Exercises Results

5.2 Detailed analysis of SESAR Solution Validation Results per Validation objective

5.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

5.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

| OBJ-PJ05-W2-35-V3-VALP-H01 Assess SUP situation awareness when working in an RTC | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The majority of participants at the SUP workplace indicate a positive situation awareness.</p> <p>In the DLR exercise the SUP situational awareness was supported by information on the available ATCOs and the amount of predicted traffic for each aerodrome.</p> <p>In the INDRA/AVINOR exercises the information of traffic tool (timeline indicating the present and forecasted traffic) was not sufficiently reliable for the SUPs. The ATCO workload could not sufficiently be assessed (e.g. information on vehicles missing).</p> <p>In the INDRA/HC exercise the information of the traffic tool was extended to show also traffic counts over periods and simultaneous movements for each MRTM which contributed to the situational awareness.</p> <p>In the ENAV exercise, the expected workload of the ATCOs (based on traffic for IFR and VFR, weather conditions and vehicle missions) was presented by a SUP planning tool to support the SUPs situational awareness. In addition, the SUPs were provided with the FDP flight list to support their situational</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H01 Assess SUP situation awareness when working in an RTC | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | awareness. Because the SUP planning tool was based on planned traffic rather than live traffic, the SUPs monitored the live traffic on the FDP and by coordinating with the ATCOs in order to keep their mental model constantly updated. | |
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | <p>In general SUPs were able to prioritise tasks (e.g. between coordination task, planning aerodrome allocation to MRTMS and supporting the ATCO in an emergency).</p> <p>The criteria was set to the status 'POK' due to the results of the INDRA/AVINOR and DLR exercise.</p> <p>In the INDRA/AVINOR exercise it was not always possible for the supervisors to satisfactorily plan the allocation of aerodromes to MRTMs and ATCOs. The problem was not that supervisors did not have sufficient time to prioritise task but rather information that was missing (traffic timeline tool did not provide to the supervisor a reliable picture of the current traffic situation at the MRTMs due to problems in the technical implementation). Furthermore the information on ATCO availability was missing.</p> <p>In the DLR exercise operators were not used to the new task and might have needed more training/experience.</p> | POK |
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient | The majority of the Supervisors agreed that the HMI supported their situational awareness and decision-making process | OK |

| OBJ-PJ05-W2-35-V3-VALP-H01 Assess SUP situation awareness when working in an RTC | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | level of individual situation awareness | | |
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | <p>The majority of SUP confirmed that they could maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes</p> <p>The criterion was not addressed in the ENAV and INDRA/HC exercise</p> | OK |

5.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H01 Assess SUP situation awareness when working in an RTC | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness | <p>The ATCOs HMI generally supported an acceptable level of team situation awareness. Nevertheless, an improved alignment between ATCO and SUP HMI needs to be investigated.</p> <p>In the INDRA/AVINOR exercise the supervisors' HMI did not support an acceptable level of situational awareness of the ATCOs workload and traffic situation at the MRTMs.</p> | POK |

| OBJ-PJ05-W2-35-V3-VALP-H01 Assess SUP situation awareness when working in an RTC | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | when working in an RTC with a flexible allocation of aerodromes between MRTMs | The criterion was not addressed in the ENAV and INDRA/HC exercise | |

5.2.2 HUMAN PERFORMANCE – WORKLOAD

5.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

| OBJ05-W2-35-V3-VALP-H05 Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The majority of SUPs assessed that the workload was at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs.</p> <p>The exercises focussed mainly on the tasks related to the flexible allocation of aerodromes.</p> <p>The SUPs in the ENAV exercise had sufficient buffers and agreed that they could still take over some ATCO tasks (e.g. coordination tasks with other entities).</p> | OK |

5.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

5.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Supervisors reported that they were able to efficiently support ATCOs in non-nominal situations and were also able to make decisions about the flexible transfer of aerodromes.</p> <p>In the INDRA exercises however, they also expressed the need to have additional information (like access to visual representations, EFS information and voice communication in case of non-nominal situations).</p> <p>In the DLR exercise only normal operating methods were tested.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower | <p>The majority of supervisors assessed that the changes in roles and responsibilities were acceptable.</p> <p>However the SUPs in the INDRA/AVINOR exercise expressed the need for improvements to support their situation awareness (compare CRT-PJ05-W2-35-V3-VALP-H01.010)</p> | OK |

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | concept are clear, consistent, stable and acceptable. | | |

5.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

5.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H10 Results

| OBJ-PJ05-W2-35-V3-VALP-H10 Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Majority of Supervisors confirmed the feasibility and acceptability of supervising the assigned number of clusters of aerodromes | OK |

5.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H12 Results

| OBJ-PJ05-W2-35-V3-VALP-H12 Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Supervisors assessed that they did not always have all required information available. In some cases this was due to the way the information was presented rather than the availability of the information.</p> <p>The status of the criteria was set to 'POK' due to the following results:</p> <p>In the DLR exercise the results show that all information was available but were difficult to acquire fast enough.</p> <p>In the INDRA/AVINOR exercise Supervisors assessed that they did not always have all required information available to monitor the traffic situation and workload at MRTMs (due to technical limitations of the prototype) and to plan the allocation of aerodromes (as information on ATCO availability and their endorsements was missing).</p> <p>In the ENAV exercise the data provided for the planning tool was not updated during the simulation due to technical limitations. Therefore, no conclusive result could be provided.</p> | POK |
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | The majority of SUPs agreed that the input devices on the supervisor position were easy to use | OK |
| CRT-PJ05-W2-35- | Majority of Supervisors confirm adequate | In general the SUPs agreed that the planning tool was easy to use but there was some room for improvement (e.g. information on ATCOs availability and endorsements). | POK |

| OBJ-PJ05-W2-35-V3-VALP-H12 Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| V3-VALP-H12.030 | usability and utility of supervisor planning tool | <p>In the DLR exercise the planning tool covered only the duration of the simulation.</p> <p>In the INDRA/AVINOR exercise the timeline was easy to use. The SUPs were missing the information on the ATCO availability and endorsements. A functionality to schedule the future allocation of aerodromes to MRTMs was missing.</p> <p>In the ENAV exercise SUPs recommended some further improvements on the HMI design.</p> | |
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | <p>In the ENAV exercise the majority of Supervisors confirm adequate usability and utility of alarms for the SUP. The Supervisor was informed on an emergency when the ATCO pressed a respective button.</p> <p>The criteria was not assessed in the other exercises.</p> | OK |
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | <p>The supervisor HMI did not lead to human errors during the validation. Some HMI improvements are needed to reduce the potential of human errors.</p> <p>In the INDRA/HC exercise number of human errors made in the simulation was negligible and was due to the unfamiliarity with the system.</p> | OK |

5.2.5 HUMAN PERFORMANCE – TRUST

5.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

| OBJ-PJ05-W2-35-V3-VALP-H14 Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors could not always trust the planning tool to give them a correct picture of the situation at aerodromes/MRTMs. | POK |

5.2.6 HUMAN PERFORMANCE – Transition Factors

5.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

| OBJ-PJ05-W2-35-V3-VALP-H15 Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---------------------------------|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35- | Knowledge, skill and experience | More information on new requirements on knowledge, skills and experience are given in the HPAR. | OK |

| OBJ-PJ05-W2-35-V3-VALP-H15 Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| V3-VALP-H15.010 | requirements are identified/consolidated per actor group | <p>The SUPs need to have sufficient knowledge on all of the aerodromes they are responsible for.</p> <p>SUPs might hold the endorsement for (some of) the aerodromes.</p> <p>The status is set to OK referring to preliminary identification only</p> | |
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors. | OK |

5.2.7 SAFETY

5.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35- | Supervisor is able to support an ATCO in | Supervisors were able to support the ATCO in case of an emergency at one aerodrome by supervising the handover of aerodromes to another ATCO and offloading the ATCO from the coordination tasks. | OK |

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| V3-VALP-S08.010 | abnormal situations(e.g): <ul style="list-style-type: none"> • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | | |

5.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

| OBJ-PJ05-W2-35-V3-VALP-S09 Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> • Communication • Visualisation system <p>Other systems in the MRTM</p> | Supervisors could manage the technical failure occurring in one MRTM by supporting the ATCO in the transfer of an aerodrome to a another MRTM | OK |

5.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results

| OBJ-PJ05-W2-35-V3-VALP-S10 Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | Supervisors assessed that they did not always have all required information available. In some cases this was due to the way the information was presented rather than the availability of the information. (compare CRT-PJ05-W2-35-V3-VALP-H12.010) | POK |

5.3 Confidence in Validation Results

5.3.1 Limitations of Validation Results

5.3.1.1 Quality of Validation Results

All results in this validation exercises were subjectively assessed by the participants. Their opinions, estimations and evaluations have been collected by the means of questionnaires (including validated and tailored questions) after each simulation and after the exercise run; adapted scales during the runs and semi-directed interviews in the debriefing phase. Participants were either active supervisors or ATCOs and provided therefore reliable data from an expert point of view. An adequate briefing and training before starting the simulation was conducted to avoid motivational biases.

The standardized experimental conditions and the study design (repeated measures, within-subject) allowed each participant to realize all simulation runs. The scenario order was randomized in order to reduce a learning effect which could not fully be counterbalanced.

Considering that the results are independent, reliable and in addition to that as well valid for the respective profession, the validation exercise results can be considered of high quality.

5.3.1.2 Significance of Validation Results

The significance of the validation results is high as the solution was validated on three different platforms. Normal as well as non-nominal and degraded modes were considered.

However, the significance of the validation results is limited regarding the following aspect:

- Not all the tasks a supervisor has to do in an operational environment were covered.
- The duration of an exercise run never exceeded 1 hour.

6 Conclusions and recommendations

6.1 Conclusions

6.1.1 Conclusions on SESAR Solution maturity

The exercises mainly addressed a set-up with two measured MRTMs, each providing the capability to allocate 3 aerodromes at a time within each MRTM. There were 4 aerodromes in the simulation, which were flexibly allocated to the MRTMs based on SUP decision or on ATCO request.

Flexible allocation means that any aerodrome under control could be handed over to another MRTM with the aim of balancing the ATCO workload at both MRTMs. Compared to previous Multiple Remote Tower solutions this could now lead to the situation that aerodromes are not always placed in the same position within the MRTM.

The validations were focussing on evaluation of human performance and safety aspects.

The validation exercises were based on quite a diversity of specific local environments and specific validation platforms. While the general concept could be successfully validated, the exercises revealed the differences in the local environments and specific platforms that need to be addressed in the deployment phase

The validation exercises have shown that solution 35 (SDM-210: 'Highly Flexible Allocation of Aerodromes to Remote Tower Modules') has reached V3 maturity. All Enablers for solution 35 were positively validated.

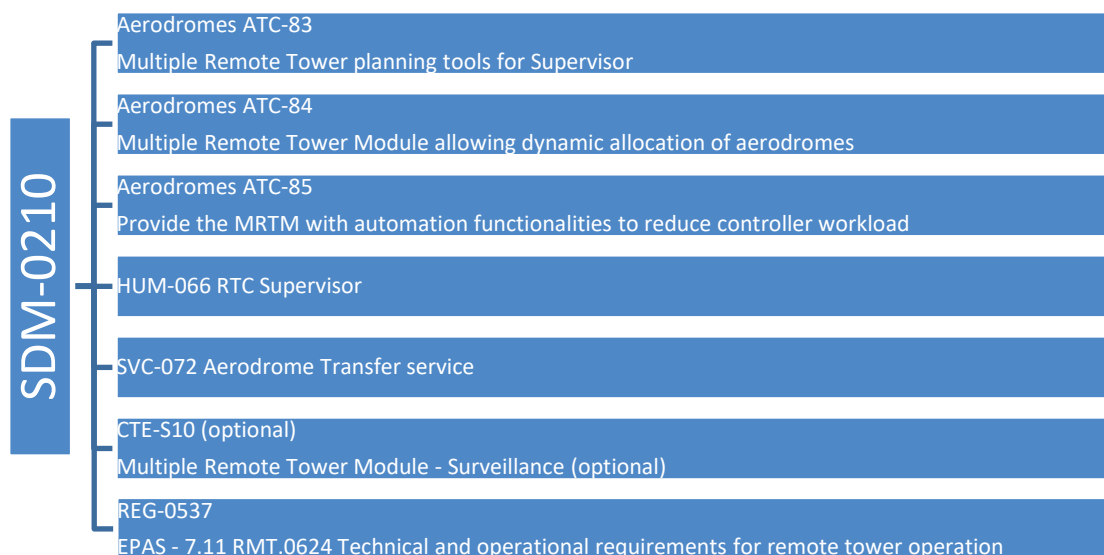


Figure 1: OI and enablers for solution 35

6.1.2 ATCO - Conclusions on concept clarification

6.1.2.1 Flexible Allocation - Positioning

ATCOs could work with a flexible allocation of aerodromes to MRTMs that was either initiated by a handover to or from another MRTM or by manually switching the position of aerodromes within a MRTM. ATCOs were always aware which aerodrome was displayed in which position within the MRTM.

In some exercises the layout of the size of the displayed information changed depending on the number of aerodromes that were under control while in other exercises the layout remained constant (just showing blank areas when no aerodrome was allocated to a certain position within the MRTM).

6.1.2.2 Flexible Allocation - Handover procedure

ATCO initiated Handover

The flexible allocation and transfer in some exercises was initiated by the ATCOs assessing the situation based on the electronic flight strips and radar information. In other exercises, it was initiated using the ATCO planning tool. The ATCO contacted the ATCO at the other MRTM (only two MRTMs were validated) inquired about the possibility to hand over an aerodrome and negotiated the best time to perform the handover. The point in time for a handover procedure is best selected by the ATCO with the most traffic at his MRTM.

A checklist should be used by the ATCOs for handover of aerodromes between MRTMs.

When receiving an aerodrome the ATCO at the respective MRTM needs to be provided with all the information for the aerodrome that is being transferred in order to build up situation awareness.

ATCOs agreed that their roles and responsibilities when providing ATS to multiple aerodromes with flexible allocation were clear and acceptable. It was clear to the ATCOs who was responsible for monitoring of traffic and for initiating an aerodrome allocation.

SUP initiated Handover

In other exercises the flexible allocation and transfer was initiated by the SUP who assessed the situation based on the SUP planning tool. The exact timing of the handover was then determined by the ATCO's taking into consideration assessment of the current and forecasted traffic and other relevant circumstances like e.g. weather conditions.

Both approaches worked well and it might be chosen based on the specific local situation in the RTC which one to implement. If the ATCOs are responsible for the flexible allocation, workload buffers for this task need to be considered. Managing a higher number of aerodromes in an RTC should be supported by a SUP role.

Handover Considerations

Transfer of aerodromes should happen in lower traffic periods, when the ATCOs have spare capacity for the handover process and to build up the situational awareness.

In case of an emergency, the other aerodrome(s) should be handed over to make sure that the ATCO can fully focus on the non-nominal situation. It is better to split as soon as possible, and not to wait for additional information on the emergency to predict the expected workload, because such a situation can quickly escalate, which would make the handover process more challenging.

6.1.2.3 Automation Support for ATCO

The majority of the ATCOs confirmed that the alarms and alerts were adequate.

In the DFS exercise ATCOs rated the usability and utility of the automation support provided by the events as being quite helpful. Alarms and alerts were provided for conflicting clearances as well as for non-conformances (as defined in the airport safety nets in the Eurocontrol Specification for A-SMGCS Services). Events like landing and take-off reminder and the safety alerts and warnings were well appreciated by the ATCOs. Automatic PTZ-Tracking and automatic zooming was seen as a very helpful system support.

6.1.2.4 Training Needs

The need to frequently monitor all the allocated aerodromes (and to avoid longer periods focussing on just one aerodrome) was identified. It must be trained that safety has absolute priority over efficiency.

The need for a dedicated training on ATCO/SUP teamwork to deal with abnormal situations or degraded modes was raised by both ATCOs and supervisors.

6.1.3 SUP - Conclusions on concept clarification

The SUP role should cover the following tasks with respect to the flexible allocation of MRTMs:

- plan allocation of aerodromes to MRTMs
- plan staffing of the MRTMs
- monitor the situation at the MRTMs
- support the ATCO in cases of high workload (e.g. emergencies or degraded mode),
- trigger allocation of aerodromes to MRTMs

The workload associated with these tasks might be quite different depending on the specific local implementation (e.g. big RTC with many aerodromes vs. 2-3 aerodrome RTC). Depending on the specific local implementations the SUP role might also cover different general coordination and administration tasks.

Depending on the associated workload the SUP Role might therefore be allocated to either an ATCO or a dedicated Supervisor.

6.1.3.1 Supervisor – Planning Role

The supervisors were able to flexibly allocate the aerodromes to MRTMs in the simulated environment.

In an operational environment the information on ATCO availability as well as on ATCO endorsements and MET information needs to be included in the SUP planning tool.

6.1.3.2 Supervisor – Support Role

While the ATCO is assumed to be able to hold up to 4 endorsements, the SUP will probably have less (if any full endorsements). Depending on the local implementation and the degree of experience with aerodromes within the RTC, the SUP can be assigned the tasks that are part of his/her role.

6.1.4 Team - Conclusions on concept clarification

No team errors were identified during the exercises for the flexible transfer of an aerodrome.

The ATCOs HMI generally supported an acceptable level of team situation awareness. Nevertheless, an improved alignment between ATCO and SUP HMI needs to be investigated to ensure a common shared picture of the situation at the MRTMs. (e.g. Radar views may be added to the SUP position, notably HMI with the capability to select and open radar views for any airport in different windows on a single screen)

The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors.

6.1.5 Conclusions on technical feasibility

Technical feasibility of MRTM (ATCO)

The validation results confirm the technical feasibility of the flexible allocation of aerodromes to MRTMs and the supervision of multiple MRTMs/aerodromes.

The MRTM must be designed to display up to 3 aerodromes at a time with the possibility of a flexible allocation. The ATCO should be able to flexibly position aerodromes within one MRTM (move the position of displayed aerodromes manually in order to arrange them according to his/her needs and/or preferences).

The ATCOs must be able to receive and hand over an aerodrome on their MRTM. During a handover procedure all information of the aerodrome that is being handed over must be displayed on both MRTMs.

Technical feasibility of SUP Workplace

In an operational environment the information on ATCO availability as well as on ATCO endorsements and MET information needs to be included in the SUP planning tool.

While some SUPs in one exercise expressed the need to have quick access to radar screens and visuals of a specific aerodrome, this information was almost never used in another exercise, due to the focus of the selected use cases that did not require these information in detail.

6.1.6 Conclusions on performance assessments

Conclusions related to Human Performance, Safety, Capacity and Cost Efficiency are described in detail in chapters 4 and 5.

6.1.6.1 Workload and Situation Awareness

ATCO Results

Situation awareness was at a satisfactory to acceptable level when providing ATS to three aerodromes at a time and using flexible allocation of aerodromes. Nevertheless, ATCOs stated they needed a generally higher level of attention to keep their SA for all three aerodromes compared to controlling just one aerodrome. Flexible allocation of aerodromes had about no effect on situation awareness and ATCOs stated that they easily could get used to it.

Nevertheless, situation awareness decreased rapidly when traffic levels became too high, or the situation became very complex (which occurred mainly when ATCOs controlled three aerodromes at a time or when unforeseen traffic popped up).

Flexible allocation of aerodromes requires that sufficient buffers are foreseen in order to avoid ATCO overload to consider e.g. unforeseen traffic like police or rescue helicopters or various incoming calls. ATCOs need to be trained to avoid complex situations with increasing traffic levels (e.g. by applying conservative separations)

Flexible allocation of aerodromes allows balancing tolerable ATCO workload and high traffic levels. While some situations might result in small delays, aerodrome capacity will not be reduced by introducing multiple remote tower concept (if more capacity is required, flexible allocation needs to be adjusted or another MRTM to be opened) The majority of ATCOs were aware which aerodrome was placed at which position of the MRTM. Even the flexible allocation of aerodromes did not lead to any confusion about which aerodrome was placed at which position.

The following aspects supported the ATCOs in maintaining situation awareness:

- ‘Column-wise’ arrangement of information belonging to one aerodrome supported them to distinguish between the different aerodromes.

The ATCOs highlighted that the pilots starting a call using the respective tower in the phraseology helped to maintain situation awareness. While the airport name **shall** be used in all runway related transmissions, it **should** be used in all transmissions (in order to balance situation awareness and workload). The ATCOs overall workload remained at a satisfactory or acceptable level in all the exercises during most of the time. ATCOs confirmed the feasibility and acceptability of providing ATS to the assigned number of aerodromes on condition that clear rules and procedures were established to prevent overload on the position. During the handover process for the flexible allocation of aerodromes, the workload was reported to increase. This requires a good timing for the handover process to be executed in phases with acceptable workload.

Supervisor Results

The majority of participants at the SUP workplace indicated a positive situation awareness. In general SUPs were able to prioritise tasks (e.g. between coordination task, planning aerodrome allocation to MRTMS and supporting the ATCO in an emergency).

The majority of SUPs assessed that the workload was at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs. It should be noted that the exercises focussed mainly on the tasks related to the flexible allocation of aerodromes.

Supervisors assessed that they did not always have all required information available. In some cases this was due to the way the information was presented rather than the availability of the information. In an operational environment the information on ATCO availability as well as on ATCO endorsements and MET information needs to be included in the SUP planning tool.

6.1.6.2 Safety

ATCOs were able provide ATS in a safe manner, being able to solve conflicts and potentially hazardous situations in a timely manner as well as being able to identify and manage abnormal situations

The Safety Net alerts were considered helpful in the DFS exercise in terms of situation awareness. Especially reminder events - such as landing reminders and safety alerts - helped to maintain situation awareness.

The majority of the ATCOs confirmed that they were able to detect and recover from a technical failure occurring at one of the aerodromes.

6.1.6.3 Capacity

The majority of ATCOs agree that providing ATS with up to 6 simultaneous movements is in general feasible and acceptable. It must be emphasised that spare capacity needs to be considered for unforeseen events, non-nominal situations, degraded modes or other operational tasks.

The ATCOS suggested that the number of simultaneous movements might be lowered if one or more of the following items apply:

- Number of aerodromes
- Increased traffic complexity
- Aerodrome complexity (e.g. backtracking, hot spots)
- Weather conditions
- Number of tasks (e.g. met reporting, coordination tasks)

Especially traffic that cannot be delayed (like rescue or police helicopters), and might increase the number of simultaneous movements, must be considered. All procedures and separation minima should be designed in a way to make sure that the ATCO has a capacity reserve for handling unusual and unexpected situations.

Flexible allocation of aerodromes allows balancing tolerable ATCO workload and high traffic levels. While some situations might result in small delays, aerodrome capacity will not be reduced by introducing multiple remote tower concept (if more capacity is required, flexible allocation needs to be adjusted or another MRTM to be opened)

6.1.6.4 Efficiency

ATCOs stated that they can provide ATS for up to three aerodromes applying flexible allocation of aerodromes. The required staff will depend on the need to have spare capacity and resources available to dynamically change the allocation of aerodromes. (All exercises assumed that the ATCOs have up to 4 endorsements).

6.2 Recommendations

6.2.1 Recommendations for next phase

During deployment phase it needs to be considered how local availability of real data (e.g. flightplans for VFR flights) might affect integrated SUP and ATCO planning tools.

Based on the specific locally defined roles, the ATCO and SUP planning tools need further optimisation regarding HMI design in order to allow more intuitively assessment of the situation.

Depending on the complexity of the SUP planning task and the SUP workload, the SUP planning tool needs to be extended by weather information and information on ATCO endorsements and ATCO availability (alternatively it might be sufficient to retrieve this information from existing other systems).

The supervisor role might be allocated different tasks depending on the specific local implementation. During the deployment phase, the supervisor role should reflect those locally defined tasks for the supervisor. (compare chapter 6.3.1)

The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was raised by both ATCOs and supervisors.

6.2.2 Recommendations for updating ATM Master Plan Level 2

The following recommendations for updating of ATM Master Plan were identified.

SDM-210

The provision of remote ATS service to the remote aerodromes can be flexibly assigned (over time) to other Multiple Remote Tower Modules (MRTM) within a Remote Tower Centre (RTC). Supervisor Planning tools support an efficient deployment of staff in an RTC.

MRTMs should be able to host up to 3 aerodromes. In the validations an environment with 2 MRTMs and ATCO holding up to four endorsements was investigated. This setup is scalable in a remote tower center depending on the local needs.

AERODROE-ATC-83 Multiple Remote Tower planning tool for Supervisor

Provide Remote Tower planning tool for a Supervisor role that support flexible allocation of airports and staff to a number of Remote Tower Modules (Single and Multiple) within a Remote Tower Centre.

The supervisor planning tool should provide information like actual and forecasted traffic, ATCO availability and endorsements and weather conditions.

The planning tool might include a what-if functionality to allow the supervisor to compare different parameters.

AERODROE-ATC-84 Multiple Remote Tower Module allowing flexible allocation of aerodromes

Provide Multiple Remote Tower Modules (MRTM) with a capability to flexibly allocate aerodromes between MRTMs within a Remote Tower Centre (RTC).

The MRTM must be designed to display up to 3 aerodromes at a time with the possibility of a flexible allocation. The ATCO should be able to flexibly position aerodromes within one MRTM (move the position of displayed aerodromes manually in order to arrange them according to his/her needs and/or preferences).

AERODROE-ATC-85 Provide the Multiple Remote Tower Module with automation functionalities to reduce controller workload

Provide the Multiple Remote Tower Module with automation functionalities (like clearances to be provided by the controller or airport safety nets with conformance monitoring and identification of conflicting clearances) to reduce controller workload in high traffic volumes and/or complex traffic.

6.2.3 Recommendations on regulation and standardisation initiatives

EASA and EUROCAE have developed the following Guidance Material for regulatory, operational and technical issues for Remote Tower solutions:

- EASA Guidance Material on remote aerodrome air traffic services, Decision 2019/004/R, Issue 2 still valid, Issue3 published as NPA
- ED-240A, MINIMUM AVIATION SYSTEM PERFORMANCE STANDARD FOR REMOTE TOWER OPTICAL SYSTEMS, ED-240B in preparation

Conclusions and recommendations from PJ05 solutions should be considered by those initiatives.

7 References

7.1 Applicable Documents

Content Integration

- [1] PJ19_D5.11_EATMA_guidance_material_ (2019.0)
- [2] PJ19 Enablers Development and Usage Guidance (1.0)

Content Development

- [3] D2.5 SESAR 2020 Concept Of Operations Edition 2019 v01.00.00 (1.0)

System and Service Development

- [4] D3_14 - RSIT - 2019 (1.0)

Performance Management

- [5] SESAR Performance Framework ed. 01.00.01 - 2019 (1.0)
- [6] Validation Targets W2 (1.0)

Validation

- [7] EOCVM V3 Volume 1 (1.0)
- [8] EOCVM V3 Volume 2 (1.0)
- [9] Validation Strategy VALS (2019.0)

System Engineering

- [10] D3_14 - RSIT - 2019 (1.0)

7.2 Reference Documents

- [11] SESAR 1 P06.08.04-D94-OSED Single Remote TWR Ph2 – Final Update, Edition 00.07.01, Dated 27/07/2016
- [12] SESAR 1 P06.09.03-D32 SAR for Multiple Remote Tower (two low density aerodromes), Edition 00.01.01, Dated 18/11/2015

Appendix A Validation Exercise EXE-2.1 DLR

A.1 Summary of the Validation Exercise EXE-2.1-DLR Plan

This section covers the EXE-05-W2-35-V3-2.1. This includes the following exercises:

- EXE-PJ05-W2-35-V3-2.1.1 Real Time Simulation by DLR/FRQ/ON/PANSA
- EXE-PJ05-W2-35-V3-2.1.2 Passive Shadow Mode by DLR/FRQ Comsoft

A.1.1 Validation Exercise description, scope

A.1.1.1 EXE-PJ05-W2-35-V3-2.1.1 Real Time Simulation

The operational scope of this exercise includes the dynamic allocation with a maximum of 15 simulated small sized airports. The excessive focus is on the interaction of several multiple remote tower modules with the supervisor workplace. In relation to the supervisor workplace, the focus is on dynamic situations within such an environment. This includes that the supervisor interacts with each remote tower workplace.

The objective was to assess the interaction between three working positions (one supervisor and two MRTMs). The two MRTMs provide ATS to three small sized aerodromes, all operating in single-runway configuration. The MRTMs are responsible for Clearance Delivery, Ground- and Tower Control (manoeuvring area and aerodrome traffic circuit) for up to three aerodromes simultaneously. They provide the ATCO perspective on the Remote Tower Center. The supervisor supports up to 15 airports and has to coordinate the distribution of airports to the MRTM in accordance with requirements and endorsements. The supervisor workplace provides the supervisor perspective.

This exercise focused on the ATCO's capability to provide flexible ATS (MRTM) to three aerodromes simultaneously or support (supervisor workplace) multiple MRTMs, evaluating Human Performance, Safety, Usability, and Capacity by varying different use cases.

The validation platform is a DLR NARSIM platform. It is extended by an adapted smart strip planning tool for the MRTM and a planning tool for the supervisor workplace, both provided by Frequentis.

A.1.1.2 EXE-PJ05-W2-35-V3-2.1.2 Passive Shadow Mode

The focus area of the validation exercise is how the correlation and fusion of electro-optical and traditional surveillance detections and thereby possible safety net improvements can enhance the situational awareness.

Passive Shadow Mode for a selected airport (Braunschweig Airport) with the aim to maximise the situational awareness with the additional surveillance information gained by correlation and fusion of traditional surveillance and electro-optical detections.

The objective was to assess benefit of the enhanced situational awareness for (M)RTM and the influence of enhanced safety net support functions in the context of ATS.

The Passive Shadow Mode consisted of visually enhanced OTW views that represent special situations which are important for ATS provision for multiple aerodromes. To generate the enhanced views, on the one hand surveillance plots delivered from ADS-B (CAT21) and electro-optical object detection (CAT15) are correlated and fused by Frequentis Comsoft multi-sensor data fusion and forwarded to the safety net component as well as to the surveillance display and OTW view functions. Surveillance data and video recordings for specific use cases are used to evaluate the benefit of the enhanced situational awareness. The recordings have been selected to cover final approach situations and different environmental situations with an impact on the electro-optical detection performance.

In addition, it was evaluated how the enhanced surveillance track update rates can be used to enhance safety net functionality.

A.1.2 Summary of Validation Exercise EXE-2.1-DLR Validation Objectives and success criteria

The following table provides an overview on the validation objectives and success criteria applied in EXE-PJ05-W2-35-V3-2.1.1 and EXE-PJ05-W2-35-V3-2.1.2.

| SESAR Solution Validation Objective | SESAR Solution Success criteria | Coverage and comments on the coverage of SESAR Solution Validation Objective in EXE-PJ05-W2-35-V3-2.1.1 and W2-35-V3-2.1.2 | Exercise Validation Objective | Exercise Success criteria |
|-------------------------------------|---------------------------------|--|-------------------------------|---------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01.010 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H01.020 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H01.030 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H01.040 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3- | Fully covered | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--------------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H02 | VALP-H02.010 | SASHA | | |
| | CRT-PJ05-W2-35-V3-VALP-H02.020 | Fully covered AIM-s | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H02.030 | Fully covered SASHA | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H02.040 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H03 | CRT-PJ05-W2-35-V3-VALP-H03.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04.010 | Fully covered NASA TLX | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H04.020 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H05 | CRT-PJ05-W2-35-V3-VALP-H05.010 | Fully covered NASA TLX | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H06 | CRT-PJ05-W2-35-V3-VALP-H06.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07.010 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H07.030 | Fully covered Questionnaire | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--------------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H08 | CRT-PJ05-W2-35-V3-VALP-H08.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H09 | CRT-PJ05-W2-35-V3-VALP-H09.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H10 | CRT-PJ05-W2-35-V3-VALP-H10.010 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H10.030 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.010 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H11.020 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H11.040 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H11.050 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H11.060 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3- | Fully covered Questionnaire | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--------------------------------------|-------------|-------------|
| | VALP-H11.070 | | | |
| | CRT-PJ05-W2-35-V3-VALP-H11.080 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H12.010 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H12.020 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12.030 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H12.040 | Fully covered Questionnaire | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H12.050 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3-VALP-H13.040 | Fully covered Questionnaire /SATI | as solution | as solution |
| | CRT-PJ05-W2-35-V3-VALP-H13.080 | Fully covered Questionnaire /SATI | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H14 | CRT-PJ05-W2-35-V3-VALP-H14.010 | Fully covered Questionnaire /SATI | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04.030 | Fully covered Questionnaire | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|---|-------------|-------------|
| | CRT-PJ05-W2-35-V3-VALP-S04.050 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S05 | CRT-PJ05-W2-35-V3-VALP-S05.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S06 | CRT-PJ05-W2-35-V3-VALP-S06.010 | Partly covered, depending on scenario development Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S10 | CRT-PJ05-W2-35-V3-VALP-S10.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | CRT-PJ05-W2-35-V3-VALP-CA1.010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | CRT-PJ05-W2-35-V3-VALP-CE1.010 | Fully covered Questionnaire | as solution | as solution |

A.1.3 Summary of Validation Exercise EXE-2.1-DLR Validation scenarios

EXE-PJ05-W2-35-V3-2.1.1

For this study, the set-up of a Remote Tower Center (RTC) was simulated in a high fidelity setting. One SUP, two real MRTM (Module 1 and 2) and 4 virtual MRTM (Module 3 to 6) were simulated to create an RTC. This covers an application of the concept when flexible allocation is changed within the available endorsements. Each scenario was designed to last for one hour. A within-subject design was used for the factor working position. Therefore, this section is separated into MRTM and SUP. The scenarios represent normal workday situations within an RTC.

For the ATCO

Authentic traffic patterns and flight information were simulated. There were around 18 movements per MRTM/Hour in each of the scenarios. All scenarios were at VMC daytime condition with no significant wind. 6 Airports could be flexible allocated for each of the MRTM.

The following characteristics of the table shown above were varied:

Founding Members

- **Traffic distribution** of the traffic volume over the six aerodromes was kept equal.
- **Traffic complexity** was that VFR traffic amounts \approx 50%
- **Runway directions** were kept equal for all six airports.

For the SUP

The difference for the SUP, between scenario 1 and 2, was the order of the emerging scenario events (Table 7) and scenario 2 had 4 additional scenario events with coordination phone calls. These additional scenario events had a duration of approximately 30 seconds and only required an additional phone call. The SUP overlooked a total of 15 airports. In general, the scenario events were planned to happen at least once per scenario. Only “scheduled airport opening” and “scheduled workload” were planned with an average of two, because they are the common use cases for the SUP task.

| Derived scenario events | Description | Derived from Use Case |
|------------------------------|---|-----------------------|
| Daily planning | Due to an unexpected event a ATCO is not available for his/her shift that starts in a couple of hours | UC 3:2 |
| Handling SUP/ATCO Request | Due to increased traffic volume on a specific airport, the ATCO on a MRTM either request an additional ATCO for a specific airport or gets proposed an additional ATCO by the supervisor. | Handling ATCO Request |
| Scheduled Workload increase | Due to excepted increase in workload the one airport is hand over away from the assigned MRTM to a different ATCO on second MRTM | UC 3:1 / UC 3:2 |
| Scheduled airport closing | The scheduled closing hours of an airport starts and the airport needs to be closed | UC 3:1 / UC 3:2 |
| Scheduled airport opening | The scheduled opening hours of an airport start and the airport needs to be opened | UC 3:1 |
| Unplanned airport closing | Due to severe weather events in the near future (e.g. low visibility) a specific airport has to be closed | UC 3:1 |
| Unplanned airport opening | An aircraft requests landing for an airport that is closed | UC 3:1 |
| Unplanned runway closing | Due to a technical failure an aircraft blocks the runway on a specific airport | UC 3:1 / UC 3:2 |
| Unscheduled ATCO replacement | Due to unexpected circumstances, an ATCO has to be relieved and replaced for some time by another ATCO (Ex. health issues) from his/her MRTM | UC 3:2 |

Table 7 Scenario Events Derived from the Use Cases

Founding Members

Each scenario event depended on traffic situations. Scenario events could be activated either by time (opening of an airport) or by traffic situation, e.g., the amount of parallel movements was expected to exceed 8 at a single MRTM (use case “Scheduled workload increase”).

EXE-PJ05-W2-35-V3-2.1.2

For this study the objective was to evaluate how correlation and fusion of electro-optical and ADS-B/MLAT detections enable safety net improvements that enhance the situational awareness.

In the scope of this exercise the recordings of DLR PTZ (pan-tilt zoom) cameras together with FRQ object bounding form electro-optical sensors that provide detection reports in ASTERIX CAT15 as well as time-synchronised recordings of standard ADS-B surveillance data in ASTERIX CAT21 were used (i.e. both the electro-optical sensor as well as the ADS-B sensor detecting the same traffic situation at the same time).

FRQ MSDF (Multi Sensor Data Fusion) tracker correlated and tracked the electro-optical object-bounding detections (ASTERIX CAT15) together with classical surveillance (ASTERIX CAT21) and provided track services (ASTERIX CAT62) with an equally high update rate as the video cameras (i.e. 10 Hz).

FRQ Safety Nets used the correlated data (ASTERIX CAT62) and generated Safety Nets APW (Area Proximity Warning) alerts in ASTERIX CAT004 respective to the specific configuration deployed for the Braunschweig airport.

Generated APW alerts were also visualized on the panorama screen (OTW) respective to the individual APW volumes together with the camera recordings.

A.1.4 Summary of Validation Exercise EXE-2.1-DLR Validation Assumptions

The same assumptions applied as mentioned in chapter 3.2.3 (

Table 4)

A.2 Deviation from the planned activities

Due to time constraints and necessary training the baseline configuration without a SUP was removed from the experimental design.

A.3 Validation Exercise EXE-2.1-DLR Results

In this section, results for each validation objective and success criterion are provided for the ATCOs working at the MRTMs and SUP workplace. Therefore, the following section A.3.1. covers the aspects for ATCOs working at the MRTMs and section A.3.2. covers the ATCOs at the SUP workplaces. Independent from the workplace, the criteria were assessed with standard and tailor-made questionnaires. Questionnaires were administered after each run (post-run, PR) and the second at the end of the second day (post-exercise, PE). Each participant completed 3 trainings runs (2 x at the MRTM and 1 x at the SUP), before starting the 6 evaluation runs. Each participant completed the evaluation runs consisting of three workplaces (2x MRTM and 1 x SUP) varied with 2 scenarios. The two different scenarios were used in a randomized order.

For the MRTM workplace the allocation of aerodromes changed at least twice within each run. For the SUP, the allocation of aerodromes changed at least 8 times per run.

The standard questionnaires and tailored questionnaire were applied PR and PE. For PR, this means every item was completed 60 times for the MRTM and 30 times for the SUP workplace. PE means that every item was completed 15 times. In some cases, the success criteria's were answered with a selected item from the standard questionnaire. In those cases, the items are reported in the result section, otherwise only the summarized questionnaire scores are reported. We use boxplot to show the summarized values and also indicate the scale mean value to show how we interpret the result. The applied standard questioners were:

- Situational Awareness for SHAPE (SASHA-s) Questionnaire
 - to assess level of situational awareness during the previous working period(s)
 - contains of 6 items
 - rated on a scale from 0 to 6 (0 = “Never”; 6 = “Always”)
 - average of 3
- China-Lake
 - to self-asses their perceived level of SA for the last run
 - rated on a scale from 1 to 10 scale (1 = SA very poor; 10 = SA very high)
- Assessing the Impact of Automation on Mental Workload (AIM-s) Questionnaire
 - to assess the impact of various ATC tasks in the previous working period(s)
 - contains of 16 items



- rated on a scale from 0 to 6 (0 = “None”; 6 = “Extreme”)
- average of 3
- Bedford scale
 - to identify operator's spare mental capacity while completing a task
 - self-assessment of the experienced workload
 - rated on a scale from 1 to 10 scale (1 = WL insignificant; 10 = unable to perform)
- Nasa-TLX
 - multidimensional assessment tool that rates perceived workload in order to assess a task, system, or team's effectiveness or other aspects of performance
 - contains of 6 items
 - Nasa-TLX score from 0 to 100 (0 = WL insignificant; 100 = unable to perform)
- SHAPE Automation Trust Index (SATI)
 - assess your level of trust in the system
 - contains of 6 items
 - SATI score from 0 to 6 (0 = No Trust in the System; 6 = Trust in the System)
- System Usability Scale (SUS)
 - giving a global view of subjective assessments of usability
 - contains of 10 items
 - SUS score from 0 to 5 (0 = System not usable; 6 = System usable)
 - SUS is always applied PE
- Adapted Cooper-Harper Scale
 - subjective self-assessment method
 - contains a 10 Level answer possibility



- 4 categories: Impairment of task efficiency (1-3), impairment of situation awareness (4-6), impairment of safety (7-9), and unsafe (10)
- Used in relation to the scenario events derived from the use cases
- the adapted Cooper-Harper Scale was applied PR for the MRTM and mid run for the SUP workplace

to the standard questionnaires EXE-PJ05-W2-35-V3-2.1.1 and EXE-PJ05-W2-35-V3-2.1.2 used tailored questionnaires consisting of statements that had to be rated on a 5-point or 7-point rating scale. These scales were either "Strongly disagree", "Disagree", "Neither disagree nor agree", "Agree", "Strongly agree", or "Never", "Rarely", "Sometimes", "Very often", "Always", or "Strongly agree", "Agree", "Partially agree", "Neutral", "Partially disagree", "Disagree", "Strongly disagree", depending on the nature of the item. We note each item and use bar plots to show the summarized results. The bar plots show percentage of agreement or disagreement. No individual answers are reported.

This report also states final comments from the participants for every success criterion. These comments were acquired in a final feedback workshop and are presented in italic and orange at the end of each result section. They contain a constructive feedback (which will transfer to lessons learned) as well as a final comment on the task. They are considered for the validation result.

In some cases, participants decided not to answer an item, which was always an option. We also note in the results section if more than 2 participants decided to not answer, because it could give us feedback about the validity of the item.

A.3.1 ATCO - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|---|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants stated an above average situation awareness in the PR assessment when working MRTM with a flexible allocation. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | The participants average answer is 3, indicating that participants had difficulties prioritizing task. 22 Times out of 60 participants answered with a 0, 1, or 2, which shows that there is still place for improvement. This is supported by the comments. | Partially Ok |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | For EXE-PJ05-W2-35-V3-2.1.1 this criterion is covered with the SASHA as well as CRT-PJ05-W2-35-V3-VALP-H02.010. The SASHA looks at the system and the SA and therefore the same results apply here. For EXE-PJ05-W2-35-V3-2.1.2 the results show that the majority of participants | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|------------------------------|---|--------------------------------|--|--|-----------------------------|
| | | | | confirms that the user interface supports a sufficient level of situation awareness. | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | The results show that the majority of participants could keep a mental picture of the different aerodromes and was able to divide their attention if the setting was changing. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | ATCO part Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Overall workload remained at a satisfactory or tolerable level. Only in approximately 20% of the scenarios ATCOs reported high or above high workload for the Bedford Scale. NASA-TLX answers show the same effect for the average NASA-TLX score below 50. This might be mitigated with more time for the | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|---|-----------------------------|
| | | | | allocation process, as stated by the final comment. | |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The results show that the majority of the ATCOs working MRTM find the different types of communication and the frequency acceptable, even in situations with 3 active airports on one MRTM. | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | The results show that the majority of participants took below medium effort to issue timely commands. The tailor-made PE questionnaire shows that the majority of participants agrees with the statements concerning the different modes of operation. And the final comment indicates a general need for more training of the operational methods. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are | The results show that the majority of participants finds the changes clear, consistent, acceptable, and applicable. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|---|-----------------------------|
| | providing ATS to multiple aerodromes | | clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | For PR and PE the majority of participants confirms the feasibility of the assigned number of aerodromes, the amount of traffic and the traffic mix. They also state that this is the maximum number of aerodromes. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | The ATCOs agreed that they were able to apply the phraseology independent from the operating conditions. This is only ok with the adaption that no abnormal and degraded modes were part of the validation. | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The majority of the ATCOs agreed that the System / HMI supported the transfer of an Aerodrome and was in accordance with the operating methodology. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | ATCO part Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | The SATI shows that the ATCOs trust the system, which includes the that the ATCOs trusted the required information. The PE questionnaire also shows that a majority of ATCOs agreed with the visual panorama, radar and strip presentation. This is also reflected in the final comment. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | The majority of participants agrees that the strip and planning tool was usable. This also applies for the SUS questionnaire score, which is above the medium scale value. This is also reflected in the final comment. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | For EXE-PJ05-W2-35-V3-2.1.1 the majority of the ATCOs confirms that the alarms and alerts were applicable in the situations. But additional features for the safety net are essential. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|--------------------------------|---|---|-----------------------------|
| | | | | For EXE-PJ05-W2-35-V3-2.1.2 the majority of the ATCOs confirms that the alarms and alerts were applicable in the situations as well. | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | For EXE-PJ05-W2-35-V3-2.1.1 again, the SATI scores show that the ATCOs trust the system and the interface. They see the increased human error in the changed role and responsibilities. For EXE-PJ05-W2-35-V3-2.1.2 the majority of the ATCOs confirms that the interface does not increase the potential for human error. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | The majority of the ATCOs found the tool useful in terms of short-term planning and its different aspects. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | The results show that the majority of participants was aware of the displayed aerodromes and radar configurations. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | The majority of the ATCOS were aware which airport will be transferred and under which conditions. | OK |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | For EXE-PJ05-W2-35-V3-2.1.1 the general trust into the system is shown by an average sum score for the SATI questionnaire. This is also reflected in the final comment. For EXE-PJ05-W2-35-V3-2.1.2 the majority of the ATCOs trust in reliability of alarms and alerts. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | The results show that the majority of participants has general trust into the system (see CRT-PJ05-W2-35-V3-VALP-H13.040 SATI). The tailor-made questions are also indicating that the majority trust the | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| | | | | system to complete transfers. But it has to be noted that the final comment indicates that more automation and clearer procedures are necessary. | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between | CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none">In the vicinity of the aerodromeIn the runway areaOn the manoeuvring area | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|-----------------------------------|--------------------------------|--|--|-----------------------------|
| | MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> • Unstable approaches • Bird strikes • Aircraft not vacating RWY as expected | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | The results show that the majority of participants agrees with the tailor-made statements concerning their ability to communicate and identify the communication partner. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | The general number of conflicts was always zero and therefore not a good indicator for this success criterion. The results of the cooper-harper scale show that no scenario contained a situation that was unsafe. The most situations with effects on efficiency and situation awareness occurred in scenarios 1. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | The majority of participants confirms PR and PE the ability to foresee the short-term traffic and plan ahead. Strips need to be provided as essential to this task. | OK |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g): | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none">• Communication• Visualisation system• Other airport systems / infrastructure | | |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g): <ul style="list-style-type: none">• Communication• Visualisation system | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| CAPACITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | The majority of participants agrees with the amount of airports, mixture of traffic, and amount of traffic to be feasible. The comment of the ATCOs increase the necessity of the SUP in this concept. | OK |
| COST EFFICIENCY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to | The majority of participants agrees with the amount of airports, mixture of traffic, and amount of traffic to be feasible. The | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|----------------------|--|---|-----------------------------|
| | | | the limit on endorsements out of a group of 4 aerodromes | comment of the ATCOs increase the necessity of the SUP in this concept. | |

Table 8: ATCO - Validation Results for Exercise 1

A.3.2 ATCO - Analysis of Exercise Results per Validation objective

A.3.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

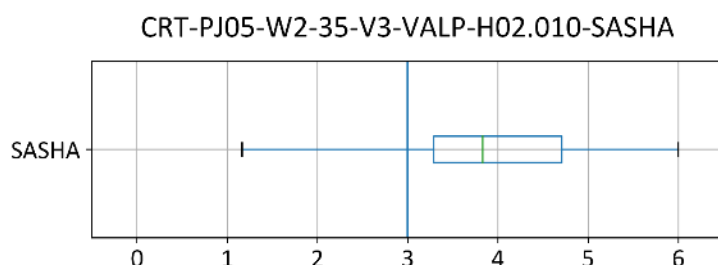
A.3.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants stated an above average situation awareness in the PR assessment when working MRTM with a flexible allocation. | OK |

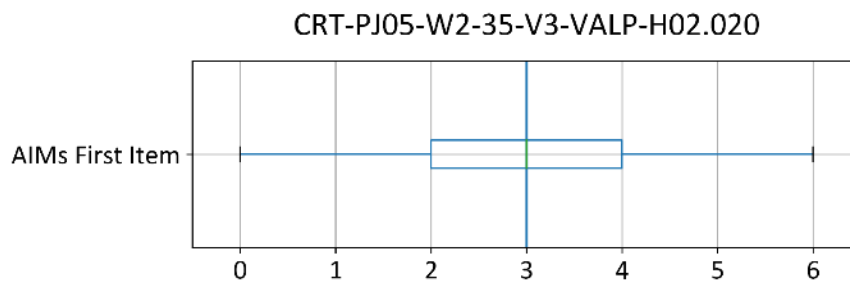
The questions was applied PR and the results summarized shown in the figure below.



“Situational awareness is at an acceptable level, but prior allocation plans (daily plans) would be helpful to raise the level of situational awareness”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | The participants average answer is 3, indicating that participants had difficulties prioritizing task. 22 Times out of 60 participants answered with a 0, 1, or 2, which shows that there is still place for improvement. This is supported by the comments. | Partially Ok |

For this criterion only the first item of the AIM (“Were you able to prioritise tasks?”) was selected for analysis. The results were summarized in a boxplot and presented in the figure below.



“The tasks could be done in more effective way if standardised by particular rules which would definitely be established in real operations”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>For EXE-PJ05-W2-35-V3-2.1.1 this criterion is covered with the SASHA as well as CRT-PJ05-W2-35-V3-VALP-H02.010. The SASHA looks at the system and the SA and therefore the same results apply here.</p> <p>For EXE-PJ05-W2-35-V3-2.1.2 the results show that the majority of participants confirms that the user interface supports a sufficient level of situation awareness.</p> | OK |

EXE-PJ05-W2-35-V3-2.1.1

For EXE-PJ05-W2-35-V3-2.1.1 the same results as for CRT-PJ05-W2-35-V3-VALP-H02.010 apply, because the SASHA covers the system interface as main source of support for situation awareness.

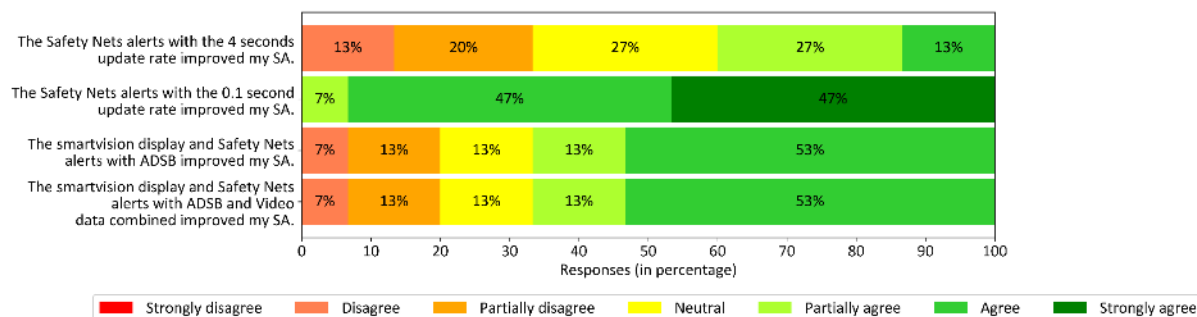
“The user interface is quite good and support situational awareness, but there are plenty of space to even improve it before operational status”

EXE-PJ05-W2-35-V3-2.1.2

For EXE-PJ05-W2-35-V3-2.1.2 the following tailor-made questions were applied to participants. The results are presented in the figure below.

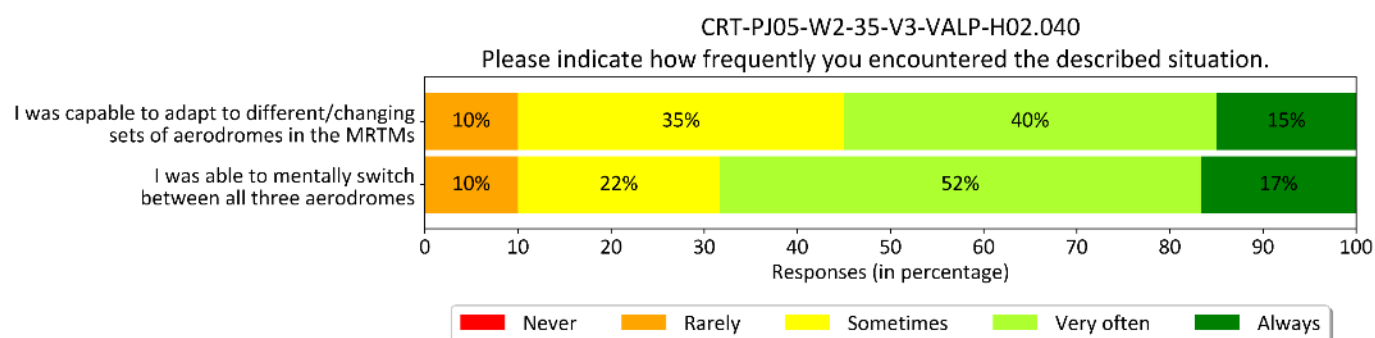
CRT-PJ05-W2-35-V3-VALP-H02.030

Please indicate your level of agreement with the following statements about your role as the ATCO.



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | The results show that the majority of participants could keep a mental picture of the different aerodromes and was able to divide their attention if the setting was changing. | OK |

The following tailor-made questions were applied PR. The results are presented in the figure below.



“The situational awareness was at acceptable level during whole validation. Nevertheless, If well acquainted and experienced with operational environment, situational awareness would be even higher.”

A.3.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | ATCO part Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.2.2 HUMAN PERFORMANCE – WORKLOAD

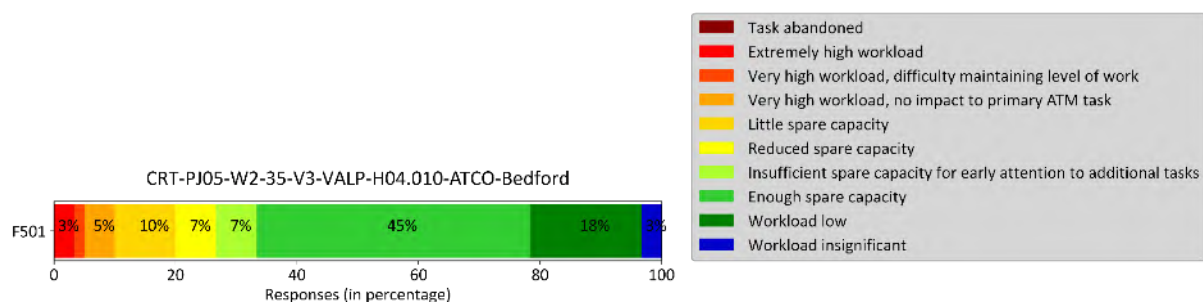
A.3.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

| OBJ-PJ05-W2-35-V3-VALP-H04 Assess ATCO workload when providing ATS to multiple aerodromes | | | |
|--|--|--|--|
|--|--|--|--|

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Overall workload remained at a satisfactory or tolerable level. Only in approximately 20% of the scenarios ATCOs reported high or above high workload for the Bedford Scale. NASA-TLX answers show the same effect for the average NASA-TLX score below 50. This might be mitigated with more time for the allocation process, as stated by the final comment. | OK |

Bedford Scale

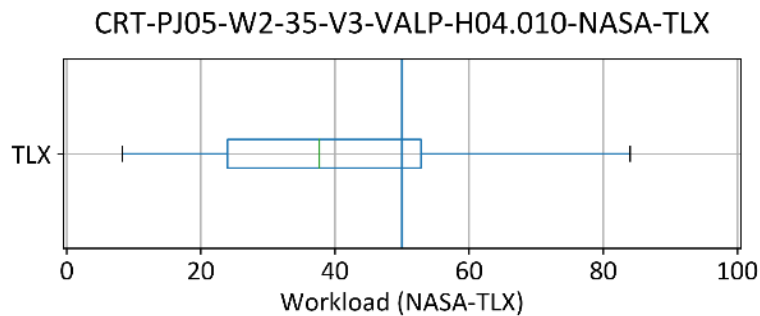
The Bedford scale was applied PR.



Founding Members

NASA-TLX

The NASA-TLX scale was applied also PR.



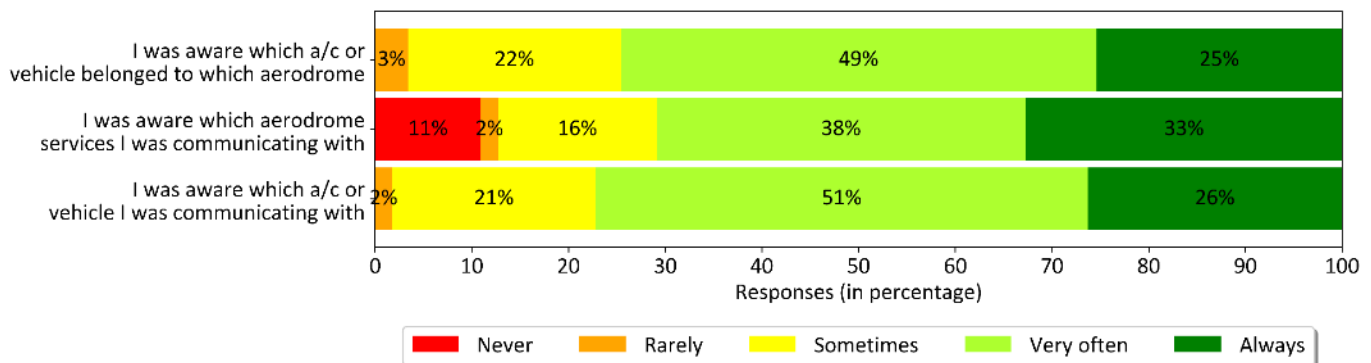
“The workload was at an acceptable level most of the times. Nevertheless, more time would be recommended for allocation process.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The results show that the majority of the ATCOs working MRTM find the different types of communication and the frequency acceptable, even in situations with 3 active airports on one MRTM. | OK |

For CRT-PJ05-W2-35-V3-VALP-H04.020 2 types of tailor-made PR questionnaires were used. The first types assesses the timely restriction of the communication and the second at the general acceptance of during the scenarios.

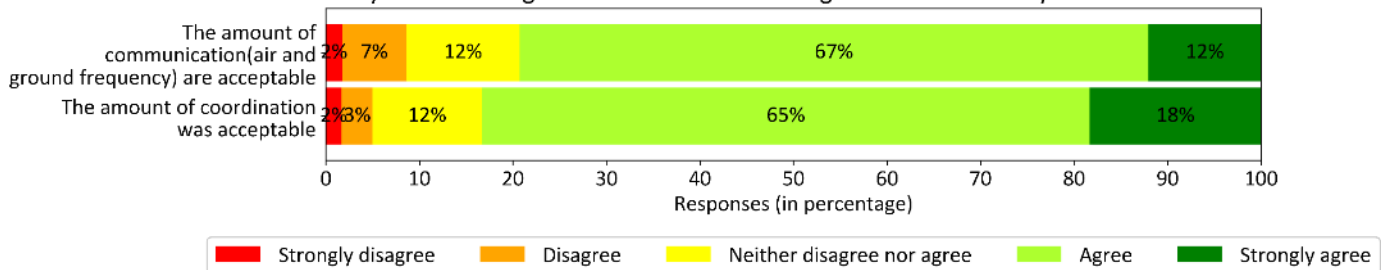
CRT-PJ05-W2-35-V3-VALP-H04.020_1

Please indicate how frequently you encountered the described situation.



CRT-PJ05-W2-35-V3-VALP-H04.020_2

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.



“The communication and time on frequency was acceptable even when 3 airports were allocated in one MRTM”

A.3.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

A.3.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

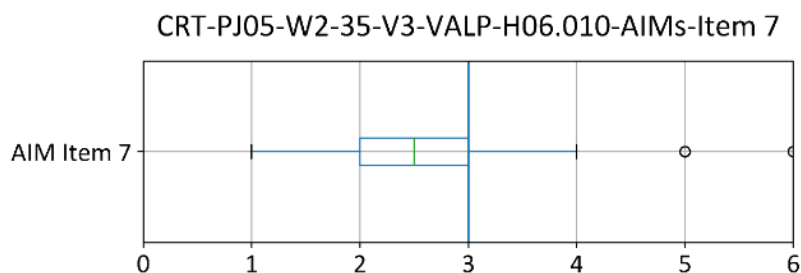
OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a | The results show that the majority of participants took below medium effort to issue timely commands. The tailor-made PE questionnaire shows that the majority of participants agrees with the statements concerning the different modes of operation. And the final comment | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---|--|--------|
| | flexible allocation of aerodromes between MRTMs | indicates a general need for more training of the operational methods. | |

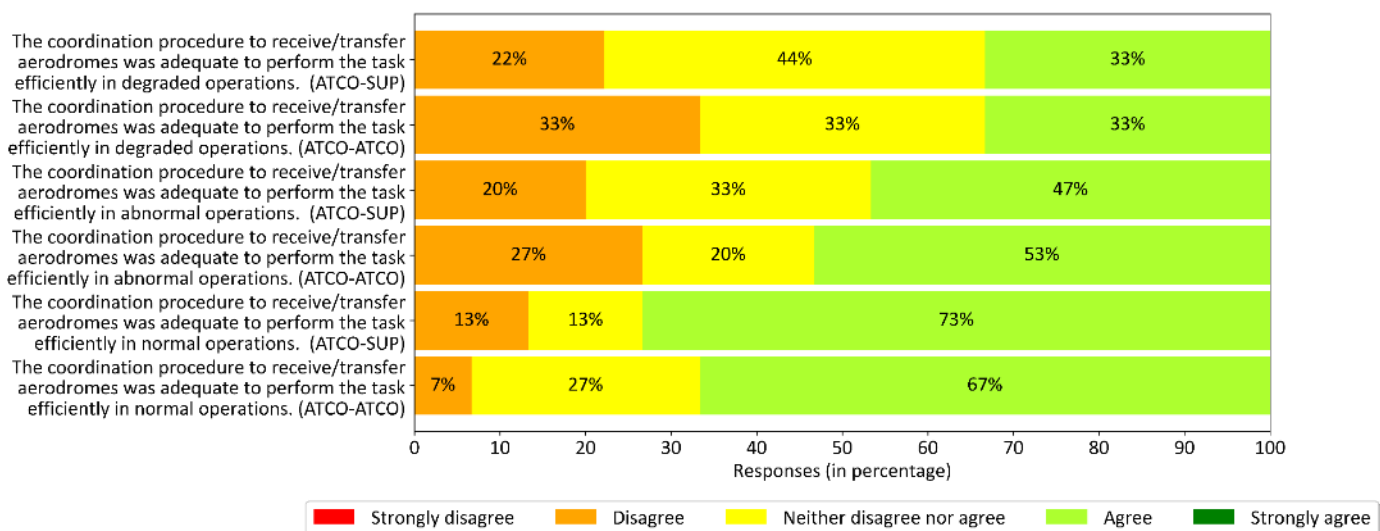
The AIM item 7 asks for the timely effort during the last run. It was applied PR. A score for item number 7 is then summarized in the figure below.



The following questions were from the tailor-made PE questionnaire concerning the different modes of operation and the related communication.

CRT-PJ05-W2-35-V3-VALP-H06.010

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.



“Operating methods which were validated works well. Its believed, that more experience would make it better.”

A.3.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

OBJ-PJ05-W2-35-V3-VALP-H07

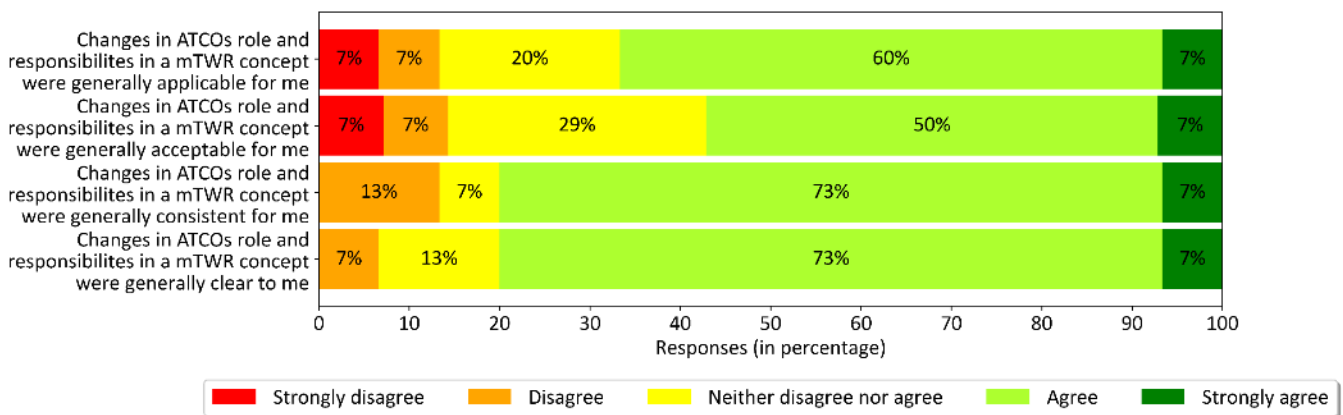
Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | The results show that the majority of participants finds the changes clear, consistent, acceptable, and applicable. | OK |

The following questions were from the tailor-made PE questionnaire. The questions covered the changes in roles and responsibilities that are changes in connection to the normal tower operations.

CRT-PJ05-W2-35-V3-VALP-H07.010

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.

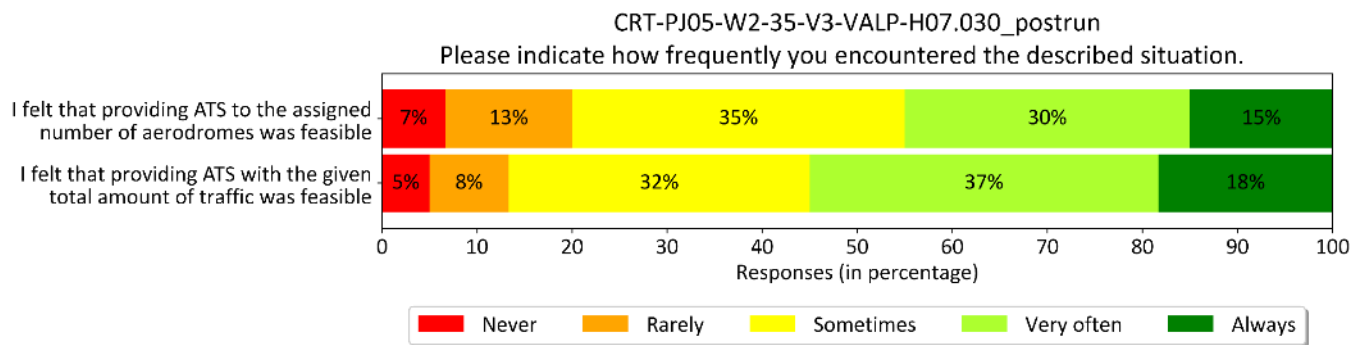


"The roles and responsibilities are clear, consistent and stable. It shows that the concept of RTC is fully operational"

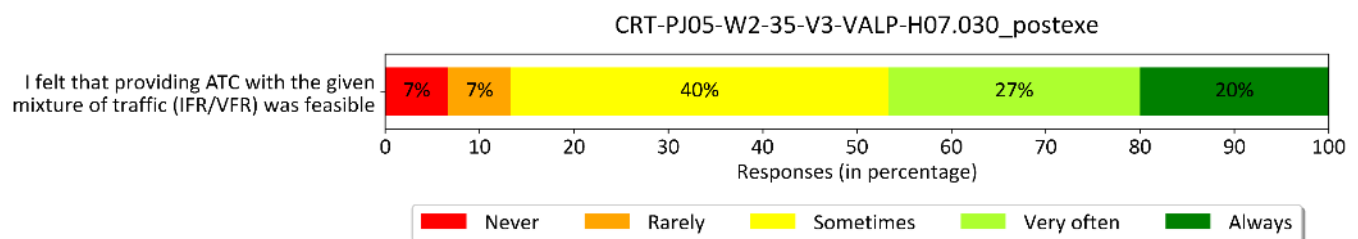
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | For PR and PE the majority of participants confirms the feasibility of the assigned number of aerodromes, the amount of traffic and the traffic | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | mix. They also state that this is the maximum number of aerodromes. | |

questions were from the tailor-made PR and PE questionnaire. The questions covered the changes in roles and responsibilities that are changes in connection to the normal tower operations.



The following questions were from the tailor-made PE questionnaire.



"In our opinion, 3 TWRs is the highest number of aerodromes which could be controlled from one CWP"

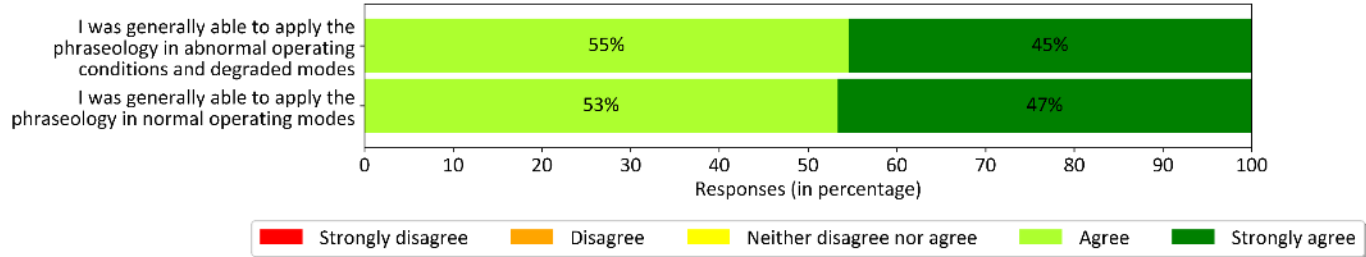
A.3.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | The ATCOs agreed that they were able to apply the phraseology independent from the operating conditions. This is only ok with the adaption that no abnormal and degraded modes were part of the validation. | OK |

The following questions were from the tailor-made PE questionnaire.

CRT-PJ05-W2-35-V3-VALP-H08.010

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.



“There is no difference between standard phraseology and the one used during the validation.”

A.3.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

A.3.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

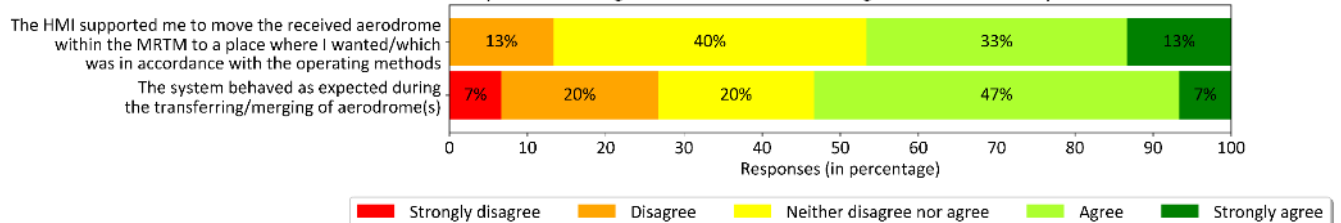
Assess that human-machine interface supports the team in carrying out their tasks

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The majority of the ATCOs agreed that the System / HMI supported the transfer of an Aerodrome and was in accordance with the operating methodology. | OK |

The following questions were from the tailor-made PE questionnaire.

CRT-PJ05-W2-35-V3-VALP-H18.010

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.



“It fully supports ATCOs and SUP, but there is still place to make it better and increase the reliability.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | ATCO part Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

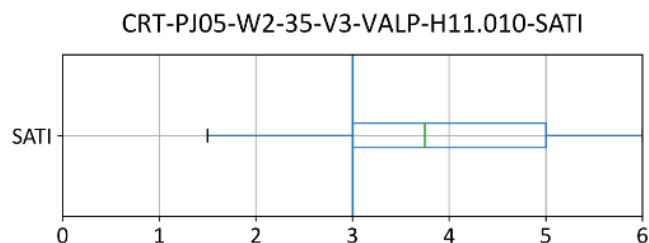
OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | The SATI shows that the ATCOs trust the system, which includes the that the ATCOs trusted the required information. The PE questionnaire also shows that a majority of ATCOs agreed with the visual panorama, radar and strip presentation. This is also reflected in the final comment. | OK |

SATI Scale

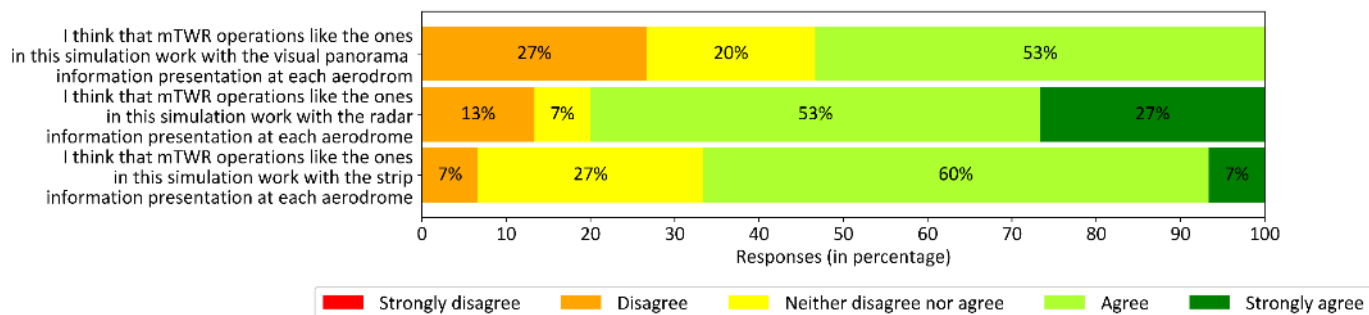
The SATI was applied PR.



The tailor-made questions were applied PE.

CRT-PJ05-W2-35-V3-VALP-H11.010

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.

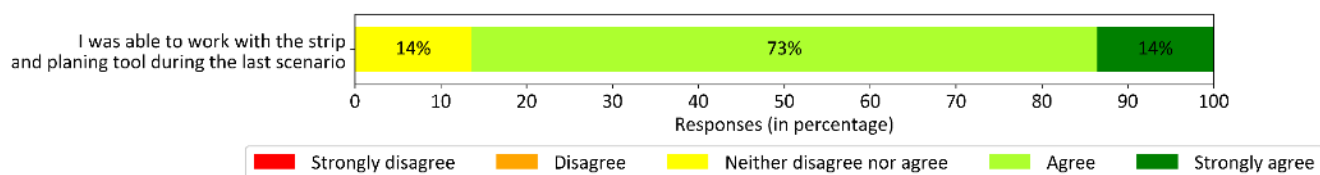


“The essential information was provided for efficient ATS”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | The majority of participants agrees that the strip and planning tool was usable. This also applies for the SUS questionnaire score, which is above the medium scale value. This is also reflected in the final comment. | OK |

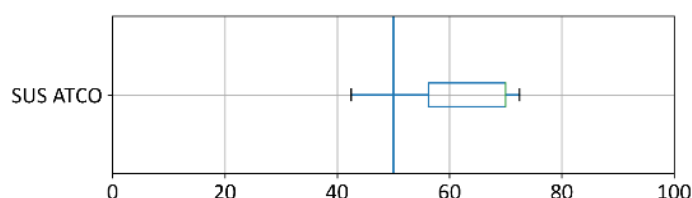
The tailor-made questions were applied PR.

CRT-PJ05-W2-35-V3-VALP-H11.020



The SUS was applied PE.

CRT-PJ05-W2-35-V3-VALP-H11.020-SUSATCO

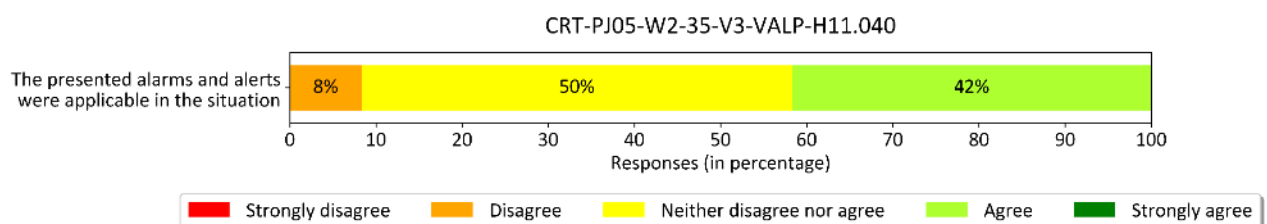


“The usability of input devices was adequate, providing the functions needed”

Founding Members

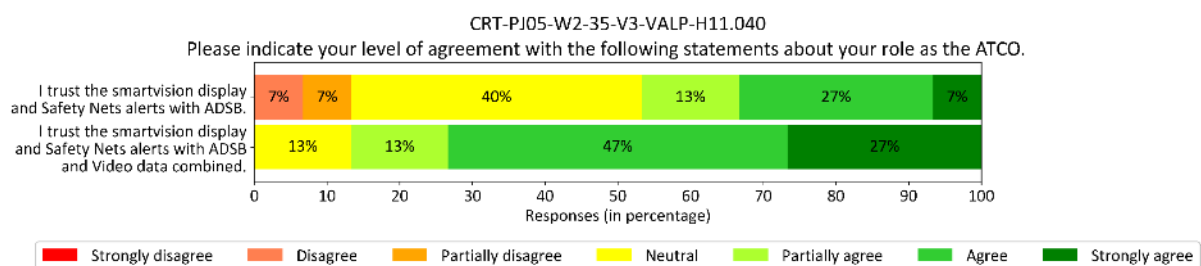
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | <p>For EXE-PJ05-W2-35-V3-2.1.1 the majority of the ATCOs confirms that the alarms and alerts were applicable in the situations. But additional features for the safety net are essential.</p> <p>For EXE-PJ05-W2-35-V3-2.1.2 the majority of the ATCOs confirms that the alarms and alerts were applicable in the situations as well.</p> | OK |

For EXE-PJ05-W2-35-V3-2.1.1 the tailor-made questions were also applied PE.



“The alarms and alerts are useful, nevertheless we think that the safety nets should be expanded with more features”

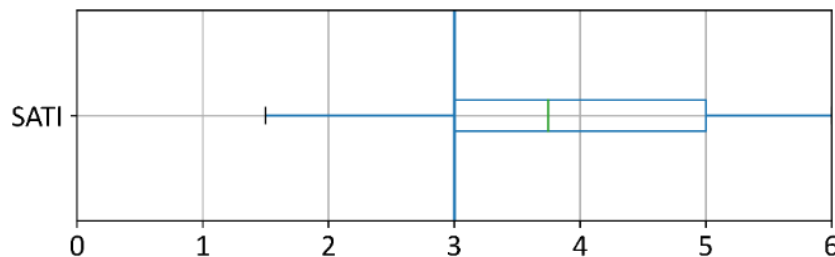
For EXE-PJ05-W2-35-V3-2.1.2 the following tailor-made questions were applied to participants. The results are presented in the figure below.



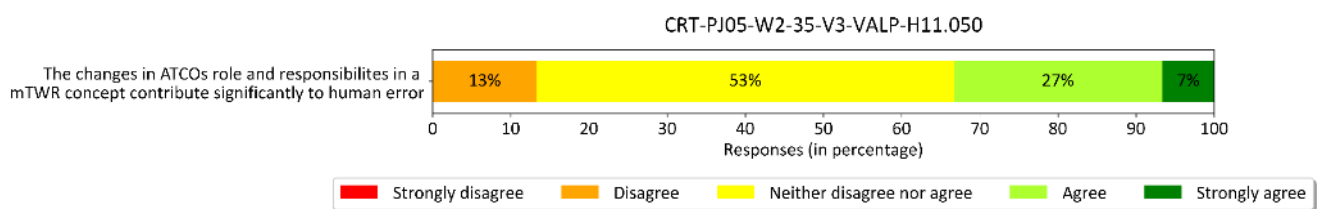
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | <p>For EXE-PJ05-W2-35-V3-2.1.1 again, the SATI scores show that the ATCOs trust the system and the interface. They see the increased human error in the changed role and responsibilities.</p> <p>For EXE-PJ05-W2-35-V3-2.1.2 the majority of the ATCOs confirms that the interface does not increase the potential for human error.</p> | OK |

For EXE-PJ05-W2-35-V3-2.1.1 the SATI was applied PR.

CRT-PJ05-W2-35-V3-VALP-H11.050-SATI

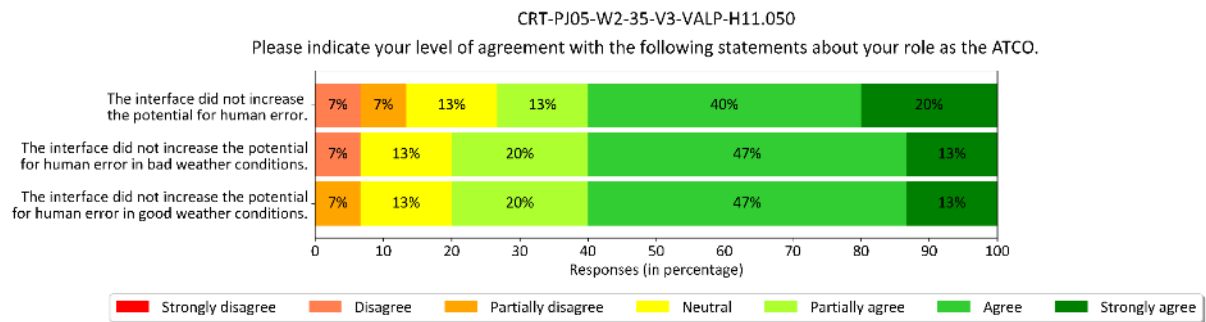


The tailor-made questions were applied PE.



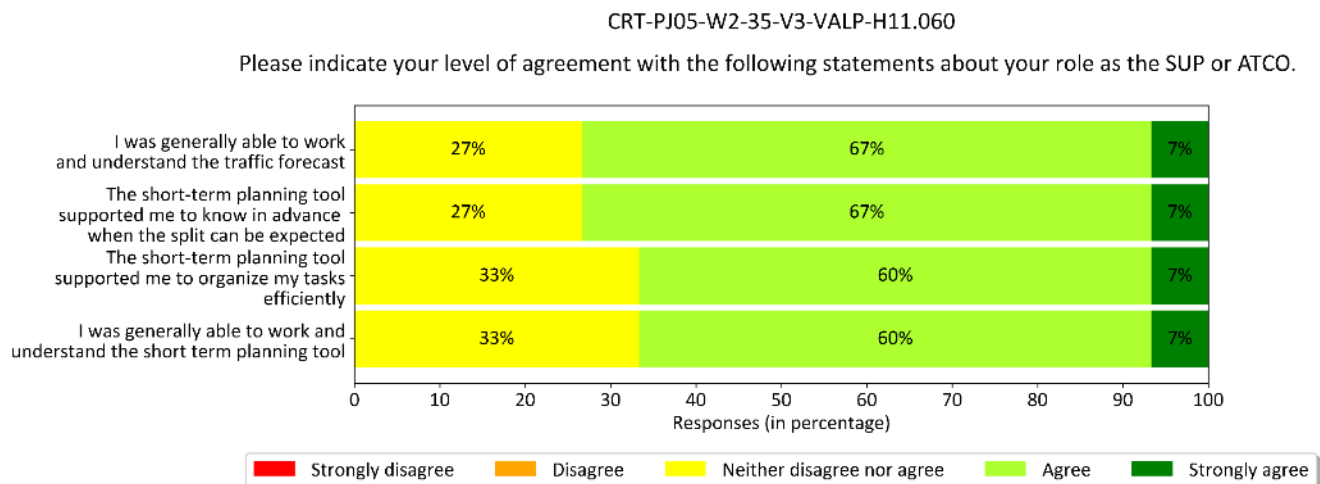
"Our team does agree that HMI does not increase the potential for human error, but when on-hands experience is received."

For EXE-PJ05-W2-35-V3-2.1.2 the following tailor-made questions were applied to participants. The results are presented in the figure below.



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | The majority of the ATCOs found the tool useful in terms of short-term planning and its different aspects. | OK |

The tailor-made questions were applied PE.

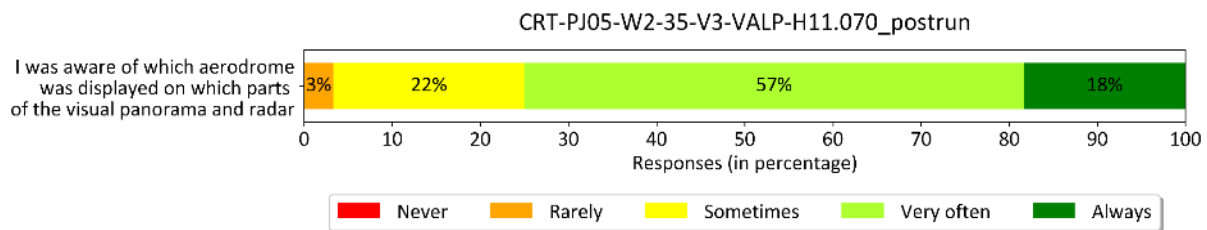


“Our teams can confirm that short term planning/traffic forecast and/or prioritisation tool is very helpful and after the validations we see that the functionalities or metrics could be changed to make it more useful.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which | The results show that the majority of participants was aware of the | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---|--|--------|
| | aerodromes are displayed on which display | displayed aerodromes and radar configurations. | |

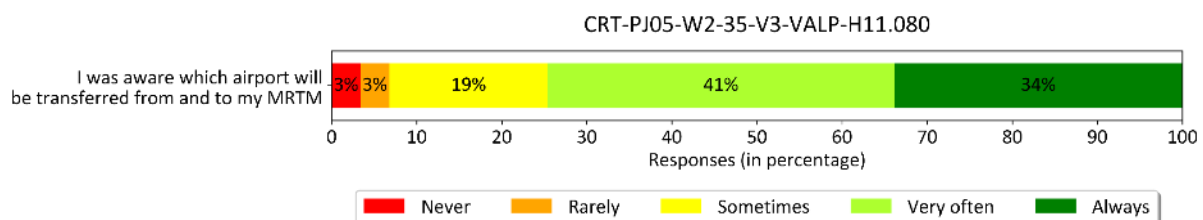
The tailor-made questions were applied PR.



"If there is an adequate time provided to prepare the setting of CWP, there is no confusion. If there is lack of time – it may get confusing at first, but nothing critical."

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | The majority of the ATCOS were aware which airport will be transferred and under which conditions. | OK |

The tailor-made questions were applied PR.



"There is no confusion as SUP where following the agreed procedures. HMI also provided the notifications needed."

A.3.2.5 HUMAN PERFORMANCE – TRUST

A.3.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

Assess ATCO trust in support systems when providing ATS to multiple aerodromes

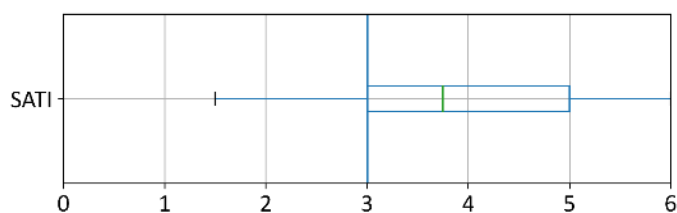
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | <p>For EXE-PJ05-W2-35-V3-2.1.1 the general trust into the system is shown by an average sum score for the SATI questionnaire. This is also reflected in the final comment.</p> <p>For EXE-PJ05-W2-35-V3-2.1.2 the majority of the ATCOs trust in reliability of alarms and alerts.</p> | OK |

For EXE-PJ05-W2-35-V3-2.1.1 the results are covered with the SATI questionnaire, which indicates a general trust into the system. The SATI was applied PR.

CRT-PJ05-W2-35-V3-VALP-H13.040-SATI

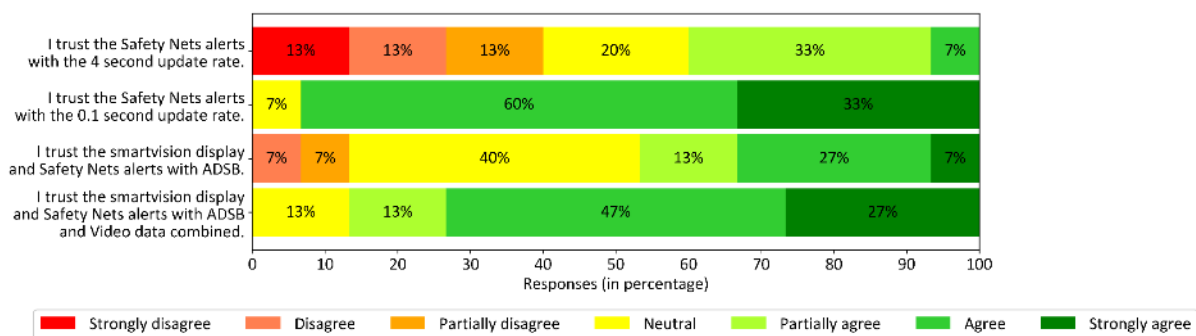


“The reliability of alarms and alerts are basically the same as in the traditional TWR environment, so ATCOs were comfortable with them”

For EXE-PJ05-W2-35-V3-2.1.2 the following tailor-made questions were applied to participants. The results are presented in the figure below.

CRT-PJ05-W2-35-V3-VALP-H13.040

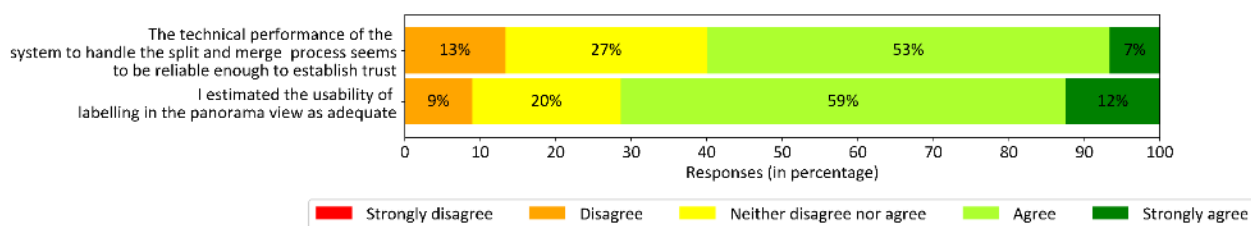
Please indicate your level of agreement with the following statements about your role as the ATCO.



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | The results show that the majority of participants has general trust into the system (see CRT-PJ05-W2-35-V3-VALP-H13.040 SATI). The tailor-made questions are also indicating that the majority trust the system to complete transfers. But it has to be noted that the final comment indicates that more automation and clearer procedures are necessary. | OK |

The tailor-made questions were applied PR.

CRT-PJ05-W2-35-V3-VALP-H13.080



"The transfers of aerodromes were quite manual at the platform the validation took place. It needs to be more automated or the procedures have to be clearer."

A.3.2.6 HUMAN PERFORMANCE – Transition Factors

A.3.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.2.7 SAFETY

A.3.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

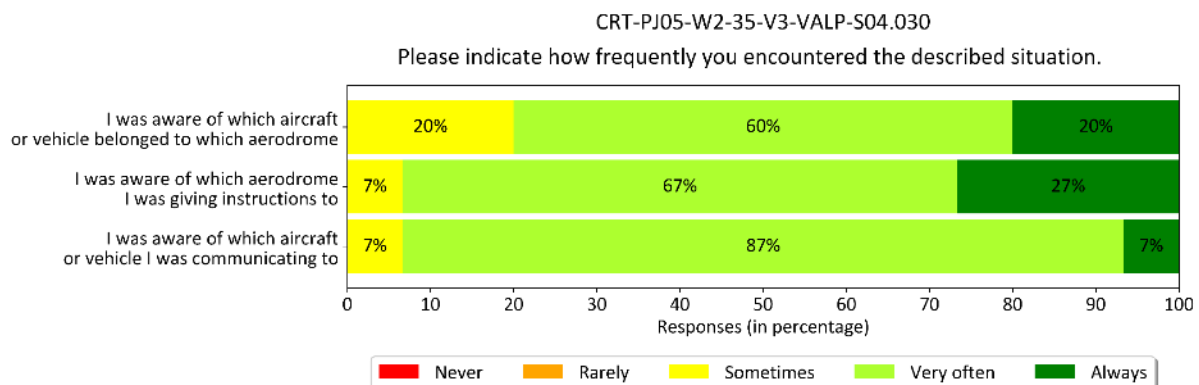
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> Unstable approaches Bird strikes | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---------------------------------------|-------------------|--------|
| | Aircraft not vacating RWY as expected | | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | The results show that the majority of participants agrees with the tailor-made statements concerning their ability to communicate and identify the communication partner. | OK |

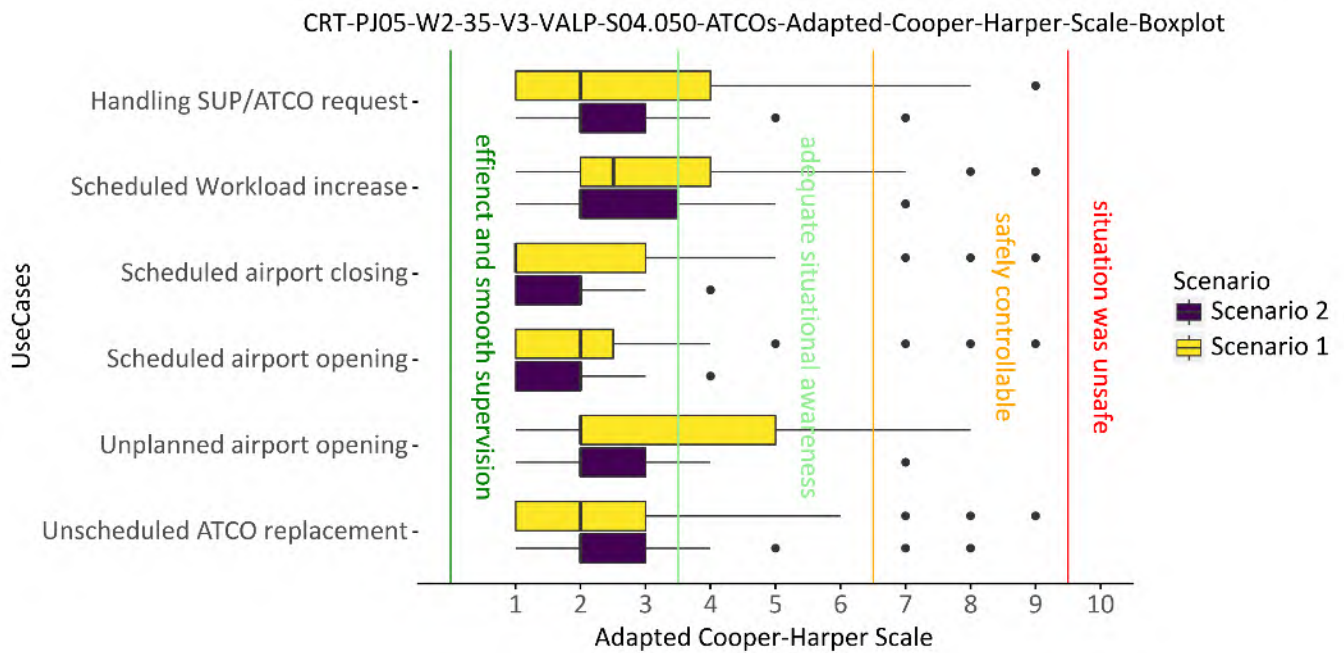
The tailor-made questions were applied PR.



"The system fully provided this capability"

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | The general number of conflicts was always zero and therefore not a good indicator for this success criterion. The results of the cooper-harper scale show that no scenario contained a situation that was unsafe. The most situations with effects on efficiency and situation awareness occurred in scenarios 1. | OK |

The cooper-harper scale questions were applied PR separated for each scenario event.



"It can happen, if very high workload is put on a particular ATCO"

A.3.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

OBJ-PJ05-W2-35-V3-VALP-S05

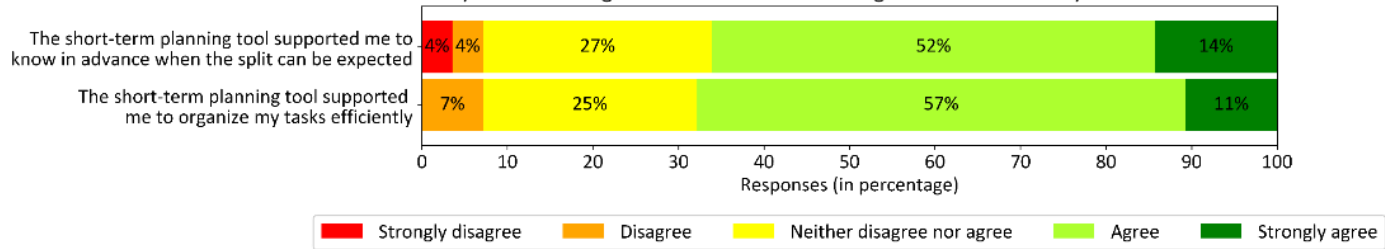
Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | The majority of participants confirms PR and PE the ability to foresee the short-term traffic and plan ahead. Strips need to be provided as essential to this task. | OK |

The tailor-made questions were applied PR.

CRT-PJ05-W2-35-V3-VALP-S05.010-PR

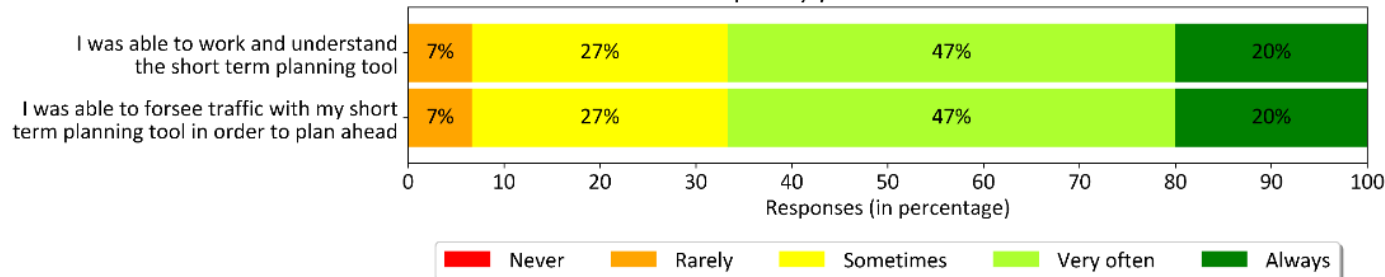
Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.



The tailor-made questions were applied PE.

CRT-PJ05-W2-35-V3-VALP-S05.010-PE

Please indicate how frequently you encountered the described situation.



“As the strips are provided, ATCO could check and effectively plan his/her workload”

A.3.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

| OBJ-PJ05-W2-35-V3-VALP-S06 Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> Aircraft emergency Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results

OBJ-PJ05-W2-35-V3-VALP-S07

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system <p>Other airport systems / infrastructure</p> | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication <p>Visualisation system</p> | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.2.8 CAPACITY

A.3.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

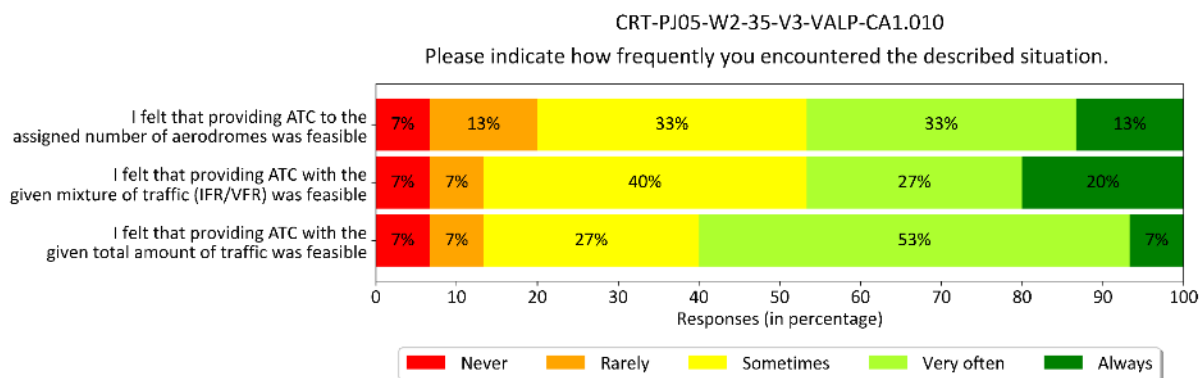
OBJ-PJ05-W2-35-V3-VALP-CA1

Assess capacity constraints when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to | The majority of participants agrees with the amount of airports, mixture of traffic, and amount of traffic to be feasible. The comment of the ATCOs | OK |

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | 6) when ATS is provided to multiple remote towers | increase the necessity of the SUP in this concept. | |

The tailor-made questions were applied PE.



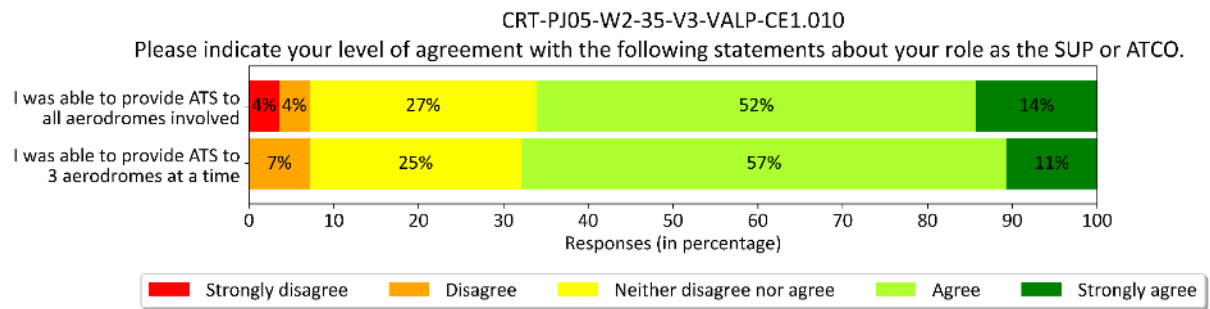
“Capacity constrains where successfully monitored by SUP, which was very helpful for ATCOs and the way the aerodromes are allocated in RTC.”

A.3.2.9 COST EFFICIENCY

A.3.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | The majority of participants agrees with the statements and therefore were able to provide ATS to 3 aerodromes at the same time, with an endorsement of 4. The range of cost-efficient is seen especially for small airports and night operations of medium airport. | OK |

The tailor-made questions were applied PR.



“It may be considered to be cost-efficient for small airports and night operations of medium airports as well.”

A.3.3 Supervisor - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|---|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants at the SUP workplace indicates a positive SA. The PE tailor-made questionnaire even indicates so much that the participants thought they could also keep the same SA under abnormal condition. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | The results show that the SUP on average was only sometimes able to “priorities task”. Considering the final comments from the ATCOs this was mainly due to the new approach of the SUP workplace. | Partially Ok |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | The majority of the participants confirms by an above average SASHA score which indicates an above average situation awareness. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|--|---|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | China Lake and tailor-made results show that the participants were able to divide their attention and keep SA on an adequate level. | OK |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants working at the SUP workstation reported a low workload. Bedford and Nasa-TLX were completed in the PR and therefore no run can be categorized as high workload. Even so, the SUP had to support up to 15 airports. | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of the participants agreed that their mental workload was not above average and therefore in a timely manner and that they could perform their task efficiently. No abnormal or degraded modes were tested in the scenarios. It has to be noted that abnormal operating conditions and degraded modes were not tested and were only part of the tailor-made questionnaire. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | The majority of the participants at the SUP workplace agreed with their roles and responsibilities and also confirmed that they are clear, consistent, stable and acceptable. Even so, the expert comments suggests that there is still work to do and the roles and responsibilities have to be defined in more detail. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | The majority of participants confirms the feasibility and acceptability of the 15 assigned aerodromes. | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | The results show that all information’s are available but they are difficult to acquire, especially at a fitting time. | Partially Ok |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | The SUS confirms that the majority of the participants agrees with an above average usability. The tailor-made questionnaires also | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| | | | | show that the interaction was rated as user friendly. | |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | The majority of the participants confirmed that the SUP HMI supported them in split/merge procedures. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | Even so, the system is usable above average the participant agreed that changes to the SUP role would significantly contribute to human error. The human error could be decreased with automation in the SUP user interface. | OK |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | The assessed level of trust in the system is above average. This is supported by the answers to the PE questions. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): <ul style="list-style-type: none">Crash on an airport or its vicinityFire on an airportUnplanned closure of an airportATCO overload in one or more MRTM of the RTC | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a | CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g: | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|--|--|-----------------------------|
| | flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none"> • Communication • Visualisation system • Other systems in the MRTM | | |
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | The majority of the participants agreed with the task, the possibly to control the traffic, and especially with the split & merge operations. But they also see deficits in the timed provision of task relevant information in preparation for the split & merge. A limited set of data was provided for the simulation's environment's needs, which is limited to real time operation. | Partially ok |

Table 9: Supervisor - Validation Results for Exercise 1

A.3.4 Supervisor - Analysis of Exercise Results per Validation objective

A.3.4.1 HUMAN PERFORMANCE – SITUATION AWARENESS

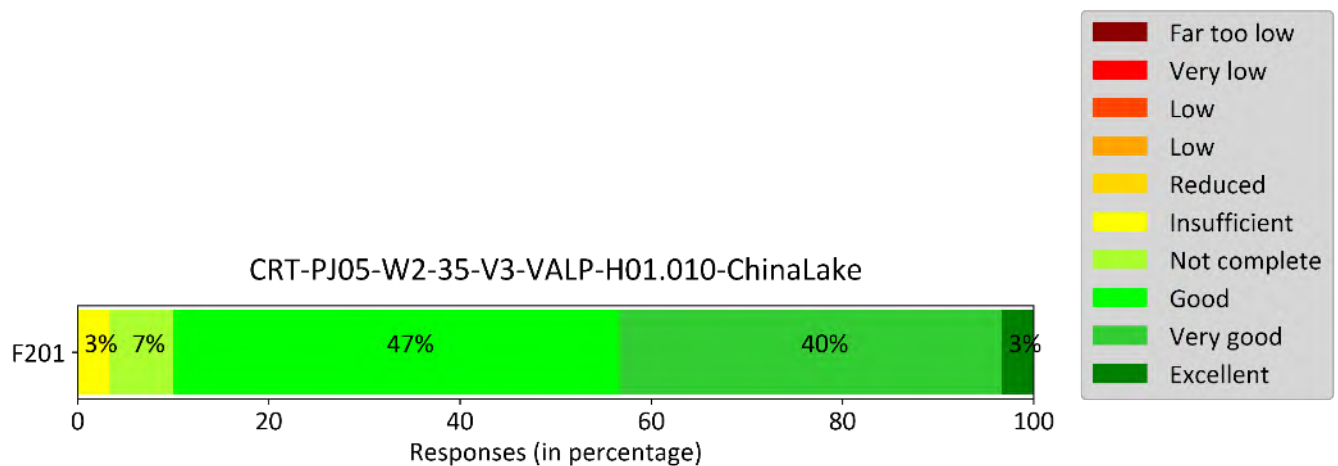
A.3.4.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

OBJ-PJ05-W2-35-V3-VALP-H01

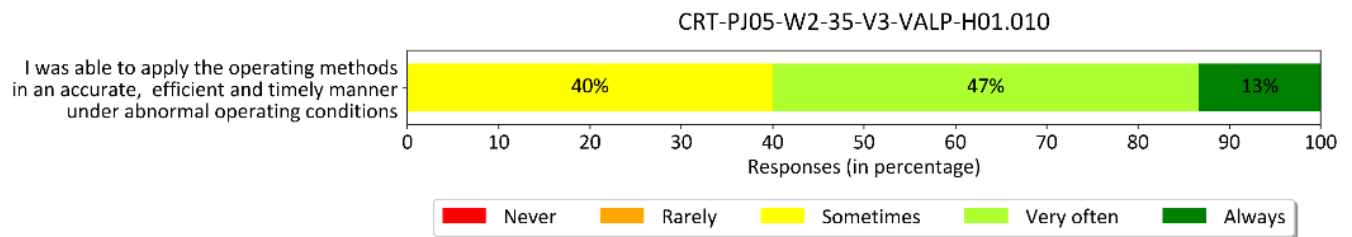
Assess SUP situation awareness when working in an RTC

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants at the SUP workplace indicates a positive SA. The PE tailor-made questionnaire even indicates so much that the participants thought they could also keep the same SA under abnormal condition. | OK |

The China Lake was applied PR.



The tailor-made questions were applied PE.

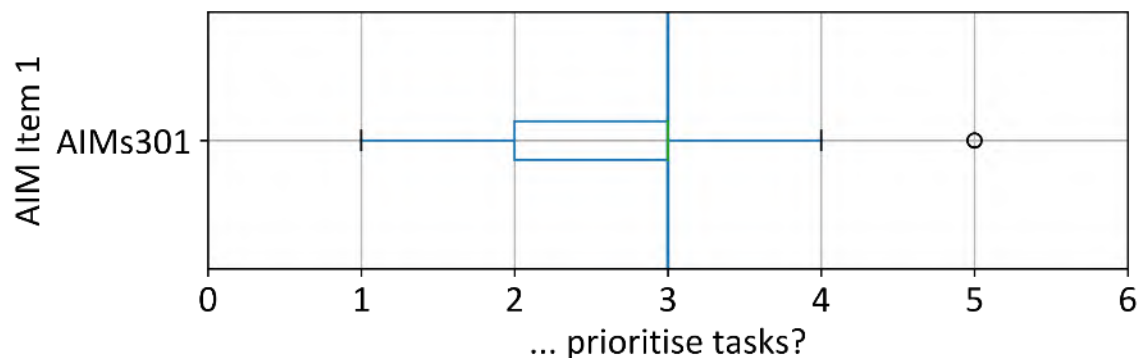


“Our TEAM agrees that SUP awareness is at an acceptable level during normal operational environment in place”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks. | The results show that the SUP on average was only sometimes able to “priorities task”. Considering the final comments from the ATCOs this was mainly due to the new approach of the SUP workplace. | Partially OK |

The AIM was applied PR.

CRT-PJ05-W2-35-V3-VALP-H01.020-AIM_Item_1_SUP

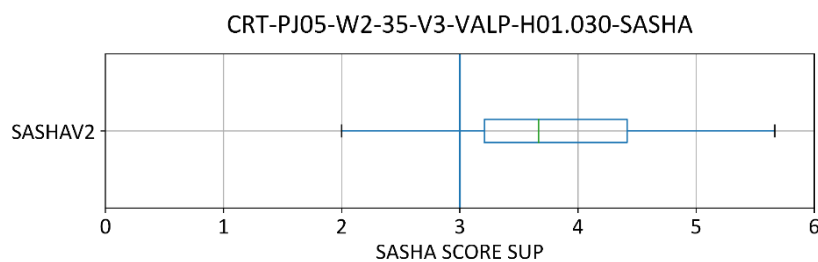


“The prioritisation is quite a hard task, when the SUP position differs from the conventional supervisor position and tasks dedicated at the moment. As its absolutely new approach to SUP responsibilities at TWR centre, it may cause some discrepancies during validations as there were no strict rules and procedures in force.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design | The majority of the participants confirms by an above average SASHA | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---|---|--------|
| | supports a sufficient level of individual situation awareness | score which indicates an above average situation awareness. | |

The SASHA was applied PR.

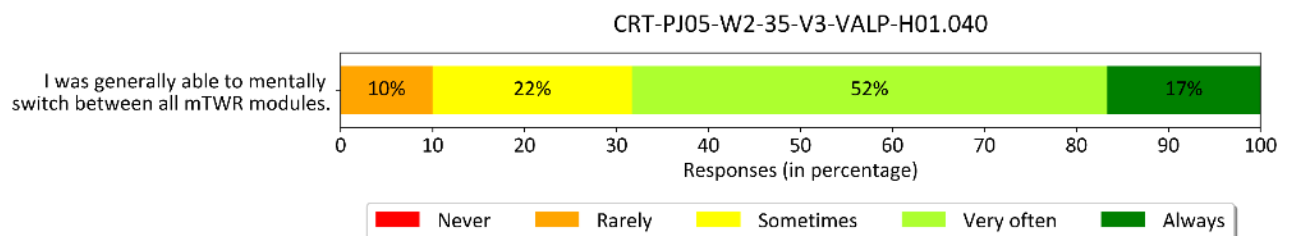


“The pilot version of SUP tool looks like a good start for future development and our TEAM agrees that its fully operative in the operational environment.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | China Lake and tailor-maid results show that that the participants were able to divide their attention and keep SA on an adequate level. | OK |

This CRT is also covered by the china lake results, see CRT-PJ05-W2-35-V3-VALP-H01.010.

The tailor-maid question was applied PR.

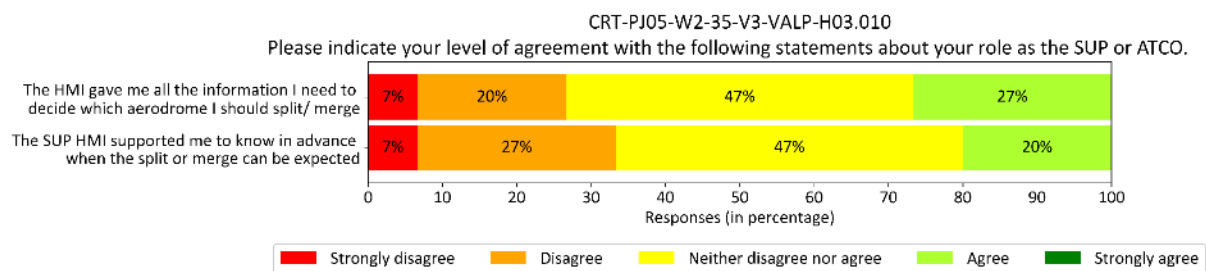


“Reference to comment about prioritisation. Lack of similar experience and no strict rules, methodology of prioritisation and procedures made a big impact for poor results.”

A.3.4.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|---|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | The PE questionnaire results show that there is still missing information or information in poor quality which makes the task of splitting and merging less. The comments from the debriefing fill this gap with ideas how the improve the interface. | Partially OK |

The tailor-made questions were applied PE. The results show that not all information is available for the SUP or are not explicit enough to support the decision process.



“The HMI supported situational awareness in good way, but our team believes that after the validation there are more ideas how to improve HMI support.”

Ideas for improvement:

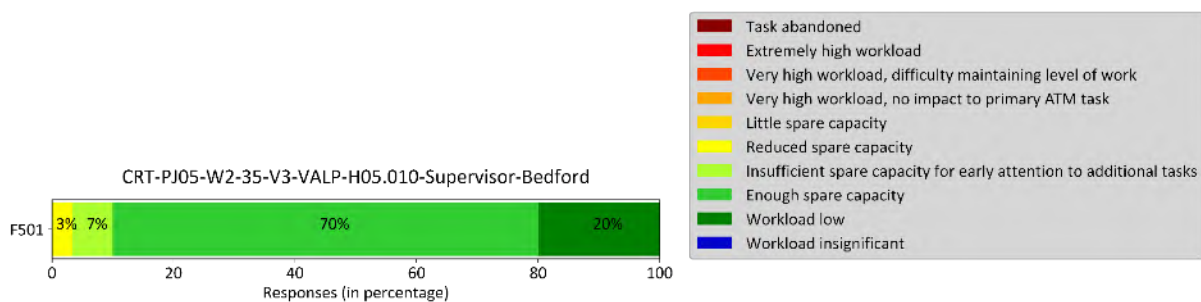
- “separate active airports and inactive airports in one view with colour coding or keep the active ones at the bottom”
- “highlight ATCOs with fitting endorsements”
- “Note somewhere the plan for moving and opening airports”

A.3.4.2 HUMAN PERFORMANCE – WORKLOAD

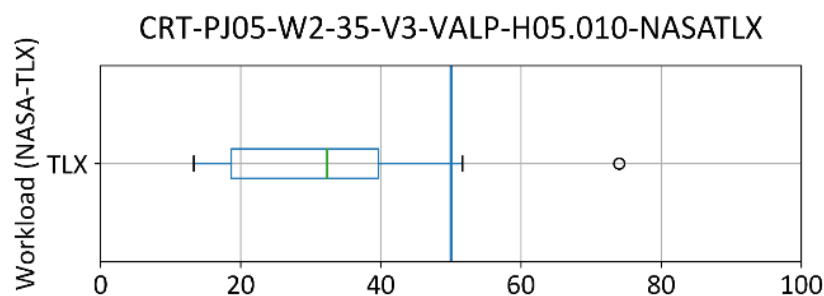
A.3.4.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

| OBJ05-W2-35-V3-VALP-H05 Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of participants working at the SUP workstation reported a low workload. Bedford and Nasa-TLX were completed in the PR and therefore no run can be categorized as high workload. Even so, the SUP had to support up to 15 airports. | OK |

The Bedford scale was applied PR.



The Nasa-TLX was applied PR. The Nasa-TLX score is between 0 (no workload) and 100 (extrem high workload). A boxplot below 50 means that the majority of participants had a low to medium workload.



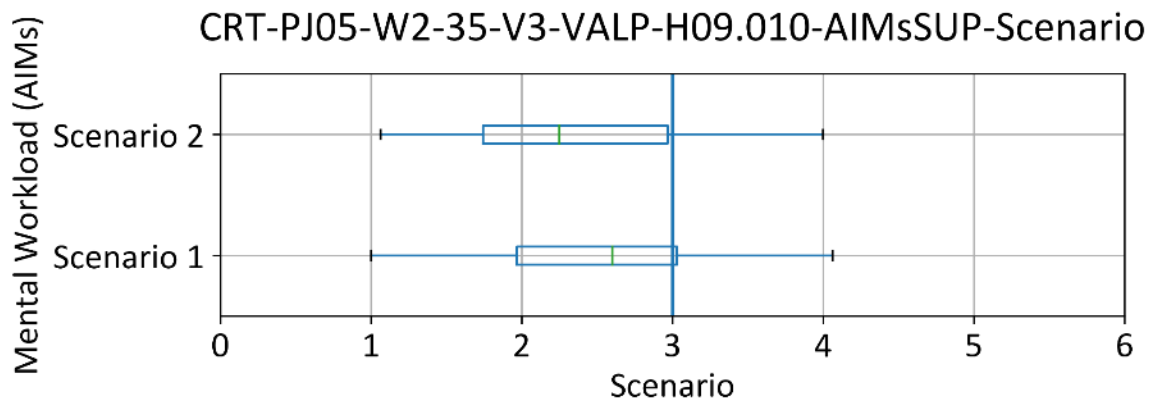
“We do agree, that workload was acceptable.”

A.3.4.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

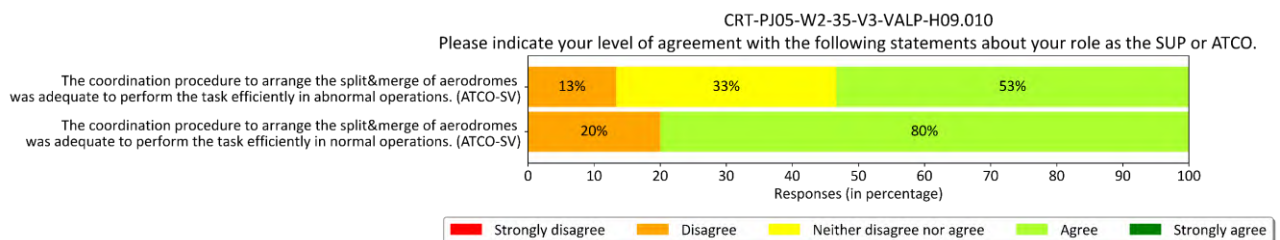
A.3.4.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The majority of the participants agreed that their mental workload was not above average and therefore in a timely manner and that they could perform their task efficiently.</p> <p>No abnormal or degraded modes were tested in the scenarios. It has to be noted that abnormal operating conditions and degraded modes were not tested and were only part of the tailor-made questionnaire.</p> | OK |

The AIM was applied PR.



The tailor-made questions were applied PE.



“This criterium has a lot future potential if the operating methods are clarified, procedure based and etc.”

A.3.4.4 HUMAN PERFORMANCE – USABILITY and UTILITY

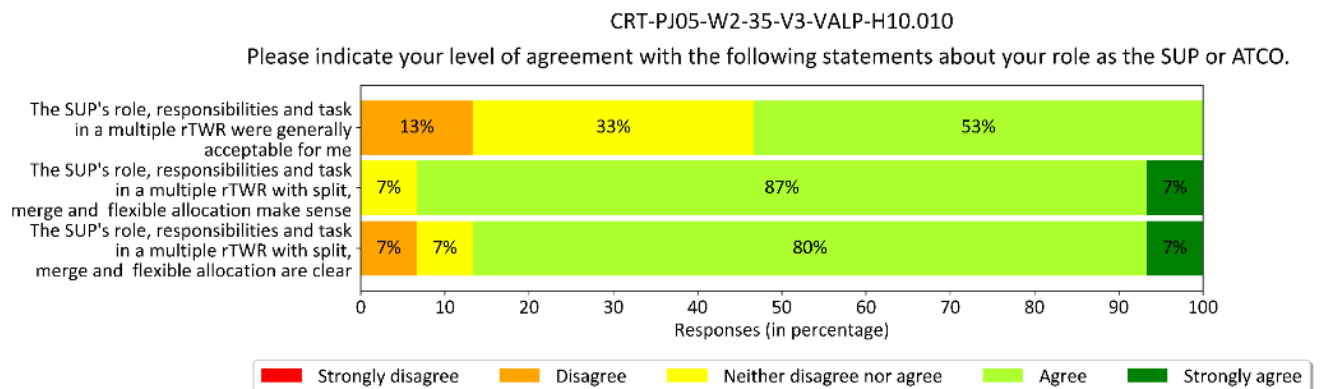
A.3.4.4.1 OBJ-PJ05-W2-35-V3-VALP-H10 Results

OBJ-PJ05-W2-35-V3-VALP-H10

Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | The majority of the participants at the SUP workplace agreed with their roles and responsibilities and also confirmed that they are clear, consistent, stable and acceptable. Even so, the expert comments suggest that there is still work to do and the roles and responsibilities have to be defined in more detail. | OK |

The tailor-made questions were applied PE.

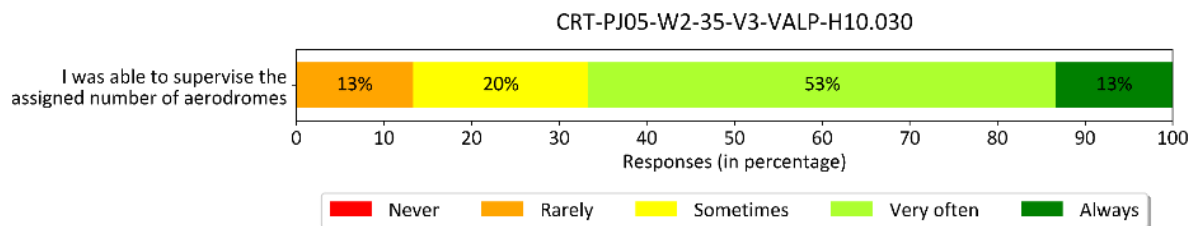


“It is “Partially ok” in our opinion.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned | The majority of participants confirms the feasibility and acceptability of the 15 assigned aerodromes. | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|----------------------------------|-------------------|--------|
| | number of clusters of aerodromes | | |

The tailor-made questions were applied PE.



“It needs further improvements for WP (working position) and SUP tool, but it’s fully acceptable to supervise the given number aerodromes. It may be higher if more actions automated and etc.”

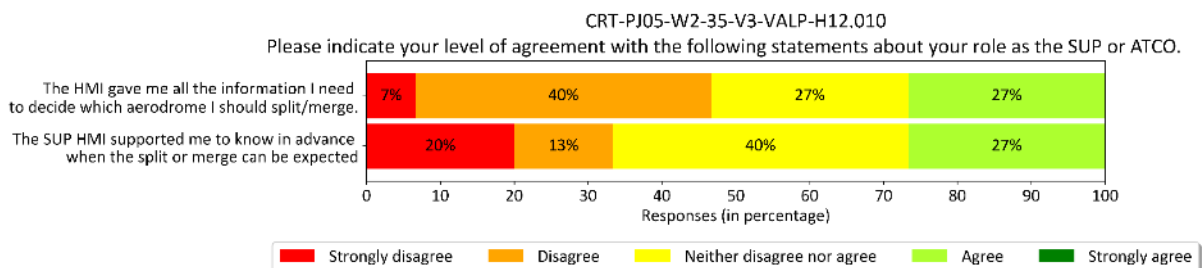
A.3.4.4.2 OBJ-PJ05-W2-35-V3-VALP-H12 Results

OBJ-PJ05-W2-35-V3-VALP-H12

Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | The results show that all information's are available but they are difficult to acquire, especially at a fitting time. | Partially OK |

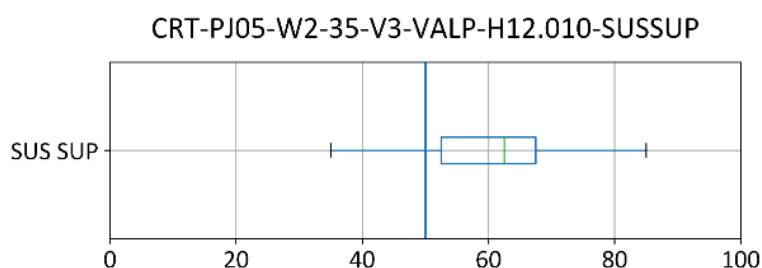
The tailor-made questions were applied PE.



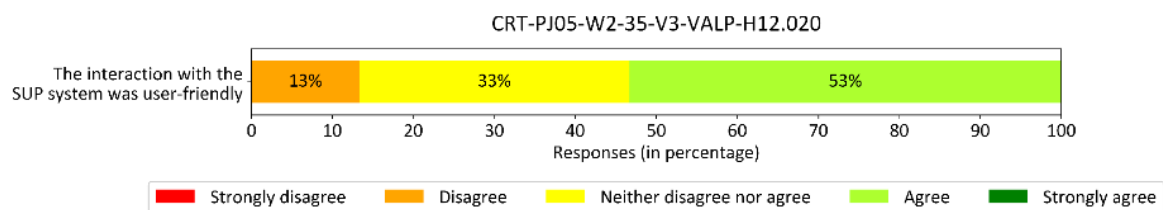
“It may be more related with the information provision (there is all information needed, but it’s hard to reach at the time its needed)”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | The SUS confirms that the majority of the participants agrees with an above average usability. The tailor-made questionnaires also show that the interaction was rated as user friendly. | OK |

The SUS was applied PE.



The tailor-made questions were applied PE.

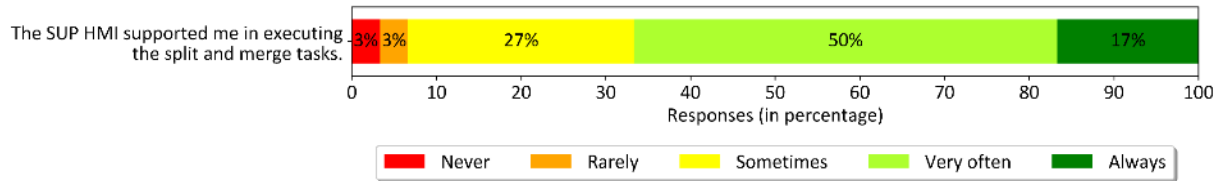


“The input devices where fully useful.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | The majority of the participants confirmed that the SUP HMI supported them in split/merge procedures. | OK |

The tailor-made questions were applied PR.

CRT-PJ05-W2-35-V3-VALP-H12.030



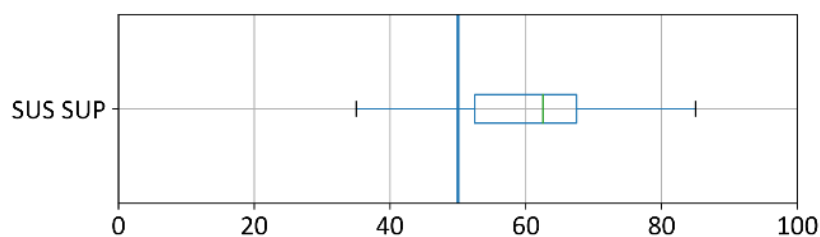
“The SUP tool, which was created from the scratch, was a very useful and we believe that further development should be done on that kind of model.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | Even so, the system is usable above average the participant agreed that changes to the SUP role would significantly contribute to human error. The human error could be decreased with automation in the SUP user interface. | OK |

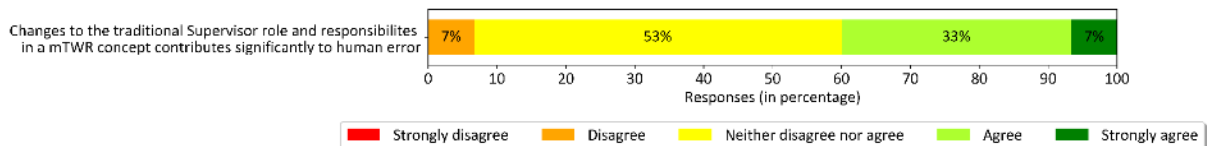
The SUS for the SUP workplace was collected PE.

CRT-PJ05-W2-35-V3-VALP-H12.050-SUSSUP



The tailor-made question was applied PE.

CRT-PJ05-W2-35-V3-VALP-H12.050



“The system (SUP tool) needs more automation to reduce the risk level of human error”

Founding Members

A.3.4.5 HUMAN PERFORMANCE – TRUST

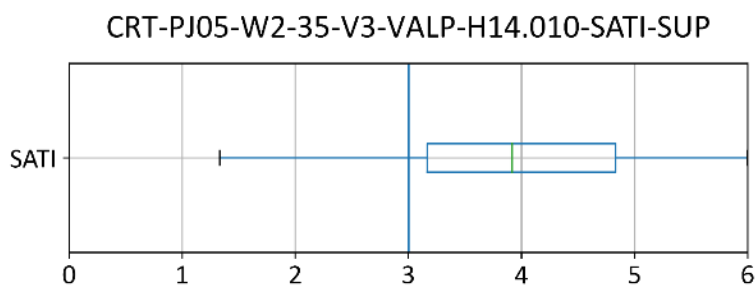
A.3.4.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

OBJ-PJ05-W2-35-V3-VALP-H14

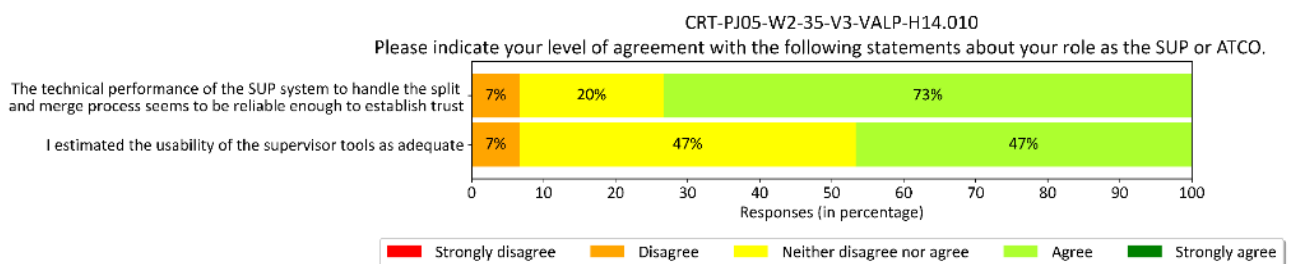
Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | The assessed level of trust in the system is above average. This is supported by the answers to the PE questions. | OK |

The SATI for the SUP workplace was collected PR.



The tailor-made questions were applied PE.



“The functionalities are trustworthy and our TEAM relied on it.”

A.3.4.5.2 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.4.6 SAFETY

A.3.4.6.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.4.6.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

OBJ-PJ05-W2-35-V3-VALP-S09

Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> • Communication • Visualisation system <p>Other systems in the MRTM</p> | Not addressed in the EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2 validation | N/A |

A.3.4.6.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results**OBJ-PJ05-W2-35-V3-VALP-S10**

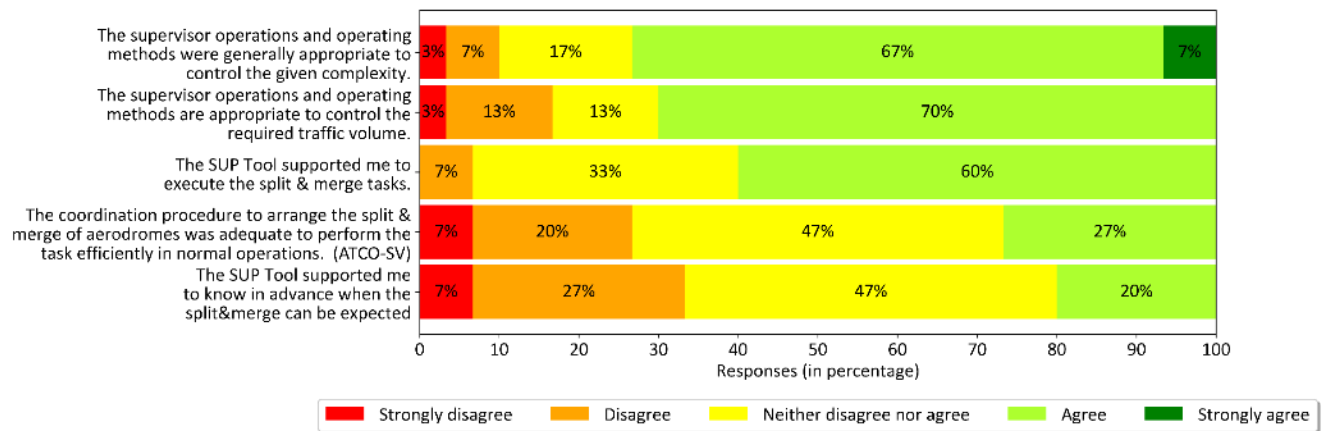
Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | <p>The majority of the participants agreed with the task, the possibly to control the traffic, and especially with the split & merge operations. But they also see deficits in the timed provision of task relevant information in preparation for the split & merge. A limited set of data was provided for the simulation's environment's needs, which is limited to real time operation.</p> | partially ok |

The tailor-made questions were applied PE.

CRT-PJ05-W2-35-V3-VALP-S10.010

Please indicate your level of agreement with the following statements about your role as the SUP or ATCO.



“We do agree that SUP tool is useful, but it lacks ergonomic at the moment. Some of information should be more detailed and etc.”

A.3.5 Unexpected Behaviours/Results

No showstoppers were encountered for EXE-PJ05-W2-35-V3-2.1.1 or EXE-PJ05-W2-35-V3-2.1.2.

A.3.6 Confidence in Results of Validation Exercise

A.3.6.1 Level of significance/limitations of Validation Exercise Results

EXE-PJ05-W2-35-V3-2.1.1

The following items were not considered in the EXE-PJ05-W2-35-V3-2.1.1 validation exercise:

- No abnormal or degraded situations were considered in the scenarios
- No ground vehicles were considered in the scenarios

EXE-PJ05-W2-35-V3-2.1.2

The following items were not considered in the EXE-PJ05-W2-35-V3-2.1.2 validation exercise:

- No abnormal or degraded situations were considered in the scenarios
- No ground vehicles were considered in the scenarios

A.3.6.2 Quality of Validation Exercises Results

For EXE-PJ05-W2-35-V3-2.1.1 and EXE-PJ05-W2-35-V3-2.1.2

The exercise results are based on ATCOs' subjective opinions and have been collected by means of questionnaires. Data collection and analysis were adequately monitored and are considered to be of very good quality. Questionnaires were filled in by the participants following each validation run and after having completed all runs. The completeness of the answers was checked and assured by the system. The timing of questionnaires and debrief sessions were appropriately planned and carried out capturing the recollections of the ATCOs.

A.3.6.3 Significance of Validation Exercises Results

For EXE-PJ05-W2-35-V3-2.1.1 and EXE-PJ05-W2-35-V3-2.1.2

The operational significance of the validation exercise results can be considered acceptable since the operational environment was accepted as such by the ATCOs. The setting was rated as realistic, even so some situations, especially in the coordination between SUP and MRTM were unrealistic. The

amount of 15 participants can also be considered as high in the context of comparable studies. The mixture of the ATCOs' experience (from different airports and different ANSP) increases the significance of the results through the different perspectives on RTO, MRTM, and the SUP workplace.

A.3.7 Conclusions

For the ATCO

ATCOs were able to provide ATC to up to three aerodromes at a time. Situation awareness, workload and safety were not considerably impaired during standard procedures. Situations in connections to the SUP workplace increased the coordination (split & merge) but were overall mitigated due to the effective balance workload.

For the SUP

The SUPs were able to provide support for up to 15 airports. Situation awareness, workload and safety were also not considerably impaired. The selected scenarios events were handled in an efficient manner and no impairment on safety or situation awareness were measured. The SUPs in general saw the necessity of this workplace to identify and coordinate the workload ahead of the normal planning horizon. Further findings and recommendations are detailed below.

A.1.1.1. Conclusions on concept clarification

EXE-PJ05-W2-35-V3-2.1.1

For the ATCO

At the MRTM the checklist for handing one airport to a different station was applied and discussed in terms of completeness. Overall workload remained at a satisfactory or tolerable level. Most situations could be solved without impairment or by applying measures reducing capacity. Some combination of aerodromes allowed a low or high workload, but the ATCOs managed all these.

Attention must be paid to the following aspects:

- It was discussed during the debriefings that ATCOs need to have extensive training on all airports with active endorsements
- The time for a split & merge procedure is best selected by the ATCO with the most traffic.
- Providing ATS service depends on the type of traffic mixture as well as the number of simultaneous movements. All procedures and separation minima should be designed in a way to make sure, that the ATCO has a capacity reserve for handling unusual and unexpected situations.
- Approximately 15 Minutes time is needed for a handover during a simulation run and the checklist needs to be completed.

For the SUP

The necessity for the workplace was accepted and the concept was approved. The following steps need more clarification:

- The definition of the role SUP was discussed rather as support position than a supervisor to the centre. The supervision should coordinate the workload but should also assist the MRTM if requested.

EXE-PJ05-W2-35-V3-2.1.2 did not contribute to the concept clarification.

A.1.1.1. Conclusions on technical feasibility

EXE-PJ05-W2-35-V3-2.1.1

For the ATCO

- Smart strip is considered helpful for MRTM
- The system could be used to switch between airports and provide ATS to 3 aerodromes at a time.
- The flexible positioning of the airport on the MRTM was considered helpful in terms of every ATCO can make his/her own arrangements
- When splitting aerodromes to another position, ATCOs taking over traffic need to be able to see the panoramic view and listen in on all radio frequency in order to build up situation awareness.
- The ATCOs almost never requested help in terms of splitting and merging or other tasks for the SUP

For the SUP

- The indication for the SUP planning tool must be clearer in description. This accounts especial for the traffic indication and planning of the correct configuration of MRTM, airport and ATCO.
- ATCOs that are not available for the selected airport should be greyed out, and the remaining ranked by availability.
- The workflow of the planning tool was interpreting differently by the ATCOs, which was depending on the current implementation and could lead to increased errors in the future.
- The radar screens and airport overviews of the SUP station were almost never used.

EXE-PJ05-W2-35-V3-2.1.2

- The Safety Nets alerts are considered helpful for the exercise in terms of situational awareness.
- The Safety Nets alerts improved the monitoring of the apron.
- The dynamically configurable volumes were considered helpful by ATCOs.

- Adjustable prediction times of Safety Nets alerts for individual APW volumes were considered helpful by ATCOs
- The fusion of camera output and ADS-B data found helpful in terms of surveillance quality by ATCOs.
- It was observed that there are less nuisance Safety Nets alerts when a surveillance input with higher update rate is used.

A.1.1.1. Conclusions on performance assessments

EXE-PJ05-W2-35-V3-2.1.1

For the ATCO

- The ATCOs workload did never increase above 8 movements at the time.
- The split & merge procedure were the times with increased workload.
- The coordination for split & merge was sometimes the most difficult part, especially the ATCO – ATCO coordination.
- The tested transfer protocol itself did not negatively impact workload or situation awareness.
- Simultaneous landings and/or take-offs could be handled.
- All airport cameras were position in the south of the runway.
- Amount of communication was seen as a bottleneck in situations with high task load

For the SUP

- The SUPs could support up to 15 aerodromes on up to 6 MRTM with manageable workload
- The search for the fitting ATCO was the task with the highest workload
- The task offers more spare time than an ATCO working 3 airports in parallel

EXE-PJ05-W2-35-V3-2.1.2 did not contribute to the performance assessment.

A.3.8 Recommendations

EXE-PJ05-W2-35-V3-2.1.1

For the ATCO

- Splitting & Merging should be calculated with at least 15 minutes per airport for an ATCO
- Higher complexity in terms of traffic/movements per hour, simultaneous traffic, IFR/VFR mix, training flight etc. should be further investigated
- Abnormal situations and technical defects should also be further investigated

- The visual presentation of the OTW view should be enhanced with overlay information.
- Workload should be monitored in general for the individual ATC position and also for specific high peak task load situations in order to trigger a split procedure before the ATCO is overloaded or inform the SUP in advance.
- Training, especially split & merge need to be integrated into the ATCO training

For the SUP

- Splitting & merging should be planned with at least 15 minutes per airport.
- The planning tool should provide a prediction for a suited handover time, if the handover is initiated in the tool.
- The SUP should be trained as a supporter for each MRTM and not only supervise the centre. This indicates a change in the supervisor role with a transition into RTC, due to his/her limited endorsements. He/she will not have the ability to support individual modules but should have the ability to find a suitable ATCO to fulfil the role of an assistant.
- The planning tool automation should be made more reliable
- The time for ATCO finding and selecting a fitting ATCO or MRTM should be decreased (with additional automation)

EXE-PJ05-W2-35-V3-2.1.2

- The conversation of APW areas would be context sensitive regarding the configurations of ATCO's who is providing the service. The more personnel is present, the narrower their area of responsibility is and so the prediction times may be lowered.
- Closed runways, closed aprons, construction works, danger areas, physical obstacles, ILS protected areas, the areas which are less visible from tower can be considered as APW areas.
- APW alert prediction times should be adjustable for individual preferences.
- Track labels should be visible on the panorama screen.
- Object bounding boxes on the panorama screen should be more precise.

Appendix B Validation Exercise EXE-2.2-COOPANS Report

B.1 Summary of the Validation Exercise EXE-2.2-COOPANS Plan

This section covers the EXE-PJ05-W2-35-V3-2.2 COOPANS.

B.1.1 Validation Exercise description, scope

- The validation has been done as one part and the validation exercise has been performed as a Real Time Simulations.
- The operational scope of the Real Time Simulation in this validation exercise included provision of simultaneous ATS to three small operating environment aerodromes from MRTMs within the RTC by one ATCO. The aerodromes were flexibly allocated between the MRTMs and within each MRTM.
- In order to complement the whole solution 35 with more compatible and more reliable results, the exercise was run with slightly different focus:
 - The first is provision of simultaneous ATS using one MRTM with 3 aerodromes at a time
 - The second is provision of simultaneous ATS for up to three small aerodromes at the time, flexibly allocated between the MRTMs, as well as within each MRTM. A short-time planning tool supported ATCOs assessment about when the most suitable time was to initiate and conduct the transfer.

This validation approach was considered to bring stable and matured results from PJ05.03-V2 simulation as well as to provide a solid base for validating the enlarged scope of Multiple Remote Tower solutions, covering flexible allocation of the aerodromes.

- The ATCO covered the roles of Clearance Delivery, Ground Controller and Tower Runway Controller for all aerodromes simultaneously.
- The Real time simulations was run with up to 2 MRTMs.
- The validation platform used was NATMIG SAAB IBP delivered by NATMIG. The ATCO planning tool was provided by Masterman.

B.1.2 Summary of Validation Exercise EXE-2.2-COOPANS Validation Objectives and success criteria

Note: The validation objectives with their respective success criteria regarding RTC Supervisor role and Supervisor planning tool, unfortunately was not covered with COOPANS validation exercise, due to COVID-19, hence those are described as deviation from planned activities

| SESAR Solution Validation Objective | SESAR Solution Success criteria | Coverage and comments on the coverage of SESAR Solution Objective in Exercise V3-2.2 | Exercise Validation Objective | Exercise Success criteria |
|---|---------------------------------|--|-------------------------------|---------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.040 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H03 | CRT-PJ05-W2-35-V3-VALP-H03.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – WORKLOAD | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H05 | CRT-PJ05-W2-35-V3-VALP-H05.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | CRT-PJ05-W2-35-V3-VALP-H06.010 | Fully covered Questionnaire, debrief | as solution | as solution |

| | | | | |
|---|--------------------------------|---|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07.010 | Fully covered Questionnaire, Debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H08 | CRT-PJ05-W2-35-V3-VALP-H08.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H09 | CRT-PJ05-W2-35-V3-VALP-H09.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H10 | CRT-PJ05-W2-35-V3-VALP-H10.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H10 | CRT-PJ05-W2-35-V3-VALP-H10.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ0-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.040 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.050 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.060 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.070 | Fully covered Questionnaire, debrief | as solution | as solution |

| | | | | |
|--|--------------------------------|---|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.080 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12.050 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – TRUST | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3-VALP-H13.040 | Fully covered Questionnaire, | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3-VALP-H13.080 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H14 | CRT-PJ05-W2-35-V3-VALP-H14.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – TRANSITION FACTORS | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | CRT-PJ05-W2-35-V3-VALP-H15.010 | Fully covered Debrief, work shop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H15 | CRT-PJ05-W2-35-V3-VALP-H15.020 | Fully covered Debrief, work shop | as solution | as solution |
| SAFETY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04.010 | Fully covered (simulated cases) Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04.020 | Fully covered (simulated cases) Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S05 | CRT-PJ05-W2-35-V3-VALP-S05.010 | Fully covered Questionnaire, debrief | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--------------------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-S06 | CRT-PJ05-W2-35-V3-VALP-S06.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S07 | CRT-PJ05-W2-35-V3-VALP-S07.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S07 | CRT-PJ05-W2-35-V3-VALP-S07.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S08 | CRT-PJ05-W2-35-V3-VALP-S08.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S10 | CRT-PJ05-W2-35-V3-VALP-S10.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| CAPACITY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | CRT-PJ05-W2-35-V3-VALP-CA1.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| COST EFFICIENCY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | CRT-PJ05-W2-35-V3-VALP-CE1.010 | Fully covered Questionnaire, debrief | as solution | as solution |

B.1.3 Summary of Validation Exercise EXE-2.2-COOPANS

Validation scenarios

The exercise in V3 maturity level has focused on working with three aerodromes simultaneously and flexible allocation within RTC.

The validation scenarios used in the Real Time Simulation represent 2 MRTMs with up to 3 connected aerodromes per MRTM. The scenarios will have 4 possible aerodromes. Transfer of aerodromes between the MRTMs will be possible for a flexible allocation between the MRTMs. Scenarios was designed to last between 85 and 90 minutes. The scenarios represent normal workday situations within an RTC as well as degrade situations.

The following scenarios was conducted:

| SCN | MRTMs | ADs per MRTM | Comment | Transfer |
|-------|-------|--------------|-----------------------------|----------|
| SCN 1 | 2 | Up to 3 | Focus on 3 ADs and transfer | Yes |
| SCN 2 | 2 | Up to 3 | Focus on 3 ADs and transfer | Yes |
| SCN 3 | 2 | Up to 3 | Focus on degraded mode | Yes |
| SCN 4 | 2 | Up to 3 | Focus on 3 ADs and transfer | Yes |

Founding Members

The parameter list, shown below, was used in order to ensure that a combination of all the parameters was tested in different runs during the validation.

| | |
|-----------------------|---|
| Traffic volume | <ul style="list-style-type: none"> • 20- 30 movements/hour and up to 6 simultaneous movements |
| Traffic complexity | <ul style="list-style-type: none"> • Mainly IFR traffic • Mainly VFR traffic • Mix of IFR and VFR traffic and vehicles |
| Traffic distribution | <ul style="list-style-type: none"> • Even distribution |
| Operational modes | <ul style="list-style-type: none"> • Normal operations • Degraded mode |
| Runway conditions | <ul style="list-style-type: none"> • Similar operating conditions • Different operating conditions |
| Runway directions | <ul style="list-style-type: none"> • Similar RWY directions • Diverging RWY directions |
| Wind conditions | <ul style="list-style-type: none"> • Similar wind conditions |
| Visibility conditions | <ul style="list-style-type: none"> • Similar VMC conditions • Similar IMC conditions • Different visibility conditions |
| Time of day | <ul style="list-style-type: none"> • Daytime at all aerodromes |

Transfer of aerodromes between MRTMs was chosen by the ATCO with the help of the ATCO planning tool when suitable. The scenarios was developed in order to force transfers to happen, as this was part of the focus of the validation.

B.1.3.1 Data Collection Methods

A combination of both qualitative and quantitative data collection techniques was used prior and post the validation exercise.

- Quantitative data was obtained from system data recorded during each run:
 - Number of flights in each run was counted.
 - Number of surface movements (vehicles) was logged.
 - Different weather types was logged.

- Daylight conditions was predefined and logged.
- Time on frequency was logged.
- Qualitative data was collected from the actors taking part in each run by different methods

The following techniques was used:

- **Over the shoulder observations.** During the sessions, the activities of actors was observed in order to collect insights about their performance, strategies they use to perform the task and difficulties experienced. In order to better understand the reasoning and the way that provided information is used, operators has been asked to “think-aloud” while performing their tasks.
- **Questionnaires (Post-run questionnaire and Post-week questionnaire).** Specific questionnaires was be developed to obtain a feedback from the actors involved in the study on the concept, their performance, the scenarios and exercises performed.
- **Debriefing.** Structured debriefings was performed at the end of each run with the actors that was involve in the specific run and after the validation was completed called final debrief. The difficulties on the exercises was discussed among all the participants (operational, validation and technical staffs) and they were asked to reason about their performed activity based on the information provided by the system.
- **Workshops.** Workshops was performed on project level to feed the R&D needs towards deployment.

| KPA | KPIs | Metric / Indicator | method / technique |
|-----|----------------------------|--|--|
| HP | Situation Awareness | Situational awareness of relevant human actors | Post-run/week questionnaire (China Lake) Over the shoulder observations Final Debriefing |
| | Workload | Cognitive Workload of relevant human actors | System logs Post-run/ week questionnaire (Bedford / Customised Questionnaire) Over the shoulder observations Final Debriefing |
| | Trust | User Trust in the System | Post-run questionnaire/ week (SATI) Over the shoulder observations Final Debriefing |

| KPA | KPIs | Metric / Indicator | method / technique |
|------------|----------------------------------|--|---|
| | Acceptability | User acceptance of relevant human actors | Post-run questionnaire (CARS) Over the shoulder observations Final Debriefing |
| | Human error | Execution errors (Slips, lapses) Planning errors (Mistakes) | Post-run questionnaire/ week Over the shoulder observations Final Debriefing |
| | Communication | ATCO Nr. and frequency occupancy and nr of call x a/c, x airports and x ground vehicles. | System logs Expert observations Final debriefing |
| | Teamwork | Cognitive Workload of relevant human actors | Over the shoulder observations Final questionnaire Final Debriefing |
| | Tools usability | User acceptance by relevant human actors | Over the shoulder observations Final questionnaire Final Debriefing |
| SAF | Alarms and Alerts | Number and type of alerts, involved flights | Post-week questionnaire Final Debriefing |
| | Perceived level of Safety | ATCO feedback | Post-run questionnaire Final Debriefing Over the shoulder observations |
| CEF | ATCO productivity | ATCO feedback | Post-run questionnaire (Workload) Final Debriefing |

B.1.3.2 Analysis methods

The analysis of the exercise data will be executed according to the following steps:

1. **Data collection.** Collection of all qualitative and quantitative raw data;
2. **Data analysis.** The qualitative and quantitative will be analysed statistically analysed separately;
3. **Data integration.** The integration of the statistical analysis of quantitative (data logs and performance metrics) with qualitative data (questionnaires answers, interviews and debriefing results) will be performed. The subjective data will be used to provide evidence that supports or contradicts the quantitative analysis. The comments provided by operative experts and exercise experts will be gathered to support the results.
4. **Final results and conclusions.** The results obtained will be used to answer if the exercise objectives have been met or not.

B.1.3.3 Aerodromes

The ATS Airspace information is presented in the table below. Those are used in the Real time simulation.

| | Airport A | Airport B | Airport C | Airport D |
|----------------------------|---------------|--|--|--|
| Airport name (AIP) | Kiruna (ESQN) | Visby (ESSV) | Linköping/Saab (ESSL) | Malmö/Sturup (ESMS) |
| RWY designators and length | 03/21 2502m | 03/21 2000m 10/28 1100m grass <i>Note: There will be no traffic distribution on RWY 10/28</i> | 11/29 2130m | 17/35 2800m 11/29 799m <i>Note: There will be no traffic distribution on RWY 11/29</i> |
| Number of taxiways | A and B links | M parallel A and C links, G from grass RWY Other are military related | I link to civil apron C link to Saab apron joining at THR RWY11 | A and B links with Y; C links apron N; D links apron S; H links apron HA; J links apron JA; E links to RWY 11/29 that is not of interest for the validation |

| | | | | |
|-----------------------------------|----------------------|----------------------|---------------------|----------------------|
| Airspace classification | C | C | C | C |
| Movements per year actual figures | 4.664 (2019 figures) | 16732 (2019 figures) | 9952 (2019 figures) | 37352 (2019 figures) |

B.1.3.3.1 Aerodromes charts

Image below presents the geographical location of the aerodromes used in the validation activities.



Founding Members

Kiruna (ESNQ) RWY 03/21 RWY length 2622m

Kiruna airport is the most northern IFR airport in Sweden. Runway directions are the same as in Visby.

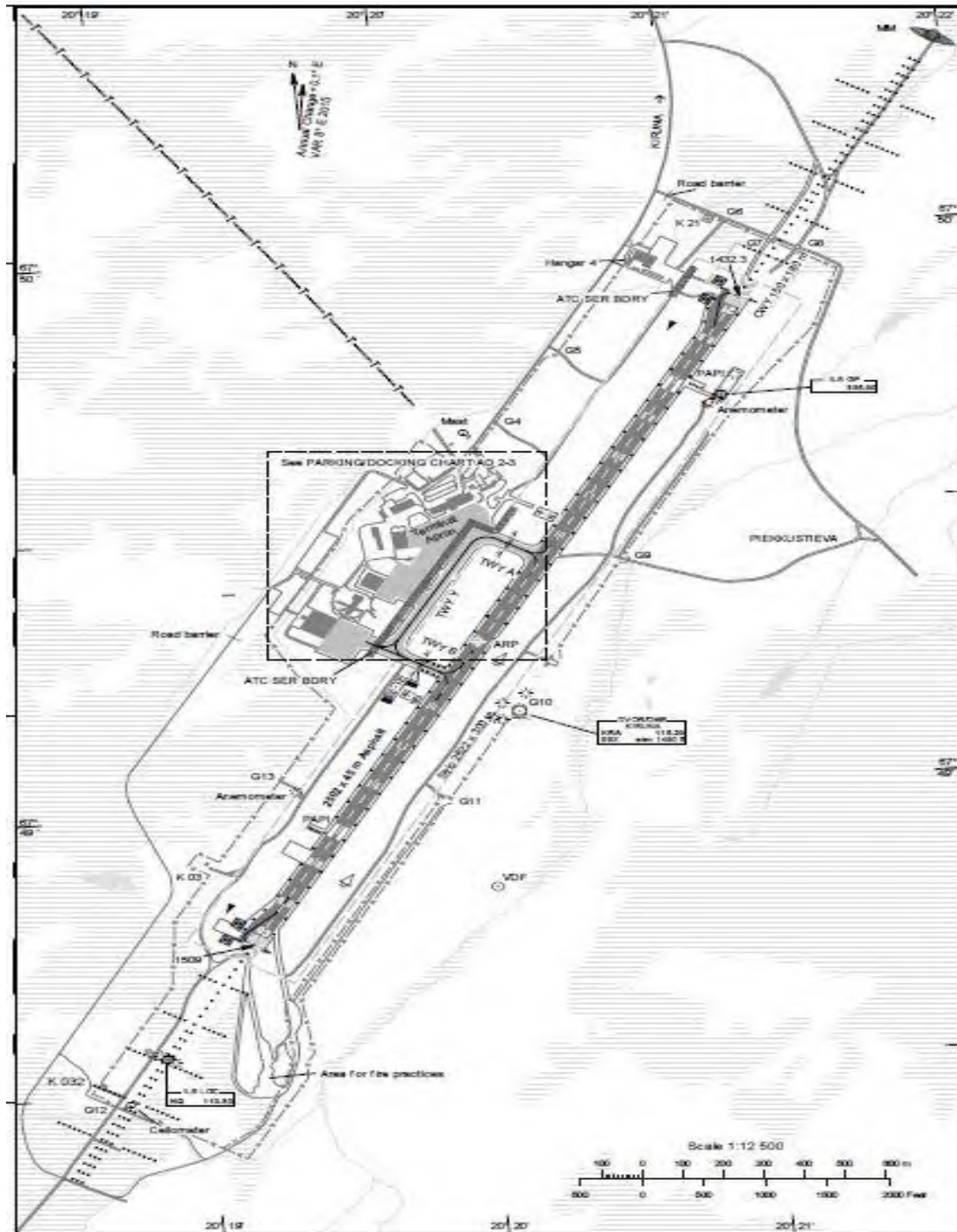


Figure 2: Aerodrome chart ESNQ – Kiruna

Visby (ESSV) RWY 03/21 length 2000m grass strip RWY 10/28 1100m

Visby airport is located on the island of Gotland in the Baltic Sea in the southeast part of Sweden. Runway directions are the same as in Kiruna. It also has a smaller grass strip for GA props.

Note: There will be no traffic simulated to RWY 10/28, hence there is no envisaged any impact to the validation results.

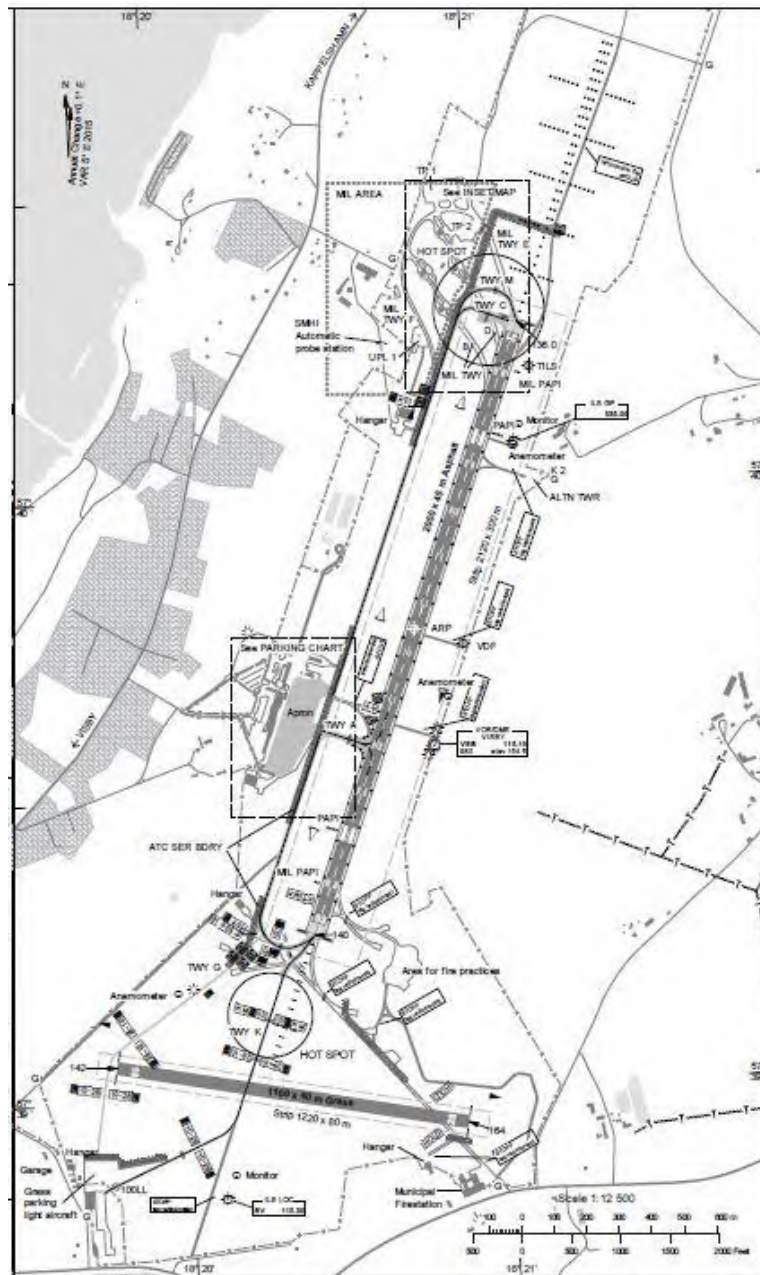


Figure 3: Aerodrome chart ESSV – Visby

Linköping/SAAB (ESSL) RWY 11/29 2135m

Linköping/SAAB airport is located in the southern part of Sweden with RWY directions perpendicular to Kiruna.

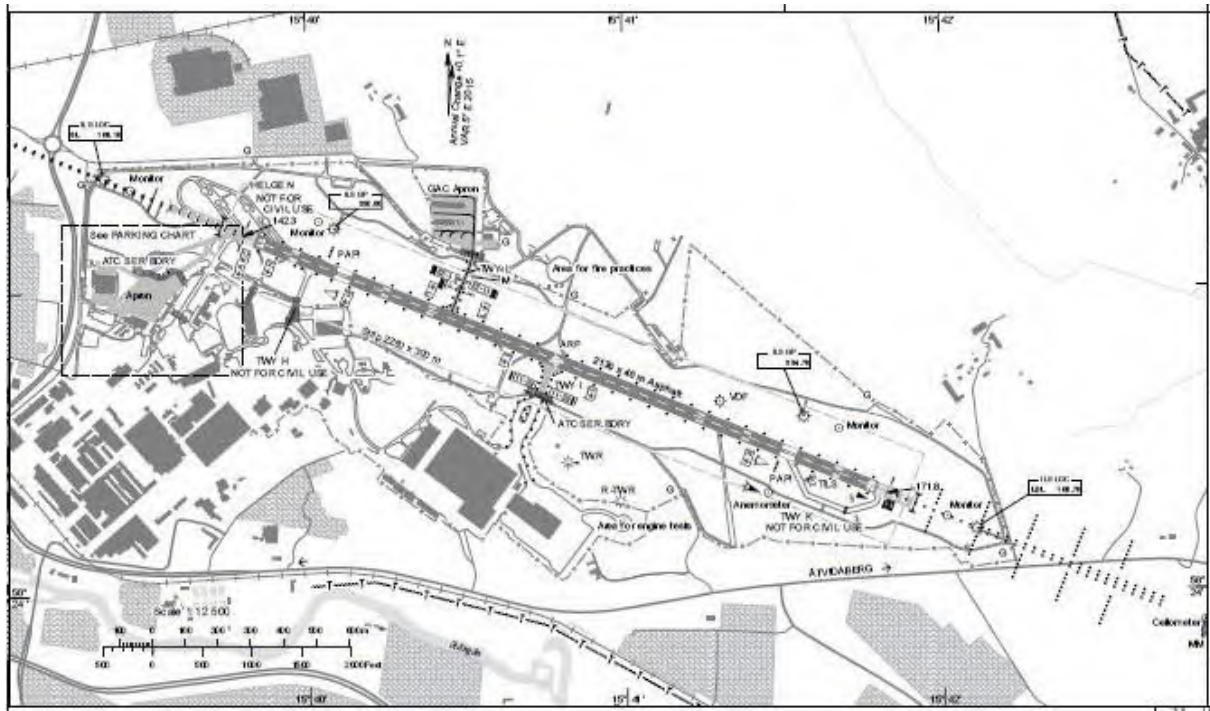


Figure 4: Aerodrome chart Linköping/SAAB, ESSL

Malmö (ESMS) RWY 17/35 2800m asphalt strip RWY 11/29 799m

Malmö airport is located in the most southern part of Sweden. This airport is characterized with the highest number of annual traffic movements in respect to other three airports that will be used in the validation.

Note: There will be no traffic simulated to RWY 11/29, hence there is no envisaged any impact to the validation results.

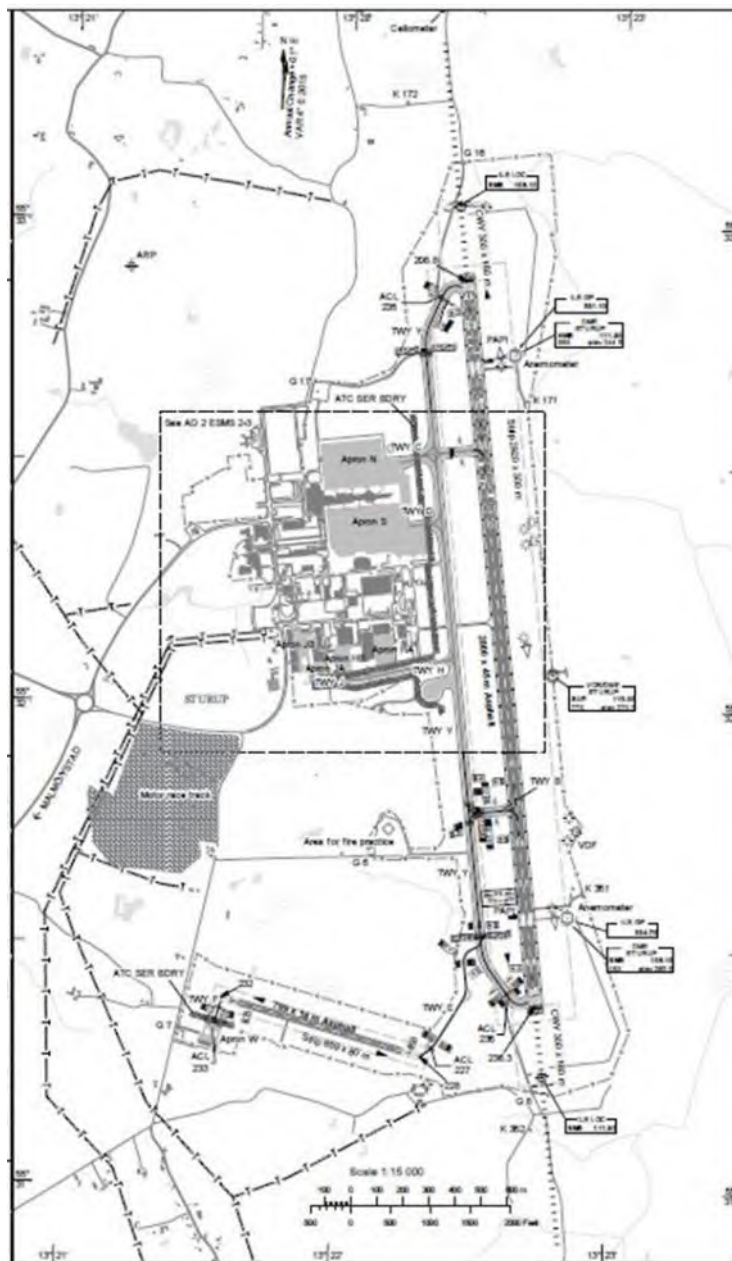


Figure 5: Aerodrome chart Malmö, ESMS

B.1.3.4 Validation Platform

The validation exercise was performed at two independent simulator modules (MRTM) with different screen set-up.



Figure: MRTM 1 – comprising of 7 (55”) screens, positioned in portrait mode



Figure: MRTM2 – comprising of 2 (82”) screens, positioned in landscape mode

The both MRTMs allowed allocation for up to three aerodromes at a time, and were connected together in order to allow ATCOs accomplishment of all necessary procedures and activities for preparation and execution of flexible allocation of the aerodromes between them.

Simulator platform was provided by SAAB (NATMIG), further developed from SESAR 1 and SESAR2020 wave 1 solutions: PJ05.02-V2 and PJ05.03-V2. The MRTMs consists from the following systems:

- VP – Visual Presentation of aerodromes. The system allowed ATCOs to choose in which mode of aerodrome presentation they prioritise to work: single, double and triple, regardless the number of presented aerodromes.
- Triple mode: when working in triple mode with three aerodromes at a time, two of the aerodromes were presented side by side at the down left/right part of the screens, while the third aerodrome was presented at the centre top of the screens. When working with two or

only one aerodrome, ATCOs were able to choose aerodrome positioning in accordance to their personal needs and preferences in triple mode, or to switch to double or single mode, depending on the number of the presented aerodrome(s).

- Double mode: when working in double mode there were possibility for ATCOs to allocate two or one aerodrome. Two aerodromes were presented side by side at the left and right part of the screens, while presentation of one aerodrome was in accordance to ATCOs preferences: on left or right part of the screens.
- Single mode: the aerodrome was presented through the entire screens.

The system allowed the presentation of 360 degree view of each aerodrome, and possibility to pan left of right and also to zoom.

- WACOM screen – presentation of aerodrome layout map, as well as presentation and handling of EFS.
- E-strip – Electronic flight strips. EFS implemented with control of aerodrome information.
- Radar – presenting radar image for all aerodromes
- VCS – Voice and Com was simulated.

Headset and sound speakers: the coupled air/ground frequencies for aircraft from all aerodromes controlled from one MRTM were transmitted in the same headset. Decoupled vehicle frequencies were transmitted through sound speakers, where each aerodrome had allocated its own speaker.

PTZ – Pan Tilt Zoom camera will be available replacing the binocular in a conventional tower.

The platform will consist of two MRTMs. Simulator operator position will conduct the role of Approach controller.

All aforementioned systems were synchronised with the aerodrome allocation in the VP, in order to positively contribute to ATCOs situational awareness.

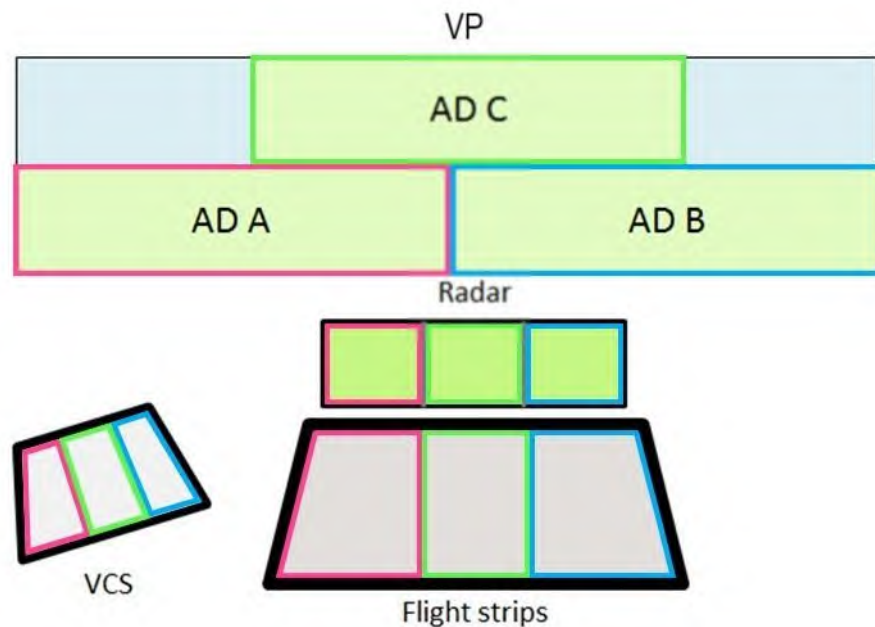


Figure: Aerodrome presentation of 3 aerodromes for EXE-05-W2-35-V3-002 COOPANS

B.1.4 Summary of Validation Exercise EXE-2.2-COOPANS

Validation Assumptions

The same assumptions applied as mentioned in chapter 3.2.3 (

Table 4).

| Identifier | Title | Description | Justification | Impact on Assessment |
|---------------------------|-------------|---|--|---|
| ASM-EXE-PJ05-W2-35-V3-2.2 | Endorsement | All ATCOs have endorsements for the cluster of aerodromes | There are no ATCO able to be part of the validation that has endorsement for all aerodromes. | Medium. ATCO does not know the aerodrome as good as if they would work with them on a daily basis, thereby impacting the way of working. |
| | | | | |

Table 10: Validation Assumptions overview

Founding Members

B.2 Deviation from the planned activities

The deviation from the planned activities are as follow:

- Validation exercise was done in one part and not divided into two parts. This in order to optimize the usage of time.
- No supervisor planning tool was tested and no supervisor was used during validation. Instead the ATCOs used ATCO planning tool and planned transfers themselves.
- Abnormal situations was not tested.
- Darkness at aerodromes was not tested.
- No aerodromes had the majority of the traffic.
- No aerodrome has strong head or crosswind.

All deviations mentioned above are due to lack of time caused by the covid-19 situation.

Due to no supervisor and no supervisor planning tool, the following CRT with focus on supervisor was not covered:

- CRT-PJ05-W2-35-V3-VALP-H01.010
- CRT-PJ05-W2-35-V3-VALP-H01.020
- CRT-PJ05-W2-35-V3-VALP-H01.030
- CRT-PJ05-W2-35-V3-VALP-H01.040
- CRT-PJ05-W2-35-V3-VALP-H05.010
- CRT-PJ05-W2-35-V3-VALP-H09.010
- CRT-PJ05-W2-35-V3-VALP-H10.010
- CRT-PJ05-W2-35-V3-VALP-H10.030
- CRT-PJ05-W2-35-V3-VALP-H12.010
- CRT-PJ05-W2-35-V3-VALP-H12.020
- CRT-PJ05-W2-35-V3-VALP-H12.030
- CRT-PJ05-W2-35-V3-VALP-H12.040
- CRT-PJ05-W2-35-V3-VALP-H12.050
- CRT-PJ05-W2-35-V3-VALP-H14.010
- CRT-PJ05-W2-35-V3-VALP-H15.010
- CRT-PJ05-W2-35-V3-VALP-H15.020
- CRT-PJ05-W2-35-V3-VALP-S08.010
- CRT-PJ05-W2-35-V3-VALP-S09.010
- CRT-PJ05-W2-35-V3-VALP-S10.010

Following CRT was not covered due to non-existing reference scenario:

- CRT-PJ05-W2-35-V3-VALP-H18.020

B.3 Validation Exercise EXE-2.2-COOPANS Results

B.3.1 ATCO - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|---|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>For majority of ATCOs situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs.</p> <p>Nevertheless, the SA could be decreased very quickly when controlling three aerodromes with this traffic volume, hence the source of information is slightly larger, the incoming calls from aircraft and vehicles are increased, traffic could become more complex, so that all these factors increase the time needed for scanning of all systems in order to keep SA updated.</p> | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | Majority of ATCOs assessed that they can prioritise task between “most of the time” and “always”. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|--------------------------------|--|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>The user interface design supports a sufficient level of situation awareness. All systems and system functionalities were well integrated which contributed to achieve this criterion.</p> <p>ATCOs possibility to self-decide where to allocate taken aerodrome in the MRTM VP was considering as very important feature for the SA. This is especially preferred during releasing one of the three aerodromes, which allows ATCOs, the remaining two aerodromes to be kept at the same position as prior the transfer occurred.</p> | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | <p>ATCOs maintained an adequate level of SA, despite having to divide their attention to maximum 3 aerodromes at a time with different procedures and characteristics.</p> <p>All inconsistencies that affect SA are more related to other factors than the differences on procedures and characteristics in itself.</p> | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|------------------------------|---|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | HMI support an acceptable level of team (ATCO and ATCO) situation awareness when working with a flexible allocation of aerodromes between MRTMs. | Partially OK |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Majority of ATCOs assess workload at tolerable level for the task. Nevertheless, the workload could rapidly increase from acceptable to non-acceptable and this cannot be ignored. Situations with high traffic volume, traffic complexity, complexity caused by the aerodrome being combined at same MRTM, transfer execution (initiation and completion) etc. is some of contributing factors workload to be increased. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The amount of communication and time on the frequency is not fully acceptable. The workload is negatively impacted by the amount of simultaneous calls. This increases | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|---|-----------------------------|
| | | | | the potential for misunderstandings caused by the overlapping calls. Communication with VFR traffic and vehicles was appointed as much more challenging than communication with the IFR traffic. Transfer and the whole communication related to transfer is also contributing to increased workload. | |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | Operating methods could be applied in an accurate, efficient and timely manner in normal operating conditions. During degraded mode, the operating methods required much more efforts to be accomplished. It depends from the ATCOs workload at the moment when degraded mode has occurred. N/A abnormal operating conditions for this validation exercise. | Partially OK |
| | Assess ATCO acceptance of roles and responsibilities when | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the | ATCOs roles and responsibilities introduced by the multiple remote tower concept when working with a flexible allocation of | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H07 | providing ATS to multiple aerodromes | | multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | aerodromes between the modules do not change, only the amount of areas in which the roles and responsibilities are executed multiply with each tower. | |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | ATCOs neither agree nor disagree that provision of ATS to three aerodromes at a time is feasible and acceptable. The main contributor to this result is the traffic volume and traffic complexity as well as the amount of communication when working simultaneous with three aerodromes at a time. | Partially OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | The phraseology was acceptable for the ATCOs in normal operating conditions and degraded mode. | Partially OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an | Technical System/HMI supported the ATCOs by being accurate, useful for task execution and well integrated . | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|--|-----------------------------|
| | supports the team in carrying out their tasks | | RTC with a flexible allocation of aerodromes between MRTMs. | However the need to change the layout on the WACOM screen for e-strips was raised. | |
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | | N/A |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs state the simulator (S-m) provided useful data in an understandable way and that they rarely needed to search for information . | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Majority of ATCOs confirm the usability of input devices and HMI controls. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | Partially covered as only alerts was used during validation. ATCOs confirmed the usability and utility of the alerts. However the ATCOs wanted to change the runway alert from red to some other colour. This based on that the alert only stated that a vehicle or aircraft was on | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---------------------------|--|--------------------------------|---|--|-----------------------------|
| | | | | the runway and not that there was a direct risk for a conflict. | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | ATCOs stated that the human machine interface could at sometimes increase the potential for human error. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | ATCOs state that the ATCO planning tool was useful, it is however in need of further development in order to be a reliable and trustful tool. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | Majority of ATCOs confirm that there was no confusion regarding where a certain aerodromes was going to be placed in the visual presentation (VP). | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | Majority of the ATCOs confirm they were never confused witch aerodromes that was going to be transferred. | OK |
| HUMAN PERFORMANCE – TRUST | | | | | |
| | Assess ATCO trust in support systems when | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|--|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H13 | providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | <p>Partially covered as only alerts was used during validation.</p> <p>The runway alert was initiated by the ATCO when placing vehicles on the runway in the WACOM screen or by placing e-strips in the runway bay. The reliability information wise was thereby never questioned. The alerts was also seen as reliable from a system perspective as the alerts was always displayed when supposed to. The ATCOs thereby trusted the reliability of the alerts.</p> | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | ATCOs confirmed trust in the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Knowledge, skills and experience requirements was identified both from ATCOs and also from observers. | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| | aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Training needs was identified by both ATCOs and observers. | Partially OK |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | The majority of the ATCOs confirm that they were able to identify and solve potential conflicts in a timely manner. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.020 | ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.): <ul style="list-style-type: none"> Unstable approaches Bird strikes Aircraft not vacating RWY as expected | The system allowed ATCOs to choose a preferred mode of aerodrome presentation. Working in triple mode, regardless the number of presented aerodromes, the picture was more compressed resulting in a reduced resolution compared to single or double mode. Nevertheless, ATCOs could mitigate the reduced resolution by (temporarily) zooming the VP. | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | The majority of the ATCOs confirm that they were able to distinguish with which aircraft/vehicle at which aerodrome the ATCO was communicating with. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | | N/A |
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | ATCOs were able to foresee traffic at their MRTM. However, in order to be completely able to avoid overloads, unplanned VFR and vehicle traffic need to be considered, and if possible, presented through the system tools e.g. EFS, RDP, ATCO planning tool. | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|--|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | <p>ATCO is able to identify and manage abnormal situations (e.g.):</p> <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | Abnormal situations were not tested. | N/A |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other airport systems / infrastructure | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure occurring at one of the aerodromes. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| | | | <ul style="list-style-type: none"> Visualisation system | | |
| CAPACITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | During the validation ATCOs stated that 6 simultaneous movements does not necessarily need to be the limit. It does however depend on what type of traffic situations the ATCO are working with. Other operational tasks that was not included in the validation is also needed to be considered. | Partially OK |
| COST EFFICIENCY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | Most of the ATCOs were able to provide simultaneous ATS to 3 aerodromes on an efficient manner. | OK |

Table 11: ATCO - Validation Results for Exercise 1

B.3.2 ATCO - Analysis of Exercise Results per Validation objective

Six ATCOs in total, with different operational experiences and background from five different ANSPs participated in this validation exercise, so that:

- One of the ATCOs has an operational experience in the single remote tower.
- Two of the ATCOs have participated during the previous COOPANS – multiple remote tower validation exercises under wave 1.
- One ATCO has also been participating to another validation exercise under the same solution.
- For the other two remained ATCOs, this was the very first experience with Multiple Remote Tower.

Their average age is 42 and they have, on average, 17.8 years of experience. They controlled multiple remote towers in four different scenarios, from two separated and independent MRTMs accommodated in the same RTC. There were twelve conducted runs in total. Each scenario was run three times in combination of two different ATCOs, to gather variety of analysis data. In order to accomplish safe ATS, ATCOs were supported by the system to transfer the aerodromes between the modules, and to flexibly allocate the aerodromes within their MRTM.

Prior validation each ATCO has been participating in a four days training period, where working with the simulation platform and their functionalities, the operational concept and working environment. According to the results from the End of the Training Questionnaire, one of the ATCOs felt uncertain but also felt able to work in a quite proper way, while the remaining five ATCOs confirmed that they felt confident with:

- The working environment.
- Aerodromes layouts.
- Accomplishment of the procedures with/through associated system.
- Phraseology.
- Provision of reliable feedback regarding ATS system and its functionalities

The main validation exercise comprised of four different scenarios. Each ATCO had a possibility to provide ATS under each scenario, so that twelve runs in total were performed. All participants filled in a questionnaire after each run (End of the Run Questionnaire) and a more comprehensive questionnaire after finishing the complete validation exercise with all scenarios (End of the Week Questionnaire). They were part of the debrief sessions after each scenario/run and the final debrief session after completing all four different scenarios.

The reader is advised to be aware that, in particular the open ended, questions in questionnaires were often answered in a different way by each ATCO. Thereby resulting in a number of different opinions for one topic. In order to draw conclusions researchers have attempted to leave individual opinions, which were not shared amongst at least half of the group of participating ATCOs out of the general conclusions.

B.3.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

B.3.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

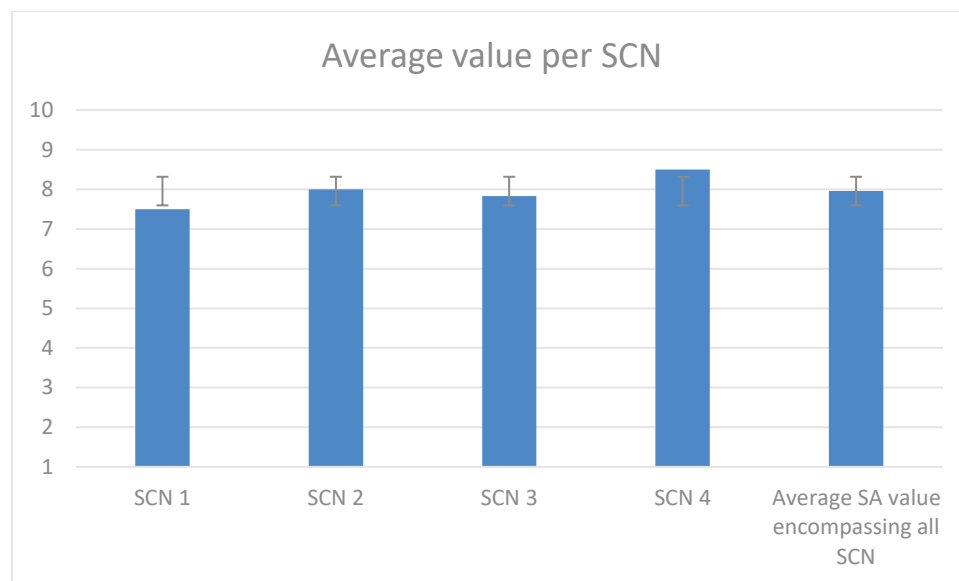
OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>For majority of ATCOs situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs.</p> <p>Nevertheless, the SA could be decreased very quickly when controlling three aerodromes with this traffic volume, hence the source of information is slightly larger, the incoming calls from aircraft and vehicles are increased, traffic could become more complex, so that all these factors increase the time needed for scanning of all systems in order to keep SA updated.</p> | OK |

The China Lakes situation awareness rating scale indicates the perceived level of situational awareness (SA). The scale encompasses a hierarchical decision tree that guides ATCOs through a ten-point rating scale where each point is accompanied by a descriptor of the associated level of SA. Value 1 indicates the lowest level while value 10 indicates the highest possible level of situational awareness.

The graph under presents the average results (including corresponding standard deviation) obtained for each scenario respectively, and the average value of SA derived from the average values of all four scenarios.



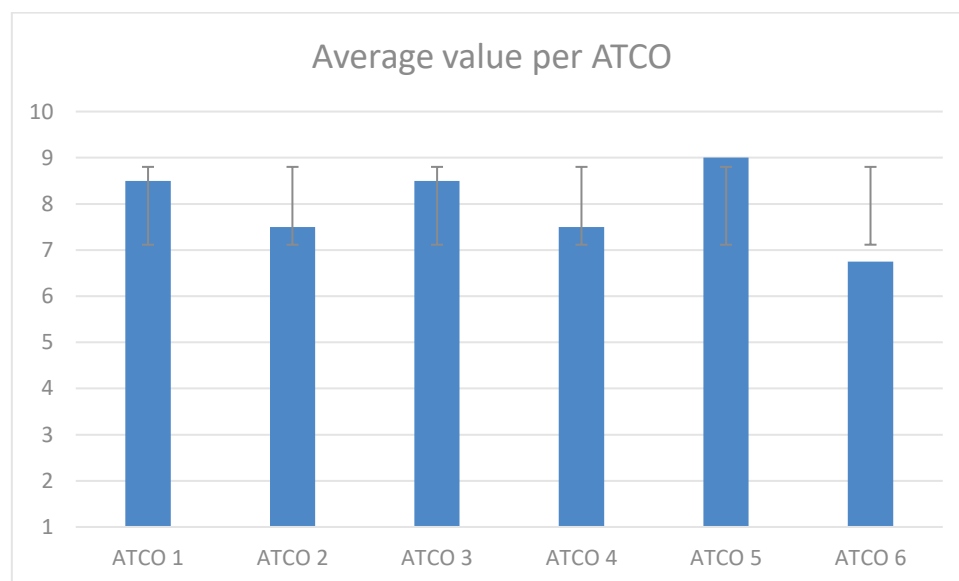
Average level of SA per scenario

In general, the average level of situation awareness was acceptable for all four scenarios. The average SA rating was below a satisfactory but in acceptable level for the first (7.5) and third (7.83) scenario, indicating that the SA of the ATCOs was not complete but they were able to complete the task.

For the second (8.0) and fourth scenario (8.5), the SA was satisfactory, indicating that ATCOs were able to perform the task well most of the time.

The average value for the level of SA encompassing all scenarios has a value 7.96, reflecting SA on the level between acceptable and satisfactory.

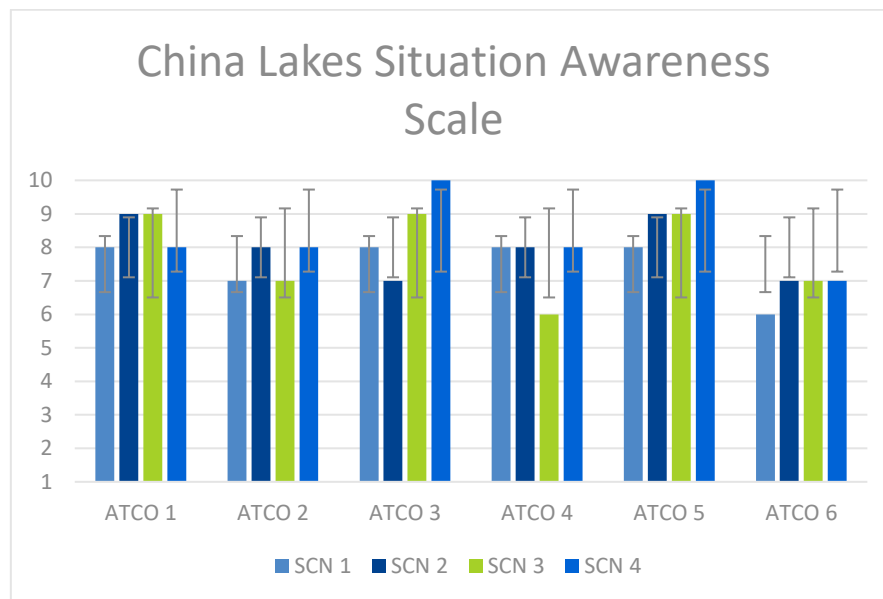
The next graph presents the obtained average results (including corresponding standard deviation) for each participant.



Average level of SA per participant

According to results for the SA average level with respect to the task per participant, the lowest average level of SA has a value 6.75 while the highest average value is 9. This indicates that the average experienced level of the SA between the participants vary between acceptable and satisfactory.

If we look closer at the next graph, which represents the SA per participant for each scenario, two of the ATCOs have experienced the SA with value 6 for only one run but different scenario each, indicating that they were not aware of all the information required to perform the task effectively. From the other side two of the ATCOs have rated their SA with value 10 for the same scenario both, indicating on excellent SA meaning that they were able to perform the task extremely well all of the time. Three of the ATCOs have rated the SA with value 9 indicating very good SA with ability to perform the task well all of the time.



Average level of SA per scenario for each participant respectively

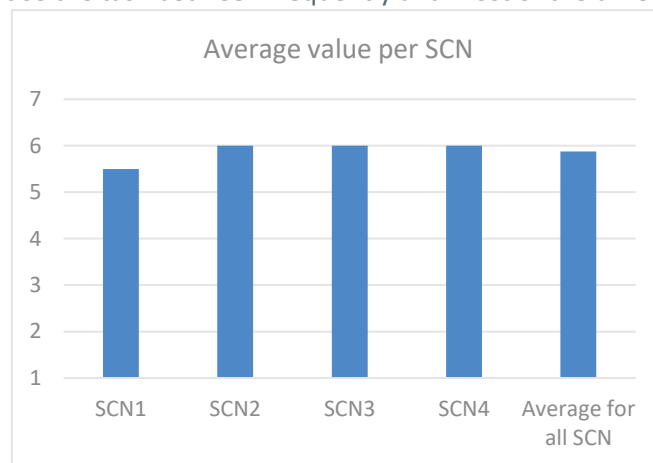
Nevertheless, the SA can be decreased very quickly during simultaneous control of three aerodromes at a time as consequence of increased workload. When controlling three aerodromes with this traffic volume, the source of information is slightly larger, the incoming calls from aircraft and vehicles are increased, traffic could become more complex, so that all these factors increase the time needed for scanning of all systems in order to keep SA updated.

Transfer as functionality was quite easy, but very dependent from the workload. According to ATCOs transfer is a must-have functionality for provision of ATS to multiple aerodromes. Under transfer, ATCOs were never confused about which aerodrome they have to take/release from/to another MRTM, they knew exactly with which aircraft they were communicating but sometimes there was a risk to miss some calls due to calls overlapping.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | Majority of ATCOs assessed that they can prioritise task between most of the time and always. | OK |

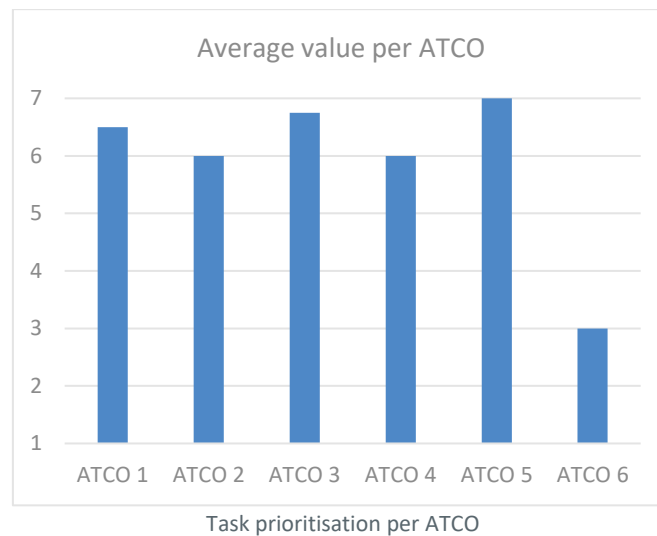
For measuring of task prioritisation a metric scale of 1 to 7 have been used, where 1 indicates that ATCOs never could prioritise the task, while 7 indicates on possibility to always prioritise the task. After each run, ATCOs were asked if they were able to prioritise tasks, and the gained results are following:

- Average value for the ability of task prioritisation per scenario:
For scenario 1 the calculated average value was 5.5, while for the rest three scenarios the calculated average value was 6. Total average value for all scenarios is 5.9, indicating that ATCOs could prioritise the task between frequently and most of the time.



Task prioritisation per scenario

- Average value for the ability of task prioritisation per ATCO:
The calculated value between the ATCOs vary between 3 and 7. Five of six ATCOs indicated that they were able to prioritise tasks most of the time, while one indicated that they could prioritise tasks only sometimes. The average calculated value for task prioritisation for ATCOs is 5.9.



Taking into consideration all 24 runs and the feedback from all ATCOs, 42% of ATCOs always could prioritise the tasks, 38% most of the time, 4% frequently and 17% sometimes.



Some of the causes why the tasks could not be prioritising are the number of simultaneous movements and traffic complexity on all of the aerodromes being controlled by one ATCO. This requires well thinking and planning in advance, otherwise it could happen very easily to miss some important details e.g. when an aircraft calls on the frequency at the same time when the transfer was ongoing. In such situation ATCOs try to solve the traffic situation rather than prioritising the tasks.

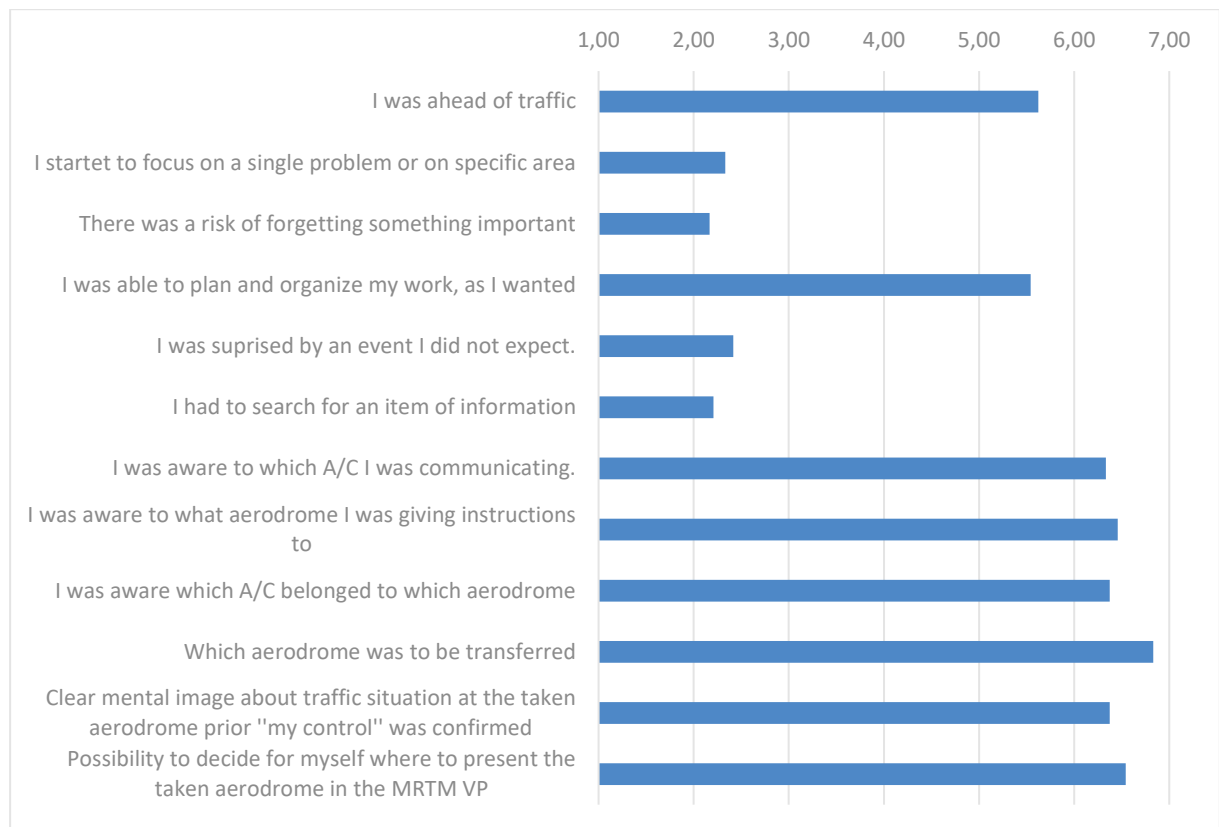
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>The user interface design supports a sufficient level of situation awareness. All systems and system functionalities were well integrated which contributed to achieve this criterion.</p> <p>ATCOs possibility to self-decide where to allocate taken aerodrome in the MRTM VP was considered as very important feature for the SA. This is especially preferred during releasing one of the three aerodromes, which allows ATCOs, the remained two aerodromes to be kept at the same position as prior the transfer occurred.</p> | OK |

Different situational awareness aspects were considered through the end of run questionnaires, to gather a knowledge about how user interface design supported ATCOs related to:

- Provision of ATS to three different aerodromes at a time, and
- Transfer conduction (initiation and completion), regardless the number of served aerodrome(s) at that moment.

The ATCOs were asked to consider how frequently they experienced these aspects on a scale from 1 (never) to 7 (always). Encompassing all 24 runs, the average ATCOs indications are following:

- They were frequently (5.63) ahead of traffic.
- Rarely (2.33) focussed on a one single problem or on a specific area.
- Rarely (2.17) experienced a risk of forgetting something important.
- Frequently (5.54) were able to plan and organise work as they wanted
- They were rarely (2.42) surprised by unexpected event.
- Rarely (2.21) had to search for information.
- They were aware of which aircraft (6.33) or aerodrome (6.46) they were communicating with most of the time and to which aerodrome each aircraft belonged (6.38).
- They were fully aware most of the time (6.83) about which aerodrome was to be transferred. In addition to this, none of the ATCOs stated that they have experienced an issue where they were not aware about which aerodrome has to be transferred.
- They had most of the time (6.38) a clear mental image about the traffic situation at the taken aerodrome prior they confirmed “my control”, which corresponded with the real traffic situation afterwards.
- The possibility to self-decide where to present the taken aerodrome in the MRTM VP (Visual Presentation) positively affected SA most of the time (6.54). The general conclusion on this was that this functionality is very important to have, especially when working with three aerodromes at a time.



Considered SA under different aspects

Some of the factors that contributed to a lower situational awareness taking into consideration the mentioned aspects are:

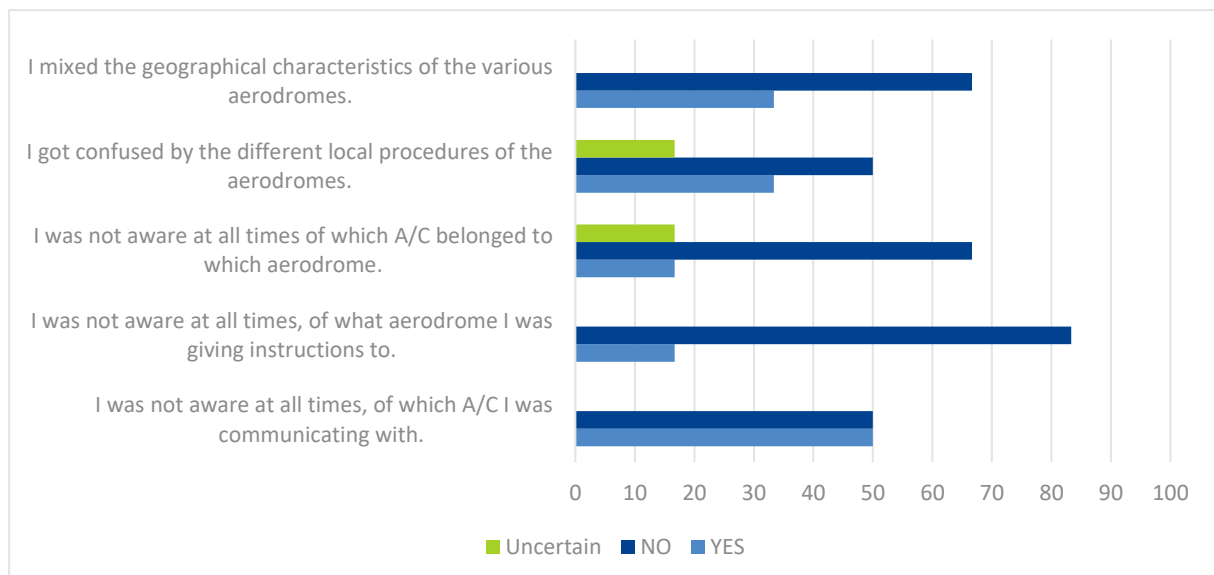
- The amount of simultaneous movements, both air and ground (A/C, vehicles), together in combination with the calls from them.
- Similarities between the call signs at the different aerodromes.
- Unscheduled VFR flights.
- Overlapping between the calls VHF/UHF when working with three aerodromes, and even more overlapping when the transfer was ongoing.

| Difficulty to decide if there is VMC or SVMC due to image quality. Criterion ID | Success Criterion | Validation Result | Status |
|--|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics | ATCOs maintained an adequate level of SA, despite having to divide their attention to maximum 3 aerodromes | OK |

| Difficulty to decide if there is VMC or SVMC due to image quality. Criterion ID | Success Criterion | Validation Result | Status |
|--|--|--|--------|
| | (geographical area, urban infrastructure, weather conditions etc.) | at a time with different procedures and characteristics. All inconsistencies that affect SA are more related to other factors than the differences on procedures and characteristics on itself. | |

In the scenarios, ATCOs controlled four different aerodromes on very different geographical locations (all within Sweden). Aerodromes used for the validation had coastal, inland and mountain characteristics. Combining three different aerodromes at a time, with similar or different characteristics required different operational procedures to be applied by the ATCOs at the same time. In this meaning the scenario design ensured that different procedures and characteristics were offered to the ATCOs

Through the end of the week questionnaire, all ATCOs were asked if they experienced any issue where they were not aware at all times when some of the following events occurred at least once during the test:



The obtained results are following:

- 4 ATCOs (67%) did not mix the geographical characteristics of the various aerodromes.

- 2 ATCOs (33%) got confused by the different local procedures of the aerodromes.
- 4 ATCOs (67%) did not experienced an issue where they were not aware at all times of which a/c belonged to which aerodrome.
- 5 ATCOs (83%) did not experienced an issue where they were not aware at all times, of what aerodrome they were giving instructions to.
- 3 ATCOs (50%) did not experienced an issue where they were not aware at all times, of which A/C they were communicating with.

The reduction of SA was affected by the differences between the ATCOs background (domestic and foreign), traffic volume and traffic complexity, etc. rather than the differences in the local procedures and aerodrome characteristics. This can be mitigated by additional training period, finding ATCOs own best practice how to allocate the aerodromes in the MRTM VP, reduction of traffic levels etc.

It was also noticed that distinction between VMC and SVMC was difficult to ensure due to a simulator image quality.

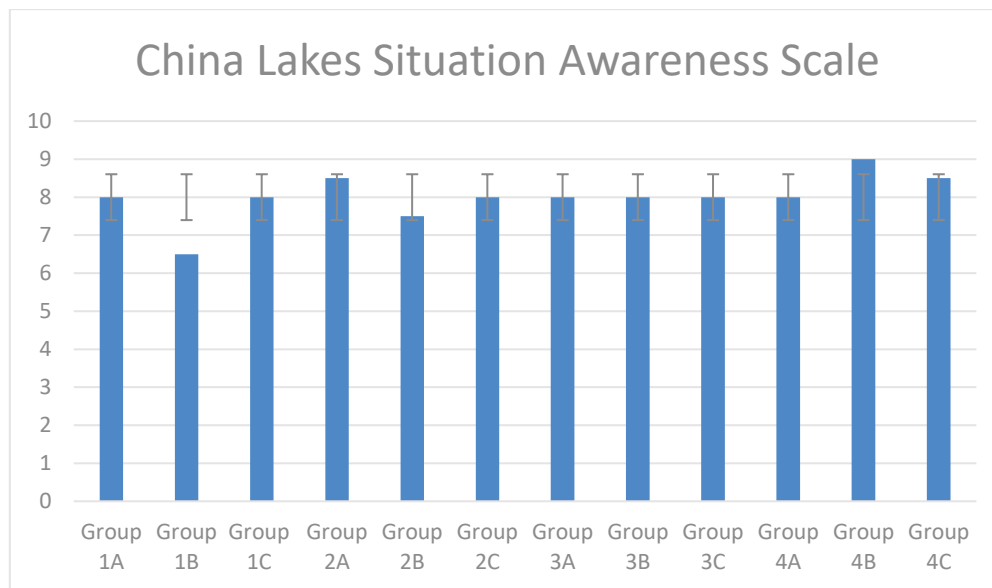
Nevertheless, the overall results related to the SA is still maintained at good level.

B.3.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|--|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | HMI support an acceptable level of team (ATCO and ATCO) situation awareness when working with a flexible allocation of aerodromes between MRTMs. | Partially OK |

Since SUP position was not a part of this validation exercise, the criteria is only partly covered. The obtained results reflects the achieved situational awareness per team, considering two different ATCOs working as a team at different and independent MRTMs.

There were twelve teams in total, consisting of two ATCOs each. The graph under describes the obtained average results (including corresponding standard deviation) for each run and each team respectively.



Average SA level per scenario taking into consideration the results from each team vary between 7.5 and 9. The lowest average value of 7.5 is for the first scenario but still indicating on acceptable SA. The highest average value of 8.5 (fourth scenario) corresponds to satisfactory level of situation awareness, indicating that ATCOs were able to perform the task well most of the time.

The lowest average value is 6.5 for the group 1B and for the first scenario, while the highest average level of 9 is for the group 4B for the fourth scenario.

Note: Please be aware that there were different combinations of all ATCOs dividing in different groups, hence group with Id 1A,1B,1C do not consists of same ATCOs in the other groups e.g. 2A, 2B, 2C etc.

The HMI has a big impact on the gained results. All tools were synchronised to follow the allocation of the aerodromes in the respective MRTM VP, colour coded (only exception VCS system) etc. in order to minimize ATCOs possible distractions and time for accomplishing the tasks as much as possibly aware. Some improvements ,was appointing out by participants, that can be taken into consideration in the future.

B.3.2.2 HUMAN PERFORMANCE – WORKLOAD

B.3.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

OBJ-PJ05-W2-35-V3-VALP-H04

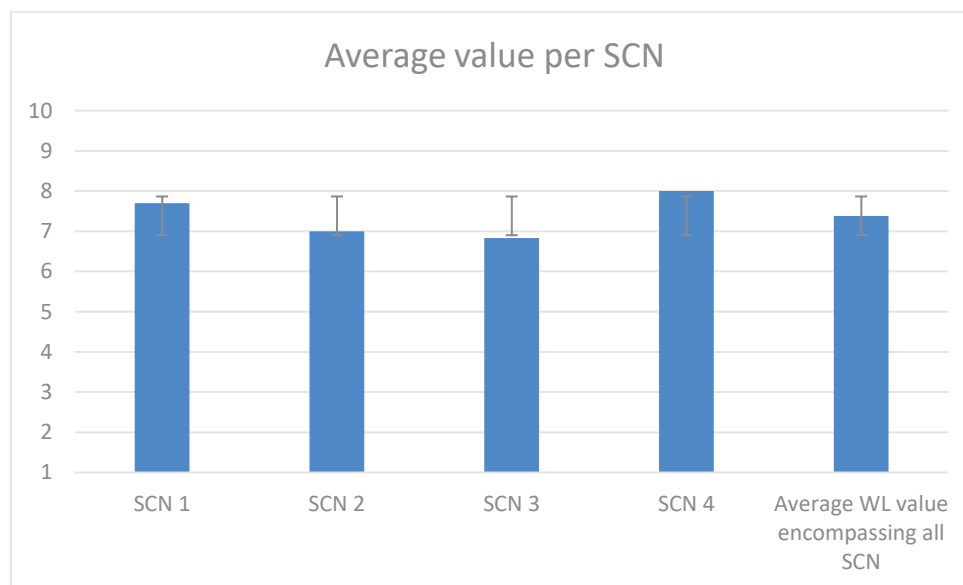
Assess ATCO workload when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a | Majority of ATCOs assess workload at tolerable level for the task. Nevertheless, the workload could rapidly increase from acceptable to | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---|---|--------|
| | flexible allocation of aerodromes between MRTMs | non-acceptable and this cannot be ignored. Situations with high traffic volume, traffic complexity, complexity caused by the aerodrome being combined at same MRTM, transfer execution (initiation and completion) etc. is some of contributing factors workload to be increased. | |

The Bedford Scale was used to identify the ATCOs spare mental capacity while completing a task. The scale encompasses a hierarchical decision tree that guides the ATCO through a ten-point rating scale where each point is accompanied by a descriptor of the associated level of workload.

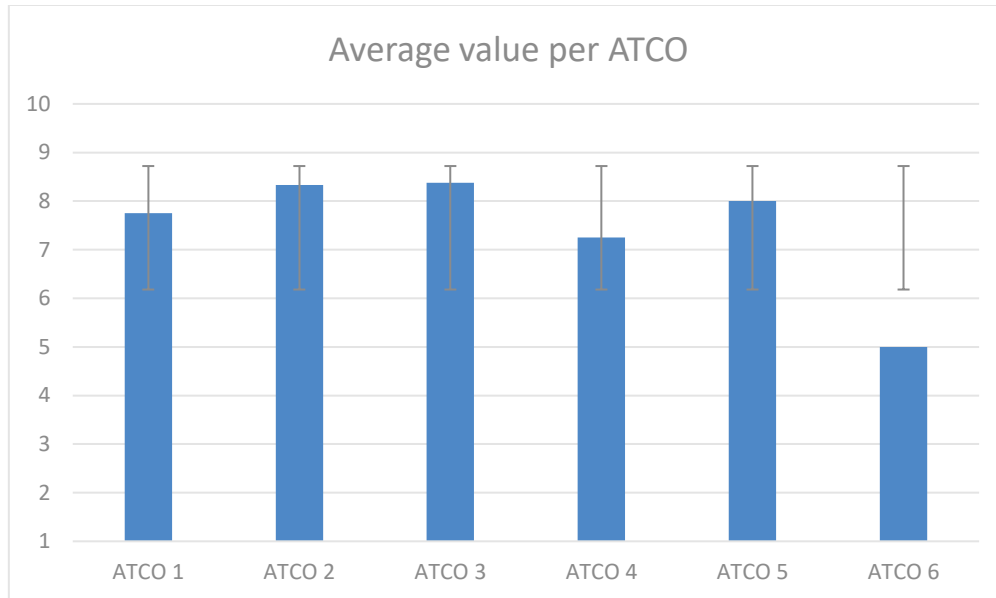
The graph under represents the average value of workload obtained throughout the four scenarios, and also the average value of workload derived from the average value of all four scenarios, with the corresponding standard deviation.



Average level of workload per scenario

The results shows that the acceptability of the workload vary between tolerable for the task for three scenarios and satisfactory for one scenario. The highest average level of workload was during the third scenario (6.83) (as expected, since a degraded mode of operation was applied) indicating on reduced spare capacity, where additional or other tasks could not be given desired amount of attention. The lowest average workload level was experienced for the fourth scenario (8.0) indicating satisfactory level of workload, where ATCOs had enough spare capacity for all desirable additional tasks. On average, the workload derived from the average value for all scenarios has a value 7.38, indicating tolerable workload for the task, but insufficient spare capacity for easy attention to additional task.

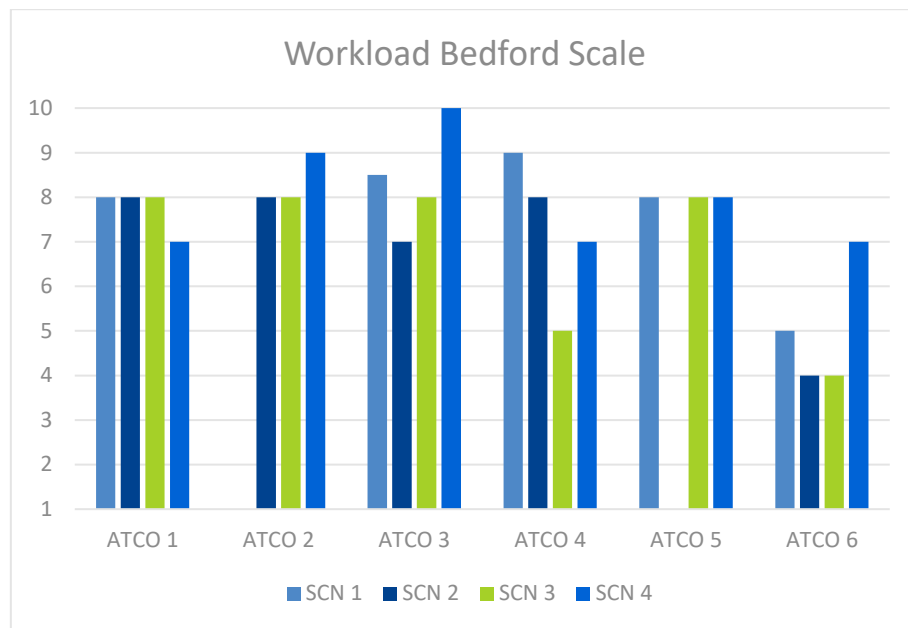
The next graph presents the obtained average level of workload (including corresponding standard deviation) for each participant.



Average level of workload per participant

According to results the average level of workload per participant. Three ATCOs reflected a satisfactory workload (8-10), while the remained three ATCOs reflected the tolerable workload (5-7) for the task. The lowest average level of workload has a value 5.0 indicating a workload with little spare capacity and level of efforts allows little attention to additional or other tasks. The highest average value is 8.38.

The next graph represents the workload per participant for each scenario. One ATCO has experienced the workload with value 4.0 for two different runs, indicating that they had a high workload with very little spare capacity, but without impact to the primary ATM task. Two ATCOs evaluated the workload with value 5, different scenario each. One of the ATCOs has evaluated the workload as insignificant (10.0) for one of the scenarios.



Average level of workload per scenario for each participant

ATCOs were asked about the level of their workload affected by simultaneous serving of three aerodromes and transfer of the aerodromes with flexible allocation between the MRTMs. On average, they neither agree nor disagree that:

- Serving three aerodromes simultaneously did not negatively affect their workload (3.0).
- During previous run, their workload remained an acceptable level (3.79).
- The impact on my workload from the transfer was not significantly increased (3.54).

They agree that possibility to flexibly allocate the aerodromes has a positive effect on their workload (4.67).



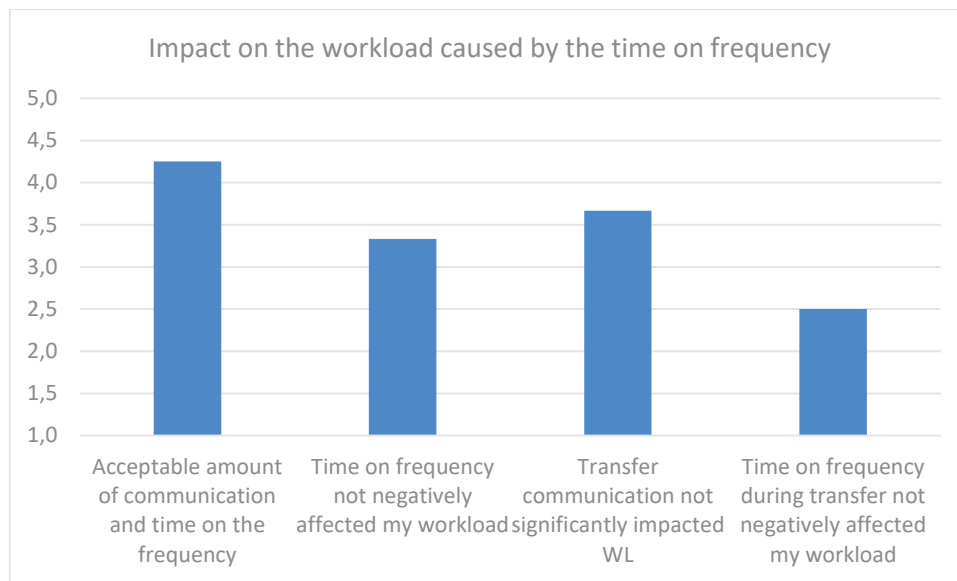
After all, the conclusion is that workload could vary between very low to non-acceptable with low spare capacities for completing other tasks. Contribution to this has a traffic volume and traffic complexity, especially vehicles and VFR flights, which take a lot of capacity. Since the vehicles and VFR flights were not presented in ATCO planning tool, they could not be planned in advance so that contributed to increased workload. Simultaneous movements at all three aerodromes with possible conflicts between them, and some kind of degraded mode can rise the workload instantly above acceptable level.

During the transfer, the workload was not immensely increased, but every time a transfer is done, it takes a non-negligible amount of capacity. The whole transfer procedure was assessed as quite easy and simple, but still ATCOs require a mental preparation in order to feel confident and secure with the new aerodrome, regardless if there is traffic or not at that aerodrome.

The same factors effects transfer when releasing some of the aerodromes to another MRTM. Namely high traffic volume imposed high level of workload. At such situations, required spare capacity for releasing the aerodrome cannot be prioritised due to the importance for the ATCOs to stay focused on the traffic situation in order to maintain safety.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | <p>The amount of communication and time on the frequency is not fully acceptable.</p> <p>The workload is negatively impacted by the amount of simultaneous calls. This increase the potential for misunderstandings caused by the overlapping calls. Communication with VFR traffic and vehicles was appointed as much more challenging than communication with the IFR traffic. Transfer and the whole communication related to transfer is also contributing to increased workload.</p> | Partially OK |

According to analysed data, ATCOs agreed that the amount of communication and time on the frequency during provision of simultaneous ATS was acceptable (4.25), while disagreed that the time spent on the frequency during the transfer did not negatively affect their workload (2.5). They neither agree nor disagree with the statement that time spent on the frequency (both UHF/VHF) did not negatively affected their workload (3.33) and the statement that the whole communication dedicated to transfer of the aerodromes had not caused a significant impact on their workload (3.67).



Despite presented results, ATCOs appointed that this traffic volume require increased level of simultaneous communication (vehicles/aircraft at same or different aerodrome). It is very easy for the ATCOs concentration level to drop after a certain period of time, which directly increases the workload. For the ATCOs I was much easier to handle a higher number of IFR movements because the communication with those were planned and followed a pattern. VFR flights and vehicles at different aerodromes, increase the workload much more, since this traffic require much more concentration and focus for communication and giving instructions to. In situations when the ATCOs had to hear e.g. three different calls at the same time with a different prioritisation, the risk to miss something important felt always present.

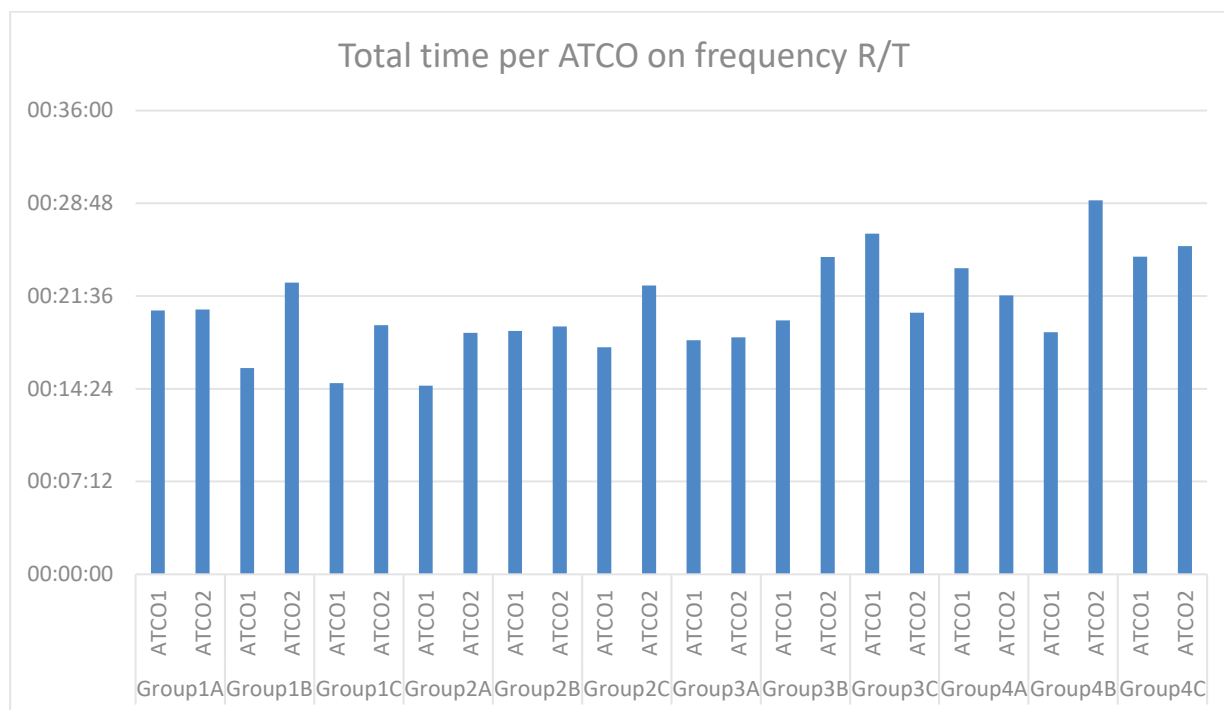
Coordination between ATCOs during transfer was done through the VCS. The incoming calls from all aircraft belonging to all aerodromes connected to same MRTM, and communication for coordination between the different MRTMs was established at the same headset. According to ATCOs, it was challenging to monitor all channels VHF/UFH and perform a transfer at the same time. The potential for overlapping calls can lead to that the whole transfer situation can be misunderstood. Depending on how the ATCOs priorities a transfer can last for a long time which may increase the workload.

In the following some log data (from the system) is presented:

- The shortest run was for SCN3/group3A and lasted 00:58:43.
- The longest run was for SCN1/Group1A and lasted 01:19:32.
- Average time per ATCO on frequency R/T was 00:20:41 (min. 00:14:38; max. 00:29:32) or 28,97% of the time.
- Average time on frequency per ATCO group during transfer was 00:12:30 (min. 00:09:18 – including 4 transfer during the run; max. 00:19:33 – including 6 transfers during the whole run).

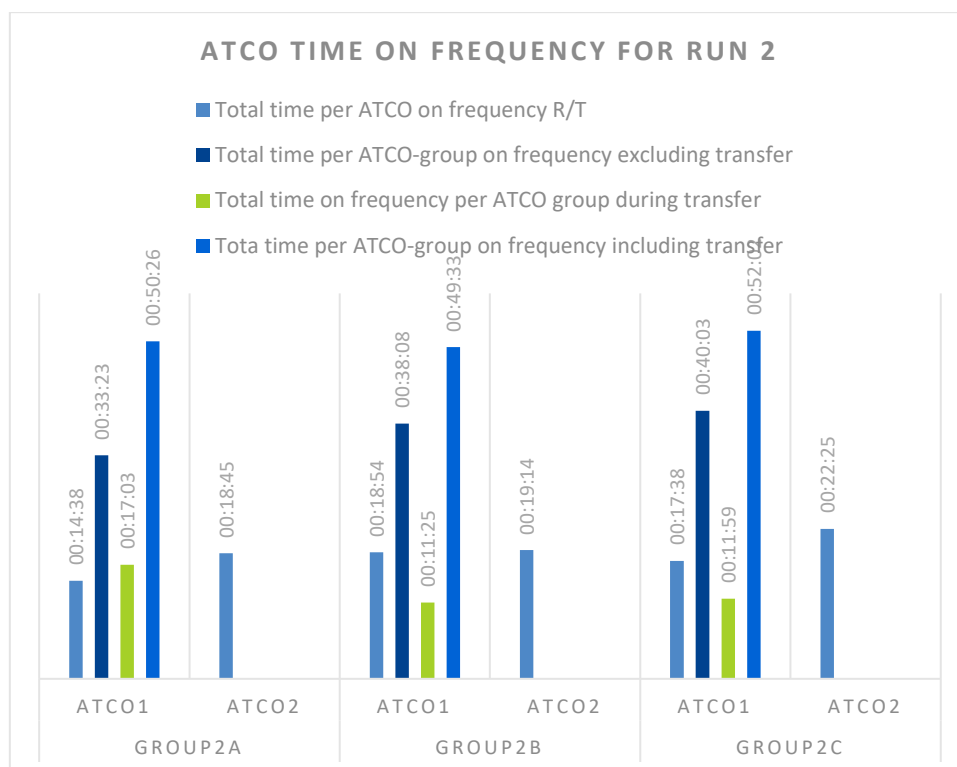
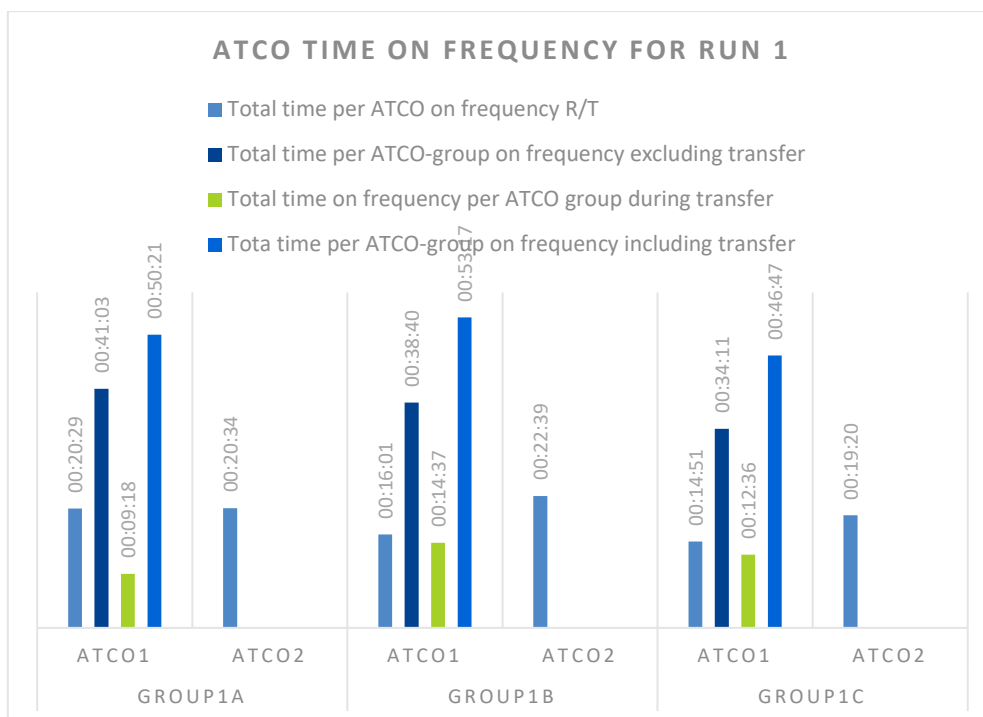
- Average time per ATCO-group on frequency including transfer was 00:53:53 (min. 00:46:47 – including 3 transfers during the whole run; max. 01:04:58 including 6 transfers during the whole run) or 75.46% of the time.

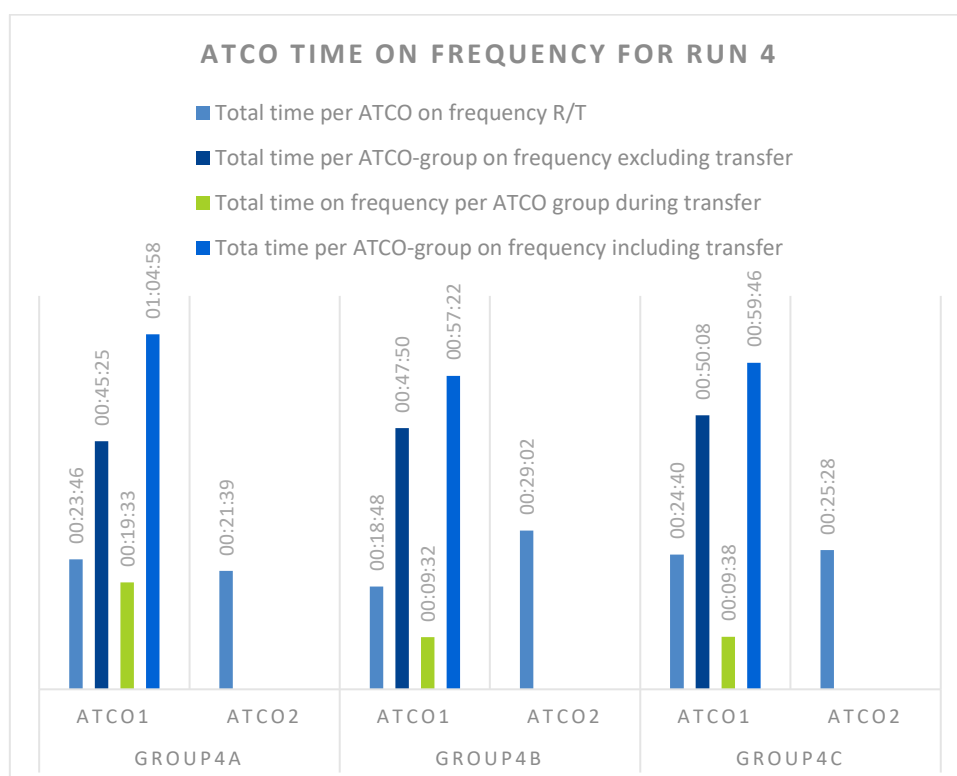
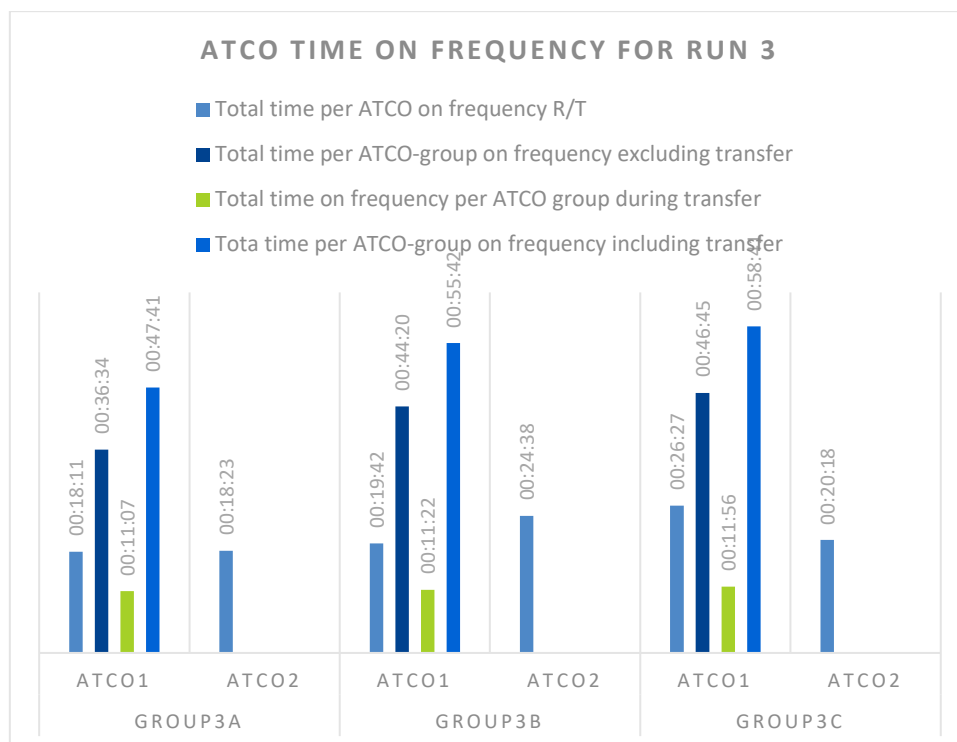
The following graph presents total time on frequency per ATCO excluding the time on frequency during transfer, for each run respectively:



Total time on frequency per ATCO/ATCO group for each run respectively

In the graphs under are presented more detailed ATCO/ATCOs group time on frequency for each run respectively:





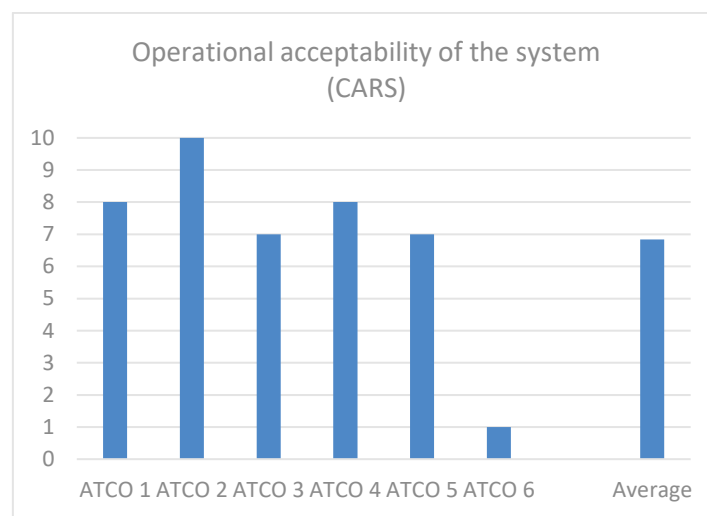
B.3.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

B.3.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

The Controller Acceptance Rating Scale (CARS) was used to measure operational acceptability of the system. The scale encompasses a hierarchical decision tree that guides the ATCO through a ten-point rating scale where each point is accompanied by a descriptor of the associated level of acceptability (rate 1 – improvement mandatory, rate 10 – deficiencies rare). Presented graph under, shows the results of the CARS, given by each participant.



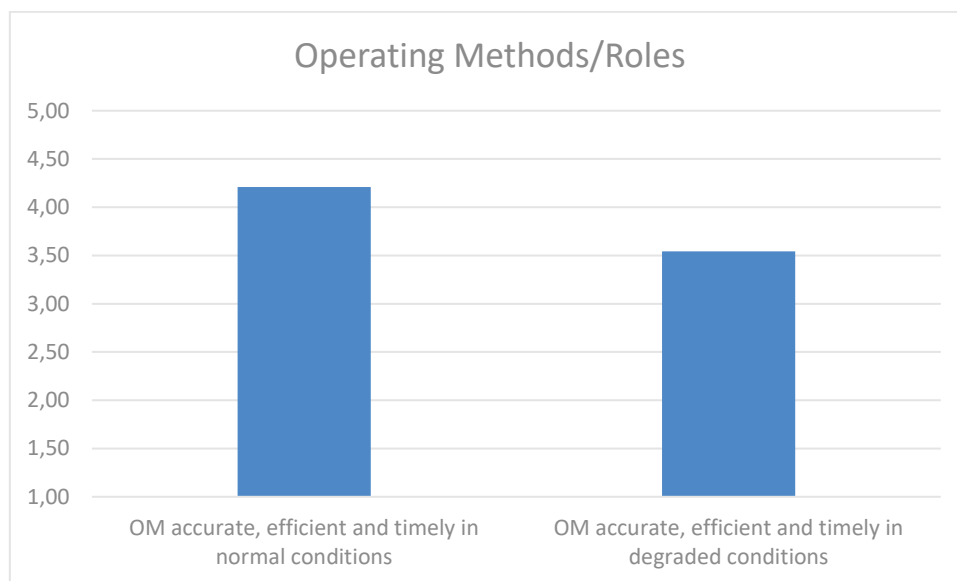
Operational acceptability of the system (CARS)

The ratings vary between 1 and 10. The lowest rate was given by one ATCO who elaborate that the peaks in the traffic during the validation contributed to lower level of SA and higher level of workload, which directly can affect the safety. Taking into consideration this issue, e.g. through the regulation, they will rate something between 5 and 7, which corresponded to the average value of 6.83.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Operating methods could be applied in accurate, efficient and timely manner in normal operating conditions.</p> <p>During degraded mode, the operating methods required much more effort to be accomplished.</p> <p>N/A abnormal operating conditions for this validation exercise.</p> | Partially OK |

This criteria was partly covered by the validation exercise, since no abnormal situation was tested. Degraded mode of operation was tested under scenario 3, where one of the ATCOs experienced a failure on radar display for one or more than one aerodrome.

The ATCOs agreed that they could apply the operating methods in accurate, efficient and timely manner in normal operating conditions (4.21), while they neither agreed nor disagreed (3.54) that the operating methods were applicable in accurate, efficient and timely manner under degraded mode. The results are presented in the graph under.



Namely, it is important if degraded mode happen under low or high workload. It took some time and effort for the ATCOs to find a good way to cope with the issue, so that forced transfer was initiated, which initially increased workload. Some of the aids that could help under these conditions are help from the RTC supervisor or well-designed error-checklist that could be followed.

B.3.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

OBJ-PJ05-W2-35-V3-VALP-H07

Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

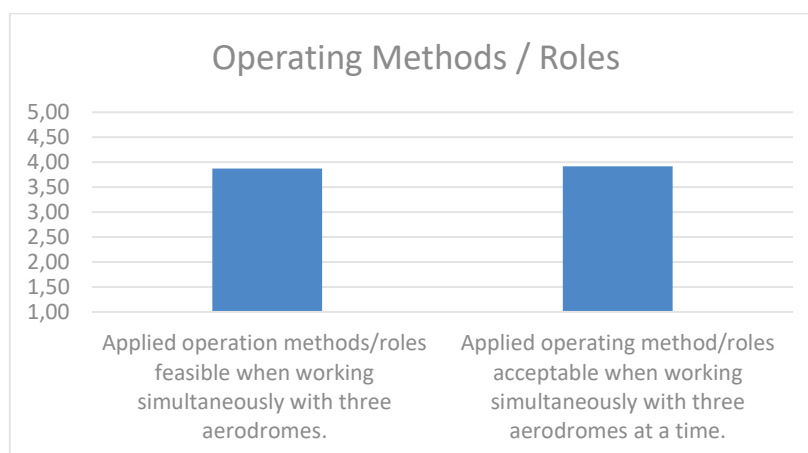
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible | ATCOs roles and responsibilities introduced by the multiple remote tower concept when working with a flexible allocation of aerodromes between the modules do not change, only the amount of areas in which the | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|--|---|--------|
| | allocation of aerodromes between MRTMs | roles and responsibilities are executed multiply with each tower. | |

In general, ATCOs agreed that applied roles and responsibilities remain as clear, consistent, stable and acceptable as they are when controlling only one tower. The ATCOs roles and responsibilities do not change, only the amount of areas in which the roles and responsibilities are executed multiply with each tower.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | <p>Majority of ATCOs agreed that applied operating methods when providing simultaneous ATS to three aerodromes were feasible and acceptable.</p> <p>The main contributor that could impacts feasibility and acceptability of provision of ATS to three aerodromes at a time, is the traffic volume and traffic complexity, as well as the required amount of communication.</p> | OK |

Three aerodromes at a time was controlled by one ATCO. Majority of ATCOs agreed that applied operating methods when providing simultaneous ATS to three aerodromes were feasible (3.88 of 5) and acceptable (3.92 of 5).



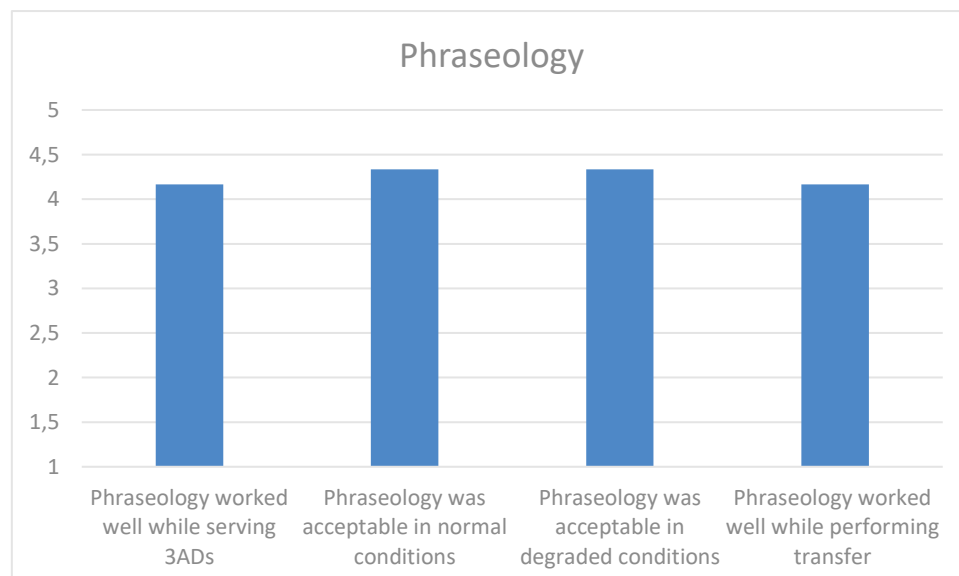
The results were obtained through the end of the run questionnaires, where each ATCO was asked about feasibility and acceptability of the operating methods/roles during the previous run. 24 answers in total have been provided for each question respectively, whereas, ATCOs 75% agreed or strongly agreed on statement for feasible and acceptable operating methods while 20.8% neither agreed nor disagreed. Only one ATCO (4.2%) and only for the last run disagree with the statement, mainly due to amount of simultaneous calls when controlling three aerodromes at a time.

B.3.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|---|--|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | The phraseology was acceptable for the ATCOs in normal operating conditions and degraded mode. | Partially OK |

This criteria was partly covered by the validation exercise, since there were not tested any abnormal situation. The ATCOs agreed that phraseology was acceptable when providing simultaneous ATS to three aerodromes in normal and degraded operating conditions.

They also agreed that phraseology worked well while performing transfer of aerodromes between the modules. They clearly confirm "my control at (aerodrome name)" when they took control over an aerodrome after completing the transfer.



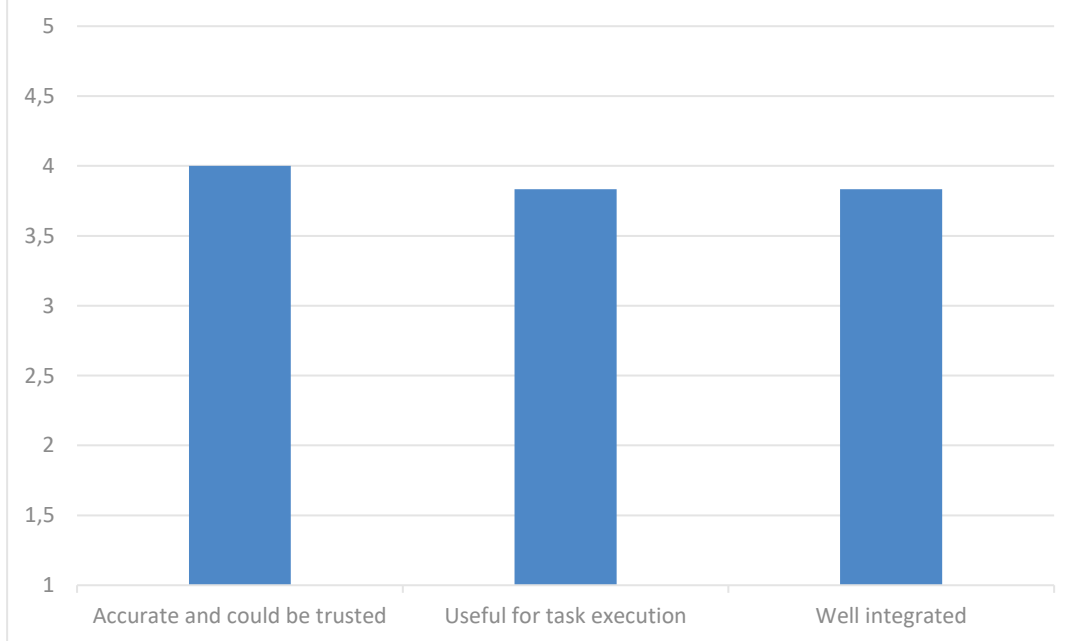
B.3.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

B.3.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

Assess that human-machine interface supports the team in carrying out their tasks

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | Technical System/HMI supported the ATCOs by being accurate, useful for task execution and well integrated . However the need to change the layout on the WACOM screen for e-strips was raised. | Partially OK |



The obtained results are following:

- Technical systems/HMI was accurate and could be trusted (4.00).
- Technical systems/HMI was useful for task execution (3.83).
- Technical systems/HMI well integrated (3.83).

The layout on the WACOM screen for e-strips changed depending on if the MRTM was in single aerodrome mode, where more information regarding strips was displayed, or double/triple aerodrome mode, where less information regarding strips was displayed. However the changing of the layout on the WACOM screen for e-strips confused ATCOs. There is a request to keep the layout in the WACOM screen the same for all modes.

Following comments of interest from ATCOs was identified:

“Different layouts in single and double/triple mode which I didn’t like. It should be the same design all the time (double layout was good, single was too big).”

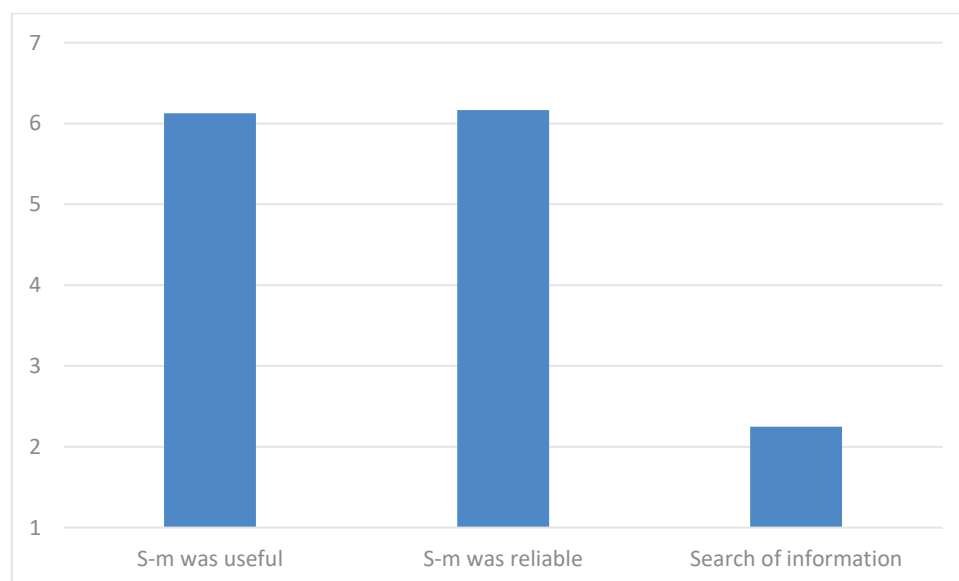
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | | N/A |

B.3.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs state the simulator (S-m) provided useful data in an understandable way and that they rarely needed to search for information . | OK |



The obtained results are following:

- Data from Simulator was useful (6.13).
- Data from Simulator was reliable (6.17).
- ATCO did not needed to search for information (2.21).

One type of information that was needed to be searched for was summarised by an ATCO in the following way:

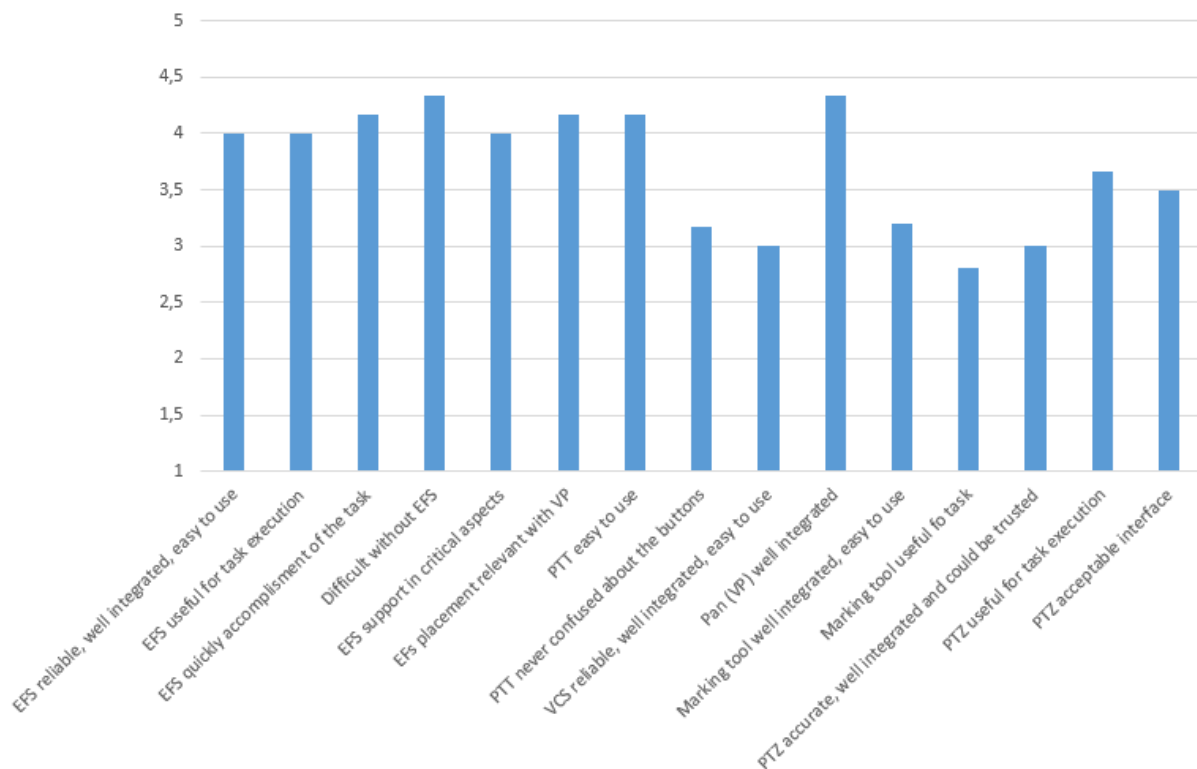
“Stand/gate configuration, VFR-entry/exit points e.g. geography”

During debriefing all ATCOs agreed that the need to search for this type of information was required mainly because most of the ATCOs was not rated on the aerodromes used in the validation.

Another type of information that was needed to be searched for are based on the changing layout for e-strips in the WACOM screen, see chapter B.3.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results for further information. This was however not seen as a big problem as the only thing needed to be further changed is so that the layout stays the same in the different display modes.

With these comments in mind, the ATCOs still stated that the simulator provided easy to access information in an effective way.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Majority of ATCOs confirm the usability of input devices and HMI controls. | OK |



The obtained results are following:

- EFS was reliable, well integrated and easy to use (4.00).
- EFS was useful for task execution (4.00).
- EFS was used to quickly accomplish tasks (4.17).
- It would be difficult to work without EFS (4.33).
- EFS supported the ATCO in critical aspects (4.00).
- EFS placement was relevant to the VP (4.17).
- PTT was easy to use (4.17).
- ATCO was often not confused with witch button to use on the PTT (3.17).
- The VCS was reliable, well integrated but not always the easiest to use (3.00).
- Pan of the VP was well integrated (4.33).
- Marking tool was well integrated and acceptable to use (3.20).
- Marking tool was not that useful for completing tasks but a good thing to have (2.80).
- PTZ was accurate, well integrated and could be trusted. It was however hard to control (3.00).
- PTZ was acceptable for task execution (3.67).
- PTZ had an acceptable interface (3.50).

Some ATCOs stated that the Push To Talk (PTT) was confusing to use during high workload. It was however stated that the PTT was *“Quite easy after having used it a while”*. Most ATCOs agreed that if they would have been able to work with the PTT for a longer period of time, this would not be an issue.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | <p>Partially covered as only alerts was used during validation.</p> <p>ATCOs confirmed the usability and utility of the alerts. However the ATCOs wanted to change the runway alert from red to some other colour. This based on that the alert only stated that a vehicle or aircraft was on the runway and not that there was a direct risk for a conflict.</p> | Partially OK |

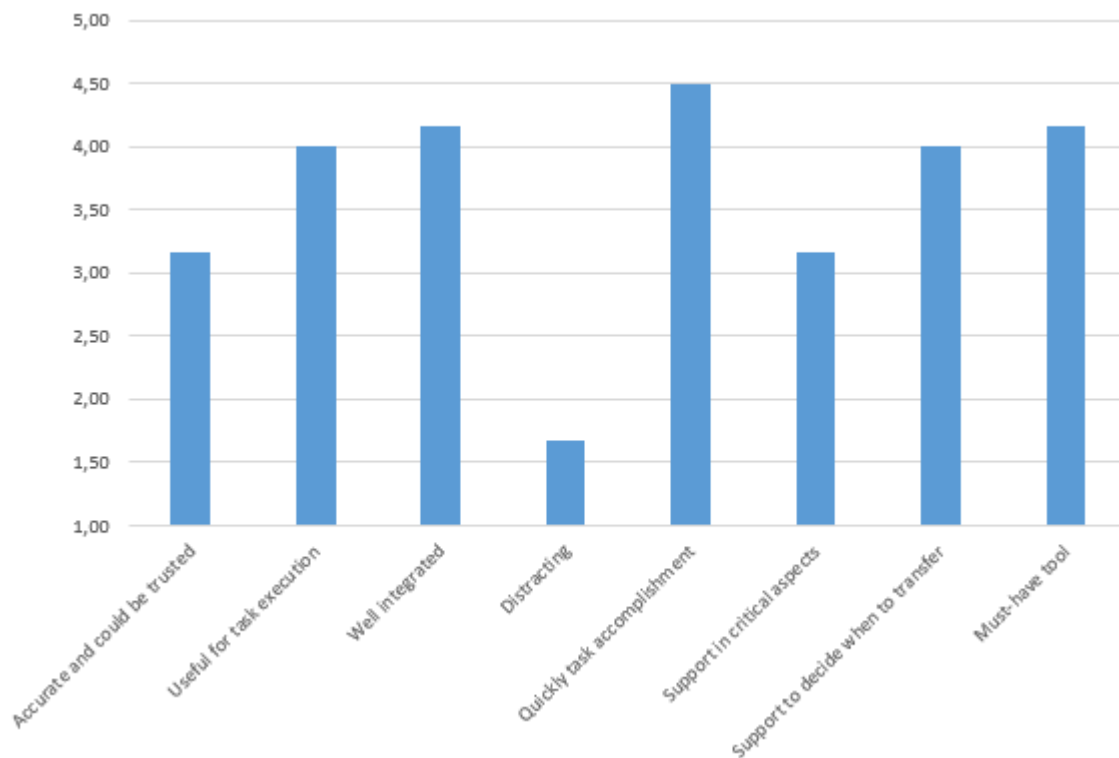
Comments from the ATCOs are as follow:

“It might be good to have green colour when runway is free, yellow when runway is occupied and then red when a real alert or even alarm are to be displayed in combination with sound that notifies the ATCO”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | ATCOs stated that the human machine interface could at sometimes increase the potential for human error. | Partially OK |

The changing layout for e-strips on the WACOM screen, see chapter B.3.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results for further information, could increase the potential for human errors as it confused the ATCOs sometimes.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | ATCOs state that the ATCO planning tool was useful, it is however in need of further development in order to be a reliable and trustful tool. | Partially OK |



The obtained results are following:

- ATCO planning tool was accurate and could be trusted to some extent (3.17).
- ATCO planning tool was useful for task execution (4.00).
- ATCO planning tool was well integrated (4.17).
- ATCO planning tool was not distracting (1.67).
- ATCO planning tool was used to quickly accomplish tasks (4.50).
- ATCO planning tool was acceptable supportive in critical aspects (3.17).
- ATCO planning tool was supportive when deciding when to transfer aerodromes (4.00).
- ATCO planning tool is a must-have tool when working with multiple aerodromes (4.17).

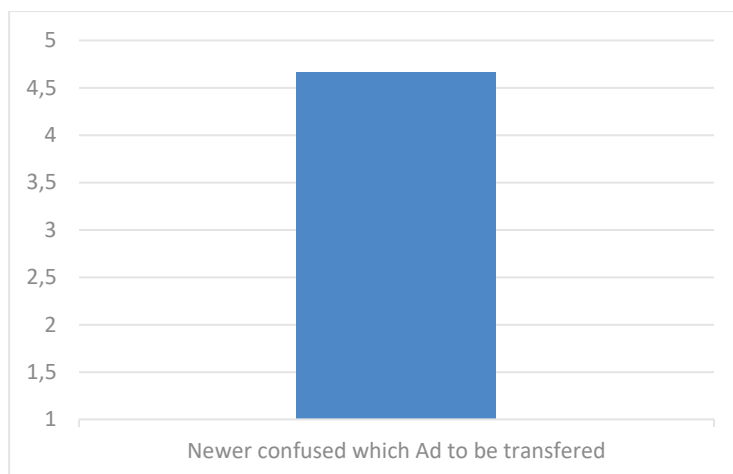
Comments from the ATCOs regarding the ATCO planning tool are as follow:

“The ATCO planning tool is good , but it does not present the real workload, it only presents number of aircraft moving at specific period of time, for me it will be good for supervisor to see when there is higher amount of traffic expected. It helped me to decide when to do transfer, but it was only the part of my decision, For me the combination of RDR screen, couple of departing strips in the bay (let’s say for next half an hour) are more important, and planning tool is one additional info that is helpful, but not in short period of time”

“The ATCO planning tool is still under development and there is still a lot of work to do on it. Just the number of movements does not reflect the expected workload. Complexity of traffic mix and airport layouts need to be implemented. Still unexpected traffic and ground movements won’t be part of the tool.”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | Majority of ATCOs confirm that there was no confusion regarding where a certain aerodromes was going to be placed in the visual presentation (VP). | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | Majority of the ATCOs confirm they were never confused witch aerodromes that was going to be transferred. | OK |



The obtained result are following:

- ATCOs were almost never confused witch aerodrome that was to be transferred (4.67).

When asked if there ever was any confusion regarding which aerodromes was going to be transferred the ATCOs said **“never”**.

B.3.2.5 HUMAN PERFORMANCE – TRUST

B.3.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

Assess ATCO trust in support systems when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | <p>Partially covered as only alerts was used during validation.</p> <p>The runway alert was initiated by the ATCO when placing vehicles on the runway in the WACOM screen or by placing e-strips in the runway bay. The reliability information wise was thereby never questioned. The alerts was also seen as reliable from a system perspective as the alerts was always displayed when supposed to. The ATCOs thereby trusted the reliability of the alerts.</p> | Partially OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | ATCOs confirmed trust in the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer. | OK |

See CRT-PJ05-W2-35-V3-VALP-H11.080 for chart.

The flexible allocation was here seen as important according to the ATCOs. It allowed the ATCOs to prepare an aerodrome before transfer was started and place it where they wanted to. An ATCO stated that flexible allocation on the Visual Presentation (VP) was “Very important to have”.

B.3.2.6 HUMAN PERFORMANCE – Transition Factors

B.3.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Knowledge, skills and experience requirements was identified both from ATCOs and also from observers. | Partially OK |

A understanding and familiarity of the system as well as knowledge about the different aerodromes such as geography, gates, stands etc. was seen by ATCOs as important skills and knowledge in order to be able to operate multiple aerodromes simultaneously.

Methods and procedures regarding prioritisation, transfers and regulations connected to number of movements allowed is also seen as a requirement in order to safely operate multiple aerodromes.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Training needs was identified by both ATCOs and observers. | Partially OK |

Similar to CRT-PJ05-W2-35-V3-VALP-H15.010 above, an understanding and familiarity of the system as well as knowledge about the different aerodromes such as geography gates, stands etc. was seen by ATCOs as important skills and knowledge in order to be able to operate multiple aerodromes simultaneously.

B.3.2.7 SAFETY

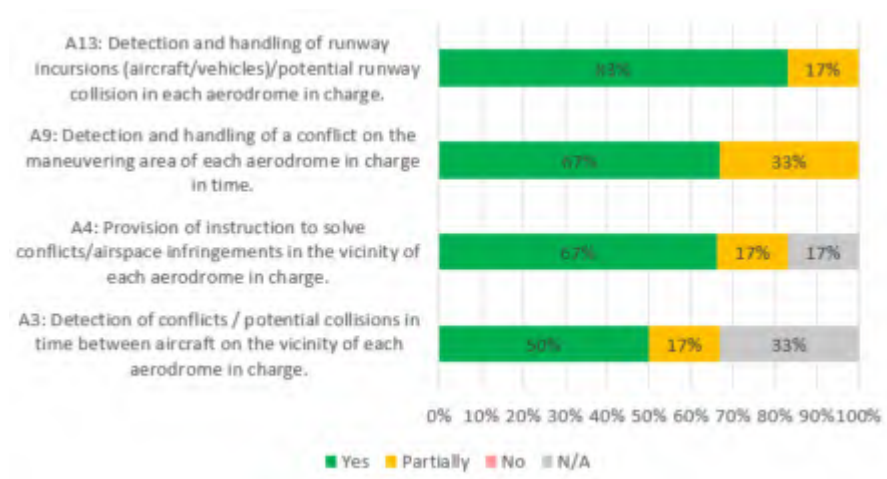
B.3.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | The majority of the ATCOs confirm that they were able to identify and solve potential conflicts in a timely manner. | OK |

The questions of relevance for this criterion and the results can be seen in the figure below.



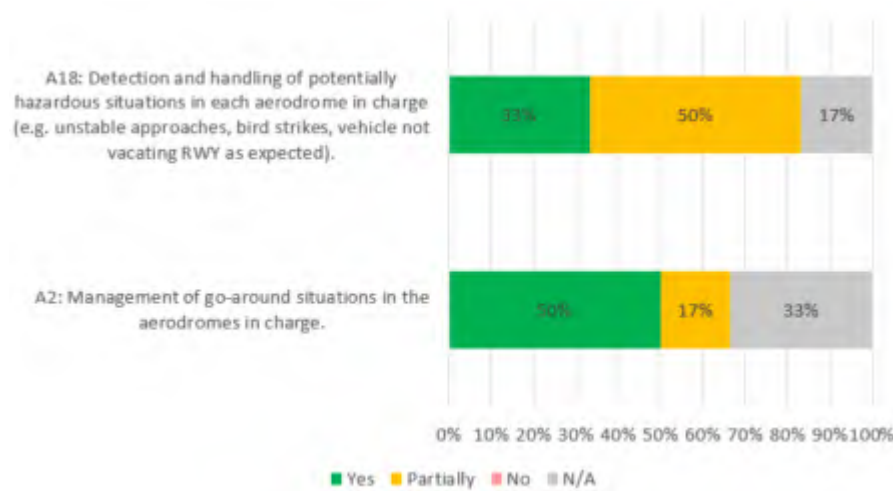
The result shows an overall acceptance from the ATCOs regarding the criterion. One comment that most ATCOs agreed upon was regarding question A13 and was written by and ATCO the following way:

“I was very careful avoiding such situations, especially when having 3 aerodromes. This was achieved by avoiding lining up if there was a remote chance of conflict so I wouldn’t have to constantly monitor the situation (i.e. delays for the departures in this case)”

This shows that there was a need to prioritize in order to minimize risks. This was seen as acceptable and natural by the ATCOs.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> • Unstable approaches • Bird strikes • Aircraft not vacating RWY as expected | ATCOs partially agreed that they were able to identify and solve potential hazardous situations in a timely manner. | Partially OK |

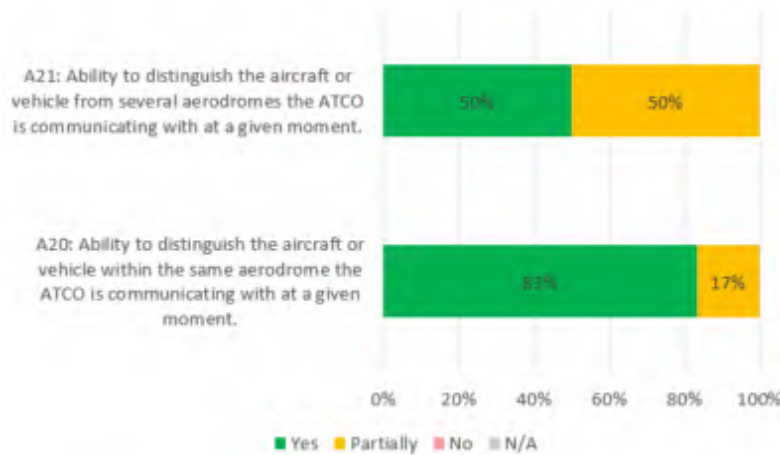
The questions of relevance for this criterion and the results can be seen in the figure below.



In order to increase ATCOs SA, the system allowed them to choose a preferred mode of aerodrome presentation: single (one aerodrome presented), double (one or two aerodromes presented) or triple (one, two or three aerodromes presented). Compressed view when working in triple mode had an impact on the resolution, regardless the number of presented aerodromes. The presented view under triple mode was identified as more challenging in identifying hazardous situations than working in single or double mode.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft/vehicle at which aerodrome the ATCO is communicating with | The majority of the ATCOs confirm that they were able to distinguish with which aircraft/vehicle at which aerodrome the ATCO was communicating with. | OK |

The questions of relevance for this criterion and the results can be seen in the figure below.



The main reason why 50% of the ATCOs answered partially in question A21 are based on several transmission at the same time. The ATCOs stated that the indication on the VP helped, but double and tippie communication often made the ATCO transmit “say again” to specific aerodrome in order to understand who said what. This is seen as acceptable and normal, but there is a need for prescribed procedures.

Comments from ATCOs regarding question A21 is as follows:

“If there were double transmission then I had to ask: say again to be sure, and that should be prescribed procedure”

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | | N/A |

B.3.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

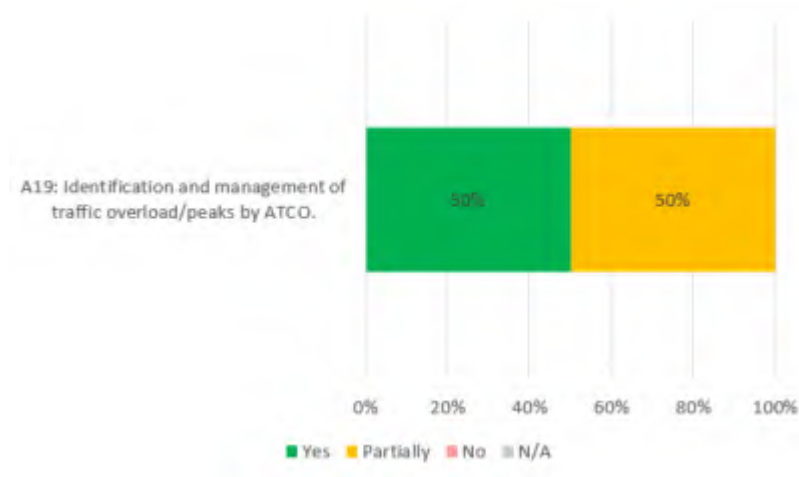
OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | ATCOs were able to foresee traffic at their MRTM. However, in order to be completely able to avoid overloads, unplanned VFR and vehicle traffic need to be considered, and if | Partially OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | possible, presented through the system tools e.g. EFS, RDP, ATCO planning tool. | |

The questions of relevance for this criterion and the results can be seen in the figure below.



None of the ATCOs stated clearly that they could not foresee traffic overloads. Half of the ATCOs agreed that they could foresee and manage traffic overloads, while the other half were partial able to foresee traffic overloads.

This was achieved with help from some of the system tools, such EFS, RDP, and mainly with the help of ATCO planning tool. ATCOs could recognize approximately at which point of time they could expect an overload situation. Nevertheless, ATCOs appointed as well that some of the issues that contributed to unreliability in the ATCO planning tool were unplanned flights and the amount of workload this flights and vehicles can generate, resulting in peaks not shown in ATCO planning tool.

B.3.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

| OBJ-PJ05-W2-35-V3-VALP-S06 Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|--|--------------------------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> Aircraft emergency | Abnormal situations were not tested. | N/A |

OBJ-PJ05-W2-35-V3-VALP-S06

Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

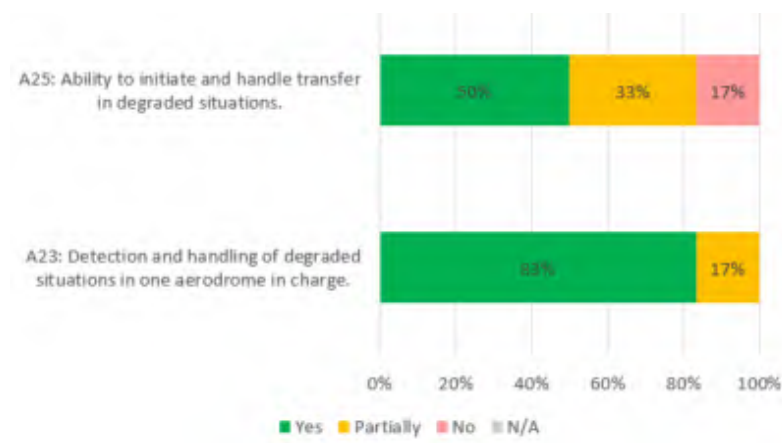
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---|-------------------|--------|
| | <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport | | |

B.3.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results**OBJ-PJ05-W2-35-V3-VALP-S07**

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

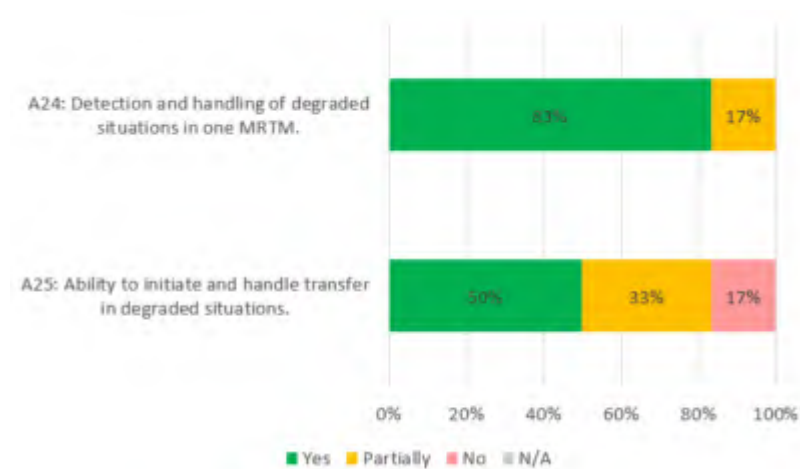
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g.): <ul style="list-style-type: none"> Communication Visualisation system Other airport systems / infrastructure | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure occurring at one of the aerodromes. | OK |

The questions of relevance for this criterion and the results can be seen in the figure below.



ATCOs stated during debrief regarding question A25 that transfer during degraded situations could be done even better if procedures was prescribed and a supervisor was used. The ATCOs that stated “No” as an answers stated that there is an absolute need for prescribed procedures and supervisor, and that there is not always enough time nor capacity to work with a transfer during these types of situations.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g.): <ul style="list-style-type: none"> • Communication • Visualisation system | The majority of the ATCOs confirm that they were able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes. | OK |



ATCOs stated during debrief regarding question A25 that transfer during degraded situations could be done even better if procedures was prescribed and a supervisor was used. The ATCOs that stated “No” as an answers stated that there is an absolute need for prescribed procedures and supervisor, and that there is not always enough time nor capacity to work with a transfer during these types of situations.

B.3.2.8 CAPACITY

B.3.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|--|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | During the validation ATCOs stated that 6 simultaneous movements does not necessarily need to be the limit. It does however depend on what type of traffic situations the ATCO are working with. Other operational asks that was not included in the validation is also needed to be considered. | Partially OK |

ATCOs stated that it can be good to, instead of just measuring the number of movements, give the different movements a value. This value, similar to the ATCO planning tool, would demonstrate how much capacity it would take and the traffic situation would thereby be part of the new guideline for when a transfer is needed to be done.

B.3.2.9 COST EFFICIENCY

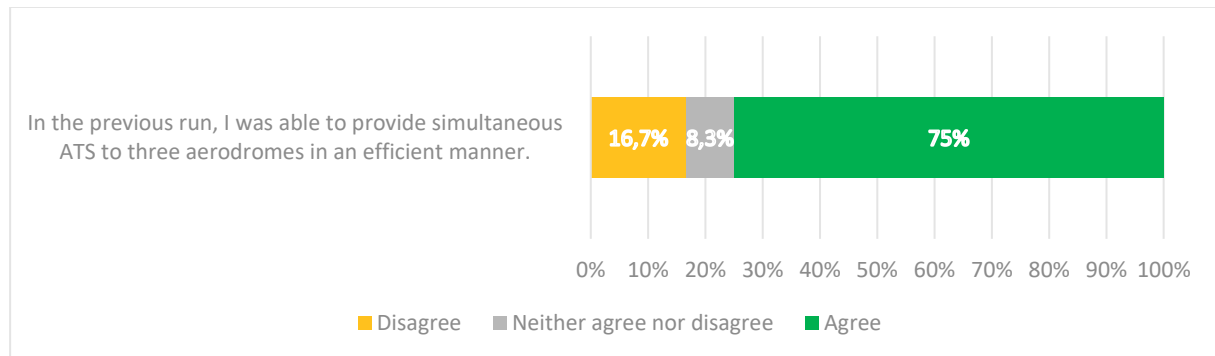
B.3.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | Most of the ATCOs were able to provide simultaneous ATS to 3 aerodromes on an efficient manner. | OK |

The result was obtained through the end of the run questionnaires, where each ATCO was asked if they were able to provide simultaneous ATS to three aerodromes in an efficient manner. In 75% of provided answers, the ATCOs agreed or strongly agreed that they were efficient, in 8.3% of answers

they neither agree nor disagree with this statement, and in 16.7% answers, ATCOs (more specifically 1 ATCO) have disagreed about their efficiency.

It should be considered that there is a correlation between the number of controlled aerodromes and provided efficiency. For instance, the higher number of controlled aerodromes, could request increased focus at one of the aerodromes which can result with delayed communication with the traffic at the other aerodromes, hence delaying clearances are inevitable and leads to delayed traffic.



B.3.3 Supervisor - Summary of Validation Exercise Results

Note: The validation objectives with their respective success criteria regarding RTC Supervisor role and Supervisor planning tool, unfortunately was not covered with COOPANS validation exercise, due to COVID-19, hence those are described as deviation from planned activities.

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|-------------------|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|--|-------------------|-----------------------------|
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|-------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | | N/A |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|-------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | | N/A |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | | N/A |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|-------------------|-----------------------------|
| | conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | | |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> Communication Visualisation system Other systems in the MRTM | | N/A |
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|----------------------|-------------------|-------------------|-----------------------------|
| | aerodromes between MRTMs | | | | |

Table 12: Supervisor - Validation Results for Exercise 1

B.3.4 Supervisor - Analysis of Exercise Results per Validation objective

Note: The validation objectives with their respective success criteria regarding RTC Supervisor role and Supervisor planning tool, unfortunately was not covered with COOPANS validation exercise, due to COVID-19, hence those are described as deviation from planned activities.

B.3.4.1 HUMAN PERFORMANCE – SITUATION AWARENESS

B.3.4.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

OBJ-PJ05-W2-35-V3-VALP-H01
Assess SUP situation awareness when working in an RTC

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | | N/A |

B.3.4.2 HUMAN PERFORMANCE – WORKLOAD

B.3.4.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

| OBJ05-W2-35-V3-VALP-H05 Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | | | |
|---|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

B.3.4.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

B.3.4.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

B.3.4.4 HUMAN PERFORMANCE – USABILITY and UTILITY

B.3.4.4.1 OBJ-PJ05-W2-35-V3-VALP-H10 Results

| OBJ-PJ05-W2-35-V3-VALP-H10 Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | | | |
|--|--|--|--|
|--|--|--|--|

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | | N/A |

B.3.4.4.2 OBJ-PJ05-W2-35-V3-VALP-H12 Results

OBJ-PJ05-W2-35-V3-VALP-H12

Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | | N/A |

B.3.4.5 HUMAN PERFORMANCE – TRUST

B.3.4.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

OBJ-PJ05-W2-35-V3-VALP-H14

Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

B.3.4.5.2 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | | N/A |

B.3.4.6 SAFETY

B.3.4.6.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S08.010 | <p>Supervisor is able to support an ATCO in abnormal situations(e.g):</p> <ul style="list-style-type: none"> • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport <p>ATCO overload in one or more MRTM of the RTC</p> | | N/A |

B.3.4.6.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

OBJ-PJ05-W2-35-V3-VALP-S09

Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g: <ul style="list-style-type: none"> • Communication • Visualisation system Other systems in the MRTM | | N/A |

B.3.4.6.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results**OBJ-PJ05-W2-35-V3-VALP-S10**

Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | | N/A |

B.3.5 Unexpected Behaviours/Results

No unexpected behaviour/result was identified during EXE-PJ05-W2-35-V3-2.2 COOPANS.

B.3.6 Confidence in Results of Validation Exercise

B.3.6.1 Level of significance/limitations of Validation Exercise Results

The following items was not considered during EXE-PJ05-W2-35-V3-2.2 COOPANS validation exercise.

- No supervisor planning tool was tested and no supervisor was used during validation. Instead the ATCOs used ATCO planning tool and planned transfers themselves.
- Abnormal situations was not tested.
- Darkness at aerodromes was not tested.
- No aerodromes had the majority of the traffic.
- No aerodrome had strong head or crosswind.

Due to no supervisor and no supervisor planning tool, the following CRT with focus on supervisor was not covered:

- CRT-PJ05-W2-35-V3-VALP-H01.010
- CRT-PJ05-W2-35-V3-VALP-H01.020
- CRT-PJ05-W2-35-V3-VALP-H01.030
- CRT-PJ05-W2-35-V3-VALP-H01.040
- CRT-PJ05-W2-35-V3-VALP-H05.010
- CRT-PJ05-W2-35-V3-VALP-H09.010
- CRT-PJ05-W2-35-V3-VALP-H10.010
- CRT-PJ05-W2-35-V3-VALP-H10.030
- CRT-PJ05-W2-35-V3-VALP-H12.010
- CRT-PJ05-W2-35-V3-VALP-H12.020
- CRT-PJ05-W2-35-V3-VALP-H12.030
- CRT-PJ05-W2-35-V3-VALP-H12.040
- CRT-PJ05-W2-35-V3-VALP-H12.050
- CRT-PJ05-W2-35-V3-VALP-H14.010
- CRT-PJ05-W2-35-V3-VALP-H15.010
- CRT-PJ05-W2-35-V3-VALP-H15.020
- CRT-PJ05-W2-35-V3-VALP-S08.010

- CRT-PJ05-W2-35-V3-VALP-S09.010
- CRT-PJ05-W2-35-V3-VALP-S10.010

Following CRT was not covered due to non-existing reference scenario:

- CRT-PJ05-W2-35-V3-VALP-H18.020

B.3.6.2 Quality of Validation Exercises Results

The results from the exercise are based on questionnaires, observations, debriefings and log data from the system. The data collection and analysis is seen to be of very good quality based on data received both through good debriefings and also through questionnaires and log data from the system. After each run a debriefing with the actors involved was performed, and then an **end of run** questionnaire was handed to the ATCOs involved in that specific run. After that all runs were finished, a final debrief was performed and then all ATCOs was handed an **end of week** and **safety questionnaire**.

B.3.6.3 Significance of Validation Exercises Results

The operational significance of the validation results are considered as acceptable as the operational environment was appropriate for V3 level and was accepted as such by 5 out of 6 (approximately 83%) ATCOs. The one ATCO that did not accept the V3 level did accept the platform and all the systems at a V3 level, the ATCO does however not like the concept of working with three simultaneous aerodromes and did thereby not accept the V3 level for the concept. The system, scenario and settings used for the exercise was seen as realistic. The different experiences that the ATCOs have (from different aerodromes, airports and different ANSP) increased the significance of the results as different perspectives of the solution was examined.

B.3.7 Conclusions

A.1.1.1. Conclusions on concept clarification

The Real Time Simulation is based on a setup with two MRTMs that provides the possibility to control three aerodromes in one MRTM. Each MRTM includes the possibility for flexible allocation of three of a total of four aerodromes in the system. The flexible allocation and transfer was initiated by the ATCOs with the help of the ATCO planning tool and instructions that the 2:2 aerodrome distribution should not be held for longer period of times was given to the ATCOs as controlling two aerodromes simultaneously was not part of the scope.

The ATCOs stated that transfers and flexible allocation would be made much easier if a supervisor with information regarding the different aerodromes such as MET information, traffic situation, etc. would plan the transfers. Many of the ATCOs stated that the transfers took longer time as they had to ask every time if the ATCO that was about to potentially receive an aerodrome had enough capacity left in order to take control over another aerodrome. The ATCO that potentially are about to receive an aerodrome then had to estimate the amount of capacity left and if they are able to take over the aerodromes that are to be potentially transferred. This extra amount of work would be minimized with the help of a supervisor.

Founding Members

Results shows that flexible allocation is important to have in order to change the layout of the workstation in a way that the ATCO feels comfortable with. This improved, according to the ATCOs, the scanning of each aerodrome as well as the SA as the aerodromes could be prepared before a transfer and also placed where the ATCOs wanted. The aspect of controlling three aerodromes simultaneously was seen as doable and acceptable by most ATCOs. However it was agreed on that there is a need for limitations on the total amount of movements, a supervisor that planned transfers before a stressed situation occurred and a need to determine which aerodromes that are suitable for pairing with each other with mostly focus on traffic situation for example, during different parts of the year.

A.1.1.1. Conclusions on technical feasibility

The technical feasibility of an operational environment could not be fully assessed as there was limitations based on that the exercised was conducted on a simulator. However many of the technical features needed for assessing the feasibility of the operational environment were available and used in the simulator during the exercise.

The ATCO planning tool was seen as useful, according to the ATCOs, when planning a transfer or making sure that they had enough capacity before accepting a new aerodrome. However all ATCOs stated that there is need for further development in order to make the ATCO planning tool fully acceptable in an operational environment.

The layout on the WACOM screen for e-strips changed depending on if the MRTM was in single aerodrome mode, where more information regarding strips was displayed, or double/triple aerodrome mode, where less information regarding strips was displayed. However the changing of the layout on the WACOM screen for e-strips confused ATCOs. There is a request to keep the layout in the WACOM screen the same for all modes.

A.1.1.1. Conclusions on performance assessments

Conclusions related to Human Performance, Safety, Capacity and Cost Efficiency are described in detail in section B.3.2..

B.3.8 Recommendations

Concept-related:

- ATCOs state that transfers should always be planned to happen when traffic is low. This is based on the results that making a transfer takes a lot of capacity and if an ATCO already have three aerodromes with high amount of traffic, then the ATCO might not be able to transfer any aerodrome.
 - There is need for a supervisor to plan transfers and work as a transfer assistance.
 - The majority of transfer communication should be done between the ATCOs and not through a supervisor.

- ATCOs stated that in case of degraded mode there is a need for having clear procedure and methods, as some of the receiving ATCOs just accepted the fact that their colleague in the other MRTM had problems and received aerodromes that they did not have fully under control when transfer was completed.
 - This type of situations would possibly have been solved with a supervisor.
- Less traffic can be used during further test and exercise in order to reach even more realistic scenarios.
 - The amount of traffic used in the scenarios for the exercises are slightly higher than the real amount of traffic on the different aerodromes, this in order to provoke the usage of transfer and flexible allocation while also testing the limit of working with three aerodromes simultaneously.

System-related:

- ATCO planning tool needs to be further developed with better estimations of capacity needed for different situations as well as better way of updating information regarding flights.
- E-strips layout in the WACOM screen needs to stay the same in single, double and triple mode.
- Alerts for runway occupancy needs to be changed from only using red colour to other colours where red are only used in direct danger of conflict.
- Some ATCOs requested to be able to minimize number of clicks while giving clearances. For example being able to give direct CFTO instead of having to click several times in order to reach CFTO.
- Colour frames around the different aerodromes as well as the marking when transmission is being received both from air and from ground should also be displayed on the WACOM screen and the RDP.

Platform-related:

- Being able to raise or lower platform, including screens where VP is displayed in order to accommodate if ATCOs wants to stand or sit when working.

Appendix C Validation Exercise EXE-2.3-INDRA Report

C.1 EXE-2.3.1 INDRA/Avinor RTS Validation

C.2 Summary of the Validation Exercise EXE-2.3.1-INDRA Plan

C.2.1 Validation Exercise description, scope

The operational scope of this real-time simulation includes simultaneous ATS provided to four Norwegian other and small size aerodromes from two MRTMs by one ATCO per RTM and a Supervisor. The scope is fully in line with the context set out in the PJ05-35 Validation Plan (i.e. Solution PJ.05.35 will address the concept of 4 different aerodromes handled within an RTC, with up to 3 aerodromes per MRTM. Exercises addressing this aspect will use a minimum of 2 MRTMs to distribute 4 aerodromes to a limit of 3 in one MRTM).

The objective was to assess i) the dynamic and flexible allocation of aerodromes to MRTMs in nominal and non-nominal situations while maintaining operations at the aerodromes and ii) the supervisor role in the RTC with regard to planning the dynamic allocation of aerodromes.

The evaluation mostly focused on situational awareness, workload, usability and the potential safety issues related to flexible allocation.

The simulation lasted for two weeks and took place in September 2021.

4 ATCOs currently working in different sized tower units participated in the validation. However, since one ATCO had to cancel his participation to the second validation day, her/his contribution to the findings is limited to the two first runs and the associated post-run questionnaires and debriefings. Data from the final questionnaire are based on 3 ATCOs instead of 4.

6 supervisors also participated in the validation, 4 currently working in a large aerodrome tower unit and 2 currently working in ACC units.

The ATCOs covered the roles of Clearance Delivery, Ground Controller and Tower Runway Controller for up to three aerodromes simultaneously.

The validation platform used by Avinor was INDRA RTWR IBP platform delivered by INDRA NAVIA.

The results for combined TWR/APP should be considered as exploratory since:

- The concept of multiple aerodromes combined with approach has not been subject to validation in the previous V phases.
- The priority in this exercise has been given to the TWR-only objectives during the exercise preparation and data collection.
- Only one run was dedicated to the validation of combined TWR/APP.
- Three ATCOs, instead of four as originally planned, have performed the run with combined TWR/APP.

C.2.2 Summary of Validation Exercise EXE-2.3-INDRA Validation Objectives and success criteria

| SESAR Solution Validation Objective | SESAR Solution Success criteria | Coverage comments on the coverage of SESAR Solution Validation Objective in Exercise 2.3.1 | Exercise Validation Objective | Exercise Success criteria |
|--|---------------------------------|--|-------------------------------|---------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-020 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-030 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-040 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-020 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-030 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-040 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H03 | CRT-PJ05-W2-35-V3-VALP-H03-010 | Fully covered | as solution | as solution |
| HUMAN PERFORMANCE – WORKLOAD | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04-020 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H05 | CRT-PJ05-W2-35-V3-VALP-H05-010 | Fully covered | as solution | as solution |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | |

| | | | | |
|----------------------------|--------------------------------|---------------------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H06 | CRT-PJ05-W2-35-V3-VALP-H06-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07-030 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H08 | CRT-PJ05-W2-35-V3-VALP-H08-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H09 | CRT-PJ05-W2-35-V3-VALP-H09-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H10 | CRT-PJ05-W2-35-V3-VALP-H10-010 | Fully covered Debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H10 | CRT-PJ05-W2-35-V3-VALP-H10-030 | Fully covered Debrief, workshop | as solution | as solution |

HUMAN PERFORMANCE – USABILITY and UTILITY

| | | | | |
|----------------------------|--------------------------------|---------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-020 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-050 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-060 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-070 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-080 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-020 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-030 | Fully covered | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|---------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-050 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18-030 | Fully covered | as solution | as solution |

HUMAN PERFORMANCE - TRUST

| | | | | |
|----------------------------|--------------------------------|---------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3-VALP-H13-080 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H14 | CRT-PJ05-W2-35-V3-VALP-H14-010 | Fully covered | as solution | as solution |

HUMAN PERFORMANCE – TRANSITION FACTORS

| | | | | |
|----------------------------|--------------------------------|---------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H15 | CRT-PJ05-W2-35-V3-VALP-H15-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H15 | CRT-PJ05-W2-35-V3-VALP-H15-020 | Fully covered | as solution | as solution |
| SAFETY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-020 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-030 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-040 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-050 | Workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S05 | CRT-PJ05-W2-35-V3-VALP-S05-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S06 | CRT-PJ05-W2-35-V3-VALP-S06-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S07 | CRT-PJ05-W2-35-V3-VALP-S07-030 | Fully covered | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|---------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-S08 | CRT-PJ05-W2-35-V3-VALP-S08-010 | Fully covered | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S10 | CRT-PJ05-W2-35-V3-VALP-S10-010 | Fully covered | as solution | as solution |

C.2.3 Summary of Validation Exercise EXE-2.3-INDRA Validation scenarios

The validation exercises used up to 4 different aerodromes for the Real Time Simulations, while providing simultaneous ATS for up to 3 aerodromes simultaneously from one MRTM. The exercises contained 2 MRTMs, each capable of handling up to 3 aerodromes simultaneously. The goal was to manage aerodromes in a flexible way to provide a continuous service at each aerodrome according to requested traffic levels. This provides the ATCOs in each MRTM with a suitable level of traffic to maintain situational awareness at each aerodrome. In order to achieve as much as possible balance of the ATCOs workload caused by the traffic requests, aerodromes could be transferred between the MRTMs.

A supervisor role was included in the scenarios. The supervisor plan the utilization of the MRTMs based on planned traffic, weather, equipment status etc. The supervisor also assist the ATCOs and may initiate a transfer of an aerodrome from one MRTM to another.

One validation exercise also included functionality for APP, and the ability for the APP function to be combined with one or two aerodromes within an MRTM. Transfer of the APP function was also validated.

The following scenarios were conducted:

| SCN | MRTMs | ADs per MRTM | Supervisor | Comment | Approach | Transfer |
|-------|-------|--------------|------------|-------------------|----------|----------|
| SCN 1 | 2 | Up to 3 | Yes | Focus on merge | No | Yes |
| SCN 2 | 2 | Up to 3 | Yes | Focus on split | No | Yes |
| SCN 3 | 2 | Up to 3 | Yes | Focus on degraded | No | Yes |
| SCN 4 | 2 | Up to 3 | Yes | Focus on abnormal | No | Yes |
| SCN 5 | 2 | Up to 2 | Yes | Focus on Approach | Yes | Approach |

Table 13: Scenarios in validation EXE-05-W2-35-V3-2.3.1 Indra/Avinor

The parameters covered in Indra validation EXE-05-W2-35-V3-2.3.1 Avinor are described in the table below.

| | |
|-----------------------|---|
| Traffic volume | <ul style="list-style-type: none"> • Max 20-30 movements per hour and up to 6 simultaneous movements for one MRTM |
| Traffic complexity | <ul style="list-style-type: none"> • Mainly IFR traffic • Mix of IFR and VFR traffic • Vehicles |
| Traffic distribution | <ul style="list-style-type: none"> • Even distribution • One aerodrome with majority of traffic (>70%) |
| Operational modes | <ul style="list-style-type: none"> • Normal operations • Abnormal cases • Degraded mode |
| Runway conditions | <ul style="list-style-type: none"> • Similar operating conditions • Different operating conditions |
| Runway directions | <ul style="list-style-type: none"> • Diverging RWY directions |
| Wind conditions | <ul style="list-style-type: none"> • Similar wind conditions |
| Visibility conditions | <ul style="list-style-type: none"> • Different visibility conditions • Similar VMC conditions |
| Time of day | <ul style="list-style-type: none"> • Daytime at all aerodromes |

Figure: Parameters overview for validation EXE-05-W2-35-V3-2.3.1 Indra/Avinor

C.2.3.1 Data Collection Methods

A combination of both qualitative and quantitative data collection techniques was used prior and post the validation exercise.

Quantitative measures

- Number of flights in each run was counted.
- Number of surface movements (vehicles) was logged.
- Different weather types and other MET data was predefined and logged
- Daylight conditions was predefined and logged

Qualitative data:

The following techniques was used:

- **Over the shoulder observations.** During the sessions, the activities of actors was observed by Human Factors and Operational Experts in order to collect insights about their performance, strategies they used to perform the task and difficulties experienced.
- **Questionnaires (Post-run questionnaire and Post-simulation questionnaire).** Specific questionnaires was developed to obtain a feedback from the actors involved in the study on the concept, their performance, the scenarios and exercises performed.
- **Debriefings and semi-structured interviews** was conducted by the Human Factors expert at the end of runs or simulation days. Difficulties experienced during the run was discussed. Specific questions related to the Human Performance and Safety objectives was asked.

| KPA | KPIs | method / technique |
|-----|----------------------------|---|
| HP | Situation Awareness | Post-run questionnaire (China Lake) / Final questionnaire Over the shoulder observations Debriefing/Semi-structured interview |
| | Workload | Post-run questionnaire (Bedford) / Final questionnaire Over the shoulder observations Debriefing/Semi-structured interview |
| | Trust | Debriefing/Semi-structured interview |
| | Acceptability | Final questionnaire (CARS) Debriefing/Semi-structured interview |
| | Human error | Post-run questionnaire / Final questionnaire Over the shoulder observations Debriefing/Semi-structured interview |
| | Communication | Final questionnaire Over the shoulder observations Debriefing/Semi-structured interview |
| | Teamwork | Final questionnaire Over the shoulder observations Debriefing/Semi-structured interview |
| | Usability | Over the shoulder observations Final questionnaire Debriefing/Semi-structured interview |

| KPA | KPIs | method / technique |
|------|---------------------------|---|
| SAF* | Alarms and Alerts | N/A |
| | Perceived level of Safety | Final questionnaire Debriefing/Semi-structured interview |
| CEF | ATCO productivity | Post-run questionnaire (Workload) / Final questionnaire Debriefing/Semi-structured interview |

Table 14: Overview data collecting methods per KPA for EXE-05-W2-35-V3-2.3.1-INDRA/AVINOR

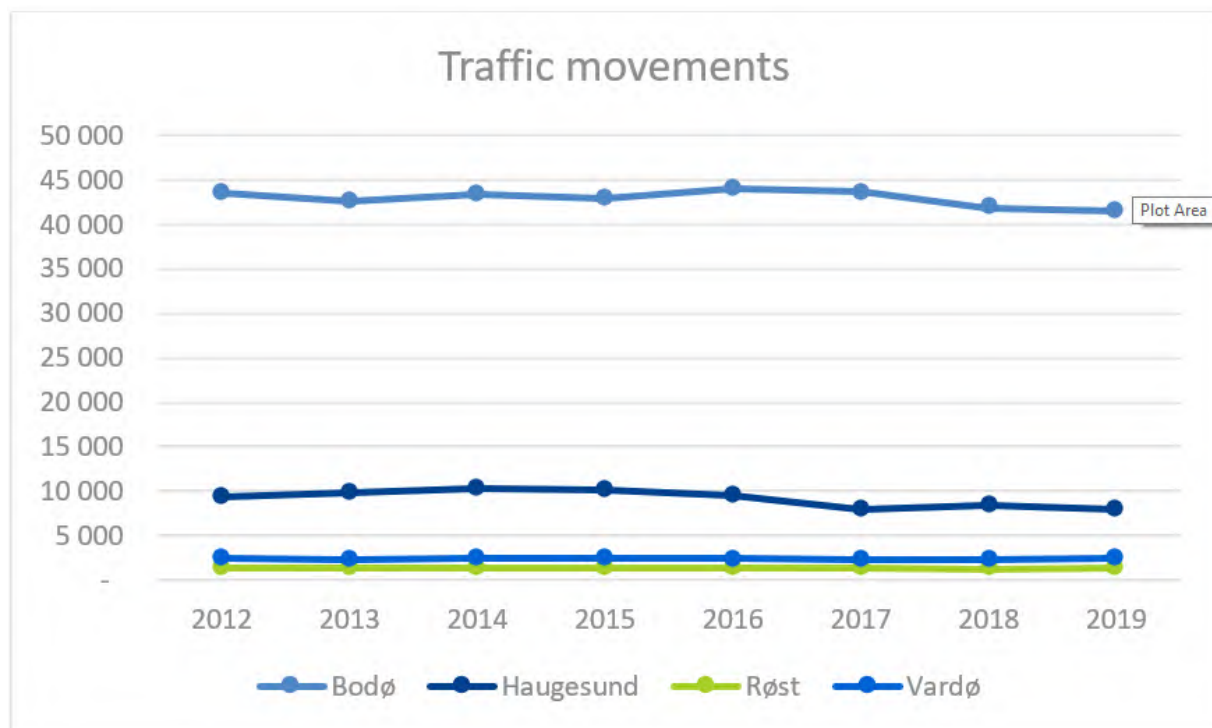
C.2.3.2 Aerodromes

The four aerodromes used in the validation are:

- ENRS - Røst
- ENBO - Bodø
- ENHD - Haugesund
- ENSS - Vardø

The selected aerodromes are all in a size that are candidates for Remote Tower operations in Norway. In fact, Røst and Vardø is already being operated remotely from an RTC in Bodø. Bodø, Haugesund and Røst were also used in the Wave 1 validation with good results as the aerodromes show a variation in characteristics and complexity.

In real life the traffic load for these aerodromes are shown in the graph below.



Number of movements on airports covered in EXE-05-W2-35-V3-2.3.1 Indra/Avinor

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Bodø | 43 507 | 42 531 | 43 392 | 42 902 | 43 982 | 43 625 | 41 860 | 41 472 |
| Haugesund | 9 382 | 9 814 | 10 331 | 10 217 | 9 574 | 7 915 | 8 420 | 7 882 |
| Røst | 1 345 | 1 360 | 1 353 | 1 345 | 1 307 | 1 316 | 1 306 | 1 342 |
| Vardø | 2 503 | 2 251 | 2 544 | 2 459 | 2 440 | 2 303 | 2 242 | 2 465 |

Table 15: Number of movements on airports covered in EXE-05-W2-35-V3-2.3.1 Indra/Avinor

The main characteristics of these aerodromes are described hereunder.

Røst Aerodrome (ENRS)

Regional aerodrome located on the northern edge of the main island of Røstlandet in northern Norway.

The airport has a single runway (03/21) with an asphalt surface, 880 by 30 meters (2,887 ft x 98 ft) with approx. 1300 movements per year.

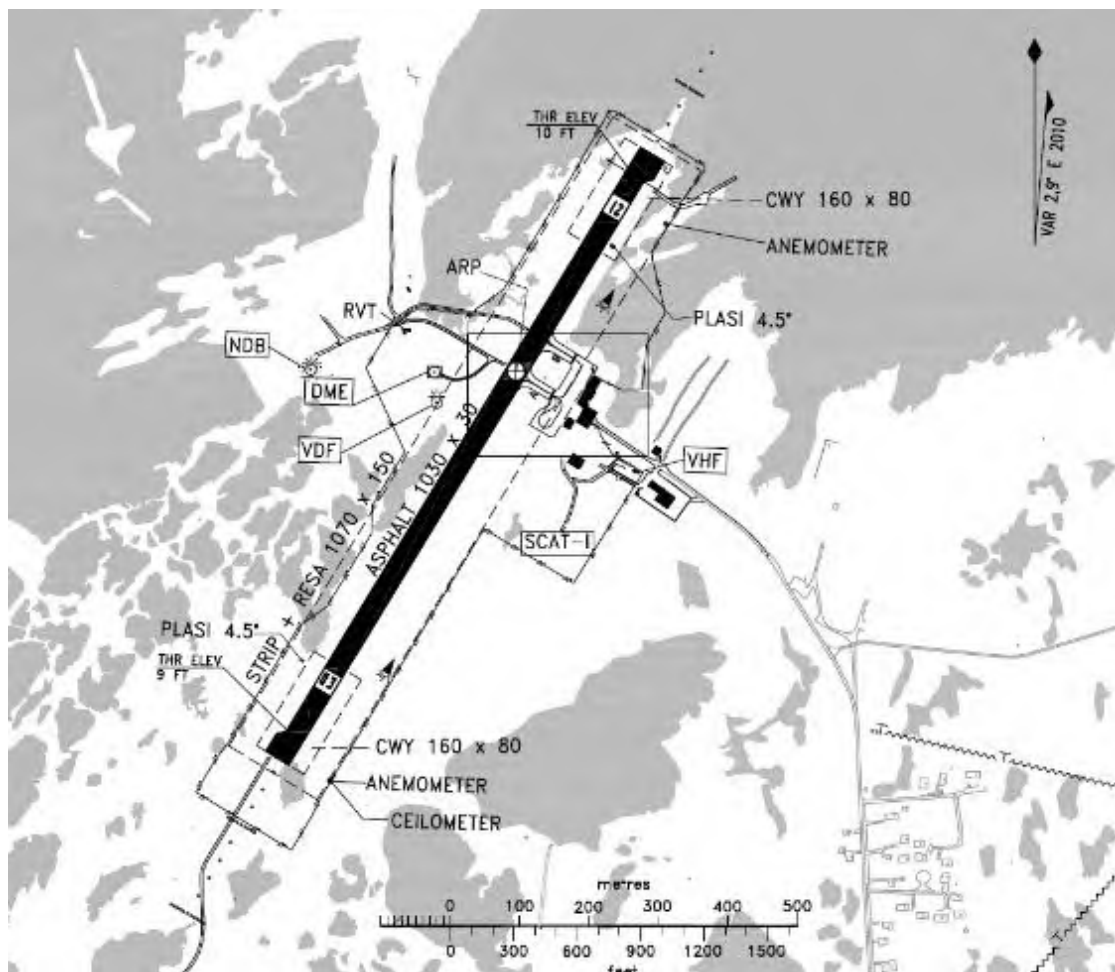


Figure 6: Røst layout

The airport is served twice daily with a de Havilland Canada DHC-8-100 Dash 8 by Widerøe. Flights operate from Bodø Airport via Røst to Leknes Airport before returning to Bodø.

Røst is a small community with approx. 600 inhabitants. Although a small community, the Government want to maintain an aerodrome to provide communication by scheduled traffic but also providing services to ambulance flights, GA, etc. The scheduled routes are operated as a public service obligation on contract with the Ministry of Transport and Communications.

The aerodrome has a small apron with two parking spots for medium sized aircraft, and two direct taxi-way connections to the runway. Backtrack is needed for all departures and most landings. Push-back is not used at Røst.

Bodø (ENBO)

Civil managed airport located on the westernmost tip of the Bodø-peninsula, it shares facilities with the military air force base Bodø Main Air Station which also houses the northern Norway Joint Rescue Coordination Centres (JRCC) equipped with Search and Rescue (SAR)-helicopters. The airport has a 24H operation.

Founding Members

The airport acts as a hub for regional airline flights to Helgeland, Lofoten and Vesterålen, and major domestic destinations such as Oslo–Gardermoen, Tromsø and Trondheim.

The airport has a single runway (07/25), 2,794 by 45 metres (9,167 by 148 ft) runway which runs in a roughly east-west direction. Approx. 50.000 movements per year with a mixture of scheduled jet, turboprop, military jets, scheduled helicopter, SAR helicopters and GA traffic.

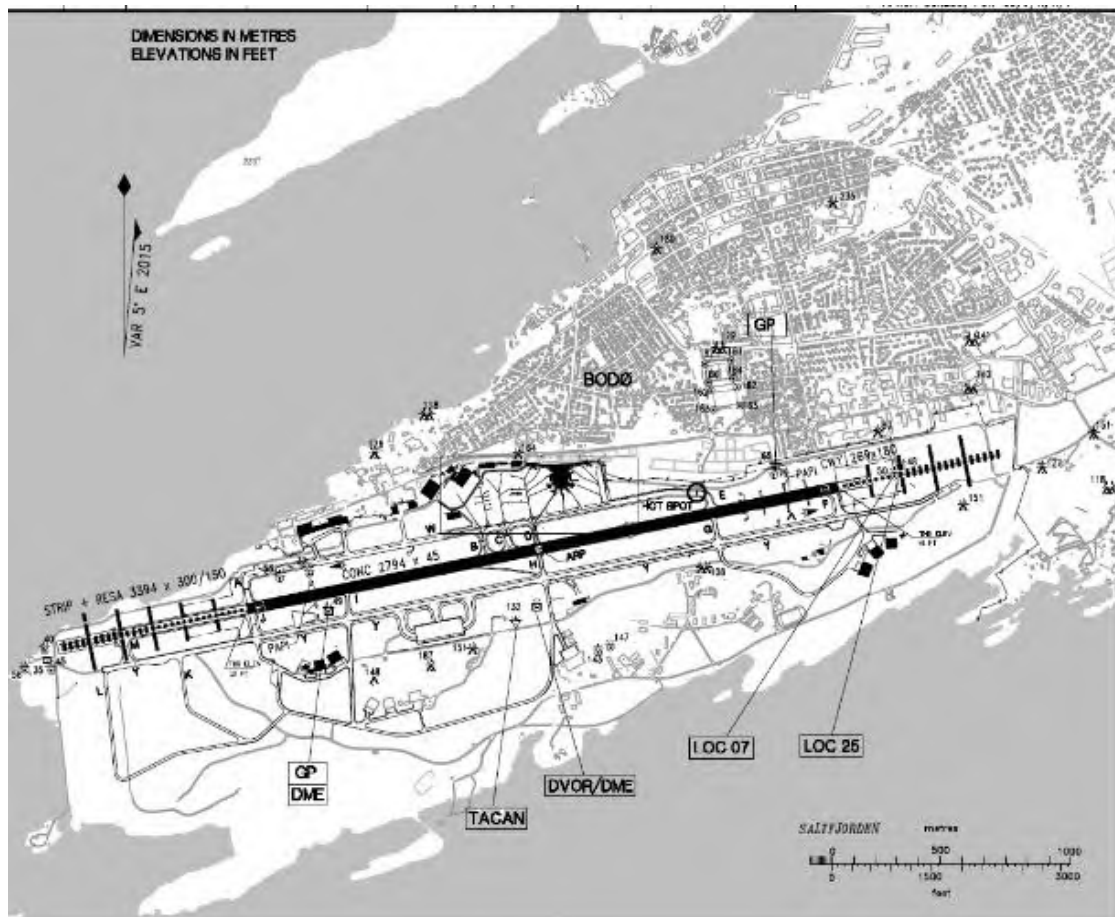


Figure 7: Bodø layout

The aerodrome has a large apron area with numerous aircraft stands and a near full-length taxiway which minimize RWY occupancy time as backtrack is avoided. Push-back is used for all airline operations utilizing stands by the terminal building.

Haugesund (ENHD)

International airport located in the Hauganes peninsula on the island of Karmøy. The airport has various services by regional, domestic and international airlines. There is also extensive helicopter traffic to the oilrigs in the North Sea. The airport is operated by a mixture of jet airlines, commuter turboprops, helicopters and GA traffic.

The airport has a single runway (14/32) with asphalt surface, 2,120 by 45 metres (6,955 ft by 148 ft) runway, which runs in a roughly southeast-northwest direction.

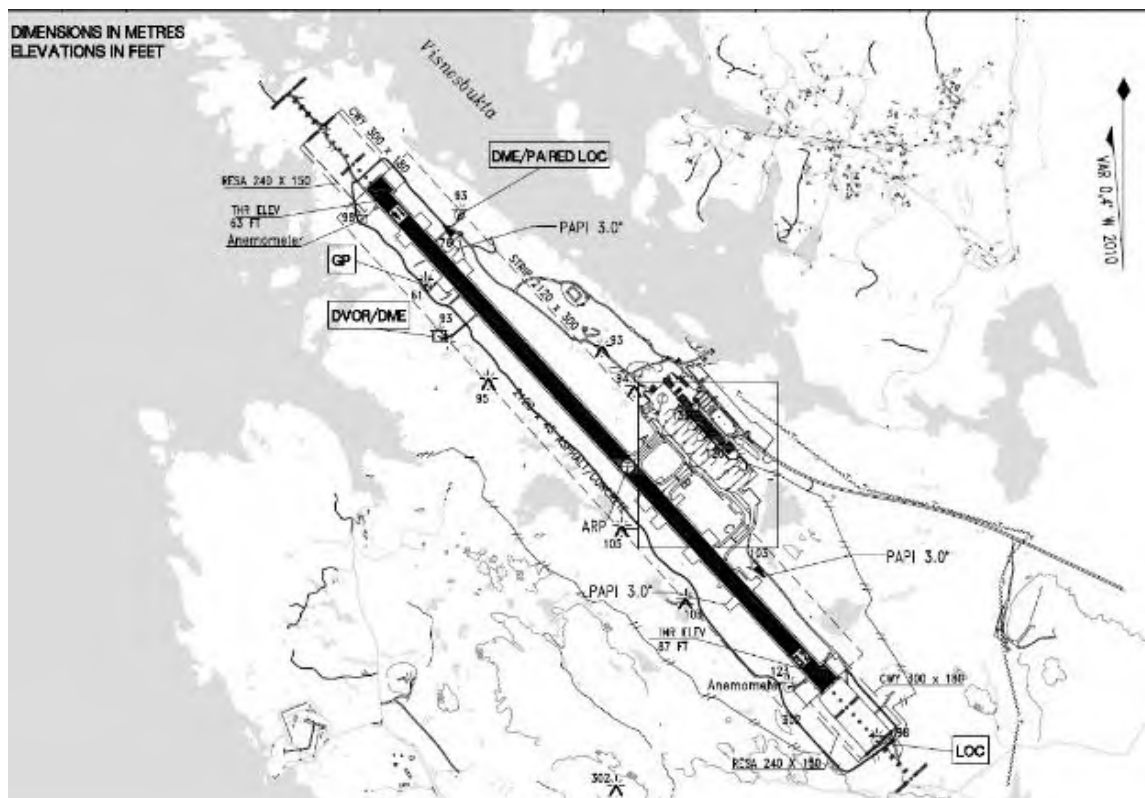


Figure 8: Haugesund layout

The apron for Haugesund has some parking stands by the terminal building which requires push-back and some smaller stands for GA traffic. The apron has three connections/taxiways connecting to the RWY but backtrack is normally required for departures, and also for landings from south-east.

Vardø (ENSS)

Vardø aerodrome, Svartnes is a regional airport in Finnmark county in northern Norway. The airport is Norway's most easterly located airport. The airport is owned and run by Avinor. Traffic is mainly regional scheduled traffic by Widerøe, operating Dash 8-100/Q200. The airport was built during the Second World War for supplies.

In 2019 the airport had 29 724 passengers. The runway measures 1145 x 30 meters.

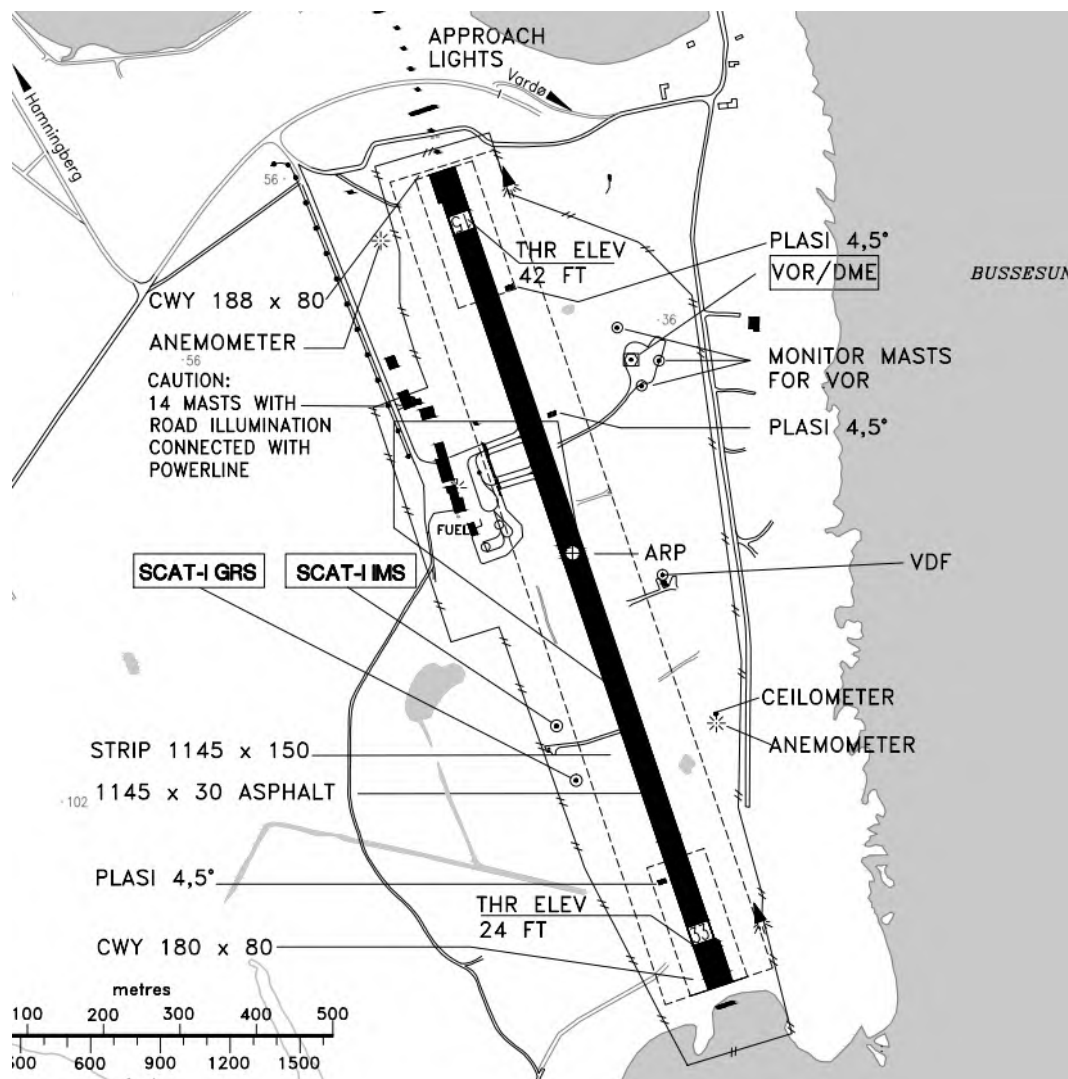


Figure 9: Vardø layout

Vardø is also a smaller aerodrome with a similar layout as Røst. The apron has stands that does not require push-back, and there are two short taxiways connecting to the runway. Backtrack is normally needed for departures and most landings.

C.2.3.3 Validation Platform

Indra provided the INDRA RTWR IBP validation platform. The platform is an extension and improvement of the IBP used for Wave 1.

The validation platform will be composed of the following elements:

Simulator

A BEST simulator from Micro Nav produce traffic data in the form of flight plans, surveillance information and MET information which was fed to and used by the rest of the platform.

Founding Members

MRTM Visual Presentation

The Out of the Window part was provided through the Micro Nav BEST virtual 3D TWR simulation.

MRTM Controller Working Position

The CWP in the MRTM is the Indra InNOVA and GAREX Tower system which provided:

- Air Surveillance
- Meteorological information
- Flight plan information
- Multiple airport allocation and layout
- ATCO Planning tools
- Approach tools
- GAREX Voice Communication System

In addition, there was a dedicated Indra Supervisor position with the following:

- Supervisor Planning Tools
- RTC Overview Tool

The layout of the validation platform was as follows:

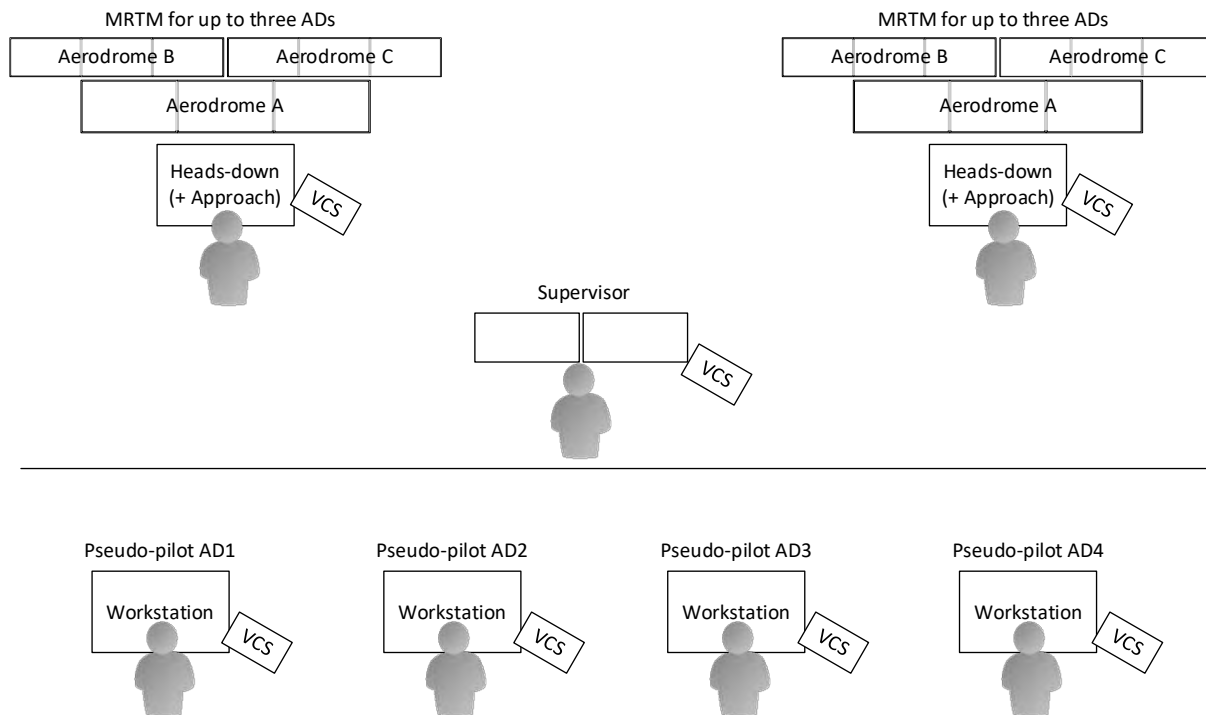


Figure 10: Validation platform layout

Each MRTM contains a Heads-Up display providing the OTW view, and a Heads-Down Display (HDD) providing the Tower tools such as surveillance, Electronic Flight Strips, MET info, etc. In addition, there is a Voice Communication System (VCS) panel for each MRTM.

The Supervisor position contains a dual 32" monitor setup with the supervisor overview and planning tools.



Figure 11: ATCO operates an MRTM with three aerodromes

C.2.4 Summary of Validation Exercise EXE-2.3-INDRA Validation Assumptions

| Identifier | Title | Description | Justification | Impact on Assessment |
|-------------------------------|---------------------|---|---|----------------------|
| ASM-EXE-PJ05-W2-35-V3-2.3.1-1 | Coupled Frequencies | Frequencies of the three airports will be coupled to one, resulting no switching needed by the ATCO to select them. | The traffic can be managed in a safe and adequate manner. | High |
| | | | | |

Table 16: Validation Assumptions overview

C.3 Deviation from the planned activities

The results are based on total of 4 ATCOs currently working in tower units. However, since one ATCO had to cancel his participation to the second validation day, her/his contribution to the findings is limited to the two first runs and the associated post-run questionnaires and debriefings. Data from the final questionnaire are based on 3 ATCOs instead of 4.

C.4 Validation Exercise EXE-2.3.1-INDRA/AVINOR Results

C.4.1 ATCO - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Situation awareness could not always be maintained at a satisfying level when the traffic level was too high. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs could not always prioritize their tasks when the traffic level was too high. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | The user interface generally supported a sufficient level of situation awareness. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | ATCOs could maintain an adequate level of SA despite having to divide their attention to several airports with different procedures and characteristics. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | The ATCOs HMI generally supported an acceptable level of team situation awareness. The supervisors’ HMI did not support an acceptable level of awareness of the ATCOs workload and traffic situation at the MRTMs. | Partially OK |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The workload level was always assessed as tolerable by ATCOs but was not always satisfactory, sometimes resulting in reduced spare capacity. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | All participants confirmed that the amount of communication and time on the frequency were acceptable. | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with | All ATCOs confirmed that Operating methods when providing ATS services to multiple aerodromes were efficient under both normal and abnormal operating conditions. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|---|-----------------------------|
| | | | a flexible allocation of aerodromes between MRTMs | | |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | All ATCOs agreed that their roles and responsibilities when providing ATS to multiple aerodromes with flexible allocation were clear and acceptable, on condition that clear rules and procedures were established to prevent overload on the position. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | All ATCOs confirmed the feasibility and acceptability of providing ATS services to the assigned number of aerodromes, on condition that clear rules and procedures were established to prevent overload on the position. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | All ATCOs confirmed that the phraseology when providing ATS services to multiple aerodromes was efficient under both normal and abnormal operating conditions. | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The HMIs did not fully support ATCOs and SUP teamwork because information was not sufficient to ensure a common shared picture of the situation at the MRTMs. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | N/A | |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs assessed that all required information were easy to access and presented in an effective way. Nevertheless, the need to optimize the “timeline” tool and the presentation of wind information were raised. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | ATCOs confirm the usability of input devices and HMI controls. Nevertheless, the need to optimize the HMI workflow of the electronic flight strips was raised. | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---------------------------|----------------------------|--------------------------------|---|---|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | N/A | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The human machine interface sometimes increased the potential for human error, i.e., action error on flight status update, non-detection of wind variation. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | ATCOs could not always rely on the traffic forecast tool to anticipate the traffic sequence or assess the future traffic load. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | ATCOs confirmed that there was generally no confusion about which aerodromes were displayed on which display. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | All ATCOs confirmed that there was no confusion about which aerodrome will be transferred between the MRTMs. | OK |
| HUMAN PERFORMANCE – TRUST | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|--|---|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | N/A | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | N/A | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | N/A | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | All ATCOs trusted the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | OK |
| HUMAN PERFORMANCE – TRANSITION FACTORS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Some knowledge and skills needs could be identified for ATCOs. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Some training needs could be identified for ATCOs. | Partially OK |
| SAFETY | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | ATCOs were able to identify and solve potential conflicts in a timely manner. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> Unstable approaches Bird strikes Aircraft not vacating RWY as expected | <p>ATCOs did not always timely detect runway incursions by unauthorized vehicles.</p> <p>(However the analysis revealed contributing factors that were not directly related to multiple tower operations (cf. detailed results of CRT-PJ05-W2-35-V3-VALP-S04.020, in section C.4.2.7.1))</p> | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | ATCO were generally able to distinguish with which aircraft, vehicle at which aerodrome they were communicating with. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | N/A | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | It was not always possible for ATCOs to foresee traffic at his/her MRTM at short term in order to avoid overloads | Partially OK |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | All ATCOs were able to identify and efficiently manage an aircraft emergency by means of a “split” and with the support of the supervisor. | OK |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage | CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g): <ul style="list-style-type: none"> • Communication • Visualisation system | N/A | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| | degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none"> Other airport systems / infrastructure | | |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> Communication Visualisation system | All ATCOs were able to detect and recover from a technical failure affecting the visualisation of an aerodrome, by means of moving to another MRTM and with the support of the supervisor. | OK |
| CAPACITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | The capacity threshold of 8 simultaneous movements (where VFR would count as 1,5) corresponded to the maximum controller capacity during the validation. However other operational tasks as well as the need to have spare capacity/buffer need to be considered. | Partially OK |
| COST EFFICIENCY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to | ATCOs could provide ATS to 3 aerodromes at the same time. The required staff will also depend on the need to have spare capacity | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|----------------------|--|---|-----------------------------|
| | | | the limit on endorsements out of a group of 4 aerodromes | and resources available to dynamically change the allocation of aerodromes. | |

Table 17: ATCO - Validation Results for Exercise 1

C.4.2 ATCO - Analysis of Exercise Results per Validation objective

The results are based on total of 4 ATCOs currently working in tower units. However, since one ATCO had to cancel his participation to the second validation day, her/his contribution to the findings is limited to the two first runs and the associated post-run questionnaires and debriefings. Data from the final questionnaire are based on 3 ATCOs instead of 4.

The analysis of exercise results for each criteria is based on the data collected from the following data collection methods: observations, debriefings and questionnaires.

Note: In the bar charts showing responses to the final questionnaire, the number of total responses can sometimes be below 3 if the question was considered as not possible to assess or not applicable by ATCO(s).

C.4.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

C.4.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Situation awareness could not always be maintained at a satisfying level when the traffic level was too high. | Partially OK |

ATCOs have self-rated the Situation Awareness (SA) they have experienced during each run using the China Lakes SA Scale shown below:

Please rate Situational Awareness (SA) you experienced during the run

Was it possible to perform the task?

No

Yes

Was your level of SA acceptable?

No

Yes

Was your level of SA satisfactory?

No

Yes

SA experienced during the run

1 My SA with respect to the task was far too low. I could not perform the task because I did not possess the necessary information.

2 My SA with respect to the task was very low. I was unaware of almost all of the information required to perform the task effectively.

3 My SA with respect to the task was low. I was unaware of most of the information required to perform the task effectively.

4 My SA with respect to the task was low. I was unaware of about half of the information required to perform the task effectively.

5 My SA with respect to the task was reduced. I was unaware of some of the important information required to perform the task effectively.

6 My SA with respect to the task was insufficient. I was not aware of all the information required to perform the task effectively.

7 My SA with respect to the task was not complete. I was able to perform the task, but not satisfactorily.

8 My SA with respect to the task was good. I was able to perform the task well most of the time.

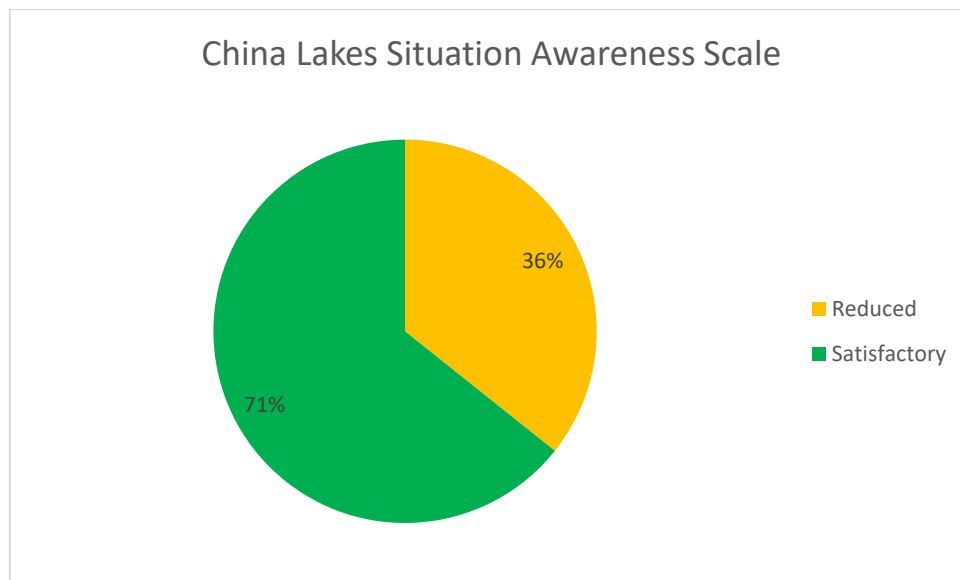
9 My SA with respect to the task was very good. I was able to perform the task well all of the time.

10 My SA with respect to the task was excellent. I was able to perform the task extremely well all of the time.

The China Lakes is a 10-points rating scale where 1 represents the lowest possible situation awareness and 10 the highest possible situation awareness.

As indicated by the colour coding on the scale, the rating scale can also be subdivided into three main categories: “Satisfactory” (8-10), “Not satisfactory / Reduced” (5-7) and “Not acceptable” (1-4).

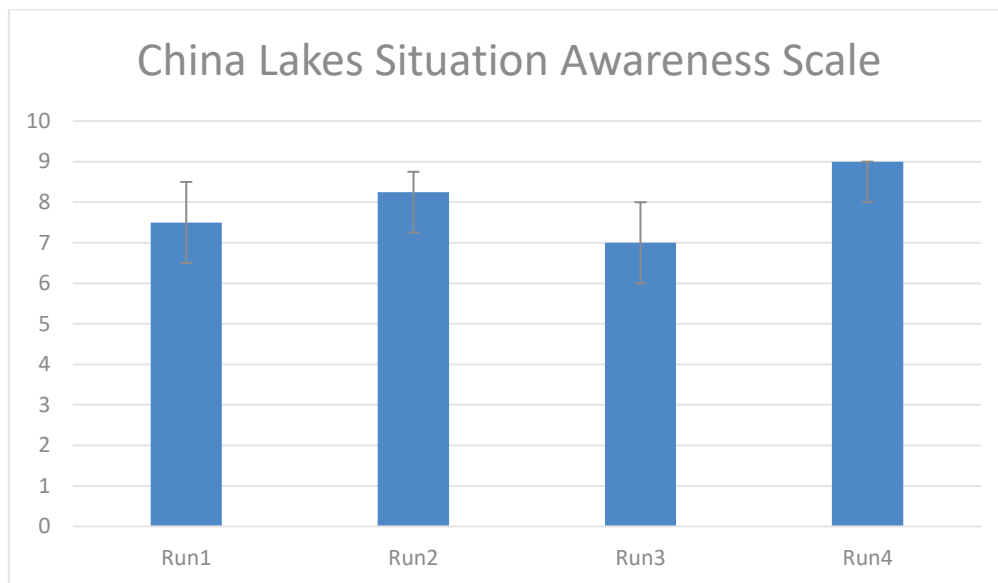
The pie chart below represents the percentage of responses for each response category, for all runs and participants combined.



Percentage of situation awareness self-ratings per response category (all runs, all participants combined).

As indicated by the pie chart, the workload was rated by ATCOs as “Satisfactory” in 71% of all runs and “Not satisfactory / Reduced” in 36% of all runs. Situation awareness was never rated by ATCOs as “Not acceptable”.

The next chart shows the average rating on the China Lakes 10-points scale for each run.



Mean (self-rated) situation awareness per run (with standard deviation).

Situation awareness for Run 1 and Run 3 was, in average, experienced as “not complete”, while situation awareness for Run 3 and Run 4 was, in average, experienced as “satisfactory”.

Depending on the runs, several factors have contributed to decreasing situation awareness:

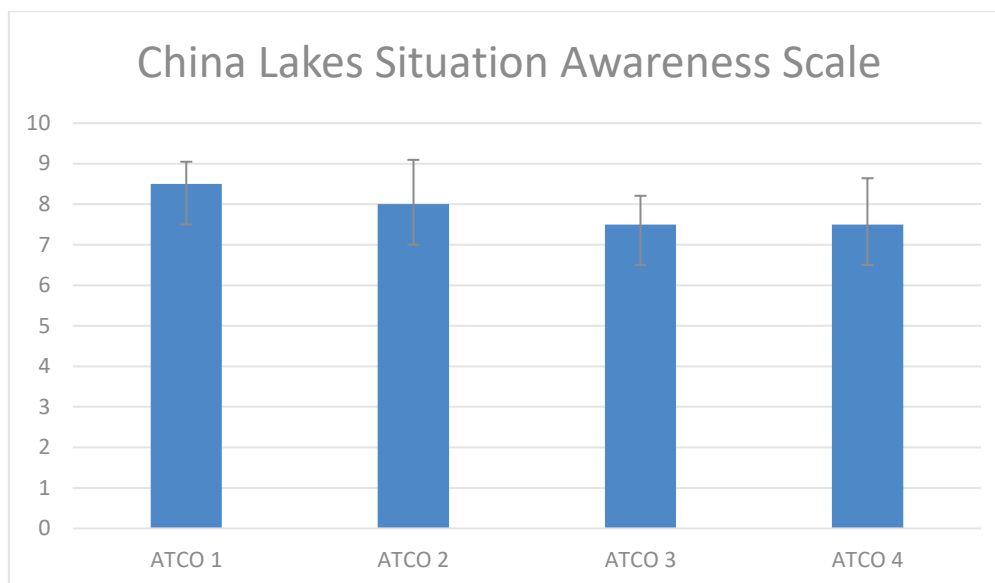
- Run1: Lower familiarity with the system, the aerodrome characteristics and handling simultaneous traffic on different aerodromes.
- Run 3: A scenario with an unexpected handover of aerodrome where ATCOs had to immediately take over a third aerodrome with ongoing traffic movements while already handling simultaneous traffic on two aerodromes and soon after moving to another position because of a technical problem.

In Run 2, even though the workload was experienced as too high before having the possibility to “split” (see workload objective findings), ATCOs reported that they were able to maintain a good level of situation awareness.

The higher average level of situation awareness in Run 4 can be explained by the combination of:

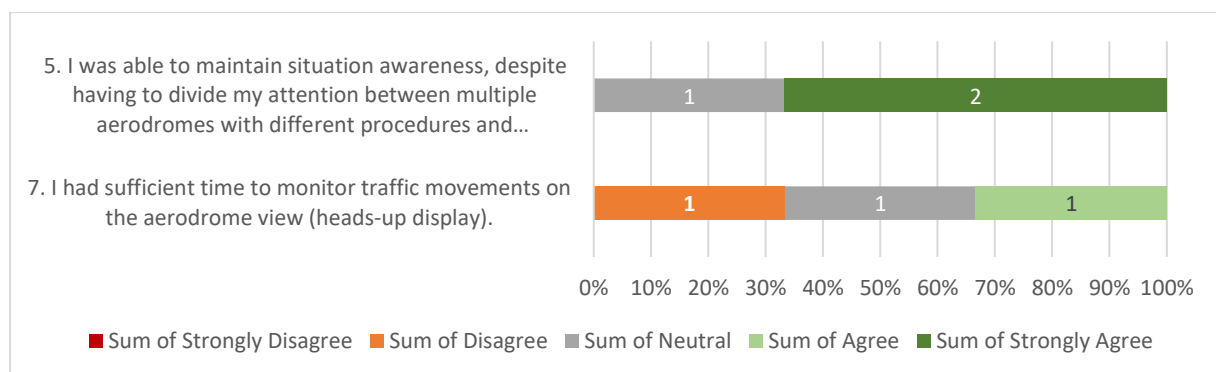
- A higher familiarity of ATCOs with the system, the aerodrome characteristics and handling simultaneous traffic on different aerodromes.
- A scenario with less complex traffic situations: less VFR movements, less simultaneous traffic on the different aerodromes.
- The efficient management of an emergency situation on one aerodrome with the possibility to hand over the two other aerodromes to another position (split).

The chart below indicates the average rating on the China Lakes 10-points scale for each participant.



Mean (self-rated) situation awareness per participant (with standard deviation).

Results indicate individual differences in how ATCOs experienced situation awareness. For example, one participant always rated the level of situation awareness as “satisfactory” while the other participants rated situation awareness as “not complete” for the runs where the traffic level was higher.

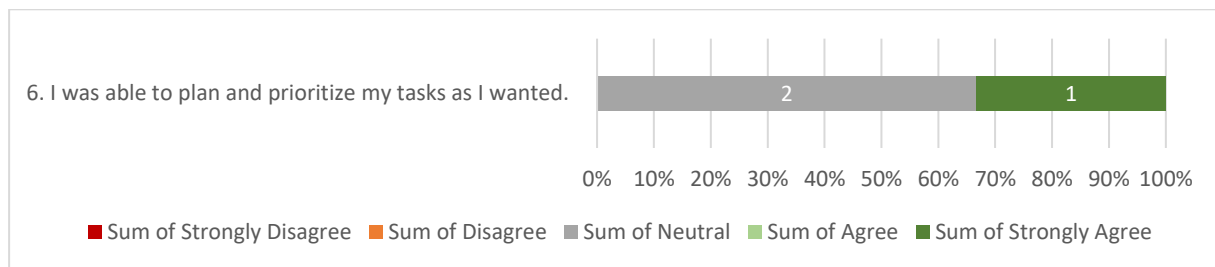


Participants response to the criteria related statement(s) in the final questionnaire.

One ATCO stated in the final questionnaire that the level of situation awareness was highly dependent on the level of simultaneous traffic to handle and that situation awareness on several aerodromes became harder to maintain when traffic level was too high.

One ATCO reported in the final questionnaire that she/he did not have sufficient time to look up and monitor the aerodrome view (located on the heads-up display) because her/his attention was dedicated to look down at the heads-down screen where all information and tools were displayed.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs could not always prioritize their tasks when the traffic level was too high. | Partially OK |



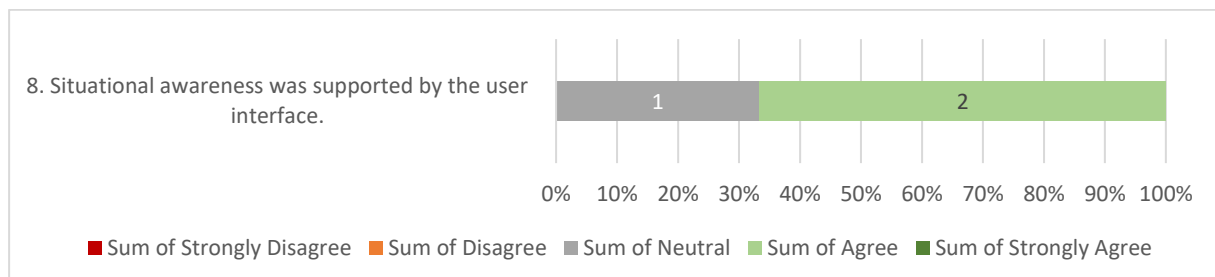
Participants response to the criteria related statement(s) in the final questionnaire.

The neutral responses reflect the fact that task prioritization could be easily achieved when traffic level was acceptable but was more difficult when traffic level was too high.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | The user interface generally supported a sufficient level of situation awareness. | OK |

The HMI generally supported the ATCOs situation awareness. Some areas of improvements in design were identified. All issues are not reported here in detail because they were not always related to the concept of multiple operations and dynamic allocation of aerodromes.

One difficulty impacting SA and associated to dynamic allocation of aerodromes was both observed and reported: when handing over (i.e., splitting), taking over (i.e., merging) or swapping aerodrome(s) on the same position, the HMI of the heads-down display did not fully support SA because the system did not automatically reposition all HMIs elements in the correct place to follow the new aerodrome display slot on the screen.

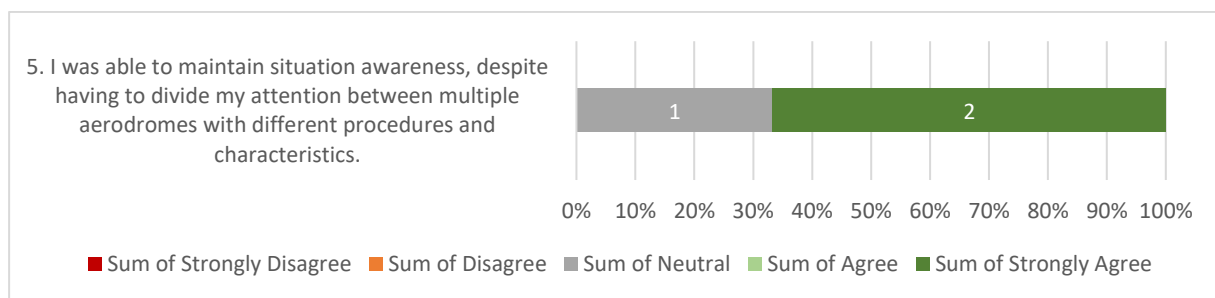


Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | ATCOs could maintain an adequate level of SA despite having to divide their attention to several airports with different procedures and characteristics. | OK |

After the first runs, ATCOs were familiar with the different procedures (e.g., with/without back tracking) and aerodrome characteristics.

In the first run, All ATCOs experienced difficulties identifying runway directions on the different aerodromes. This was due to both unfamiliarity with aerodromes and absence of overlaid information aids, such as compass and/or RWY directions, on the heads-up display aerodrome views.

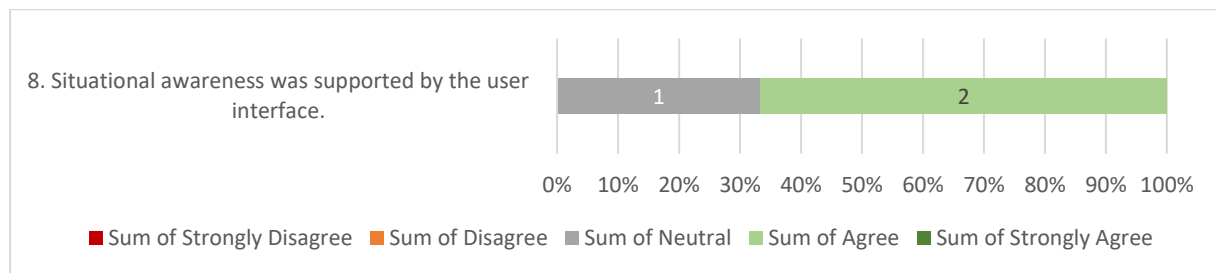


Participants response to the criteria related statement(s) in the final questionnaire.

C.4.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

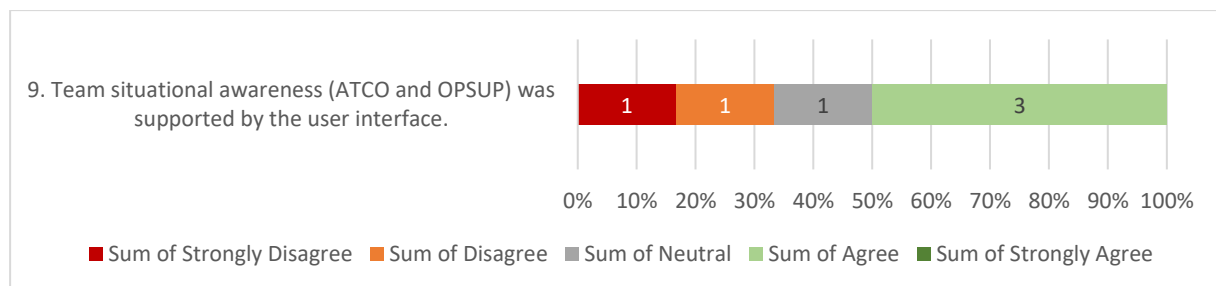
| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|--|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The ATCOs HMI generally supported an acceptable level of team situation awareness.</p> <p>The supervisors' HMI did not support an acceptable level of awareness of the ATCOs workload and traffic situation at the MRTMs.</p> | Partially OK |

The ATCOs HMI generally supported an acceptable level of team situation awareness.



ATCOs response to the criteria related statement(s) in the final questionnaire.

The supervisors' HMI did not support an acceptable level of team situation awareness because the information about traffic situation and workload at MRTMs was not sufficient and not accurate enough.



Supervisors' response to the criteria related statement(s) in the final questionnaire.

C.4.2.2 HUMAN PERFORMANCE – WORKLOAD

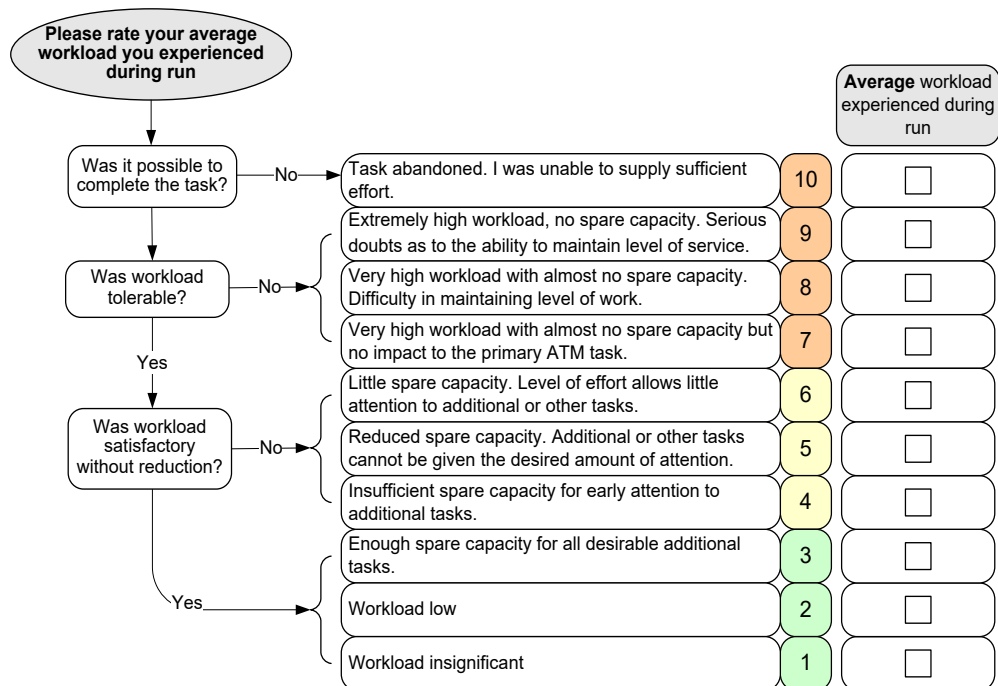
C.4.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

OBJ-PJ05-W2-35-V3-VALP-H04

Assess ATCO workload when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The workload level was always assessed as tolerable by ATCOs but was not always satisfactory, sometimes resulting in reduced spare capacity. | Partially OK |

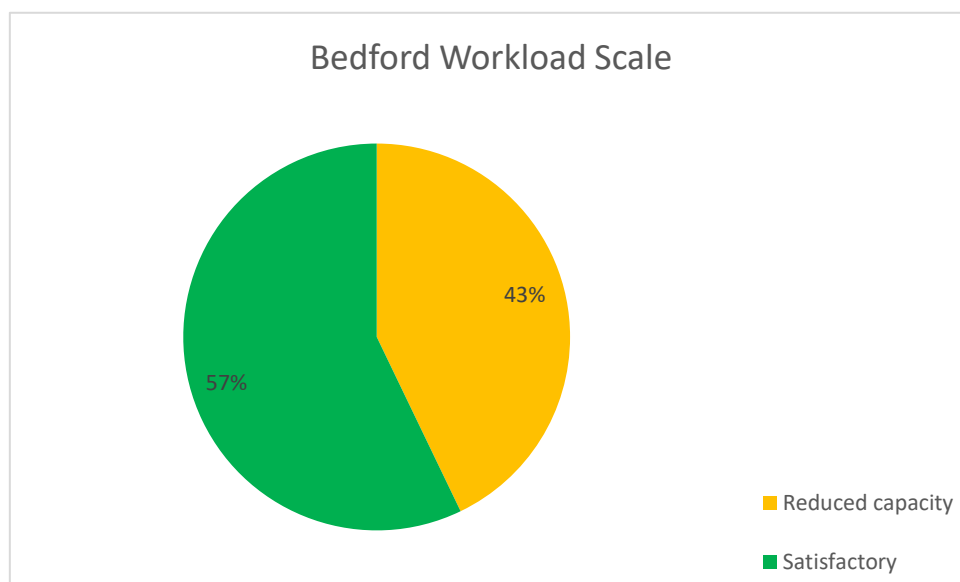
ATCOs have self-rated the average workload experienced during each run by use of the Bedford Workload Scale shown below:



The Bedford is a 10-points rating scale where 1 represents the lowest possible workload and 10 the highest possible workload.

As indicated by the colour coding on the scale, the rating scale can also be subdivided into three main categories: “Satisfactory” (1-3), “Not satisfactory / Reduced capacity” (4-6) and “Not tolerable” (7-10).

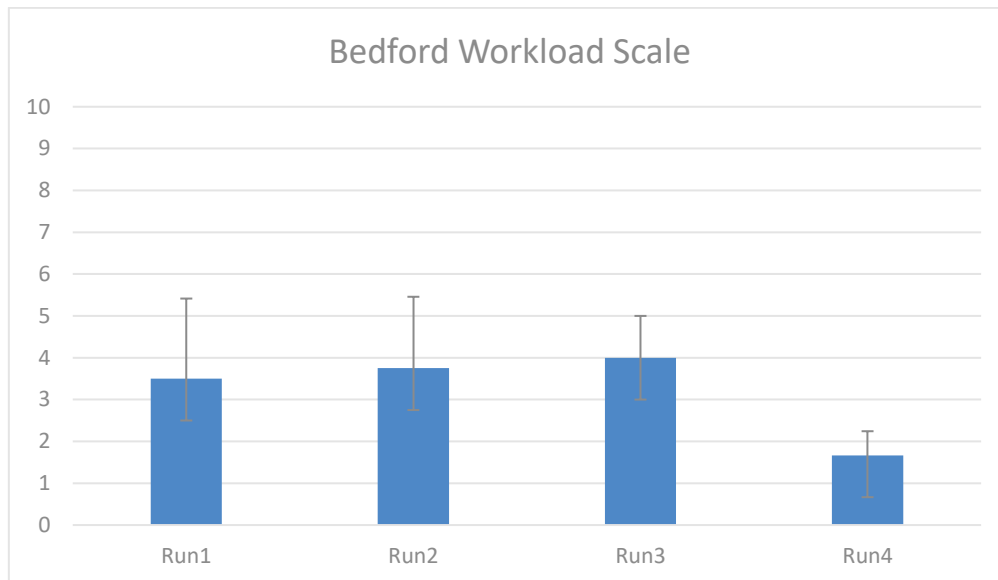
The pie chart below represents the percentage of response falling into each response category, for all runs and all participants combined.



Percentage of workload self-ratings per response category (all runs, all participants combined).

As indicated by the pie chart, the workload was rated by ATCOs as “Satisfactory” in 57% of all runs and as “Not satisfactory / Reduced capacity” in 43% of all runs. Workload was never rated by ATCOs as “Not tolerable”.

The next chart presents the average rating on the Bedford 10-points scale for each run.



Mean (self-rated) workload per run (with standard deviation).

Workload for Run 1, 2 and 3 was, in average, experienced as leading to insufficient spare capacity, while workload for Run 4 was, in average, experienced as satisfactory.

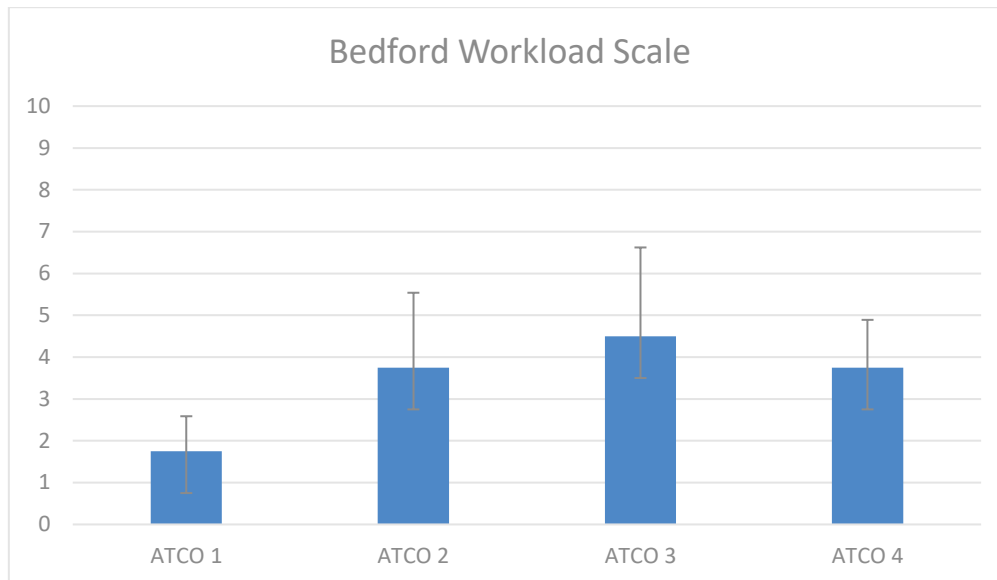
Depending on the run, several factors have contributed to a higher workload:

- Run1: Lower familiarity with the system, the aerodrome characteristics and handling simultaneous traffic on different aerodromes.
- Run 2: The higher number of total and simultaneous movements on three aerodromes before having the possibility to “split”, i.e., to transfer one aerodrome to another position.
- Run 3: A scenario with an unexpected handover of aerodrome where ATCOs had to immediately take over a third aerodrome with ongoing traffic movements while already handling simultaneous traffic on two aerodromes and soon after moving to another position because of a technical problem.

The lower average workload in Run 4 can be explained by the combination of:

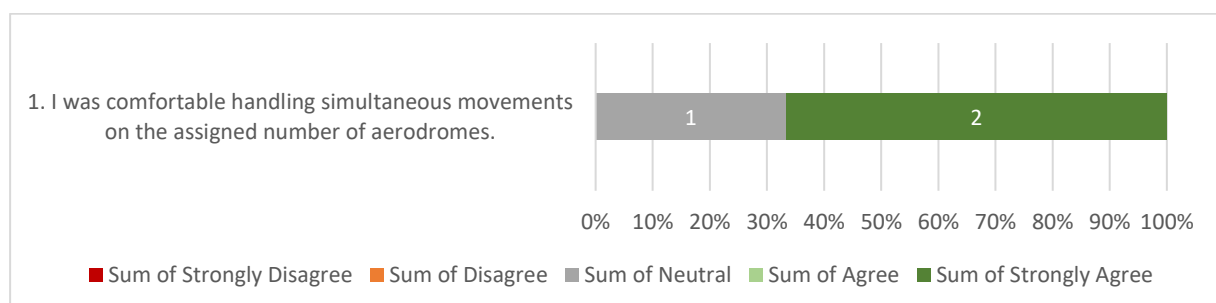
- A higher familiarity of ATCOs with the system (Run 4 was following Run 1, 2 and 3), the aerodrome characteristics and handling simultaneous traffic on different aerodromes.
- A scenario with less complex traffic situations: less VFR movements, less simultaneous traffic on the different aerodromes.
- The efficient management of an emergency situation on one aerodrome with the possibility to hand over the two other aerodromes to another position (split).

The chart below indicates the average rating on the Bedford 10-points scale for each participant.



Mean (self-rated) workload per participant (with standard deviation).

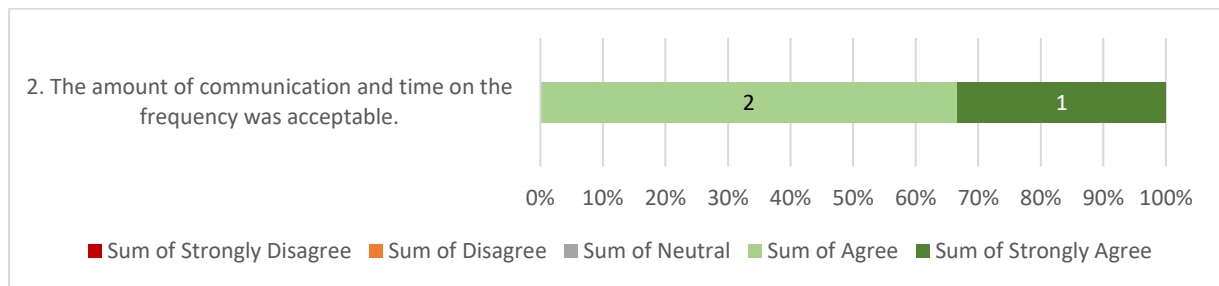
Results indicate individual differences in how ATCOs experienced workload. For example, one participant always found the level of workload as satisfactory while another participant reported reduced capacity in three out of the four runs.



Participants response to the criteria related statement(s) in the final questionnaire.

The neutral response indicates that the level of comfort to handle simultaneous movements was dependent on the amount of simultaneous traffic.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | All participants confirmed that the amount of communication and time on the frequency were acceptable. | OK |



Participants response to the criteria related statement(s) in the final questionnaire.

C.4.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

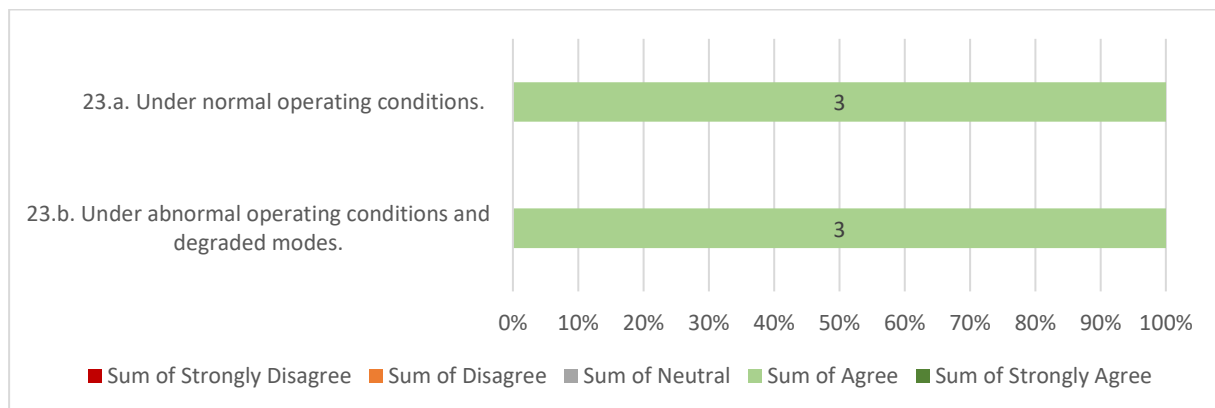
C.4.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | All ATCOs confirmed that Operating methods when providing ATS services to multiple aerodromes were efficient under both normal and abnormal operating conditions. | OK |

23. Operating methods when providing ATS services to multiple aerodromes were efficient (i.e. switching focus between aerodromes, dynamic allocation of aerodromes with split/merge, phraseology, coupling of frequency).



Participants response to the criteria related statement(s) in the final questionnaire.

All ATCOs confirmed that Operating methods when providing ATS services to multiple aerodromes were efficient under both normal and abnormal operating conditions.

The operating methods consisting in merging aerodromes on the same position (i.e., taking over a new aerodrome) or splitting aerodromes into different position (i.e., handing over aerodrome to another

position) could be applied satisfactorily to adapt to the traffic load and to manage abnormal situations during the runs.

When merging a new aerodrome on a position, it is important to consider both the capacity according to the traffic level but also according to the traffic situation to avoid taking over a new aerodrome at a bad time (e.g., in the middle of a critical flight phase) and maintain situation awareness.

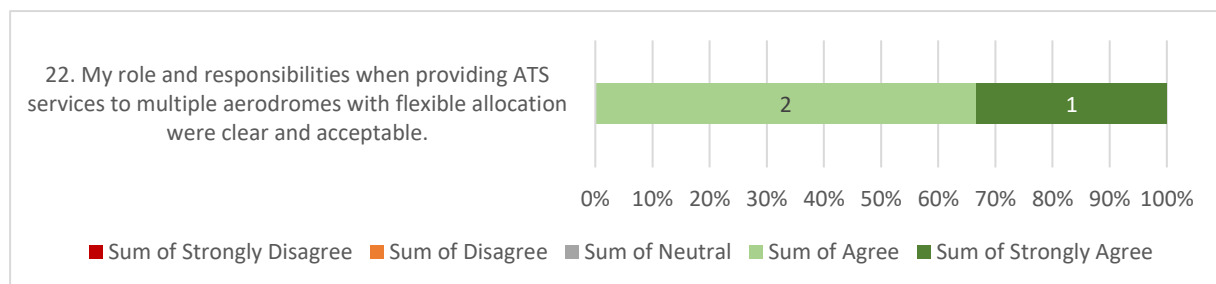
Clear procedures are also needed to ensure that traffic can be put on hold when the traffic level becomes temporarily too high on a position or when full attention is required on one of the aerodromes. Pilot awareness of the multiple tower operation context is also an important factor to ensure that these procedures can be supported by efficient air-ground cooperation.

C.4.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

OBJ-PJ05-W2-35-V3-VALP-H07

Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | All ATCOs agreed that their roles and responsibilities when providing ATS to multiple aerodromes with flexible allocation were clear and acceptable, on condition that clear rules and procedures were established to prevent overload on the position. | OK |



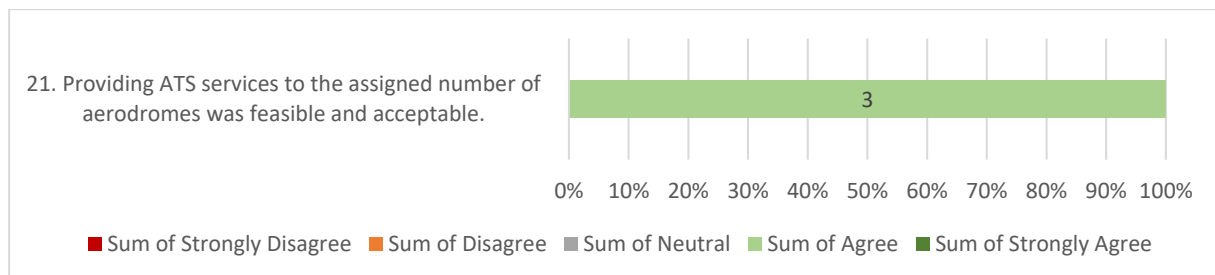
Participants response to the criteria related statement(s) in the final questionnaire.

All ATCOs agreed that their roles and responsibilities when providing ATS to multiple aerodromes with flexible allocation were clear and acceptable.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | All ATCOs confirmed the feasibility and acceptability of providing ATS services to the assigned number of aerodromes, on condition that clear rules and procedures were established to prevent overload on the position. | OK |

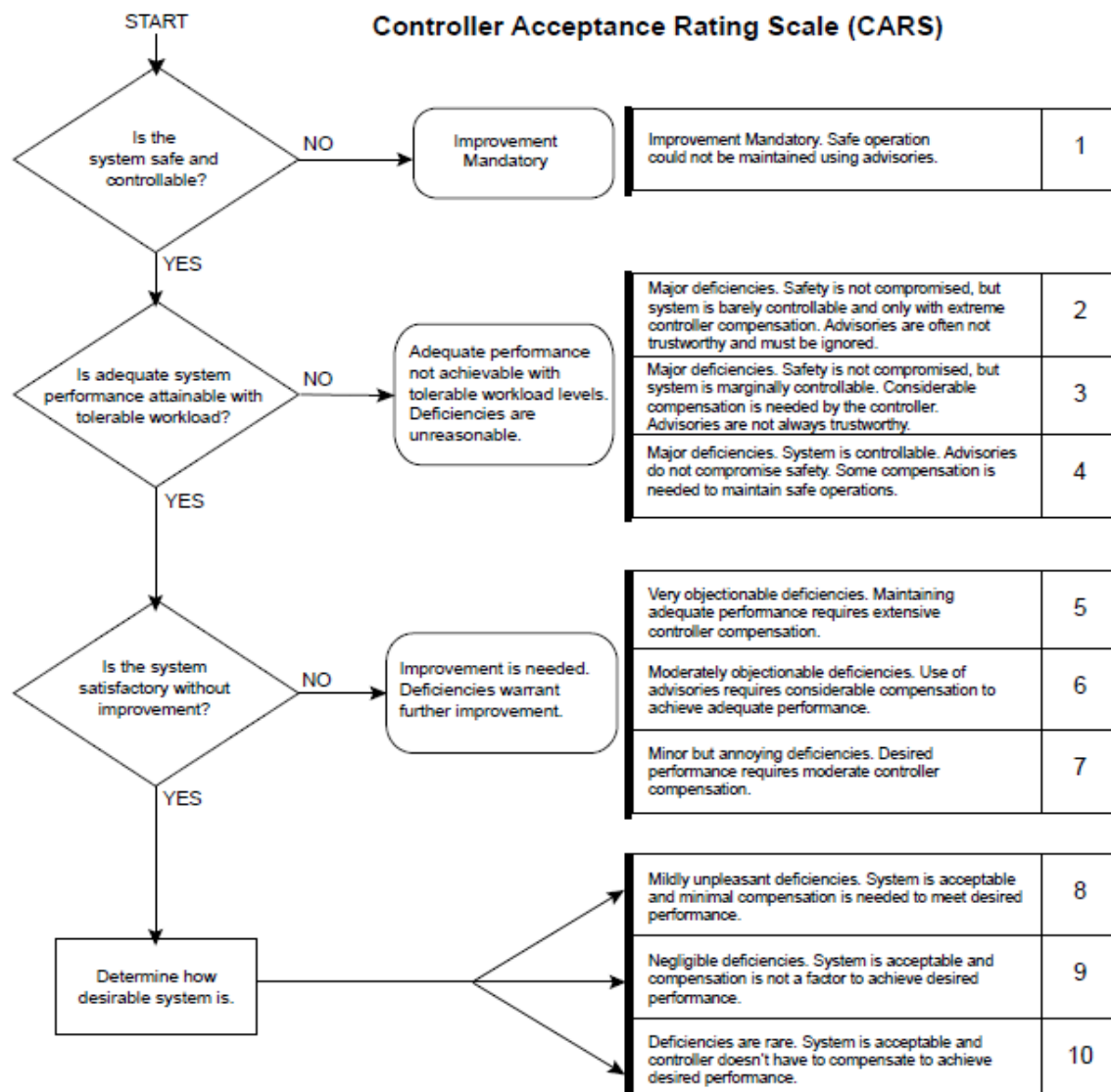
ATCOs raised the importance of setting clear rules regarding the maximum capacity at MRTMs when operating two or three aerodromes simultaneously. These rules should define the maximum number of movements that can be handled simultaneously but also take into account the weather conditions and type of operations (e.g., continuous need for runway sweeping in heavy snow conditions).

These rules should for example clearly define when there should be a split of aerodromes and should ensure that ATCOs have sufficient capacity for monitoring tasks such as scanning the runway or following landing and take-off.



Participants response to the criteria related statement(s) in the final questionnaire.

ATCOs also rated the acceptability of the system using the Controller Acceptance Rating Scale (CARS) illustrated below:



Two ATCOs gave a rate of 8 on the scale, corresponding to a system considered as acceptable with “mildly unpleasant deficiencies” and “minimal compensation” needed to meet desired performance.

One ATCOs gave a rate of 6, considering that improvements were needed. The improvements needed mainly concerned the electronic flight strips workflow that sometimes required more clicks than necessary.

C.4.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|---|---|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating | All ATCOs confirmed that the phraseology when providing ATS services to multiple aerodromes was | Partially OK |

OBJ-PJ05-W2-35-V3-VALP-H08**Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes**

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------------------|--|--------|
| | conditions and degraded modes | efficient under both normal and abnormal operating conditions. | |

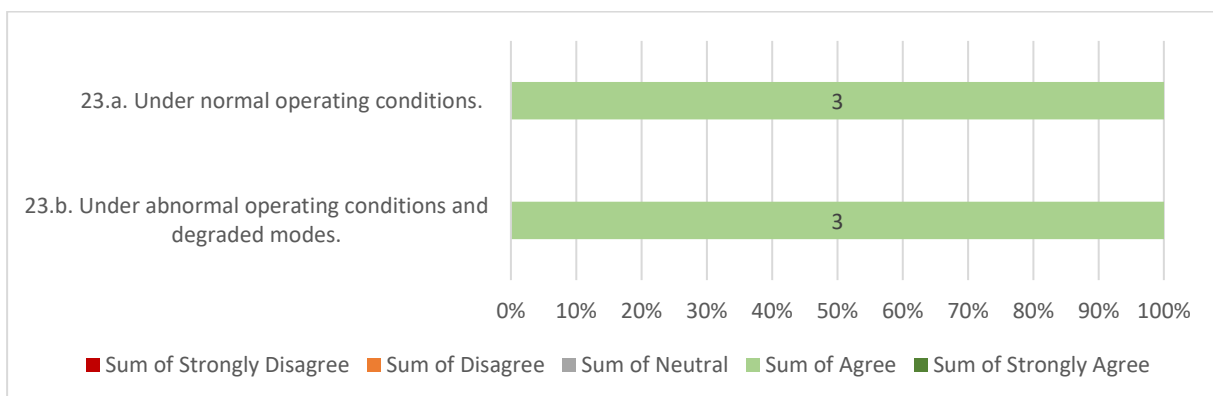
All ATCOs confirmed that the phraseology when providing ATS services to multiple aerodromes was efficient under both normal and abnormal operating conditions.

A method, consisting of systematically including the aerodrome name in the callsign of vehicles during communications, was used to avoid confusion when a same vehicle callsign number was in use on two different aerodromes.

The aerodrome name was easy to add in the phraseology and there was no confusion during the runs in the communication with vehicle that had the same callsign number, although it was mentioned once during debriefings that using different numbers from one aerodrome to another would be preferable to avoid any risk of confusion.

It should be noted that aerodrome name was not used by ATCOs in the communication to pilots since all runway designators differed from one aerodrome to another, which limited the risk of confusion. However, since air frequency were coupled, it was discussed that adding aerodrome name for take-off and landing clearances could be a need to ensure a clear distinction for pilots between communications at the aerodrome they are operating and communications at the other aerodromes.

23. Operating methods when providing ATS services to multiple aerodromes were efficient (i.e., switching focus between aerodromes, dynamic allocation of aerodromes with split/merge, **phraseology**, coupling of frequency).



Participants response to the criteria related statement(s) in the final questionnaire.

C.4.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

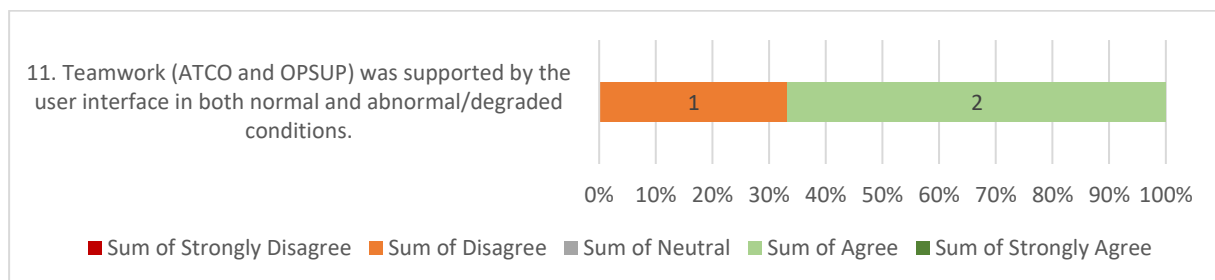
C.4.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

Assess that human-machine interface supports the team in carrying out their tasks

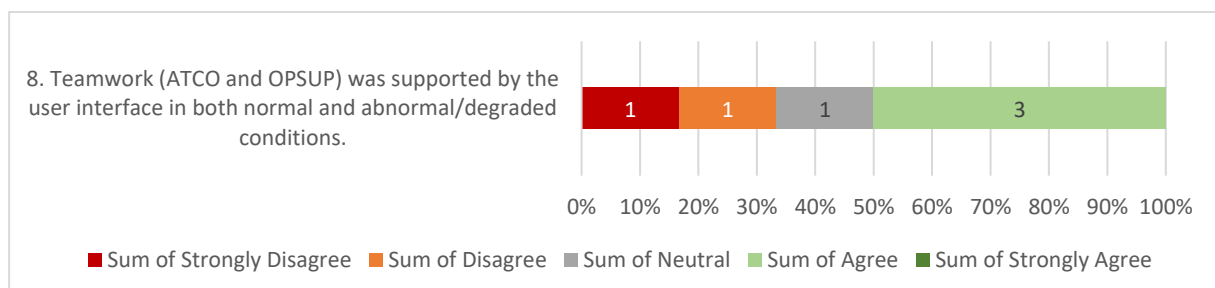
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The HMIs did not fully support ATCOs and SUP teamwork because information was not sufficient to ensure a common shared picture of the situation at the MRTMs. | |

The need for clearer visual indication of the transfer status when merging or splitting aerodromes was mentioned as important.



ATCOs response to the criteria related statement(s) in the final questionnaire.

Supervisors missed the possibility to mirror when needed a given MRTM's HMI such as strip bays and out of the window view to be able to understand or monitor the current situation for the ATCO without having to move to the position in order to keep access to their own tools and maintain supervision on the other MRTM/aerodromes.



Supervisors response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | N/A | |

C.4.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs assessed that all required information were easy to access and presented in an effective way. Nevertheless, the need to optimize the “timeline” tool and the presentation of wind information were raised. | Partially OK |

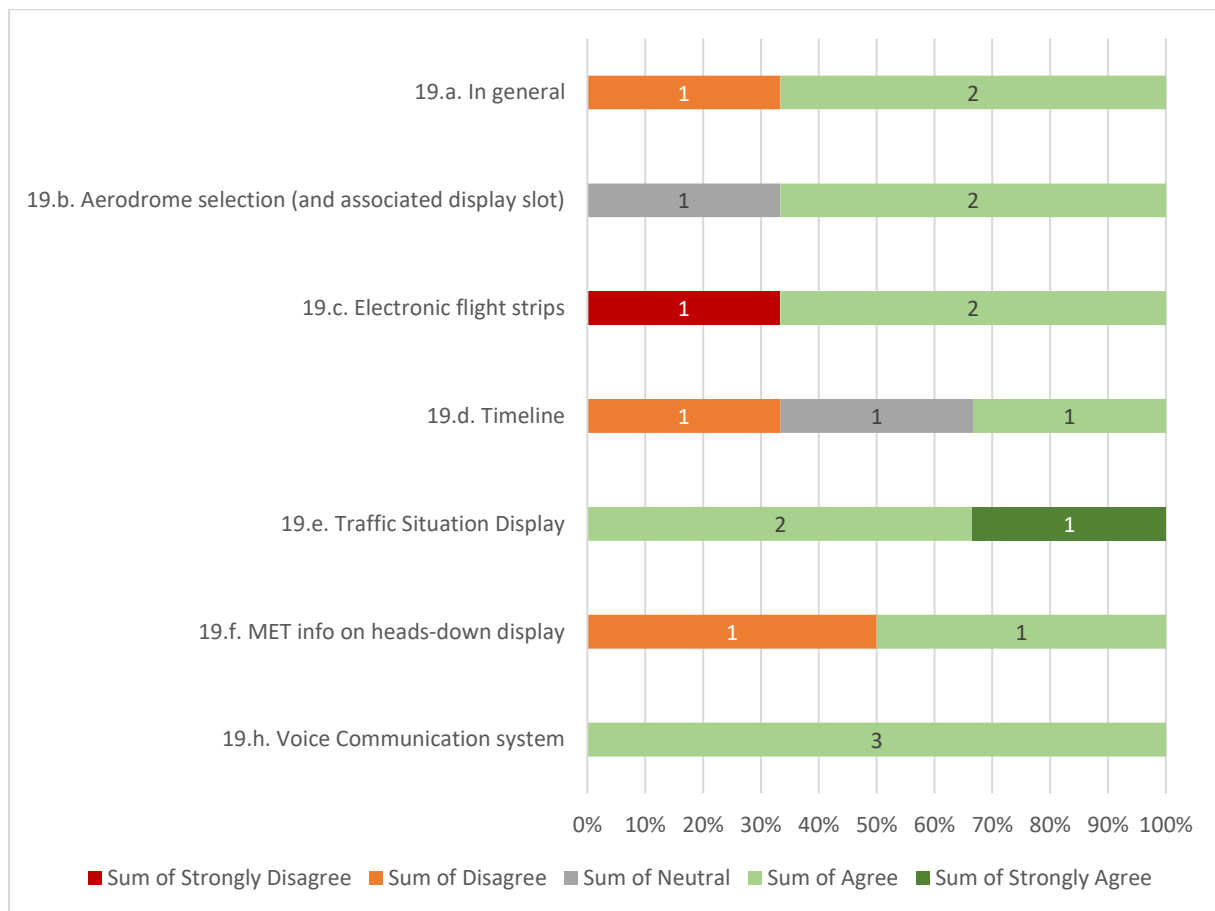
ATCOs were generally able to easily find all the information that they needed to accomplish their tasks.

However, the timeline that could be used to display the upcoming traffic movements, to assess the future traffic level or anticipate the next coming movements, was not always reflecting the traffic sequence as executed by the real-time simulation environment.

The indication of wind variation was considered as not standing out sufficiently by one ATCO, and significant changes in wind direction during the runs were not always detected by the operator. It should be noted that the wind information was only displayed on the heads-down screen. The display of wind information on the heads-up display would probably have improved the detection of change in wind direction during the runs.

19- The system was easy to use; all information were easy to access and presented in an effective way.

Founding Members



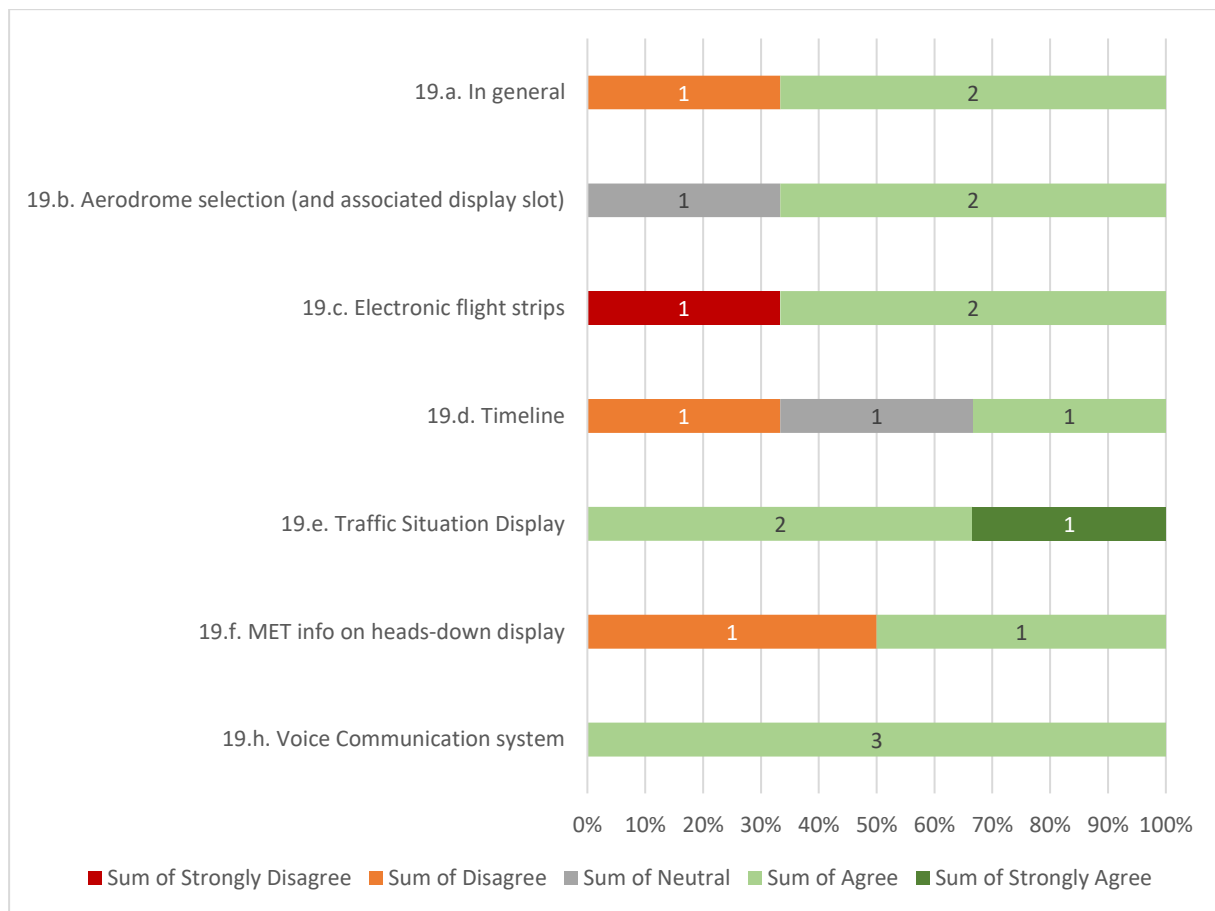
Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | <p>ATCOs confirm the usability of input devices and HMI controls.</p> <p>Nevertheless, the need to optimize the HMI workflow of the electronic flight strips was raised.</p> | Partially OK |

ATCOs were generally able to easily use the HMI and input devices to perform their tasks.

However, a lack of efficiency in the HMI workflow of the electronic flight strips often resulted in too many unnecessary clicks.

19- The system was easy to use; all information were easy to access and presented in an effective way.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | N/A | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The human machine interface sometimes increased the potential for human error, i.e., action error on flight status update, non-detection of wind variation. | Partially OK |

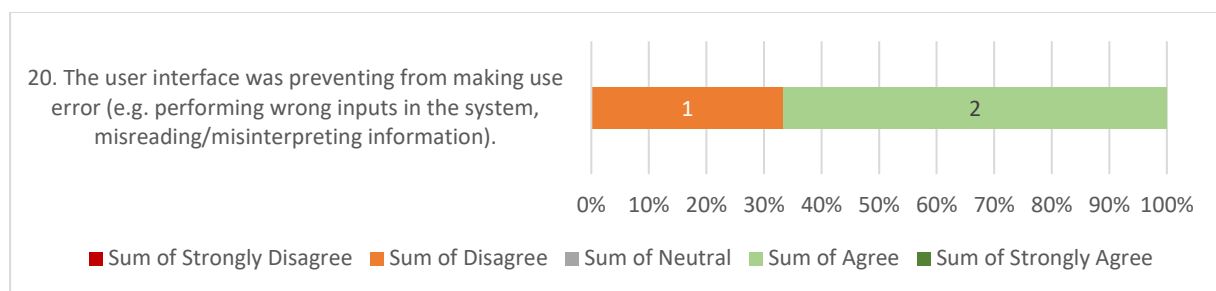
A lack of efficiency, in the way to update flight status/clearances on the electronic flight strips sometimes led ATCOs to commit action errors/mis-clicks, resulting in incorrect status updates. The

Founding Members

error was generally detected and recovered, however the action to undo/revert the incorrect input was not sufficiently easy to access.

Wind variation displayed on the wind information window was also found not sufficiently visible, which contributed to the non-detection of significant wind changes that should have led the ATCO to change the runway in use.

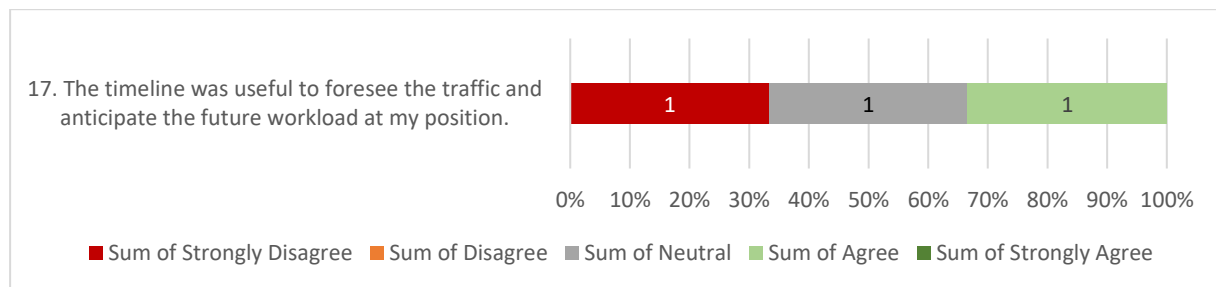
When the layout of the heads-down display was automatically reconfigured following a split, a merge, or a swapping of place between aerodromes within the MRTM, the wind information window(s) did not automatically follow the new layout and could be consequently displayed over the wrong aerodrome display slot. After the issue was firstly discovered, participants were helped to detect it during the runs and could then manually move the window to the right place.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | ATCOs could not always rely on the traffic forecast tool to anticipate the traffic sequence or assess the future traffic load. | Partially OK |

A “timeline” tool could be used to visualize the upcoming traffic movements for all aerodromes operated on the position. Since the timeline was not always accurate in reflecting the traffic sequence as executed by the simulator environment, it was considered as not sufficiently reliable to anticipate the next movements to come. In addition, when the number of simultaneous movements was high it was not possible to see all flights without scrolling which did not facilitate a global overview of the future traffic load.



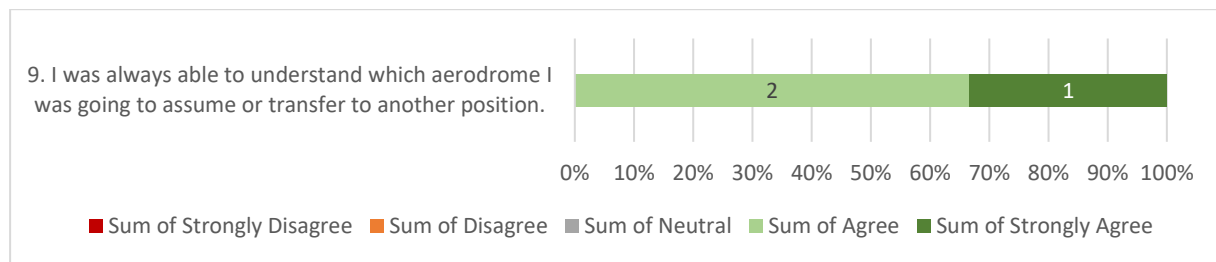
Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | ATCOs confirmed that there was generally no confusion about which aerodromes were displayed on which display. | OK |

It was generally clear for ATCOs where the different aerodromes were located on the heads-down, heads-up and VCS displays. It was only during the first run that ATCOs found difficult to locate the wind information after taking over a new aerodrome. In such case, when the layout of the heads-down display reconfigured itself to include an additional aerodrome, the wind information window(s) did not automatically follow the new layout and could be consequently displayed over the wrong aerodrome display slot.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | All ATCOs confirmed that there was no confusion about which aerodrome will be transferred between the MRTMs. | OK |

The supervisor role and the HMI supported ATCOs' awareness about which aerodrome(s) they were about to hand over or take over. When taking over a new aerodrome, ATCOs could setup the new aerodrome in a "view only" mode on the MRTM, allowing them to prepare to open a new aerodrome or receive a handover.



Participants response to the criteria related statement(s) in the final questionnaire.

C.4.2.5 HUMAN PERFORMANCE – TRUST

C.4.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

Assess ATCO trust in support systems when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | N/A | |

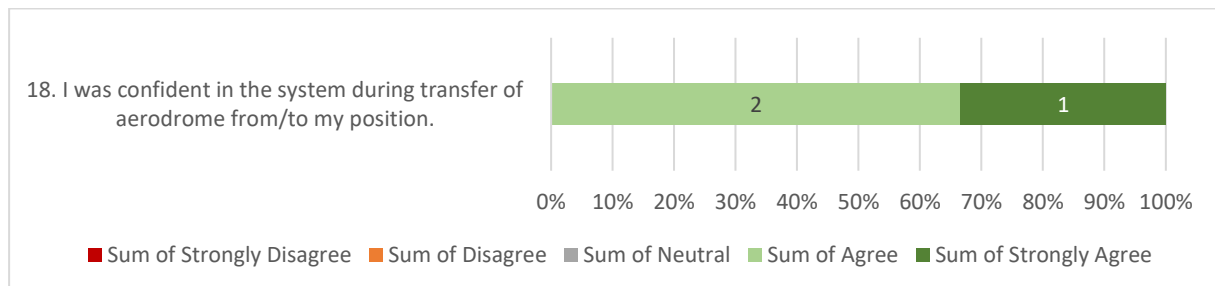
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | N/A | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | N/A | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between | All ATCOs trusted the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|--|-------------------|--------|
| | modules up to the completion of the transfer | | |

The transfer was supported by the possibility for both the supervisor and the ATCO to “prepare” the MRTM for the transfer of a new aerodrome by setting up the new aerodrome in a “view only” mode. It helped ATCO to both prepare mentally for the handover and ensure that the MRTM was properly configured before starting to operate the new aerodrome.



Participants response to the criteria related statement(s) in the final questionnaire.

C.4.2.6 HUMAN PERFORMANCE – Transition Factors

C.4.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Some knowledge and skills needs could be identified for ATCOs. | OK |

Cognitive skills such as visual scanning of information or multitasking are important to build up to ensure human performance in a multi context. However, they were considered by ATCOs as already to already be a part of their tasks in today’s tower.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Some training needs could be identified for ATCOs. | OK |

The familiarity with the system and the local knowledge of each aerodrome characteristics were mentioned as important skills/training to ensure human performance when operating multiple aerodromes.

The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes was also raised by both ATCOs and supervisors.

C.4.2.7 SAFETY

C.4.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

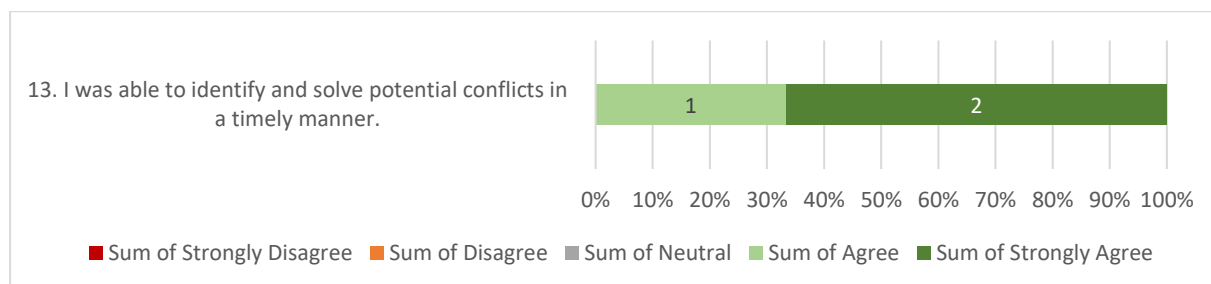
OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | ATCOs were able to identify and solve potential conflicts in a timely manner. | OK |

Potential conflicts during the runs were mainly induced by VFR traffic operating in the vicinity of the aerodromes, for example aircraft performing touch-and-go circuits or helicopter operating close to the airport. Potential conflicts with other aircraft were always detected and managed by ATCOs during the runs.

Potential conflicts on the manoeuvring area could also be managed. However, runway incursions by vehicles were not always timely detected (see results for the next criteria), however it did not result in conflicts.



Participants response to the criteria related statement(s) in the final questionnaire.

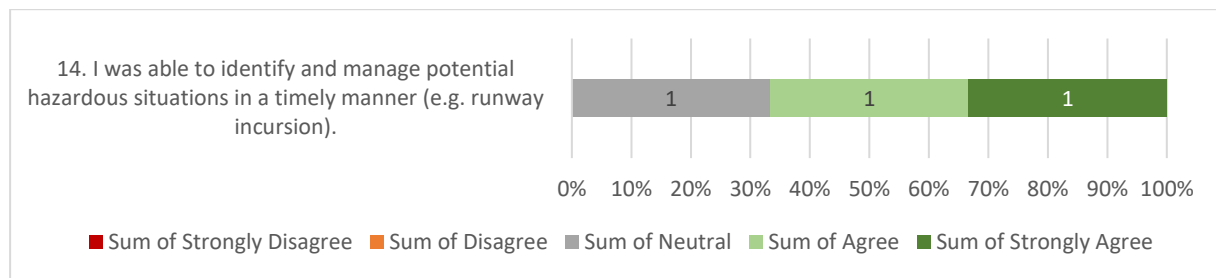
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.): <ul style="list-style-type: none"> • Unstable approaches • Bird strikes Aircraft not vacating RWY as expected | ATCOs did not always timely detect runway incursions by unauthorized vehicles. However the analysis revealed contributing factors that were not directly related to multiple tower operations (cf. detailed results of CRT-PJ05-W2-35-V3-VALP-S04.020, in section C.4.2.7.1) | Partially OK |

Three out of four ATCOs did not timely detect the runway incursion by an unauthorized vehicle driving on the runway during the first run. Several factors contributed to the late detection:

- The event occurred at a time when aircraft movements mostly concerned the other operated aerodromes which can have taken the attention of the ATCOs away from the aerodrome where the runway incursion occurred.
- The unauthorized snow clearance vehicle drove on the runway shortly after a first authorized inspection vehicle, which can also characterize normal operations in aerodromes where an authorization given to a leader also applies to the following vehicles.
- In one case a conversation on the position contributed to taking away the attention of the ATCO.

All ATCOs did detect the runway incursion by a vehicle driving on the runway, instead of crossing, during the second run.

In a run with three simultaneous aerodromes and high workload, one ATCO forgot to clear an aircraft to land because she/he was focused on another aerodrome where a departing aircraft was holding short before an arriving aircraft about to land. This omission case seems to indicate that the attention required to manage potential conflicts on one aerodrome in a high workload context can momentarily take away the attention from the other aerodromes.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | ATCO were generally able to distinguish with which aircraft, vehicle at which aerodrome they were communicating with. | OK |

Confusion between aerodromes only happened in the case where an aircraft movement was planned between two - geographically close - aerodromes operated on the same position. In such case, two - electronic flight strips (i.e., one departure, one arrival) with the same callsign were present at the same time on two different aerodromes. This situation sometimes misled ATCOs to focus on the wrong aerodrome and movement when the pilot called, which in one case caused the ATCO to give a landing clearance to a departing aircraft ready to line-up.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | N/A | |

C.4.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

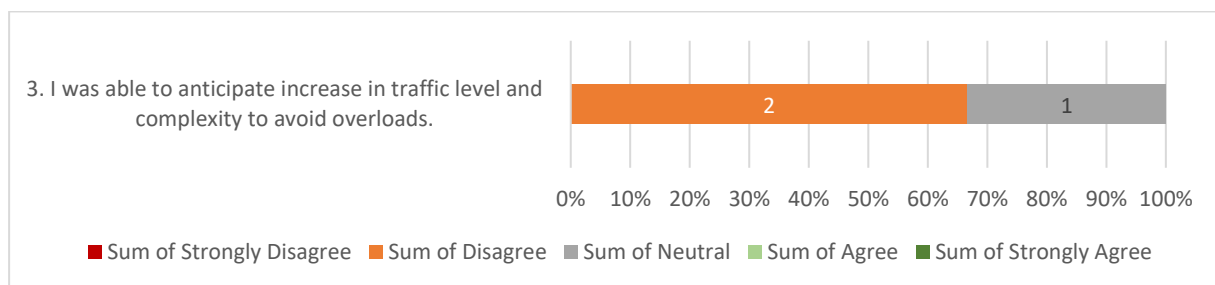
OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | It was not always possible for ATCOs to foresee traffic at his/her MRTM at short term in order to avoid overloads | Partially OK |

It was not always possible for ATCOs to anticipate and avoid overloads, when for example a run started with a high number of simultaneous traffic on three aerodromes with no possibility to split, or when it was needed to accept an unexpected handover of a third aerodrome.

Another limiting factor to anticipate the traffic load was that the “timeline” tool that could be used to display the upcoming traffic movements was not always reflecting the traffic sequence as executed by the real-time simulation environment. ATCOs mostly relied on the electronic flight strips and the radar display to anticipate future traffic movement, without the possibility to fully benefit from the dedicated “timeline” tool.

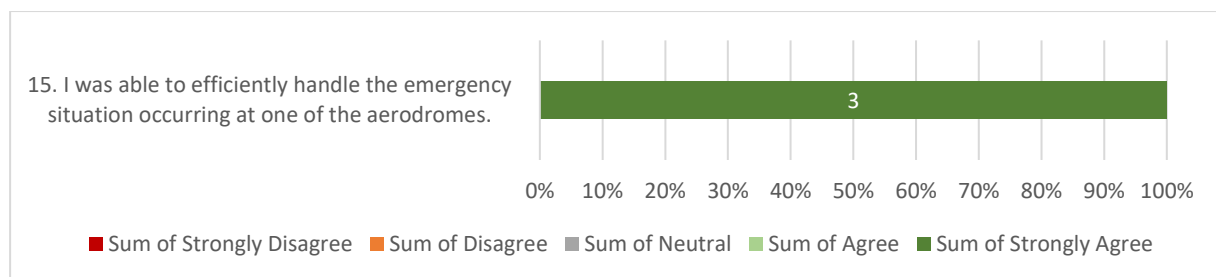


Participants response to the criteria related statement(s) in the final questionnaire.

C.4.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

| OBJ-PJ05-W2-35-V3-VALP-S06 Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> Aircraft emergency Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport | All ATCOs were able to identify and efficiently manage an aircraft emergency by means of a “split” and with the support of the supervisor. | OK |

The abnormal situation used in the validation was an aircraft emergency on a transit flight leading to a diversion to one of the three aerodromes operated by the ATCO. The expected solution to manage the situation was to perform a “split”, consisting in keeping the aerodrome with the emergency on the position while handing over the two other aerodromes to another ATCO and MRTM. During the run, the supervisors and ATCOs applied the split solution which resulted in an efficient management of the situation where the ATCO could focus on the aircraft emergency and benefit from the support of the supervisor who could take the necessary coordination phone calls. It should be noted that the time interval between the squawking of the emergency and the landing gave sufficient time for the team to orderly manage the situation. It can also be noted that one ATCO felt that she/he could have kept the two other aerodromes and still be able manage the emergency.



Participants response to the criteria related statement(s) in the final questionnaire.

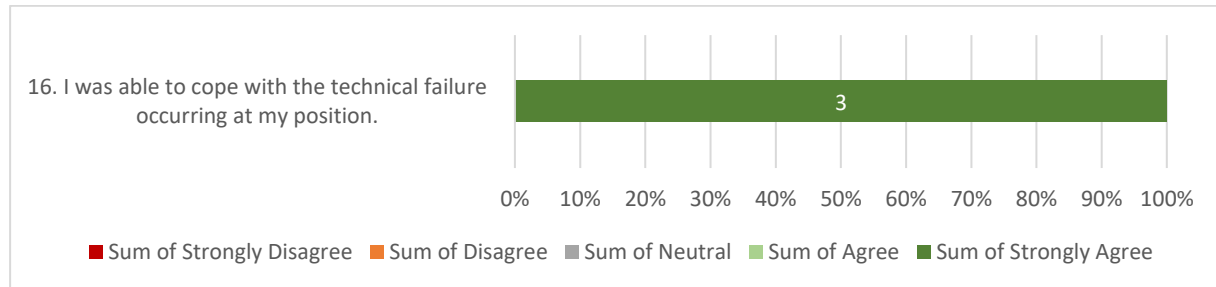
C.4.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results

OBJ-PJ05-W2-35-V3-VALP-S07

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g): <ul style="list-style-type: none"> • Communication • Visualisation system Other airport systems / infrastructure | All ATCOs were able to detect and recover from a technical failure affecting the visualisation of an aerodrome, by means of moving to another MRTM and with the support of the supervisor. | OK |

The scenario used in the validation was a black screen on the aerodrome view for one of the two operated aerodromes. The available solution consisted for the ATCO in moving to another position. The transfer to another MRTM was supported by the possibility for the supervisor to make the other MRTM ready to operate the two aerodromes. It should be noted that the traffic level was moderate and that there were no ongoing traffic movements to monitor on the aerodrome view at the time of the failure.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g): <ul style="list-style-type: none"> • Communication Visualisation system | N/A | |

C.4.2.8 CAPACITY

C.4.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|--|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | The capacity threshold of 8 simultaneous movements (where VFR would count as 1,5) corresponded to the maximum controller capacity during the validation. However other operational tasks as well as the need | Partially OK |

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|-------------------|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| | | to have spare capacity/buffer need to be considered. | |

The rule of thumb given to the supervisors during the validation for the MRTM capacity threshold was 8 simultaneous movements where VFR would count as 1,5 instead of 1. This maximum capacity threshold proved to be realistic during the Real Time Simulation since it matched with the maximum acceptable workload experienced by ATCOs.

However, it should be noted that not all ATCOs tasks (e.g., producing METAR, coordinating with overlying sectors) and operational contexts (impact of difficult weather, maintenance operations, taxiway closures etc.) were included in the validation. The rules for maximum capacity and complexity need therefore to be adjusted to take into account all ATCOs tasks, the real operational context as well as the need to have spare capacity available.

C.4.2.9 COST EFFICIENCY

C.4.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | ATCOs could provide ATS to 3 aerodromes at the same time. The required staff will also depend on the need to have spare capacity and resources available to dynamically change the allocation of aerodromes. | OK |

C.4.3 Supervisor - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|---|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Situation awareness could not always be maintained at a satisfying level because supervisors lacked sufficient information on their position to monitor workload and manage unexpected situations at MRTMs. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | It was not always possible for the supervisors to satisfactorily plan the allocation of aerodromes to MRTMs and ATCOs. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | The user interface design did not support a sufficient level of situation awareness regarding the current traffic situation and workload at the MRTMs. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | The majority of SUP confirmed that they could maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|--|---|-----------------------------|
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of SUPs assess that the workload was at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs. | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of SUPs assessed that operating methods could be applied in an efficient manner in normal operating conditions but not in abnormal operating conditions or degraded modes. | Partially OK |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | There was not a majority of supervisors assessing that the change in roles and responsibilities was acceptable since improvements were needed on the supervisor position. | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Majority of Supervisors confirmed the feasibility and acceptability of supervising the assigned number of clusters of aerodromes | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors assessed that they did not always have all required information available to monitor the traffic situation and workload at MRTMs and to plan the allocation of aerodromes. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | Input devices on the supervisor position were easy to use. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Improvements were considered necessary to make the planning tool more useful. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | N/A | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|--|---|--------------------------------|--|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | The supervisor HMI did not lead to error during the validation; however, some HMI improvements are needed to prevent use errors. | Partially OK |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors could not always trust the monitoring and planning tool to give them a correct picture of the situation at aerodromes/MRTMs. | Partially OK |
| HUMAN PERFORMANCE – TRANSITION FACTORS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Some knowledge and skills needs could be identified but a more complete assessment will be needed. | Partially OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Some training needs could be identified for supervisors a more complete assessment will be needed. | Partially OK |
| SAFETY | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S08.010 | <p>Supervisor is able to support an ATCO in abnormal situations(e.g):</p> <ul style="list-style-type: none"> • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport • ATCO overload in one or more MRTM of the RTC | Supervisors were able to support the ATCO in case of an emergency at one aerodrome by supervising the handover of aerodromes to another ATCO and offloading the ATCO from the coordination tasks. | OK |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other systems in the MRTM | Supervisors could manage the technical failure occurring in one MRTM by supporting the transfer of the ATCO to a another MRTM. | OK |
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | Improvements were considered necessary for the supervisors to foresee traffic at MRTMs. | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|--|----------------------|-------------------|-------------------|-----------------------------|
| | working in an RTC with a flexible allocation of aerodromes between MRTMs | | | | |

Table 18: Supervisor - Validation Results for Exercise 1

C.4.4 Supervisor - Analysis of Exercise Results per Validation objective

The results are based on total of 6 supervisors, 4 currently working in a large aerodrome tower unit and 2 currently working in ACC units.

The analysis of exercise results for each criteria is based on the data collected from the following data collection methods: observations, debriefings and questionnaires.

In the bar charts showing responses to the final questionnaire, the number of total responses can sometimes be below 6 if the question was considered as not possible to assess or not applicable by supervisor(s), or above 6 if supervisor(s) have put a mark between two response categories on the rating scale.

C.4.4.1 HUMAN PERFORMANCE – SITUATION AWARENESS

C.4.4.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

OBJ-PJ05-W2-35-V3-VALP-H01

Assess SUP situation awareness when working in an RTC

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Situation awareness could not always be maintained at a satisfying level because supervisors lacked sufficient information on their position to monitor workload and manage unexpected situations at MRTMs. | Partially OK |

Supervisors have self-rated the Situation Awareness (SA) they have experienced during each run using the China Lakes SA Scale shown below:

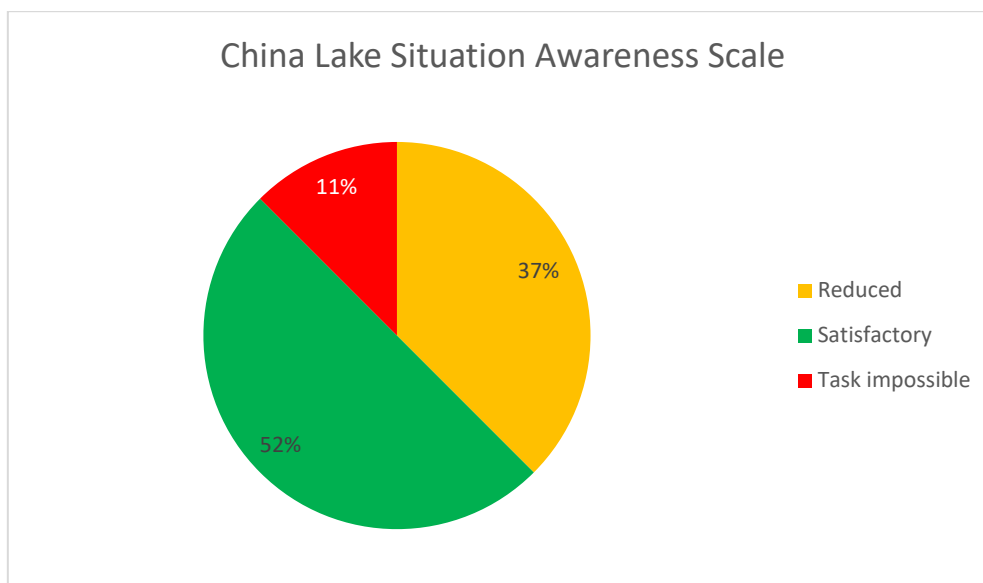
Please rate Situational Awareness (SA) you experienced during the run

| | | SA experienced during the run | | |
|--------------------------------------|-----|--|----|--------------------------|
| Was it possible to perform the task? | No | My SA with respect to the task was far too low. I could not perform the task because I did not possess the necessary information. | 1 | <input type="checkbox"/> |
| | Yes | My SA with respect to the task was very low. I was unaware of almost all of the information required to perform the task effectively. | 2 | <input type="checkbox"/> |
| Was your level of SA acceptable? | No | My SA with respect to the task was low. I was unaware of most of the information required to perform the task effectively. | 3 | <input type="checkbox"/> |
| | Yes | My SA with respect to the task was low. I was unaware of about half of the information required to perform the task effectively. | 4 | <input type="checkbox"/> |
| Was your level of SA satisfactory? | No | My SA with respect to the task was reduced. I was unaware of some of the important information required to perform the task effectively. | 5 | <input type="checkbox"/> |
| | | My SA with respect to the task was insufficient. I was not aware of all the information required to perform the task effectively. | 6 | <input type="checkbox"/> |
| | | My SA with respect to the task was not complete. I was able to perform the task, but not satisfactorily. | 7 | <input type="checkbox"/> |
| | | My SA with respect to the task was good. I was able to perform the task well most of the time. | 8 | <input type="checkbox"/> |
| | Yes | My SA with respect to the task was very good. I was able to perform the task well all of the time. | 9 | <input type="checkbox"/> |
| | | My SA with respect to the task was excellent. I was able to perform the task extremely well all of the time. | 10 | <input type="checkbox"/> |

The China Lakes is a 10-points rating scale where 1 represents the lowest possible situation awareness and 10 the highest possible situation awareness.

As indicated by the colour coding on the scale, the rating scale can also be subdivided into three main response categories: “Satisfactory” (8-10), “Not satisfactory / Reduced” (5-7) and “Not acceptable” (2-4) or “Task impossible” (1).

The pie chart below represents the percentage of responses for each response category, for all runs and participants combined.

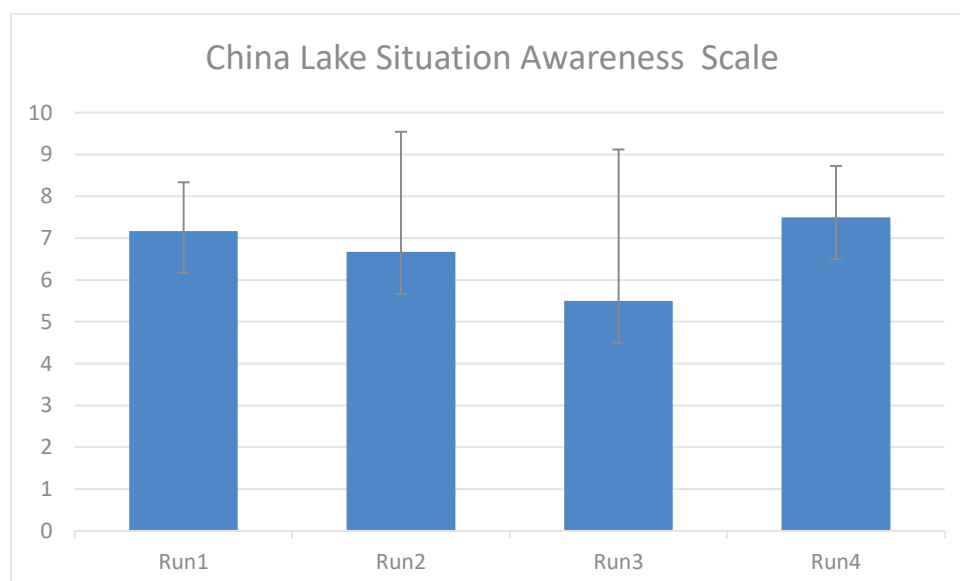


Percentage of situation awareness self-ratings per response category (all runs, all participants combined).

As illustrated by the pie chart, the workload was rated by supervisors as “Satisfactory” in 52% of all runs, as “Not satisfactory / Reduced” in 37% of all runs and as making their “Task impossible” to perform in 11% of all runs.

The results indicating that situation awareness was not satisfactory in almost half of the runs, can be explained by the fact that supervisors did not have sufficient means to assess the current traffic situation and workload at the MRTMs, from their position.

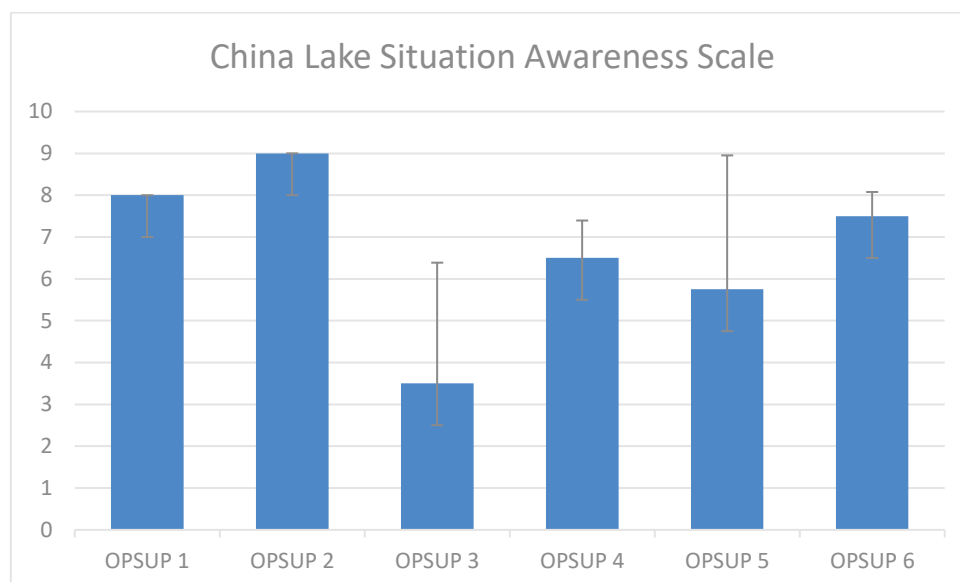
The chart below shows the average rating on the China Lakes 10-points scale for each run.



Mean (self-rated) situation awareness per run (with standard deviation).

The lowest average situation awareness corresponds to the run 3 in which the supervisor needed to ask the ATCO participant to immediately take over a third aerodrome due to the sudden (fake) illness of the other ATCO. The supervisors' situation awareness decreased and their workload during the transfer of aerodrome increased, due to the difficulty to assess the current traffic situation at the MRTMs and aerodromes because their traffic monitoring tool (i.e., the traffic "timeline") was not sufficiently accurate or lacked essential information (see results for CRT-PJ05-W2-35-V3-VALP-H01.030).

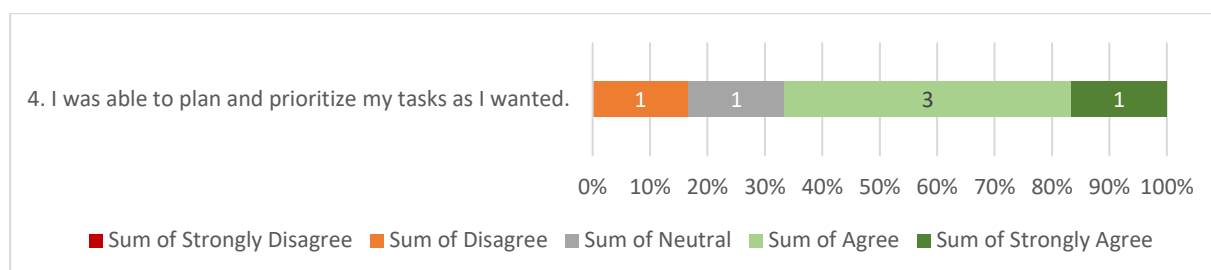
The chart below shows the average rating on the China Lakes 10-points scale for each participant.



Mean (self-rated) situation awareness per participant (with standard deviation).

Results indicate individual differences in the experienced situation awareness. For example, two supervisors rated the level of situation awareness as "satisfactory" in all the runs, while one supervisor always rated situation awareness as "reduced" or making his "task impossible" to perform.

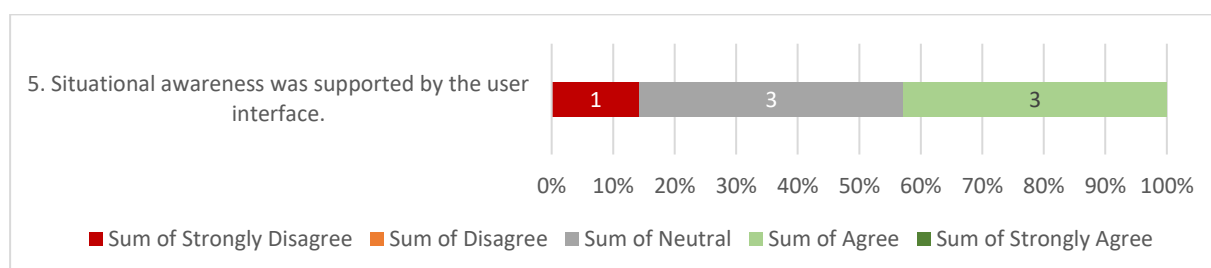
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | It was not always possible for the supervisors to satisfactorily plan the allocation of aerodromes to MRTMs and ATCOs. | Partially OK |



Participants response to the criteria related statement(s) in the final questionnaire.

The limitations of the traffic timeline tool (see next results for CRT-PJ05-W2-35-V3-VALP-H01.030), the lack of a dedicated planning tool and the incomplete overview on ATCOs availability (i.e., roster), reduced the ability of the supervisors to plan the allocation of aerodromes and prioritize their tasks.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | The user interface design did not support a sufficient level of situation awareness regarding the current traffic situation and workload at the MRTMs. | Partially OK |



Participants response to the criteria related statement(s) in the final questionnaire.

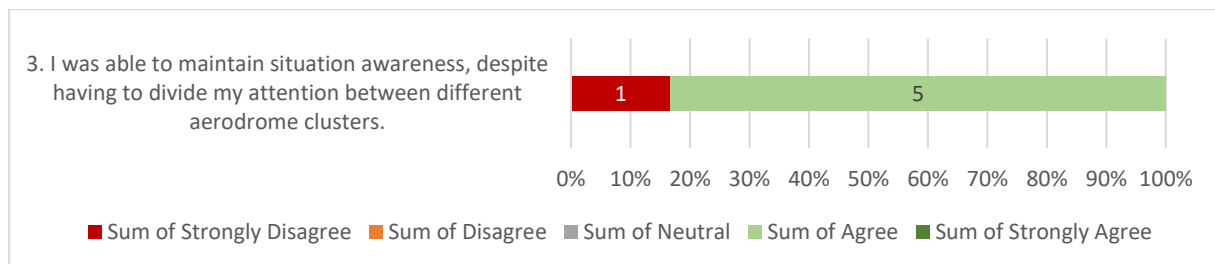
The traffic timeline tool did not provide to the supervisor a reliable picture of the current traffic situation at the MRTMs because the aircraft movements shown in the current time did not always match with the aircraft movements that the ATCOs had on frequency and that were active on his stripboard. Since the traffic timeline only showed aircraft movements, supervisors also missed information about vehicles movements and runway occupied that are important to assess the current workload for the ATCO.

The timeline was useful to predict the future traffic load, but it did not always correctly reflect the traffic sequence and the need was raised to show traffic numbers over periods of time and to get capacity threshold alerts to be able to anticipate potential overloads (note: the rule of thumb given to the supervisors for the capacity threshold was 8 simultaneous movements where VFR would count as 1,5).

Some ATCOs also reported other limitations, such as: the lack of distinction between VFR arrival and departure, the absence of flight status information (pending vs. active, last clearance given to the aircrafts) or the lack of detailed flight information (the timeline only showed aircraft callsigns and flight types).

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | The majority of SUP confirmed that they could maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes. | OK |

It must be noted here that, even though supervisors could monitor traffic movements for 15 aerodromes/MRTMs, their focus during the validation mainly remained on the set of 4 aerodromes and 2 MRTMs that were operated by ATCOs during the runs. The other 11 aerodromes/MRTMs were only simulated on the supervisor position and did not require continuous monitoring or actions. The validity of the results for the criteria therefore mainly applies to an assigned number of 4 aerodromes.



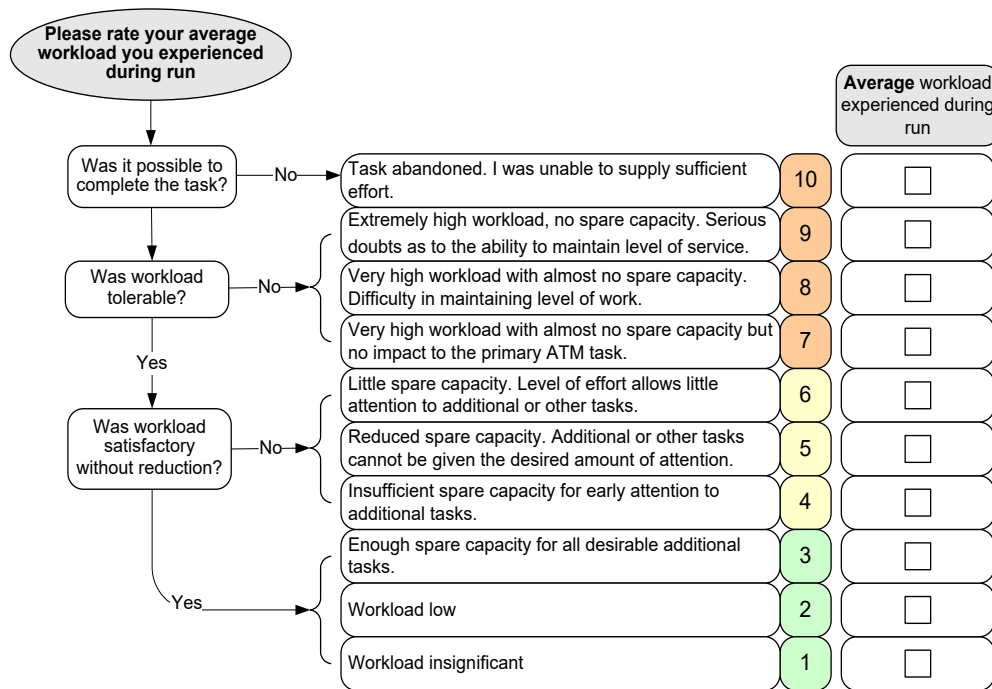
Participants response to the criteria related statement(s) in the final questionnaire.

C.4.4.2 HUMAN PERFORMANCE – WORKLOAD

C.4.4.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

| OBJ05-W2-35-V3-VALP-H05 Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of SUPs assess that the workload was at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs. | OK |

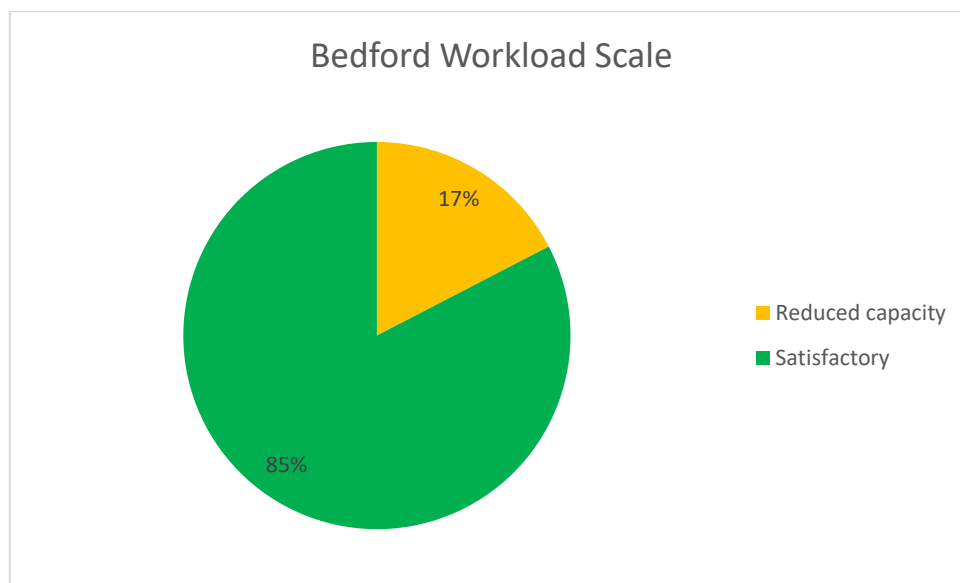
Supervisors have self-rated the average workload experienced during each run by use of the Bedford Workload Scale shown below:



The Bedford is a 10-points rating scale where 1 represents the lowest possible workload and 10 the highest possible workload.

As indicated by the colour coding on the scale, the rating scale can also be subdivided into three main categories: “Satisfactory” (1-3), “Not satisfactory / Reduced capacity” (4-6) and “Not tolerable” (7-9) / “Task abandoned” (10).

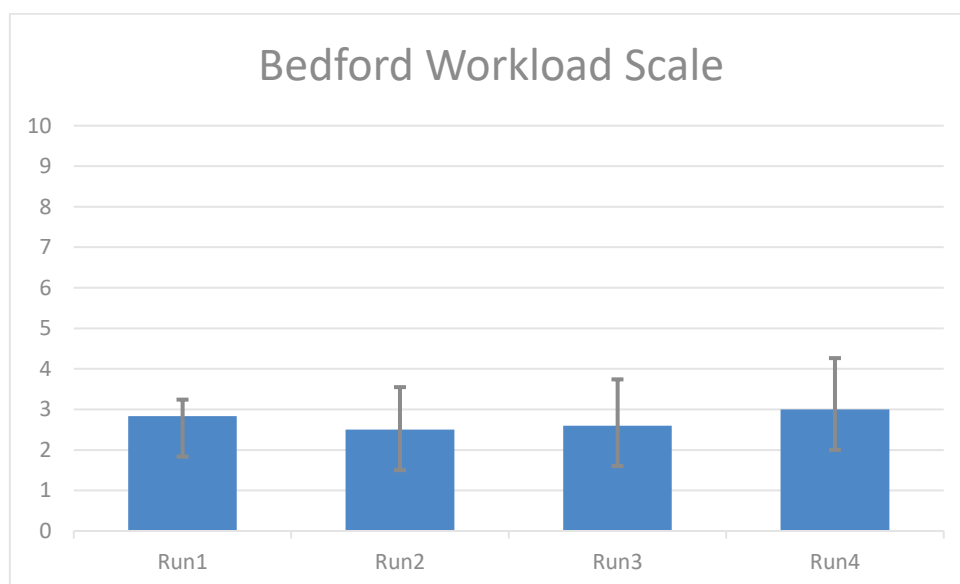
The pie chart below represents the percentage of response for each response category, for all runs and participants combined.



Percentage of workload self-ratings per response category (all runs, all participants combined).

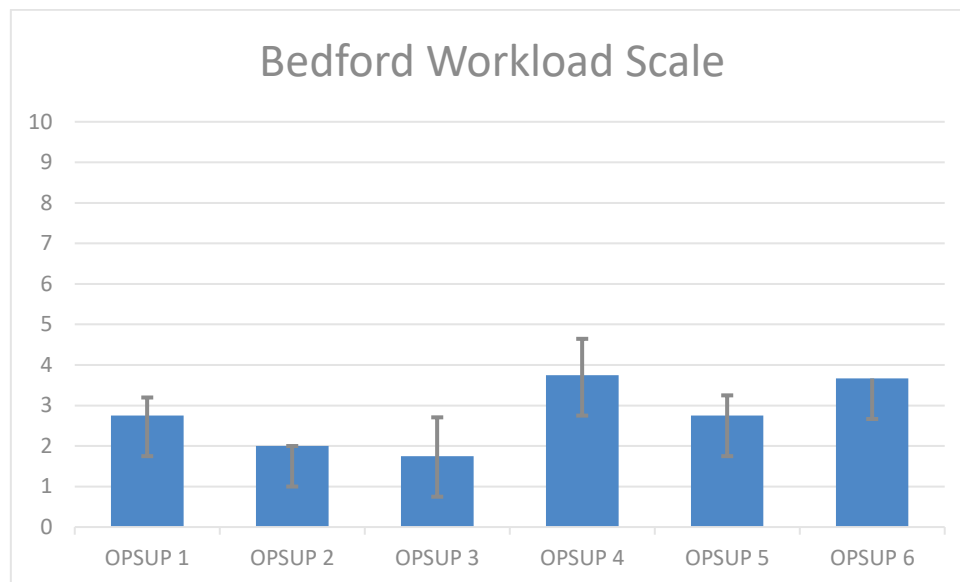
As indicated by the pie chart, the workload was rated by supervisors as “Satisfactory” in 85% of all runs and as “Not satisfactory / Reduced capacity” in 17% of all runs. Workload was never rated by supervisors as “Not tolerable”.

The next chart presents the average rating on the Bedford 10-points scale for each run.



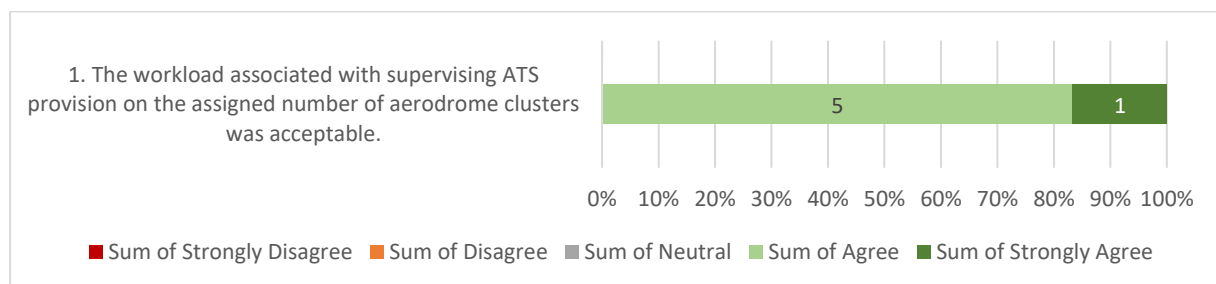
Mean (self-rated) workload per run (with standard deviation).

In average, the workload was experience as satisfactory in all runs. The overall positive rating of workload contrasts with the more negative rating of situation awareness. It indicates that low situation awareness levels were, most often, not the result of a high workload.



Mean (self-rated) workload per participant (with standard deviation).

For two supervisors, the mean self-rated workload was above the satisfactory level. The supervisors reported that their capacity was reduced in runs where they had to manage unexpected situations or workload at MRTMs exceeding the capacity threshold.



Participants response to the criteria related statement(s) in the final questionnaire.

As also mentioned in results for CRT-PJ05-W2-35-V3-VALP-H01.040, it must be noted here that, even though supervisors could monitor traffic movements for 15 aerodromes/MRTMs, their focus during the validation mainly remained on the set of 4 aerodromes and 2 MRTMs that were operated by ATCOs during the runs. The other 11 aerodromes/MRTMs were only simulated on the supervisor position and did not require continuous monitoring or actions. The validity of the results for the criteria therefore mainly applies to an assigned number of 4 aerodromes.

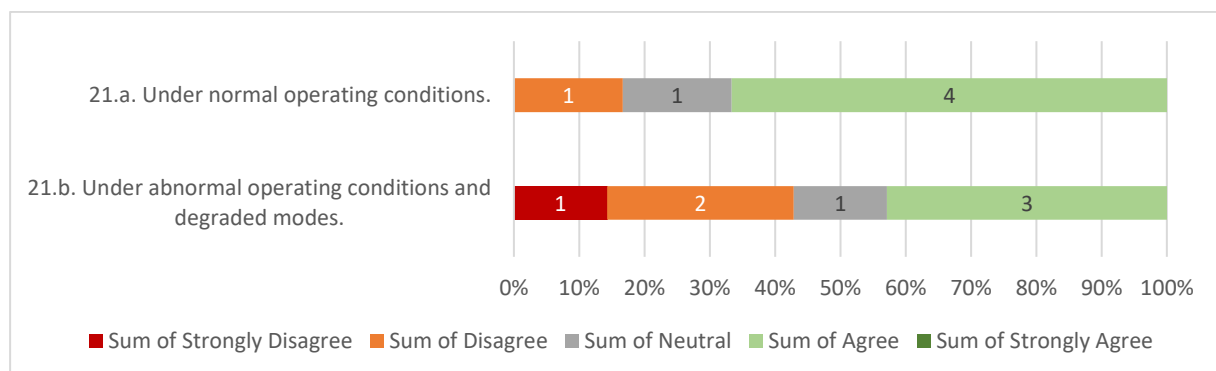
C.4.4.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

C.4.4.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|--|---|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of SUPs assessed that operating methods could be applied in an efficient manner in normal operating conditions but not in abnormal operating conditions or degraded modes. | Partially OK |

The operating methods consisting in changing the allocation of aerodromes by splitting aerodrome(s) could not always be applied in case of unexpected situations or overload on a position, because there was no other ATCO available to take over the aerodrome(s) when needed. This illustrates the necessity to have sufficient personnel available to make the dynamic allocation operating method applicable for supervisors.

21. Operating methods when supervising ATS services for the assigned number of aerodromes were efficient (i.e. switching focus between aerodromes/clusters, dynamic allocation of aerodromes with split/merge, supporting transfer of aerodromes between positions).



Participants response to the criteria related statement(s) in the final questionnaire.

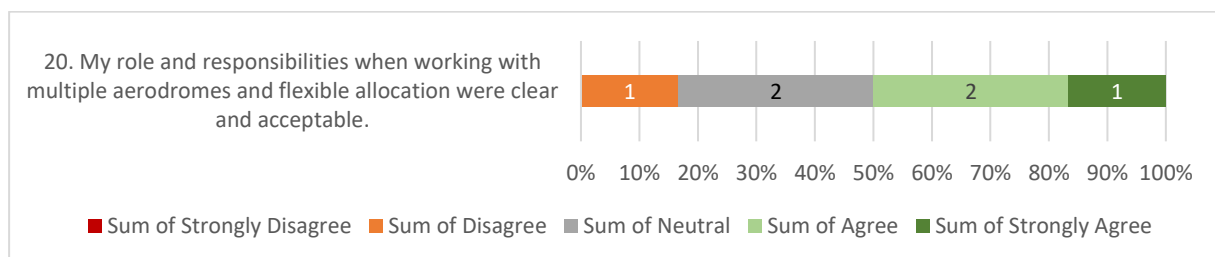
C.4.4.3.2 OBJ-PJ05-W2-35-V3-VALP-H10 Results

OBJ-PJ05-W2-35-V3-VALP-H10

Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | There was not a majority of supervisors assessing that the change in roles and responsibilities was acceptable since improvements were needed on the supervisor position. | Partially OK |

The acceptability of the change in roles and responsibilities was conditioned for supervisors to necessary system improvements to better monitor the traffic situation and workload at MRTMs, to have a cleared view on ATCOs endorsements and availability, and a better planning tool to support the flexible allocation of aerodromes.



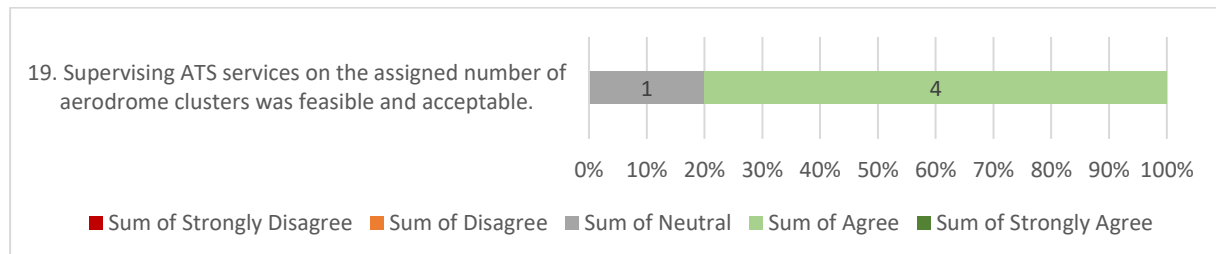
Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Majority of Supervisors confirmed the feasibility and acceptability of supervising the assigned number of clusters of aerodromes | OK |

As for CRT-PJ05-W2-35-V3-VALP-H01.040 and CRT-PJ05-W2-35-V3-VALP-H05.010, it must be noted here that, even though supervisors could monitor traffic movements for 15 aerodromes/MRTMs, their

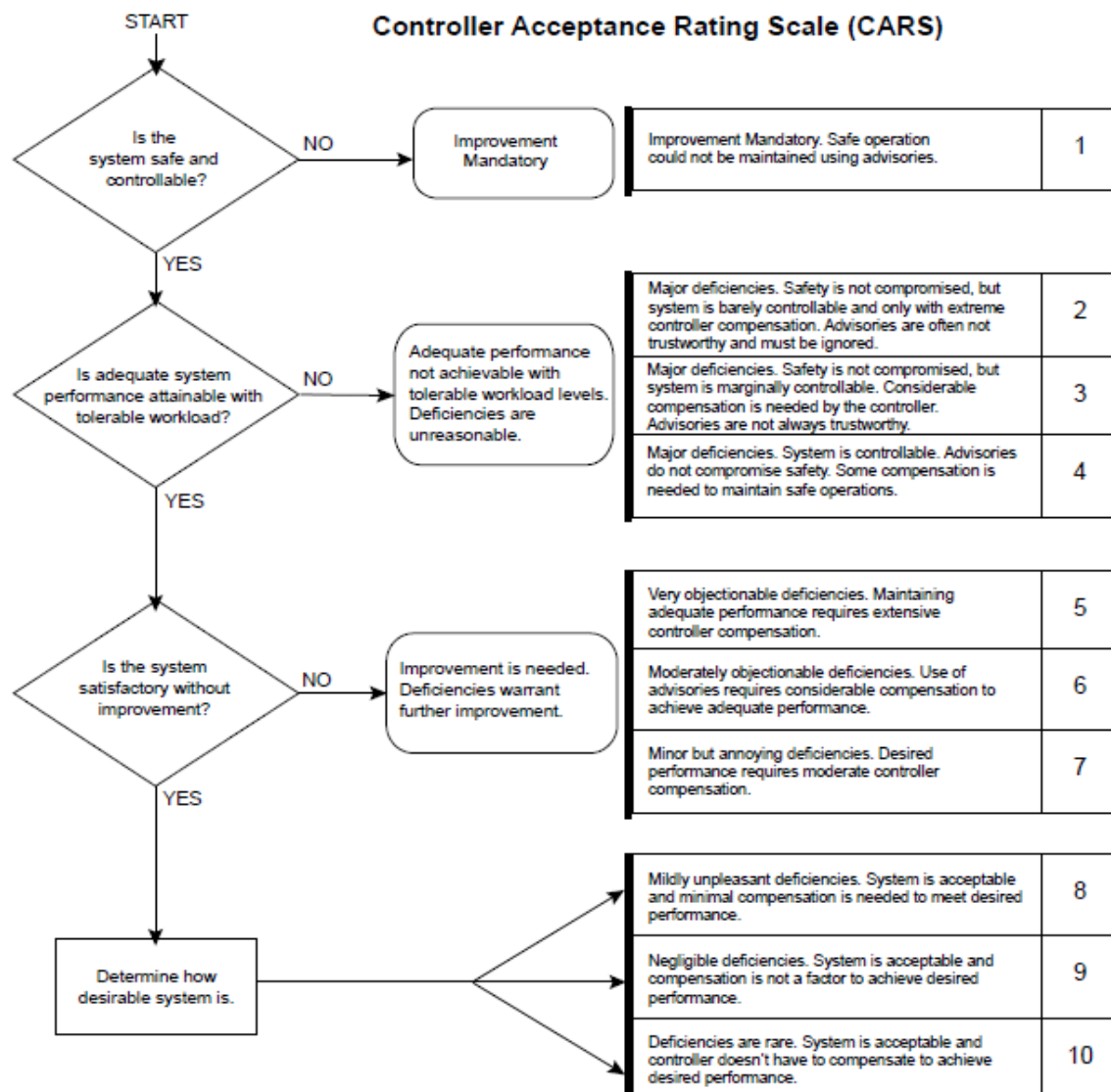
Founding Members

focus during the validation mainly remained on the set of 4 aerodromes and 2 MRTMs that were operated by ATCOs during the runs. The other 11 aerodromes/MRTMs were only simulated on the supervisor position and did not require continuous monitoring or actions. The validity of the results for the criteria therefore mainly applies to an assigned number of 4 aerodromes.



Participants response to the criteria related statement(s) in the final questionnaire.

Supervisors also rated the acceptability of the system using the Controller Acceptance Rating Scale (CARS) shown below:



One supervisor gave a rate of 1, corresponding in the scale to a system where “mandatory improvements” are needed to ensure that the system is “safe and controllable”.

One supervisor gave a rate of 3, corresponding in the scale to a system with “major deficiencies”.

Two supervisors gave rates of respectively 6 and 7, considering that improvements were needed to make the system satisfactory.

Two supervisors gave a rate of 8 on the scale, corresponding to a system considered as acceptable with “mildly unpleasant deficiencies” and “minimal compensation” needed to meet desired performance.

C.4.4.4 HUMAN PERFORMANCE – USABILITY and UTILITY

C.4.4.4.1 OBJ-PJ05-W2-35-V3-VALP-H12 Results

OBJ-PJ05-W2-35-V3-VALP-H12

Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors assessed that they did not always have all required information available to monitor the traffic situation and workload at MRTMs and to plan the allocation of aerodromes. | Partially OK |

The different tools needed by the supervisor were easily accessible. However, the information presented within these tools was not always considered as sufficient and reliable.

The traffic information presented in the “timeline” tool were not always reliable:

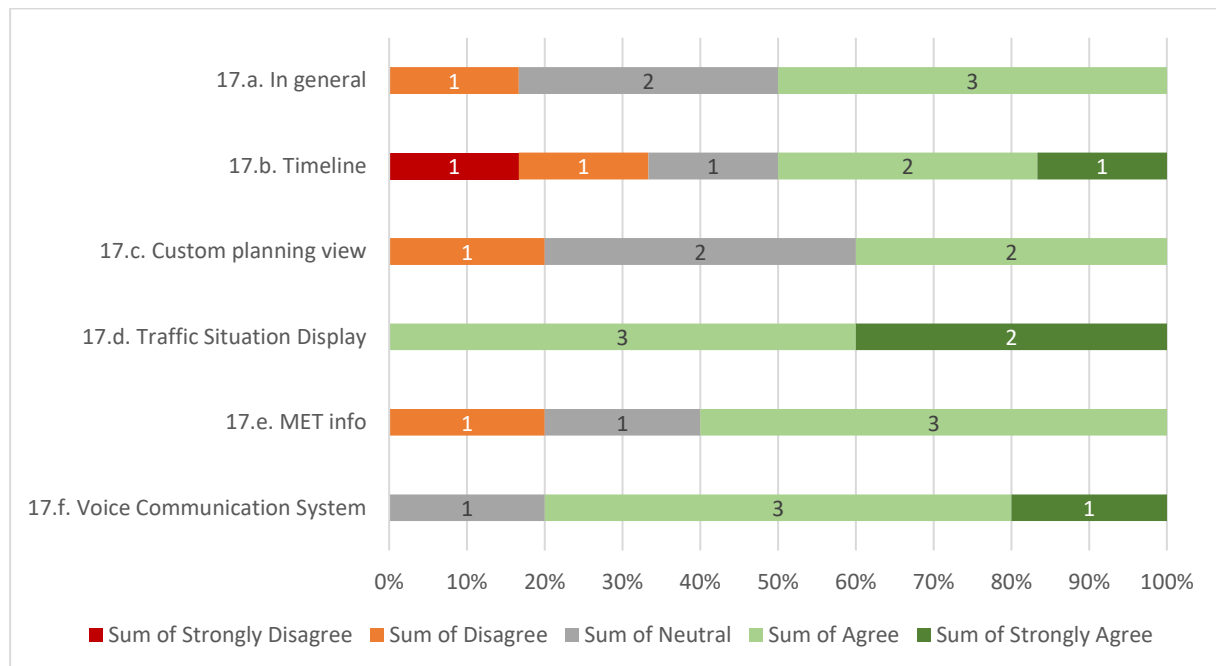
- Aircraft movements shown in the current time did not always match with the aircraft movements that the ATCOs had on frequency and that were active on the stripboard.
- The traffic sequence shown in the timeline did not always reflect the traffic sequence as executed by the real time simulation.

Information presented in the “timeline” tool were not sufficient for the supervisors to assess the traffic situation and workload at MRTMs:

- Vehicle movements and runway occupied were not represented.
- Traffic numbers over periods and threshold alerts would have helped.
- Flight information were lacking.

A roster to see ATCOs availability was missing, and it was difficult to get an overview of ATCOs endorsements.

17. The system was easy to use and all information needed were easy to access.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | Input devices on the supervisor position were easy to use. | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------------|
| CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Improvements were considered necessary to make the planning tool more useful. | Partially OK |

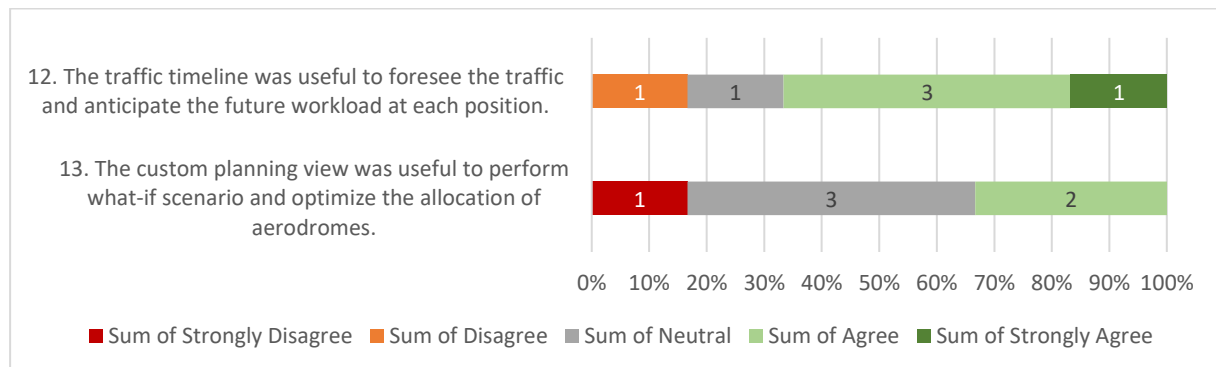
The traffic timeline was found useful to anticipate the future traffic load at MRTMs, even though improvements were considered necessary as mentioned in the results of CRT-PJ05-W2-35-V3-VALP-H12.010.

The possibility in the “planning” view to simulate clusters of aerodromes and visualize what the traffic timelines would look like, was found useful.

The “planning” view was lacking functionalities for the supervisor to be able to schedule the future allocation of aerodromes to MRTMs and ATCOs.

Founding Members

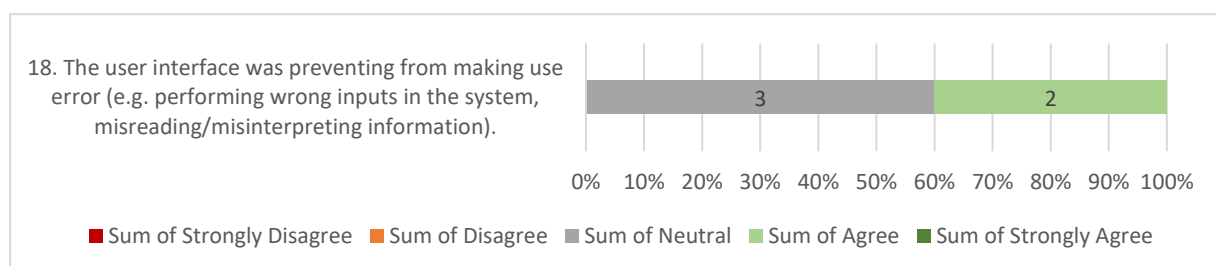
A roster to see ATCOs availability was also missing, and it was difficult to get an overview of ATCOs endorsements.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | N/A | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | The supervisor HMI did not lead to error during the validation; however, some HMI improvements are needed to prevent use errors. | Partially OK |



Participants response to the criteria related statement(s) in the final questionnaire.

The supervisor HMI did not lead to confusions or use errors during the validation.

However, the possibility to unintentionally remove ATCOs endorsements from a list or to confuse the live traffic timeline with the planning traffic timeline need to be considered.

C.4.4.5 HUMAN PERFORMANCE – TRUST

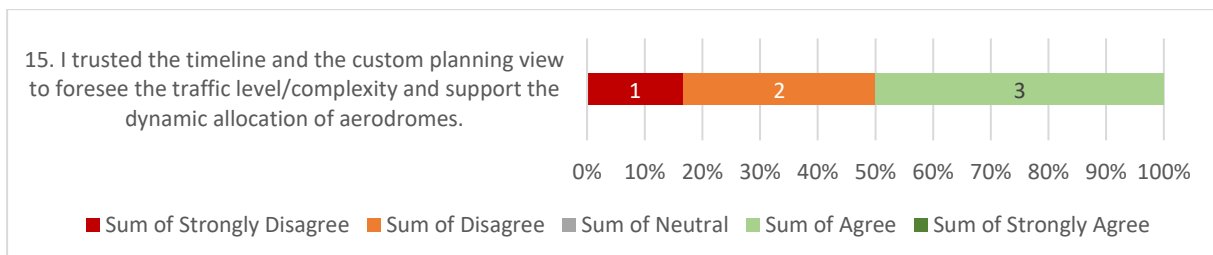
C.4.4.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

OBJ-PJ05-W2-35-V3-VALP-H14

Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors could not always trust the monitoring and planning tool to give them a correct picture of the situation at aerodromes/MRTMs. | Partially OK |

As mentioned in the results of CRT-PJ05-W2-35-V3-VALP-H01.030, supervisors could not always trust the monitoring tool on their position to give them a correct picture of the situation at aerodromes and MRTMs.



Participants response to the criteria related statement(s) in the final questionnaire.

C.4.4.5.2 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Some knowledge and skills needs could be identified but a more complete assessment will be needed. | OK |

General knowledge about each supervised aerodrome was considered necessary by supervisors. Supervisors assessed that they would not necessarily need to know each aerodrome characteristics in details, but that some key information (e.g., type of operations, specific emergency procedures) would be important to know.

Clear rules regarding maximum capacity at MRTMs need to be established and known by both ATCOs and supervisors to prevent overloads and anticipate when split of aerodromes should be performed.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Some training needs could be identified for supervisors a more complete assessment will be needed. | OK |

The need for dedicated training on ATCO/SUP teamwork to deal with abnormal situation or degraded modes were raised by both ATCOs and supervisors.

C.4.4.6 SAFETY

C.4.4.6.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

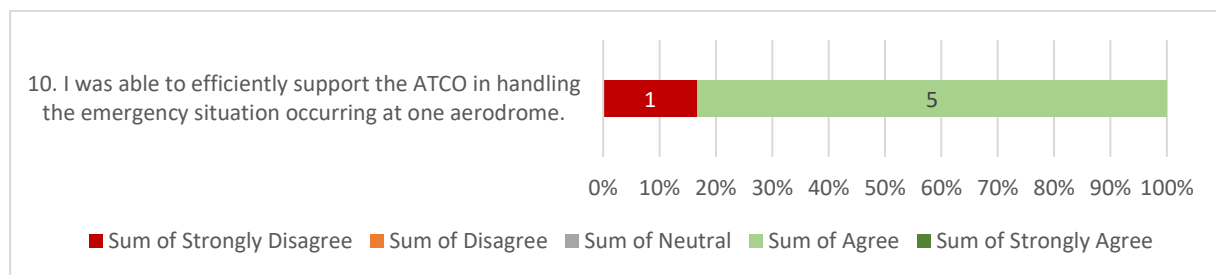
| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | Supervisors were able to support the ATCO in case of an emergency at one aerodrome by supervising the handover of aerodromes to another ATCO and offloading the ATCO from the coordination tasks. | OK |

The abnormal situation used in the validation was an aircraft emergency on a transit flight leading to a diversion to one of the three aerodromes operated by the ATCO. The expected solution to manage the situation was to perform a “split”, consisting in keeping the aerodrome with the emergency on the

position while handing over the two other aerodromes to another ATCO/MRTM. During the run, the supervisors and ATCOs applied the split solution which resulted in an efficient management of the situation where the ATCO could focus on the aircraft emergency and benefit from the support of the supervisor who could take the necessary coordination phone calls. It should be noted that the time interval between the squawking of the emergency and the landing gave sufficient time for the team to orderly manage the situation.

An important success factors for the supervisors' task in this situation was the immediate availability of an ATCO with the proper endorsements to take over the two other aerodromes. Another enabler was the proximity between the supervisor position and the MRTMs which made it possible for the supervisor to both take actions from his position and monitor the situation at the MRTM when needed.

To provide support to the ATCO in case of overload, supervisors needed to have a better picture of the MRTMs traffic situation and workload on their position to determine when it is necessary to take measures like delaying traffic.



Participants response to the criteria related statement(s) in the final questionnaire.

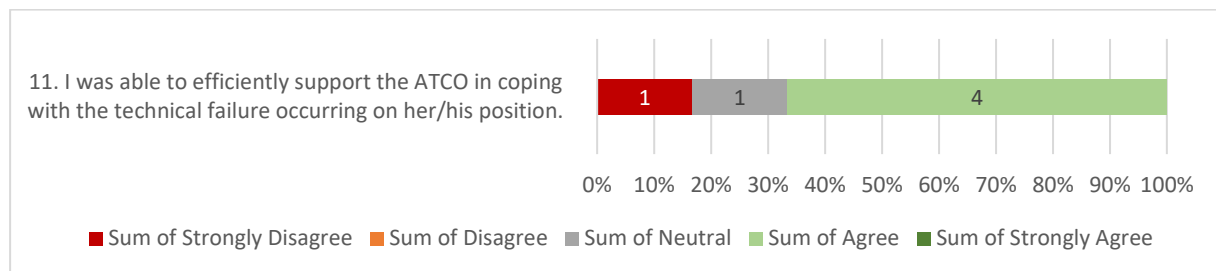
The “Strongly Disagree” response in the final questionnaire can be linked to the already reported issue that supervisors did not have all information accessible on their position to get a full picture of the situation at MRTMs.

C.4.4.6.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

| OBJ-PJ05-W2-35-V3-VALP-S09 Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g: <ul style="list-style-type: none"> • Communication • Visualisation system Other systems in the MRTM | Supervisors could manage the technical failure occurring in one MRTM by supporting the transfer of the ATCO to a another MRTM. | OK |

The scenario used in the validation was a black screen on the out of the window view of one of the two aerodromes operated by the ATCO. The expected solution consisted for the ATCO in moving to another position. The transfer to another MRTM was supported by the possibility for the supervisor to make the other MRTM ready to operate the two aerodromes. It should be noted that the traffic level was moderate and that there were no ongoing traffic movements on the affected aerodrome at the time of the failure.

The proximity between the supervisor position and the MRTMs also made it easier for the supervisor to rapidly understand and monitor the situation.



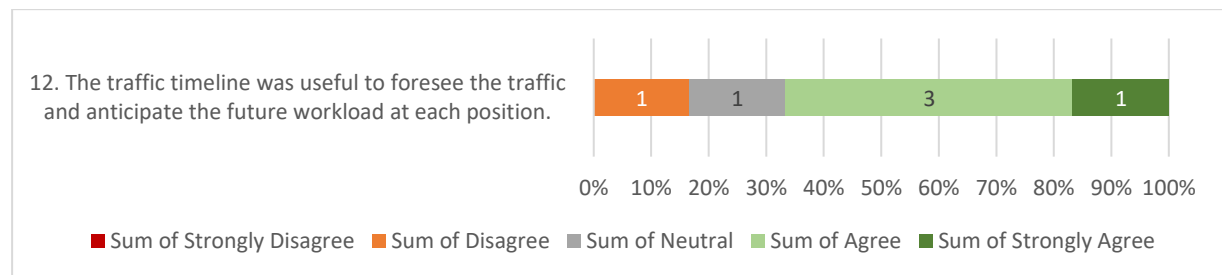
Participants response to the criteria related statement(s) in the final questionnaire.

The “Strongly Disagree” response in the final questionnaire can be linked to the already reported issue that supervisors did not have all information accessible on their position to get a full picture of the situation at MRTMs.

C.4.4.6.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results

| OBJ-PJ05-W2-35-V3-VALP-S10 Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|--|---|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | Improvements were considered necessary for the supervisors to foresee traffic at MRTMs. | Partially OK |

The supervisor monitoring tool was found useful to anticipate the future traffic load at MRTMs, however improvements were considered necessary as reported in results for CRT-PJ05-W2-35-V3-VALP-H12.030.



Participants response to the criteria related statement(s) in the final questionnaire

C.4.5 TWR/APP – Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|-------------------------------------|--|--|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes with combined Approach | OBJ-PJ05-W2-35-V3-VALP-2.3.1-01.010 | Majority of ATCOs state that situation awareness is at an acceptable level | <p>All ATCOs stated that situation awareness was at a satisfactory level in the combined TWR/APP run.</p> <p>Situational awareness when operating two aerodromes including one with TWR/APP could be achieved because the traffic level was moderate on the TMA with few aircrafts on vectors, and the traffic level on the other aerodrome was low.</p> | OK |
| | | OBJ-PJ05-W2-35-V3-VALP-2.3.1-01.020 | Majority of ATCOs assess that they can prioritise tasks | <p>ATCOs could prioritize their tasks between the aerodrome with combine TWR/APP and the other aerodrome. However, it was reported that with a higher level of traffic on the TMA and more aircrafts to vector, the focus on radar control and surveillance display could take the attention of the ATCOs away from the other aerodrome(s).</p> | Partially OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---------------------------------|---|-------------------------------------|--|--|-----------------------------|
| | | OBJ-PJ05-W2-35-V3-VALP-2.3.1-01.030 | ATCOs confirm that the user interface design supports a sufficient level of individual situation awareness | The advanced tools to monitor radar separation on the surveillance display have supported the situation awareness of the ATCOs. However, ATCOs missed the possibility to access flight level and heading clearances on radar labels, as well as a colour coding to distinguish the type of flight movements (VFR, IFR, ARR, DEP etc.). | Partially OK |
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-03 | Assess ATCO workload when providing ATS to multiple aerodromes combined with Approach | OBJ-PJ05-W2-35-V3-VALP-2.3.1-03.010 | Majority of ATCOs assess workload at an acceptable level | All ATCOs assessed that workload was at a satisfactory level in the combined TWR/APP run. For the run with combined TWR/APP, the traffic level was moderate on the TMA with few aircrafts on vectors, and the traffic level on the other aerodrome was low. | OK |
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-04 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes combined with Approach | OBJ-PJ05-W2-35-V3-VALP-2.3.1-04.010 | ATCOs can apply operating methods in an accurate, efficient and timely manner | ATCOs could efficiently apply operating methods including merging and splitting APP control with TWR control on one aerodrome, while performing TWR control on another aerodrome. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---------------------------------|---|-------------------------------------|--|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-05 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes combined with Approach | OBJ-PJ05-W2-35-V3-VALP-2.3.1-05.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable | All ATCOs assessed that their roles and responsibilities were clear and acceptable when providing ATS to two aerodromes, with one of them combined with approach. | OK |
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-06 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes combined with Approach | OBJ-PJ05-W2-35-V3-VALP-2.3.1-06.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs could easily access all required information except for the flight level and heading clearances that were lacking on flight labels for APP control. Additionally, the upcoming traffic sequence predicted by the timeline was not enough reliable. | Partially OK |
| | | OBJ-PJ05-W2-35-V3-VALP-2.3.1-06.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls | ATCOs confirmed the usability of input devices and HMI controls. | OK |
| | | OBJ-PJ05-W2-35-V3-VALP-2.3.1-06.040 | The ATCO human machine interface does not increase the potential for human error | The upcoming traffic sequence predicted by the timeline was often not accurate which could be confusing for the ATCOs. | Partially OK |
| OBJ-PJ05-W2-35-V3- | Assess ATCO capability to provide ATC services in a safe manner to | OBJ-PJ05-W2-35-V3-VALP-2.3.1-08.010 | ATCO is able to identify and solve potential conflicts in a timely manner: | ATCOs were able to identify and solve potential conflicts in a timely manner in the terminal area. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|---|-------------------------------------|--|---|-----------------------------|
| VALP-2.3.1-08 | multiple aerodromes combined with approach services under all normal conditions | | In the terminal area | | |
| | | OBJ-PJ05-W2-35-V3-VALP-2.3.1-08.020 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | ATCOs were able to distinguish with which aircraft, vehicle at which aerodrome the ATCOs were communicating with. | OK |

C.4.6 TWR/APP – Analysis of Exercise Results per Validation Objective

The results for combined TWR/APP should be considered as exploratory since:

- The concept of multiple aerodromes combined with approach has not been subject to validation in the previous V phases.
- The priority in this exercise has been given to the TWR-only objectives during the exercise preparation and data collection.
- Only one run was dedicated to the validation of combined TWR/APP.
- Three ATCOs, instead of four as originally planned, have performed the run with combined TWR/APP.

C.4.6.1 OBJ-PJ05-W2-35-V3-VALP-2.3.1-02 Results

OBJ-PJ05-W2-35-V3-VALP-2.3.1-02

Assess ATCO situation awareness when providing ATS to multiple aerodromes combined with Approach

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|---|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-01.010 | Majority of ATCOs state that situation awareness is at an acceptable level | All ATCOs stated that situation awareness was at a satisfactory level in the combined TWR/APP run. Situational awareness when operating two aerodromes including one with TWR/APP could be achieved because the traffic level was moderate on the TMA with few aircrafts on vectors, and the traffic level on the other aerodrome was low. | OK |

ATCOs have self-rated the Situation Awareness (SA) they have experienced during the combined TWR/APP run using the China Lakes SA Scale shown below:

Please rate Situational Awareness (SA) you experienced during the run

Was it possible to perform the task?

No

Yes

Was your level of SA acceptable?

No

Yes

Was your level of SA satisfactory?

No

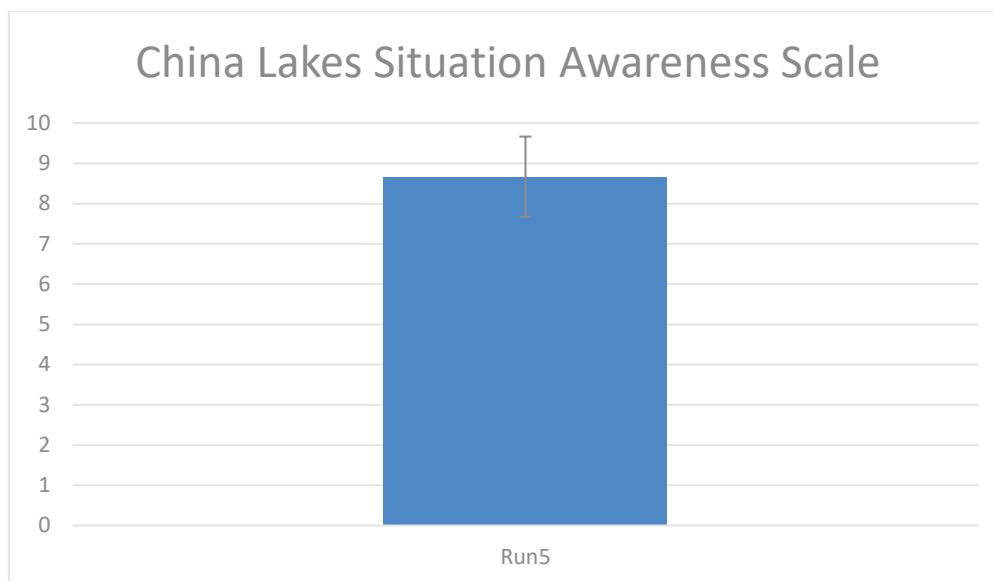
Yes

| SA experienced during the run | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| My SA with respect to the task was far too low. I could not perform the task because I did not possess the necessary information. | <input type="checkbox"/> | | | | | | | | | |
| My SA with respect to the task was very low. I was unaware of almost all of the information required to perform the task effectively. | | <input type="checkbox"/> | | | | | | | | |
| My SA with respect to the task was low. I was unaware of most of the information required to perform the task effectively. | | | <input type="checkbox"/> | | | | | | | |
| My SA with respect to the task was low. I was unaware of about half of the information required to perform the task effectively. | | | | <input type="checkbox"/> | | | | | | |
| My SA with respect to the task was reduced. I was unaware of some of the important information required to perform the task effectively. | | | | | <input type="checkbox"/> | | | | | |
| My SA with respect to the task was insufficient. I was not aware of all the information required to perform the task effectively. | | | | | | <input type="checkbox"/> | | | | |
| My SA with respect to the task was not complete. I was able to perform the task, but not satisfactorily. | | | | | | | <input type="checkbox"/> | | | |
| My SA with respect to the task was good. I was able to perform the task well most of the time. | | | | | | | | <input type="checkbox"/> | | |
| My SA with respect to the task was very good. I was able to perform the task well all of the time. | | | | | | | | | <input type="checkbox"/> | |
| My SA with respect to the task was excellent. I was able to perform the task extremely well all of the time. | | | | | | | | | | <input type="checkbox"/> |

The China Lakes is a 10-points rating scale where 1 represents the lowest possible situation awareness and 10 the highest possible situation awareness.

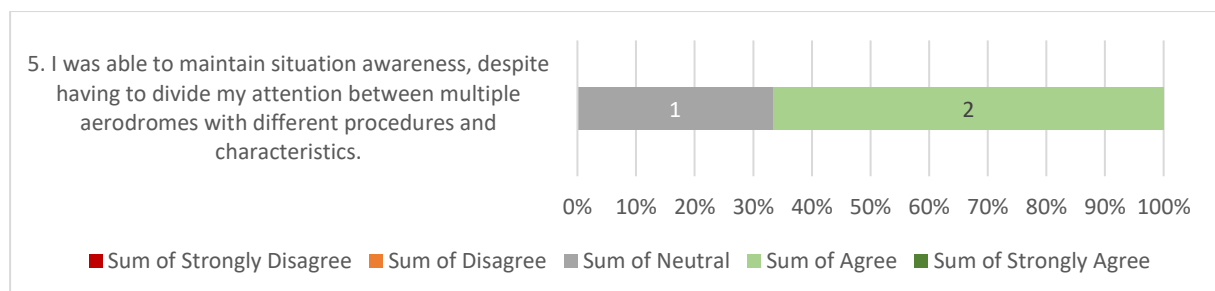
As indicated by the colour coding on the scale, the rating scale can also be subdivided into three main categories: “Satisfactory” (8-10), “Not satisfactory / Reduced” (5-7) and “Not acceptable” (1-4).

The chart below shows the average rating on the China Lakes 10-points scale for the combined TWR/APP run.



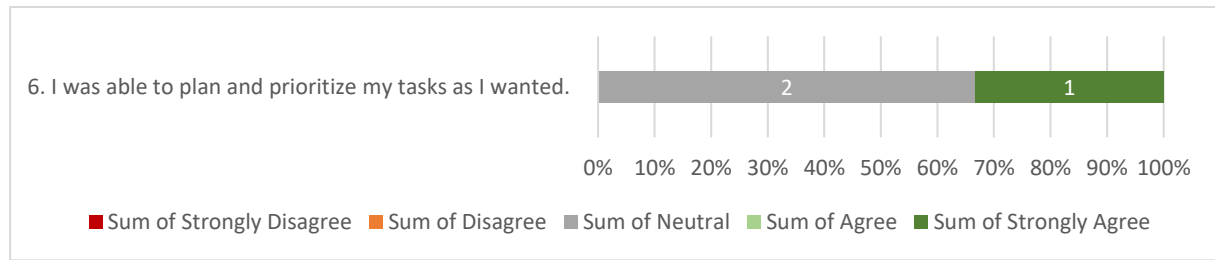
Mean (self-rated) situation awareness (with standard deviation).

All three ATCOs self-rated the SA experienced in the combined TWR/APP run as satisfactory.



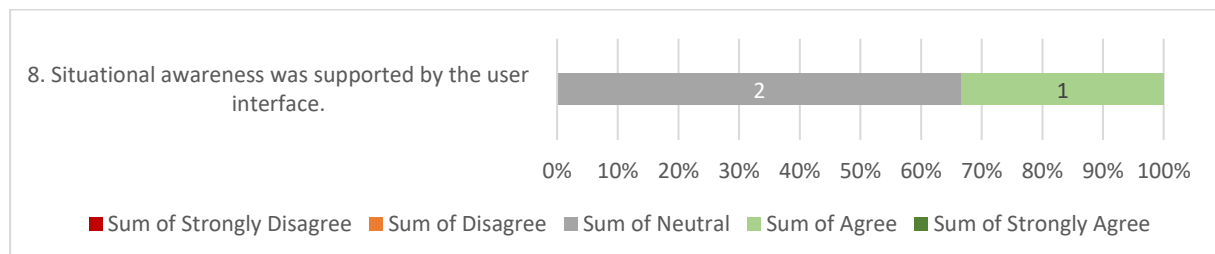
Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|---|--|--------------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-01.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs could prioritize their tasks between the aerodrome with combine TWR/APP and the other aerodrome. However, it was reported that with a higher level of traffic on the TMA and more aircrafts to vector, the focus on radar control and surveillance display could take the attention of the ATCOs away from the other aerodrome(s). | Partially OK |



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|--|--------------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-01.030 | ATCOs confirm that the user interface design supports a sufficient level of individual situation awareness | The advanced tools to monitor radar separation on the surveillance display have supported the situation awareness of the ATCOs. However, ATCOs missed the possibility to access flight level and heading clearances on radar labels, as well as a colour coding to distinguish the type of flight movements (VFR, IFR, ARR, DEP etc.). | Partially OK |



Participants response to the criteria related statement(s) in the final questionnaire.

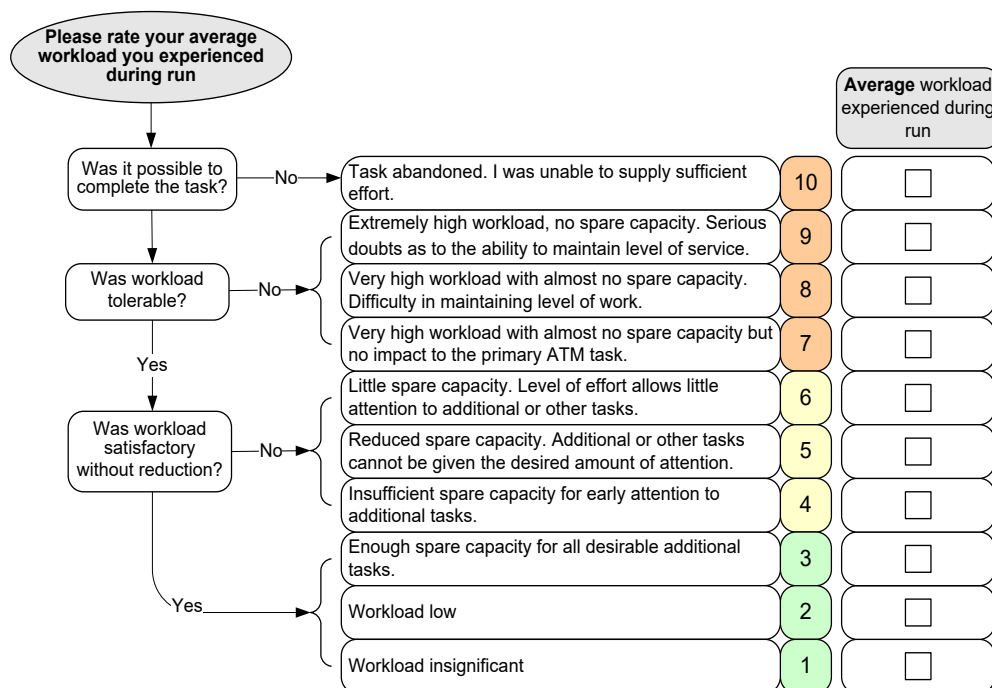
C.4.6.2 OBJ-PJ05-W2-35-V3-VALP-2.3.1-03 Results

OBJ-PJ05-W2-35-V3-VALP-2.3.1-03

Assess ATCO workload when providing ATS to multiple aerodromes combined with Approach

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|---|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-03.010 | Majority of ATCOs assess workload at an acceptable level | <p>All ATCOs assessed that workload was at a satisfactory level in the combined TWR/APP run.</p> <p>For the run with combined TWR/APP, the traffic level was moderate on the TMA with few aircrafts on vectors, and the traffic level on the other aerodrome was low.</p> | OK |

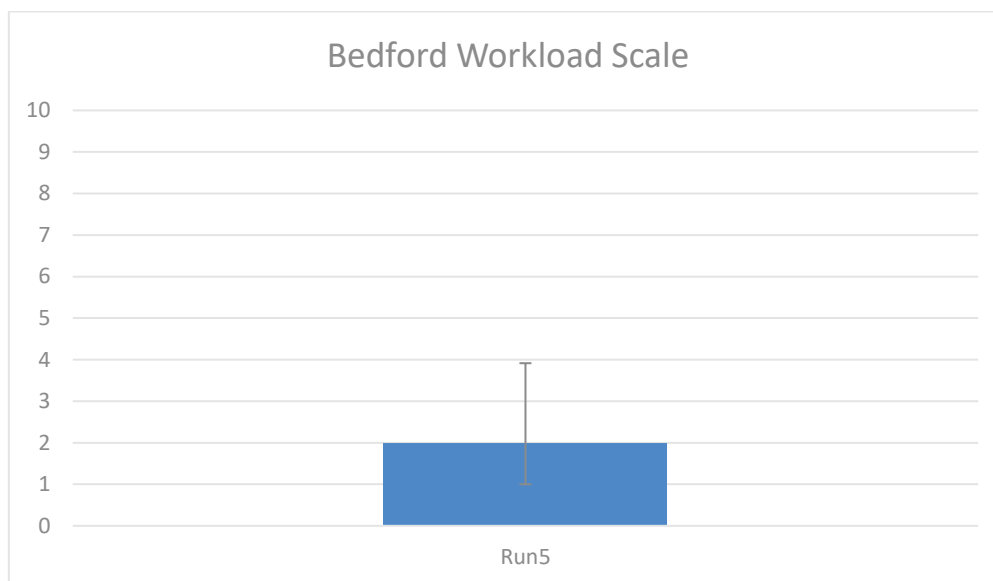
ATCOs have self-rated the average workload experienced during each run by use of the Bedford Workload Scale shown below:



The Bedford is a 10-points rating scale where 1 represents the lowest possible workload and 10 the highest possible workload.

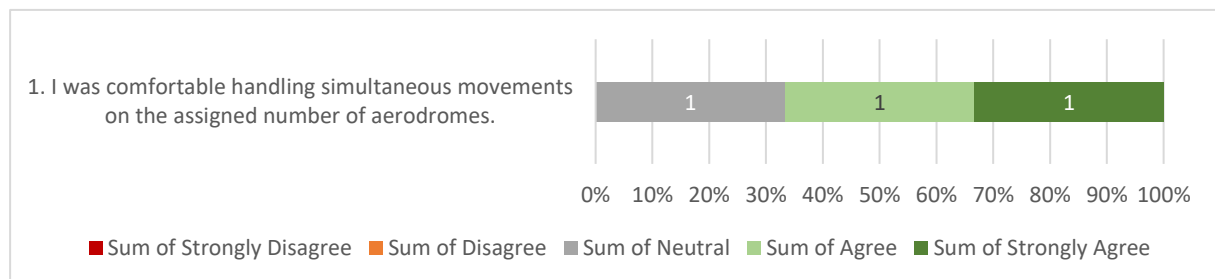
As indicated by the colour coding on the scale, the rating scale can also be subdivided into three main categories: "Satisfactory" (1-3), "Not satisfactory / Reduced capacity" (4-6) and "Not tolerable" (7-10).

The chart below shows the average rating on the Bedford 10-points scale for the combined TWR/APP run.



Mean (self-rated) workload (with standard deviation).

All three ATCOs self-rated the workload experienced in the combined TWR/APP run as satisfactory.



Participants response to the criteria related statement(s) in the final questionnaire.

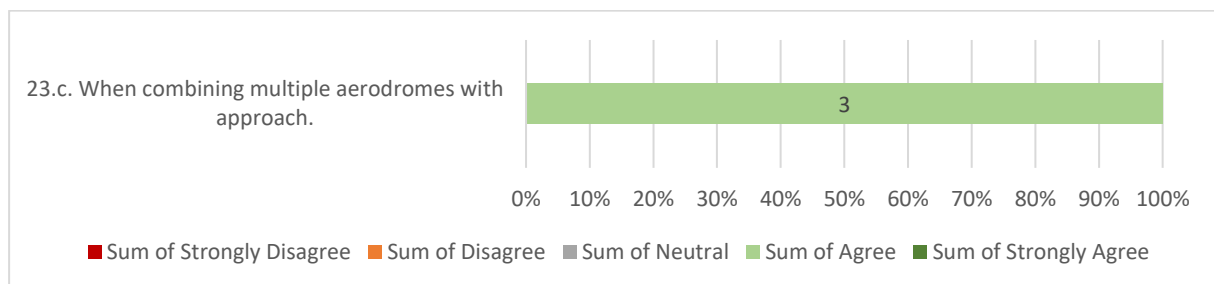
C.4.6.3 OBJ-PJ05-W2-35-V3-VALP-2.3.1-04 Results

OBJ-PJ05-W2-35-V3-VALP-2.3.1-04

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes combined with Approach

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|---|---|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-04.010 | ATCOs can apply operating methods in an accurate, efficient and timely manner | ATCOs could efficiently apply operating methods including merging and splitting APP control with TWR control on one aerodrome, while performing TWR control on another aerodrome. | OK |

23. Operating methods when providing ATS services to multiple aerodromes were efficient (i.e. switching focus between aerodromes, dynamic allocation of aerodromes with split/merge, phraseology, coupling of frequency).



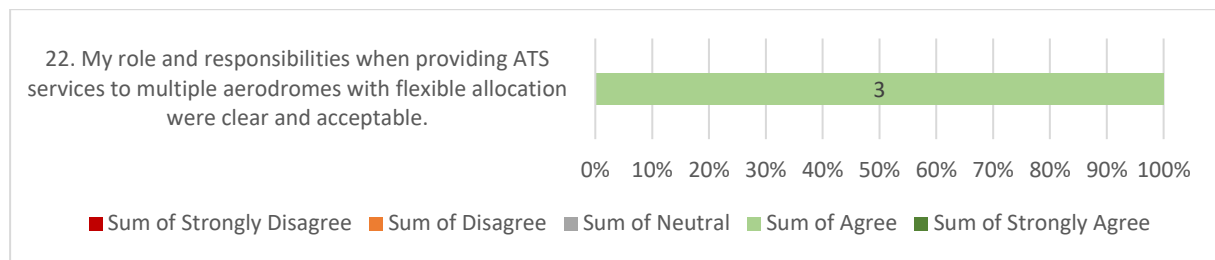
Participants response to the criteria related statement(s) in the final questionnaire.

C.4.6.4 OBJ-PJ05-W2-35-V3-VALP-2.3.1-05 Results

OBJ-PJ05-W2-35-V3-VALP-2.3.1-05

Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes combined with Approach

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|---|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-05.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable | All ATCOs assessed that their roles and responsibilities were clear and acceptable when providing ATS to two aerodromes, with one of them combined with approach. | OK |



Participants response to the criteria related statement(s) in the final questionnaire.

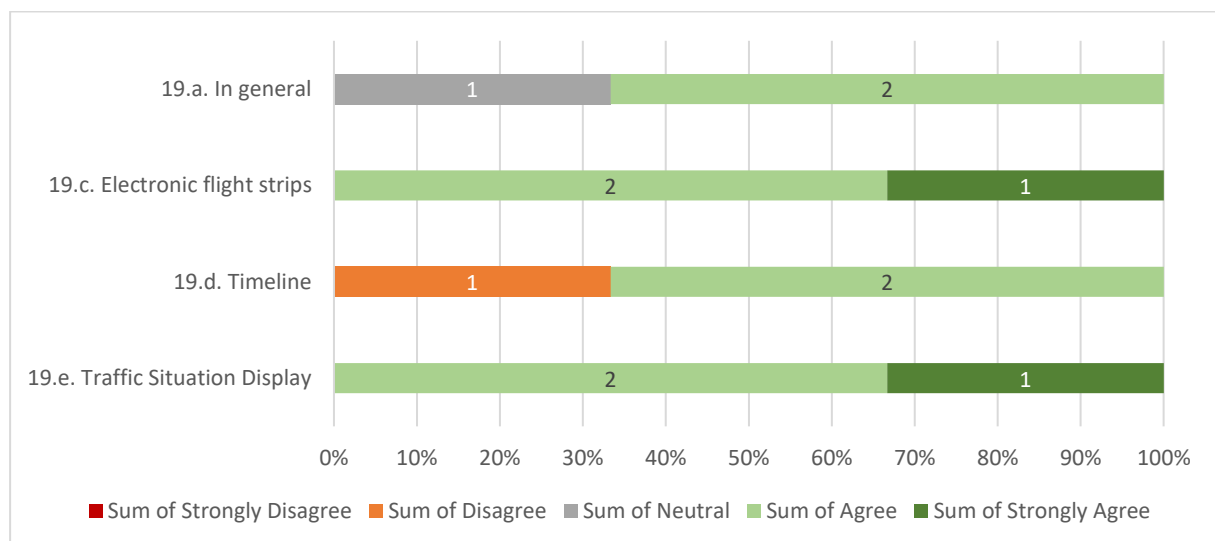
C.4.6.5 OBJ-PJ05-W2-35-V3-VALP-2.3.1-06 Results

OBJ-PJ05-W2-35-V3-VALP-2.3.1-06

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes combined with Approach

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|--|--------------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-06.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs could easily access all required information except for the flight level and heading clearances that were lacking on flight labels for APP control. Additionally, the upcoming traffic sequence predicted by the timeline was not enough reliable. | Partially OK |

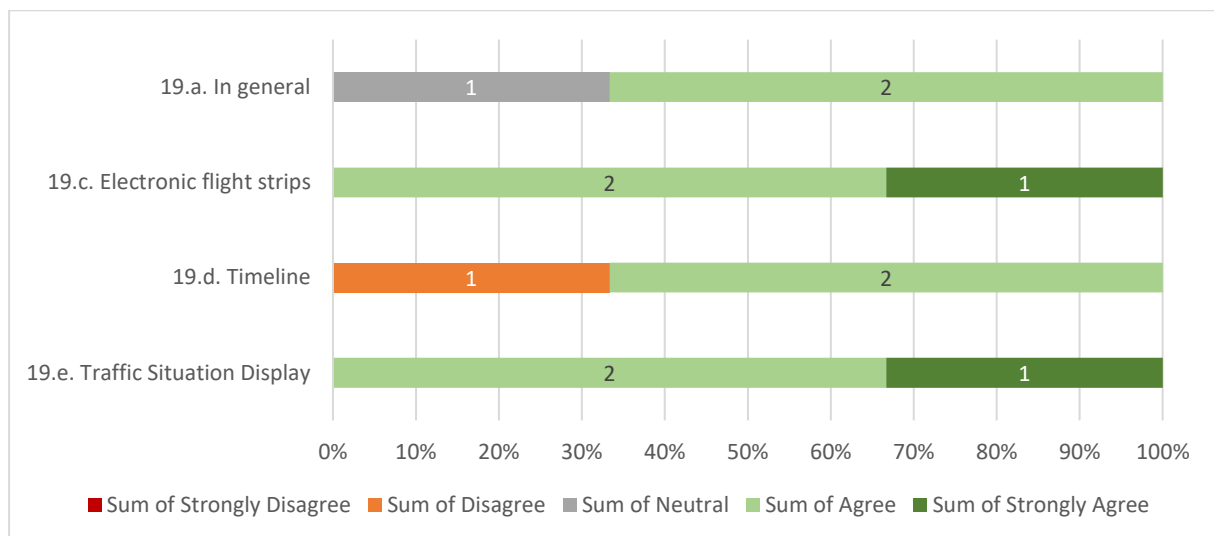
19- The system was easy to use; all information were easy to access and presented in an effective way.



Participants response to the criteria related statement(s) in the final questionnaire.

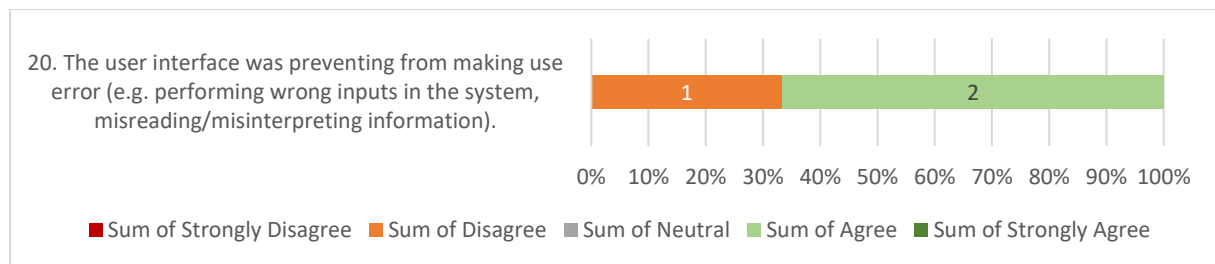
| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|--|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-06.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls | ATCOs confirmed the usability of input devices and HMI controls. | OK |

19- The system was easy to use; all information were easy to access and presented in an effective way.



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|--|--------------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-06.040 | The ATCO human machine interface does not increase the potential for human error | The upcoming traffic sequence predicted by the timeline was often not accurate which could be confusing for the ATCOs. | Partially OK |



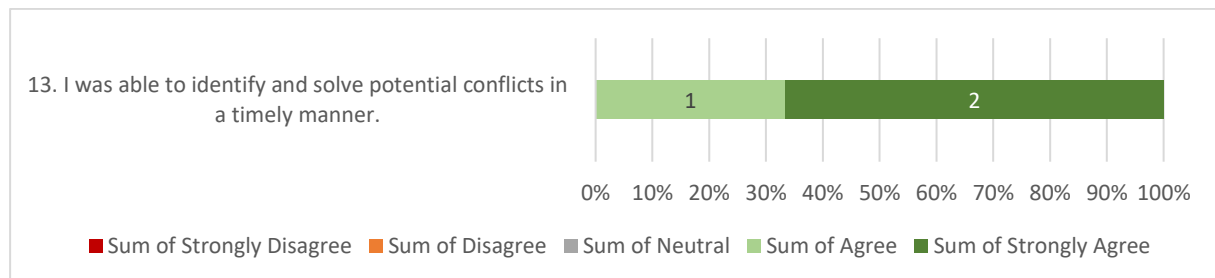
Participants response to the criteria related statement(s) in the final questionnaire.

C.4.6.6 OBJ-PJ05-W2-35-V3-VALP-2.3.1-08 Results

OBJ-PJ05-W2-35-V3-VALP-2.3.1-08

Assess ATCO capability to provide ATC services in a safe manner to multiple aerodromes combined with approach services under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|--|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-08.010 | ATCO is able to identify and solve potential conflicts in a timely manner: In the terminal area | ATCOs were able to identify and solve potential conflicts in a timely manner in the terminal area. | OK |



Participants response to the criteria related statement(s) in the final questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|-------------------------------------|--|---|--------|
| OBJ-PJ05-W2-35-V3-VALP-2.3.1-08.020 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | ATCOs were able to distinguish with which aircraft, vehicle at which aerodrome the ATCOs were communicating with. | OK |

No confusion was observed or reported for the run with combined APP/TWR.

Founding Members

C.4.7 Unexpected Behaviours/Results

One ATCO participant (out of the four ATCO participants) had to cancel his participation to the second validation day. Therefore her/his contribution to the findings is limited to the first two runs and to the associated post-run questionnaires and debriefings. Data from the final questionnaire are therefore based on three ATCOs instead of four.

C.4.8 Confidence in Results of Validation Exercise

C.4.8.1 Level of significance/limitations of Validation Exercise Results

The following limitations and potential biases need to be considered in the interpretation of the exercise results:

- There was often a discrepancy in the real-time simulation between the traffic as planned according to the ATCOs and supervisor's planning tool (i.e., the "timeline") and the traffic as executed by the simulator and the pseudo-pilots. This can explain some of the issues participants had while using the "timeline" tool.
- As mentioned in results sections, even though supervisors could monitor traffic movements for 15 aerodromes/MRTMs, their focus during the validation mainly remained on the set of 4 aerodromes and 2 MRTMs that were operated by ATCOs during the runs. The other 11 aerodromes/MRTMs were only simulated on the supervisor position and did not require continuous monitoring or actions. The significance of the results for the Situation Awareness and Workload criteria is therefore limited to an assigned number of 4 aerodromes.
- The supervisor position was very close to the MRTMs during the validation. This setup has contributed to the ability of the supervisor to support the ATCOs during abnormal situations. The setup can be different in a Remote Center with more aerodromes where MRTMs can be further away from the supervisor position.

C.4.8.2 Quality of Validation Exercises Results

The following elements contributed to the good quality of the results:

- The maturity of the solution was in line with the V phase.
- All validation scenarios could be ran as planned.
- The real time simulation environment performed well throughout the validation sessions.
- All data collection means could be used as planned.

C.4.8.3 Significance of Validation Exercises Results

- Significance of results regarding participants:

Even though the number of ATCO participants was limited to four and one ATCO participant could not complete the validation, the feedback received were sufficiently consistent to assume that the results for ATCOs are significant.

The significant number of supervisor participants (i.e., six) provides confidence in the supervisor results.

- Significance regarding scenarios:

As mentioned in the result section, not all ATCOs tasks (e.g., producing METAR, coordinating with overlying sectors) and operational contexts (impact of difficult weather, maintenance operations, taxiway closures etc.) were included in the validation. The rule for maximum capacity used during the validation (8 simultaneous movements where VFR count as 1,5) will therefore need to be adjusted to take into account all ATCOs tasks and complexity factors.

As stated in the results section, the results for combined TWR/APP should be considered as exploratory since:

- The concept of multiple aerodromes combined with approach has not been subject to validation in the previous V phases.
- The priority in this exercise has been given to the TWR-only objectives during the exercise preparation and data collection.
- Only one run was dedicated to the validation of combined TWR/APP.
- Three ATCOs, instead of four as originally planned, have performed the run with combined TWR/APP.

C.4.9 Conclusions

A.1.1.1. Conclusions on concept clarification

From the ATCO point of view, the dynamic allocation of up to three aerodromes into one MRTM was feasible, in both normal and abnormal situations. However clear rules on maximum capacity in terms of total movements, simultaneous movements, as well as complexity, need to be established to ensure that the ATCOs workload is maintained at an acceptable level in normal and abnormal conditions.

From the supervisor point of view, the supervision and monitoring of four aerodromes with dynamic allocation to two MRTMs/ATCOs was feasible, in both normal and abnormal conditions. Clear rules on maximum capacity and complexity at MRTMs need to be established to make it possible for the supervisor to make appropriate split and merge decisions. The establishment of roster models that can provide sufficient spare capacity and resources is key to ensure the feasibility of the split and merge of aerodromes in case of overload or unexpected situation at one MRTM.

A.1.1.1. Conclusions on technical feasibility

The validation results confirm the technical feasibility of the dynamic allocation of aerodromes to MRTMs and the supervision of multiple MRTMs/aerodromes.

However, improvements are needed to allow the supervisor to have a better view of the current situation at the MRTMs.

A.1.1.1. Conclusions on performance assessments

For the ATCOs, the capacity threshold of 8 simultaneous movements (where VFR would count as 1,5) corresponded to the maximum controller capacity during the validation. However other operational tasks, complexity factors, as well as the need to have spare capacity/buffer need to be considered to adjust the capacity in real operations.

The supervisor could manage a total of four aerodromes with flexible allocation to two MRTMs, and support the ATCOs in case of abnormal situations, in a setup where the supervisor position and MRTMs were very close to each other's. The maximum number of aerodromes that one supervisor can manage remains to be assessed, considering different ops room configurations, improvements of the supervisor's tools and taking into account all supervisor's tasks in real operations.

C.4.10 Recommendations

The following recommendations regarding the concept and the solution need to be considered:

- In addition to the monitoring of traffic load and meteorological conditions, the supervisor should have a better view of the current situation at any MRTMs to facilitate monitoring and ensure a shared situation awareness with the ATCOs.
- The supervisor tool should facilitate the access and integration of information such as traffic numbers and capacity thresholds, aerodrome allocation plan, roster, as well as operators' endorsement, to support the decision making and planning of the dynamic allocation of aerodromes.
- The MRTM heads-down display layout with multiple aerodromes should reconfigure itself automatically after swapping, splitting, or merging actions in such a way that all HMIs are correctly associated to the aerodrome they belong to.
- Clear capacity rules, sufficient spare capacity and/or available personnel, clear procedures and an efficient task sharing between the supervisor and the ATCO should be established to ensure that the team can safely and efficiently manage overloads and abnormal situations.

C.5 EXE-2.3.2 INDRA/HungaroControl PSM Validation

C.6 Summary of the Validation Exercise EXE-2.3.2-INDRA Plan

C.6.1 Validation Exercise description, scope

The operational scope of this passive shadow mode validation was to address the simultaneous ATS provision in small size Hungarian aerodromes from two MRTMs by one ATCO per RTM and a Supervisor. The aerodrome were the followings:

- Nyíregyháza (AFIS, mostly VFRs)
- Győr-Pér (AFIS, mostly VFRs)
- Pápa (military aerodrome)

The real environment allowed to evaluate the visualization system and other HMI elements under specific circumstances (e.g. daytime, night, various meteorological conditions), and analyze a potential degraded mode (i.e. fix camera failure). The PSM was not applicable to evaluate controller workload or situational awareness, although valuable feedback was collected concerning HMI design and the interaction with the system.

Nine ATCOs participated in the validation: six civilian and three military controllers from Pápa.

C.6.2 Summary of Validation Exercise EXE-2.3-INDRA Validation Objectives and success criteria

| SESAR Validation Objective | Solution Success criteria | Coverage and comments on the coverage of SESAR Solution Validation Objective in Exercise 2.3.2 | Exercise Validation Objective | Exercise Success criteria |
|---|--------------------------------|--|-------------------------------|---------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H06 | CRT-PJ05-W2-35-V3-VALP-H06-010 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H09 | CRT-PJ05-W2-35-V3-VALP-H09-010 | Fully covered Debrief, workshop | as solution | as solution |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-010 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-020 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-050 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-060 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-070 | Fully covered debrief, workshop | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-080 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-010 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-020 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-030 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-050 | Fully covered questionnaire, debrief | as solution | as solution |

HUMAN PERFORMANCE – TRUST

| | | | | |
|----------------------------|--------------------------------|--------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H14 | CRT-PJ05-W2-35-V3-VALP-H14-010 | Fully covered debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18-010 | Fully covered debrief | as solution | as solution |

SAFETY

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-010 | Partially covered, because it can be assessed whether the ATCO can identify potential hazardous situations but not whether s/he can solve them in a PSM. questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-020 | Partially covered, because it can be assessed whether the ATCO can identify potential hazardous | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| | | situations but not whether s/he can solve them in a PSM. questionnaire, debrief, workshop | | |
| OBJ-PJ05-W2-35-V3-VALP-S07 | CRT-PJ05-W2-35-V3-VALP-S07-010 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S07 | CRT-PJ05-W2-35-V3-VALP-S07-030 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S09 | CRT-PJ05-W2-35-V3-VALP-S09-010 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S10 | CRT-PJ05-W2-35-V3-VALP-S10-010 | Partially covered, because it can be assessed whether SUP can foresee the traffic, but not whether s/he can safely manage the RTC operations in a PSM. questionnaire, debrief, workshop | as solution | as solution |

C.6.3 Summary of Validation Exercise EXE-2.3-INDRA Validation scenarios

The traffic volume and complexity matched to reality, thus unbalanced traffic distribution was present frequently.

The traffic volume strongly depended on the weather conditions. Day 1 was a sunny day, thus there was a lot of movement in Nyíregyháza and Győr-Pér. Pápa was also busy with an exercise, pretending that a C17 has ran off the runway. According to the script, the pilot braked which caused the unsecured cargo to escape and several soldiers have been injured. The accident was detected by the air traffic controllers and the services (i.e. fire and rescue) were alerted immediately.

On Day 2 the weather was rainy, thus only limited VFR movement was present. Some helicopter activities happened on Pápa.

Day 3 was again sunny, yet the movement was considerably less than on Day 1. Simultaneous movements were rare.

C.6.4 Summary of Validation Exercise EXE-2.3-INDRA Validation Assumptions

| Identifier | Title | Description | Justification | Impact on Assessment |
|-------------------------|---------------------|--|--|----------------------|
| ASM-PJ05-V2-VALP-EX4.02 | Coupled Frequencies | Frequencies of the three airports will be coupled to one, resulting no switching needed by the ATCO to select them | The traffic can be managed in a safe and adequate manner | High |

Table 19: Validation Assumptions overview

C.7 Deviation from the planned activities

The flexible allocation functionality only worked on RTM2, as in RTM1 the different type of hardware (curved video monitors) was not compatible with the KVM matrix, thus did not allow for the flexible allocation.

The applicability of the operating methods has not been addressed, as it was already covered in the RTS.

The SUP position was not assessed because there was no such high movement that the SUP should have made a decision based on the planning tool.

The short-term planning too (i.e. the timeline) was not addressed as there was no improvement compared to the RTS. The opinions are explained in the RTS section of this document.

C.8 Validation Exercise EXE-2.3.2-INDRA Results

C.8.1 ATCO - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | ATCOs were able to adapt to different/changing sets of aerodromes. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|-------------------|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | | |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|---|-----------------------------|
| | | | a flexible allocation of aerodromes between MRTMs | | |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | ATCOs all agree that providing ATC for the selected aerodromes would be feasible, including the number of simultaneous movements. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | | |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| | Assess that human-machine interface | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an | The technical system (InNOVA) supported the ATCOs during split and merge. | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H18 | supports the team in carrying out their tasks | | RTC with a flexible allocation of aerodromes between MRTMs. | However, the IRTOS video system was not connected to the InNOVA system, which led to the situation that even though the aerodrome was not with the MRTM (not even in “view only mode”), the ATCO could still use its IRTOS menu. | |
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | | |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | Majority of the ATCOs agreed that apart from the MET data, the important information was available in the system. The IRTOS windows were quite large and covered important areas on the HDD. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | 66% of the ATCOs agreed that the IRTOS video functionalities were user-friendly. A number of design issues have been mentioned, and potential solutions have been discussed. The biggest concern was the way ATCOs had to go back to airport selection whenever they wanted to work | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|--------------------------------|---|--|-----------------------------|
| | | | | with any of the video system functions at another airport, and this issue was even more pronounced when the activity was imminent. | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The HMI design had some limitations, and it was observed that sometimes ATCOs were not aware which function was activated. | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | ATCOs were aware which aerodromes were presented on which parts of the system. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which | It was unanimously agreed that it was clear which aerodrome was transferred between the MRTMs | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| | | | aerodrome will be transferred between the MRTMs. | | |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | | |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | Everyone found the technical system's performance during split and merge reliable enough to establish trust. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | | |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | <p>The majority of ATCOs find that they are able to identify potential conflicts in a timely manner</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | POK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> Unstable approaches Bird strikes Aircraft not vacating RWY as expected | | |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | <p>ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with</p> | <p>The majority of ATCOs (56%) find that they are able to distinguish with which aircraft, vehicle at the same aerodrome they are communicating with</p> | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|-------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | | |
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | | |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | <p>ATCO is able to identify and manage abnormal situations (e.g.):</p> <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|---|-------------------|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g): <ul style="list-style-type: none">• Communication• Visualisation system• Other airport systems / infrastructure | | |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g): <ul style="list-style-type: none">• Communication• Visualisation system | | |
| CAPACITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | | |
| COST EFFICIENCY | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|--|-------------------|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | | |

Table 20: ATCO - Validation Results for Exercise 1

C.8.2 ATCO - Analysis of Exercise Results per Validation objective

C.8.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

C.8.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

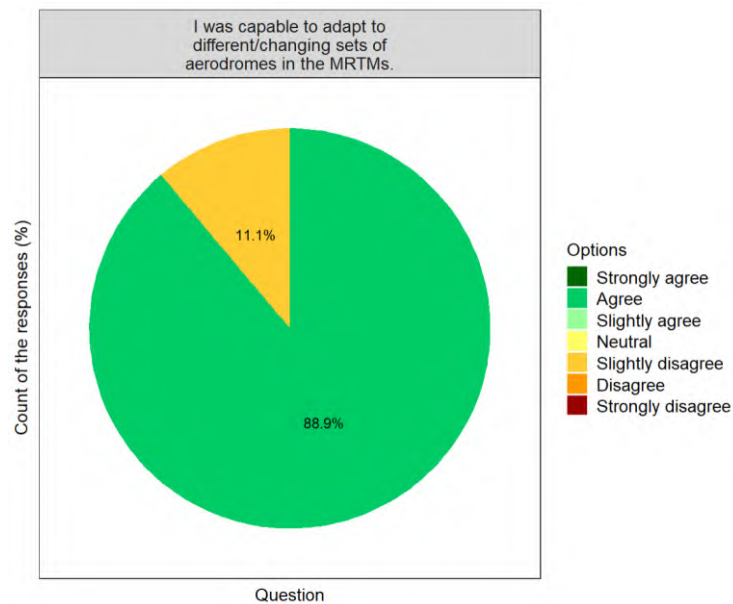
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | ATCOs were able to adapt to different/changing sets of aerodromes. | OK |

Tailor-made question: Based on **Fehler! Verweisquelle konnte nicht gefunden werden.** the majority of the ATCOs were able to adapt to changing sets of aerodromes.



Feedback received on ability to adapt to the changing set of aerodromes

C.8.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

C.8.2.2 HUMAN PERFORMANCE – WORKLOAD

C.8.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

| OBJ-PJ05-W2-35-V3-VALP-H04 Assess ATCO workload when providing ATS to multiple aerodromes |
|--|
|--|

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | | N/A |

C.8.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

C.8.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

C.8.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

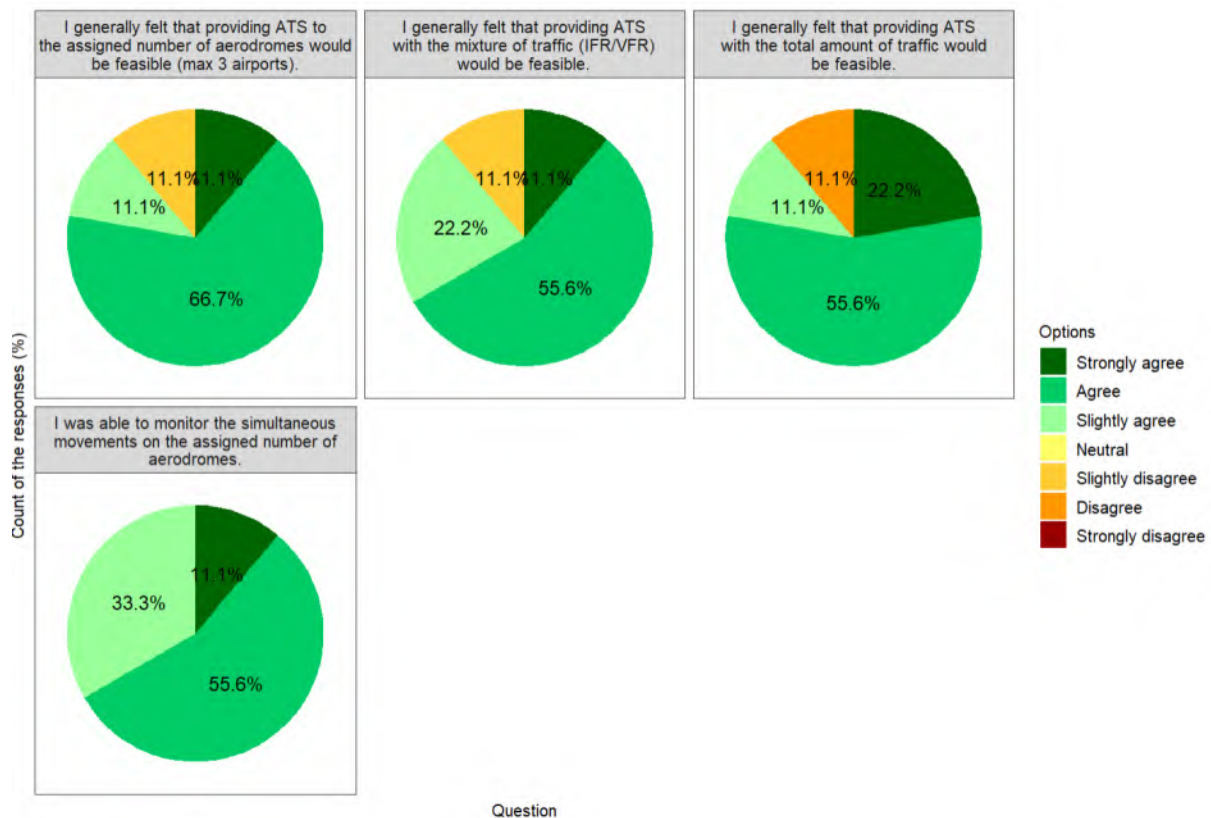
OBJ-PJ05-W2-35-V3-VALP-H07

Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | ATCOs all agree that providing ATC for the selected aerodromes would be feasible, including the number of simultaneous movements. | OK |

Tailor-made questions: Four questions were designed to address the feasibility of providing ATS to the number of tested aerodromes. According to **Fehler! Verweisquelle konnte nicht gefunden werden.**, ATCOs confirm the feasibility and acceptability. The outcome of the previous wave's PJ05-02 has been further attested in this validation: at Nyíregyháza the VFR pilots discussed with each other their current positions and plans, which blocked the frequency for a certain duration. If this was a live trial and frequencies had been coupled, the ATCO should have waited for them to transmit, which may be disturbing in case of a simultaneous movement at another aerodrome. Thus procedures shall be harmonized at the aerodrome that are selected for multiple remote tower operations.



Feedback received for the questions related to feasibility of providing ATS to the assigned number of aerodromes during the PSM.

C.8.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | | N/A |

C.8.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

C.8.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

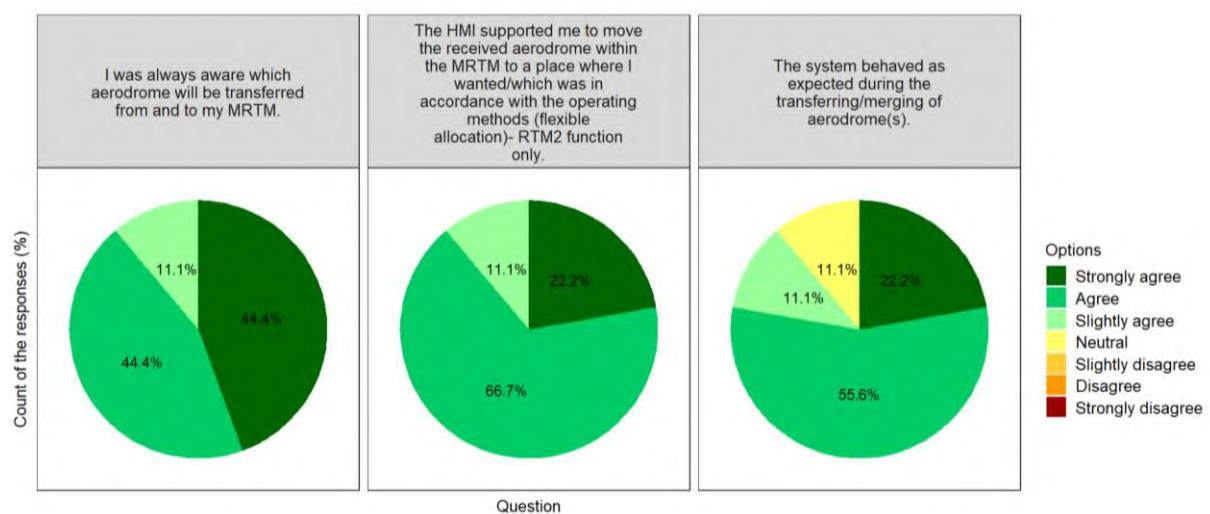
Assess that human-machine interface supports the team in carrying out their tasks

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | <p>The technical system (InNOVA) supported the ATCOs during split and merge.</p> <p>However, the IRTOS video system was not connected to the InNOVA system, which led to the situation that even though the aerodrome was not with the MRTM (not even in “view only mode”), the ATCO could still use its IRTOS menu.</p> | POK |

Tailor-made questions: Three questions have been created to address the success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** shows, ATCOs were always aware which aerodromes will be transferred to them. The split and merge was intuitive, and the most of the ATCOs agreed that the system behaved as expected during the split and merge process.

In addition, the InNOVA split and merge function was not connected to the IRTOS airport selection menu. ATCOs could still access to the video system menu of the already split aerodrome, that was even turned off on the video wall.

Importantly, the SUP position was not addressed in the passive shadow mode validation.



Results received for the HMI related questions, specifically to the split and merge and flexible allocation.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | | N/A |

C.8.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | Majority of the ATCOs agreed that apart from the MET data, the important information was available in the system. The IRTOS windows were quite large and covered important areas on the HDD. | OK |

Tailor-made questions and debriefing notes: As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.**, ATCOs agreed that required information was integrated and were easily accessible on the Head Down Display (HDD). They mentioned that when workload is high, the attention can become narrow thus it is useful that every crucial information is in front of the end-users. ATCOs expressed that they liked that all the information could be found in one big screen. In the first debriefing it was suggested to extend the VFR strips with additional information fields, make those more flexible e.g. traffic patterns or indicate which aircraft the “turn to base” was asked from.

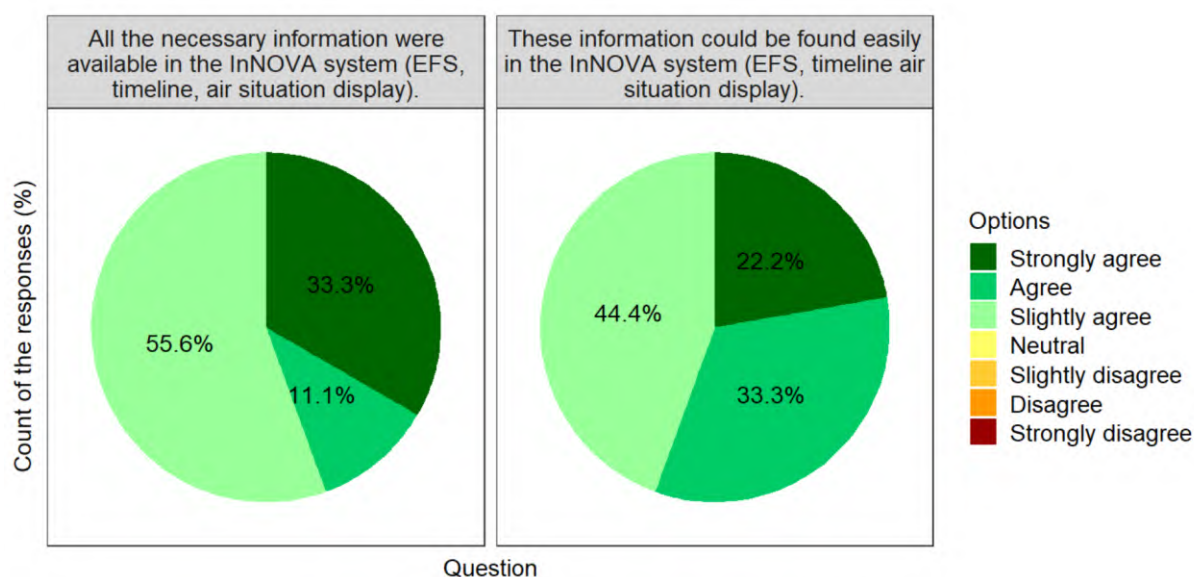


Figure: The distribution of the feedback in relation to the information availability and easy access (InNOVA).

However, the integrated IRTOS window was huge and covered a considerable part of the InNOVA radar display when it was opened.

With regards to the Visual Panorama, the sharpness and resolution of the camera images were also positively regarded, even though it was quite visible that Pápa only had Full HD cameras, and not 4K like that other two.

It would have been useful if the labels had worked as needed. There were a lot of labels that connected to unconcerned overflights, yet due to radar coverage limitations some of the arrivals/departures had no labels. Without labels it was extremely difficult to spot the small VFRs, which are visible in the actual TWR building. On the other hand, if the labels worked for the arriving VFRs, it would be a major benefit, as VFRs from a certain distance are not visible from the TWR either. The “box and follow” functionality (i.e. moving target indicator) is also an improvement compared to the conventional TWR operation, as this augmented reality solution helps to detect movements on any area of the aerodrome that is selected.

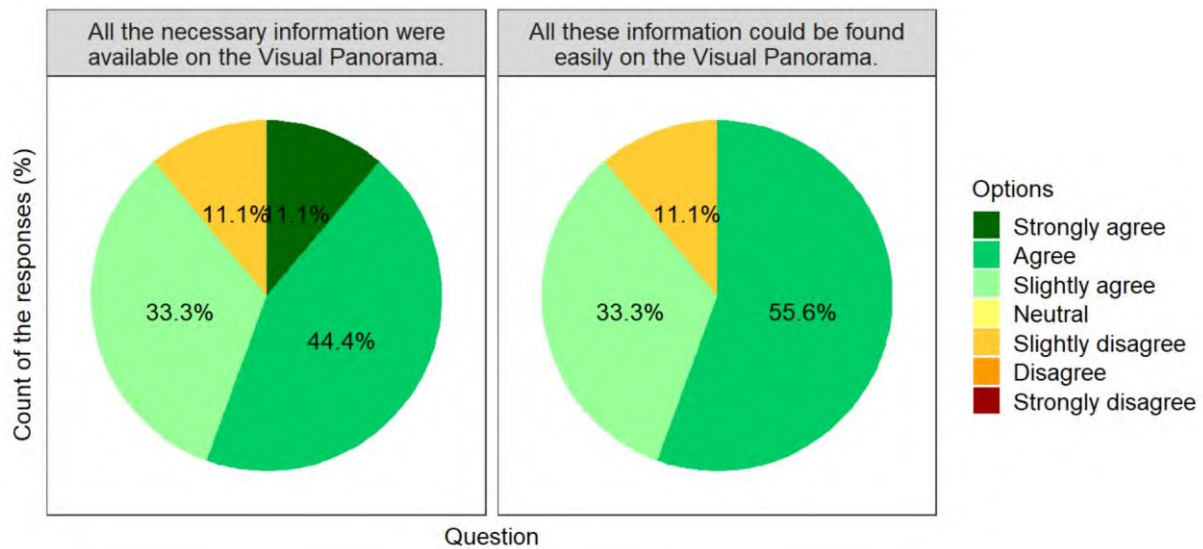


Figure: The distribution of the feedback in relation to the information availability and easy access (Visual Panorama)

The frequencies could not be coupled for the passive shadow mode validation, which turned out to be a major inconvenience, especially on Day 1 where there was a lot of overlap between the aerodromes. In line with the findings of the previous wave PJ05-02 outcome, A/G frequencies shall be coupled in order to establish and maintain situational awareness. In addition, squelch indication shall be integrated to visualize where the radio transmission is coming from, supported by coloured frames around the visual panorama monitors and the InNOVA EFS.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | 66% of the ATCOs agreed that the IRTOS video functionalities were user-friendly. A number of design issues have been mentioned, and potential solutions have been discussed. The biggest concern was the way ATCOs had to go back to airport selection whenever they wanted to work with any of the video system functions at another airport, and this issue was even more pronounced when the activity was imminent. | POK |

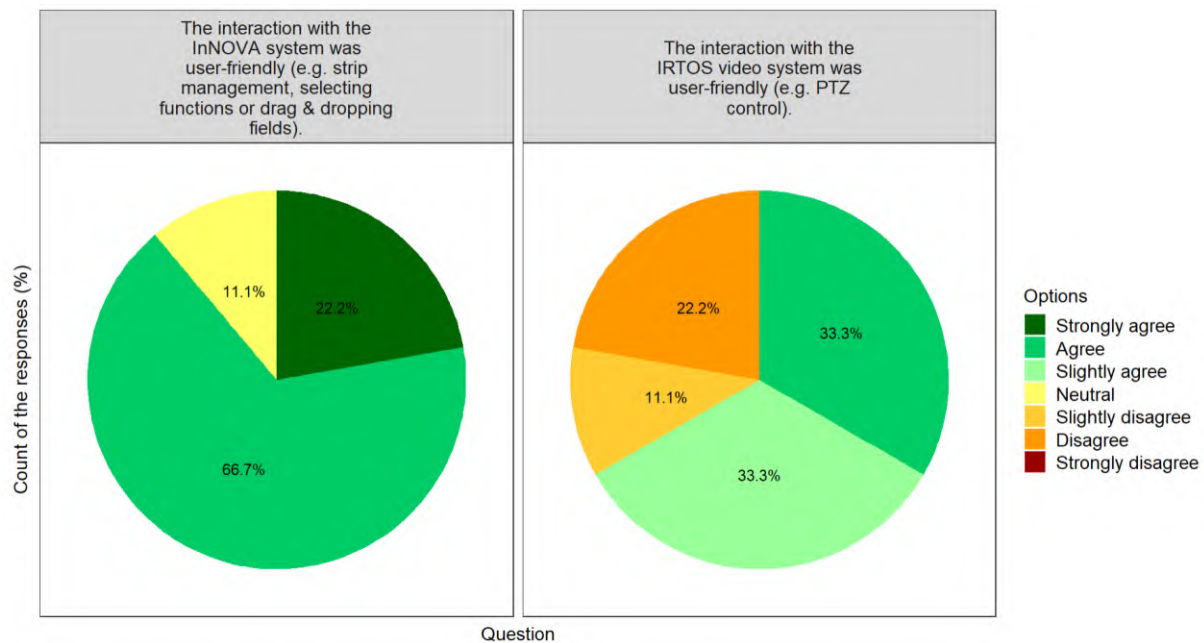


Figure: Feedback received for the interaction experience with the InNOVA and IRTOS.

Tailor-made questions and debriefing notes: ATCOs experienced some difficulties when working with the IRTOS video system, which can also be seen on the right-hand pie chart on Figure.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | | N/A |

Observation: In case of moving target indication, it would be useful to filter by size, because even the movement of people, or small object can indicate an alert, which might be unnecessary in specific areas of the aerodrome (e.g. apron).

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The HMI design had some limitations, and it was observed that sometimes ATCOs were not aware which function was activated. | POK |

Observation: ATCOs had to change between the aerodromes by explicitly clicking on the aerodrome selection button every time they wanted to use the PTZ. Sometimes it was observed that they forgot that they had to do this step and were wondering why they could not manipulate the PTZ.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | ATCOs were aware which aerodromes were presented on which parts of the system. | OK |

Tailored question: This success criteria was addressed with one post-simulation question. As seen on Figure, everyone was aware which aerodrome was placed to which positions of the system.

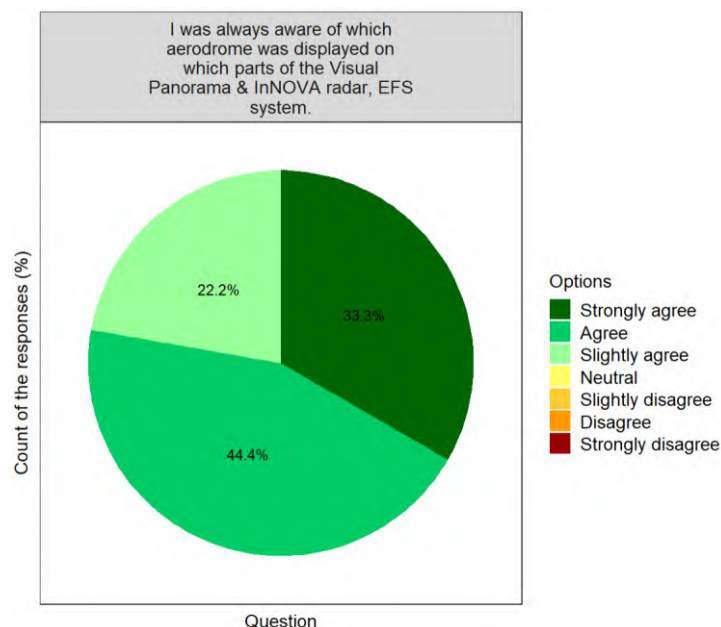


Figure: Feedback received for the awareness of the aerodrome positions in the system

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | It was unanimously agreed that it was clear which aerodrome was transferred between the MRTMs | OK |

Tailored questions: This success criterion was addressed with one post-simulation question. As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.**, it was unanimously agreed that it was clear which aerodrome was transferred between the MRTMs. However, the MRTMs only shared three aerodromes, and due to technical limitations in RTM1 all the aerodromes were visible on the Visual Panorama.

C.8.2.5 HUMAN PERFORMANCE – TRUST

C.8.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

Assess ATCO trust in support systems when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | Everyone found the technical system's performance during split and merge reliable enough to establish trust. | OK |

Tailored questions: A specific question has been created to address this success criteria. As Figure presents, everyone found the technical system's performance during split and merge reliable enough to establish trust.

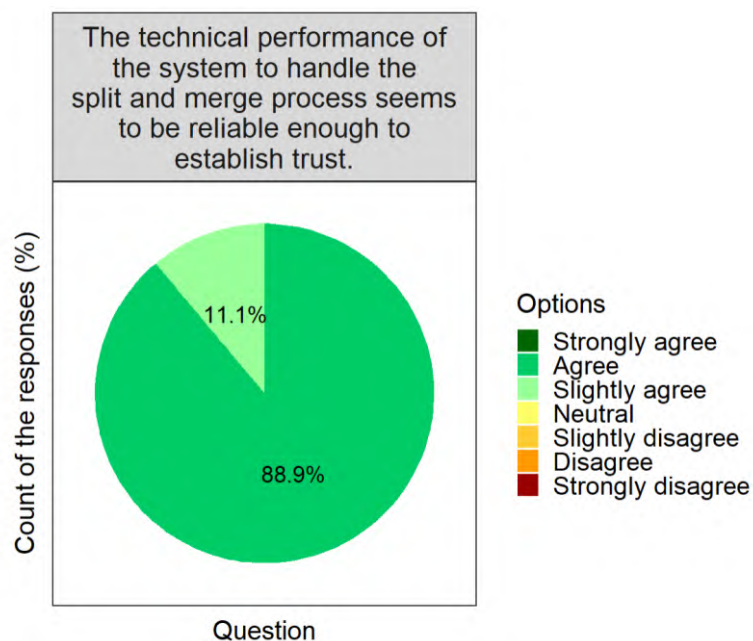


Figure: Feedback on the technical performance of the system in regards to the split and merge.

C.8.2.6 HUMAN PERFORMANCE – Transition Factors

C.8.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | | N/A |

C.8.2.7 SAFETY

C.8.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | <p>The majority of ATCOs find that they are able to identify potential conflicts in a timely manner</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | POK |

Tailored questions: Specific questions (P1, P3, P6, P7, P9-P13, P15) have been created to address this success criteria. As Figure **Fehler! Verweisquelle konnte nicht gefunden werden.** presents:

- In case of 5 questions (P1, P7, P10, P11, P12), more than 67% of the participating ATCOs stated “yes”.
- In case of 2 questions (P6, P9), still more than 50% of the participating ATCOs stated “yes”, while only one participant stated “no”, “partially” or “not applicable”.
- In case of the remaining 3 questions (P3, P13, P15), less than 50% of the participating ATCOs stated “yes”, while the others stated “no”, “partially” or “not applicable”. Share of “no” answers is 11%-11%-22%.

Generally, it was a common feedback that although the 4K pictures from LHPR and LHNY were clear (and significantly better than the full HD one from LHPA), videowall-based detection of small VFR aircraft on final/initial climb is only possible within 1-2 NM from the threshold, and can be very limited on downwind leg (taking into consideration the current setup). This can be an important constraint in aerodromes like LHNY, where VFR traffic is dominant. Effective and user-friendly PTZ control, and overlays (such as labelling, moving target indication and “box and follow” functionality) can help to solve this issue. Further results concerning this topic are detailed at CRT-PJ05-W2-35-V3-VALP-H11.010.

As a participant consequently provided “no” answer for all of the safety-related questions, which answers are not consistent with his/her answers to HP-related questions, these results might be erroneous, but as it is not possible to verify this statement due to privacy issues, the answers are kept.

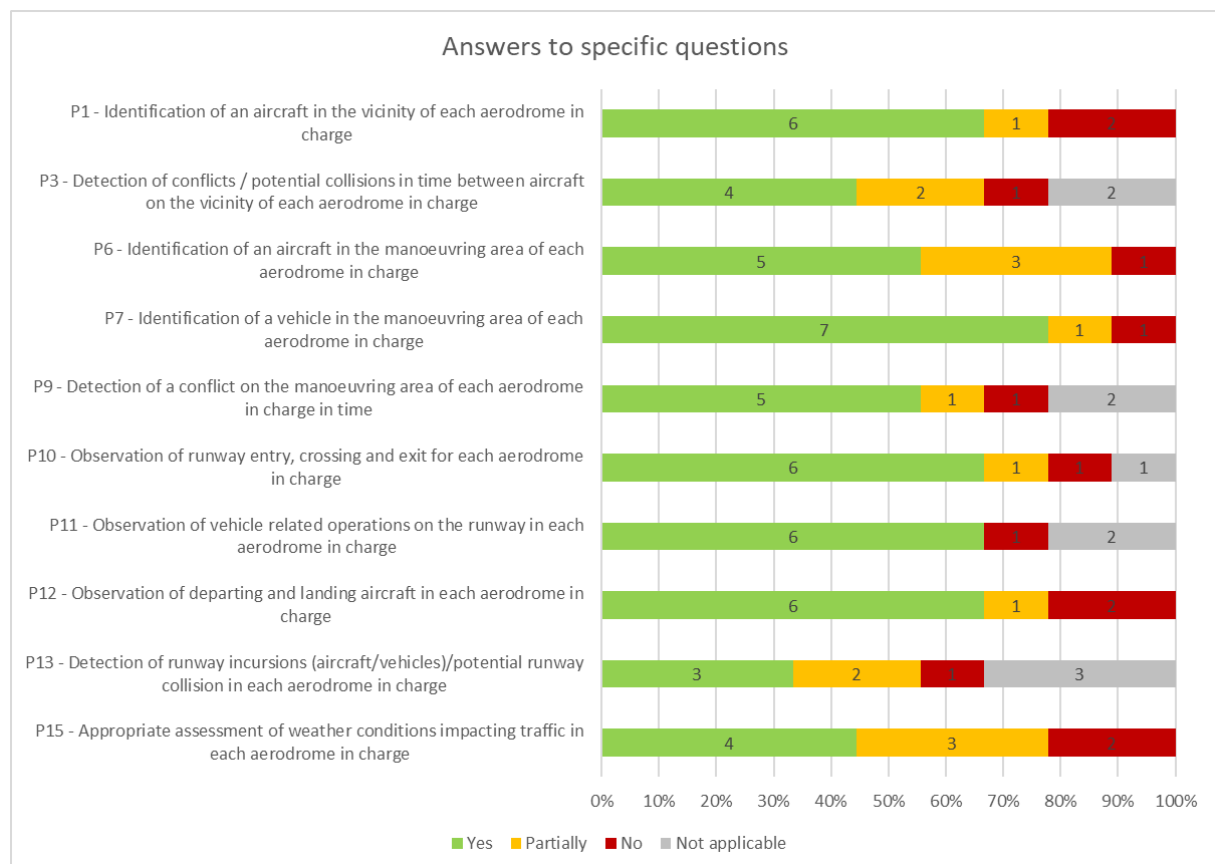


Figure: Feedback on ATCO ability to identify and solve potential conflicts in a timely manner

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> • Unstable approaches • Bird strikes <p>Aircraft not vacating RWY as expected</p> | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | The majority of ATCOs (56%) find that they are able to distinguish with which aircraft, vehicle at the same aerodrome they are communicating with | POK |

Tailored questions: Specific questions (P20 and P21) have been created to address this success criteria. As Figure presents, in case of P20, 56% of the participating ATCOs stated “yes”, while the others stated “partially” (22%), “no” and “not applicable” (11-11%). In case of P21, only 34% of the participating ATCOs stated “yes”, while the others stated “partially” (33%), “no” (11%) and “not applicable” (22%).

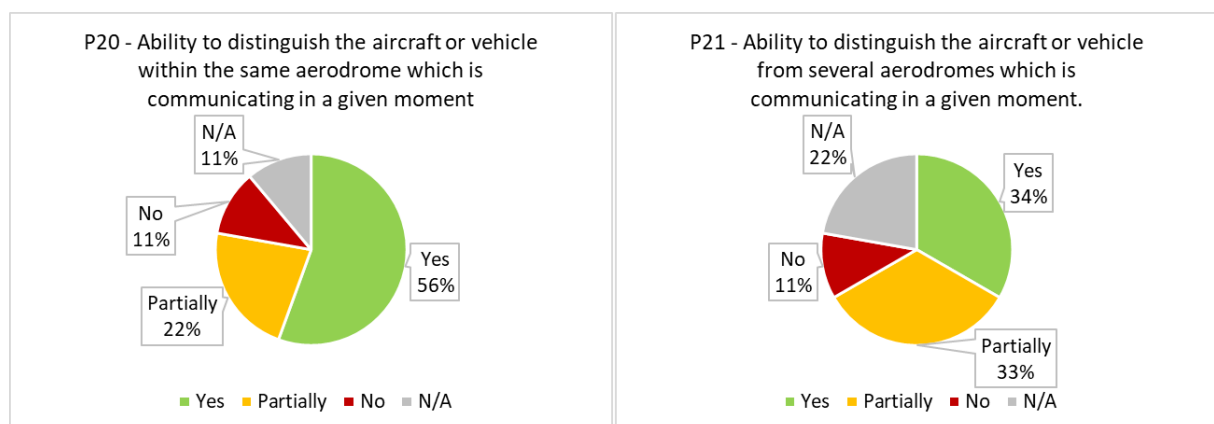


Figure: Feedback on ATCO ability to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with

Debriefing: This topic has been touched upon during the debriefing sessions. It is important to emphasize that A/G frequencies were not coupled during this validation exercise, lower acceptability rate compared to RTS is mainly due to this fact. ATCOs agreed that coupling of air frequencies is very important in MRTC environment. A frame with different colours for each aerodrome (visual presentation, air surveillance window, EFS) would be very useful, and the utilization of squelch indication shall be also considered. Further results concerning this topic are detailed at CRT-PJ05-W2-35-V3-VALP-H11.010.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | | N/A |

C.8.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | | N/A |

C.8.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

OBJ-PJ05-W2-35-V3-VALP-S06

Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport | | N/A |

OBJ-PJ05-W2-35-V3-VALP-S06

Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|---------------------------------|-------------------|--------|
| | Unplanned closure of an airport | | |

C.8.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results**OBJ-PJ05-W2-35-V3-VALP-S07**

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system <p>Other airport systems / infrastructure</p> | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication <p>Visualisation system</p> | | N/A |

C.8.2.8 CAPACITY

C.8.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | | N/A |

C.8.2.9 COST EFFICIENCY

C.8.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | | N/A |

C.8.3 Supervisor - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|-------------------|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | | |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | | |
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|--|-------------------|-----------------------------|
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|-------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | | |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | | |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | | |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|-------------------|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | | |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | | |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | | |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|-------------------|-----------------------------|
| | conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none"> • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport • ATCO overload in one or more MRTM of the RTC | | |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other systems in the MRTM | | |
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|----------------------|-------------------|-------------------|-----------------------------|
| | aerodromes between MRTMs | | | | |

Table 21: Supervisor - Validation Results for Exercise 1

C.8.4 Supervisor - Analysis of Exercise Results per Validation objective

C.8.4.1 HUMAN PERFORMANCE – SITUATION AWARENESS

C.8.4.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

OBJ-PJ05-W2-35-V3-VALP-H01

Assess SUP situation awareness when working in an RTC

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | | N/A |

C.8.4.2 HUMAN PERFORMANCE – WORKLOAD

C.8.4.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

| OBJ05-W2-35-V3-VALP-H05 Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | | | |
|---|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

C.8.4.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

C.8.4.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

C.8.4.4 HUMAN PERFORMANCE – USABILITY and UTILITY

C.8.4.4.1 OBJ-PJ05-W2-35-V3-VALP-H10 Results

| OBJ-PJ05-W2-35-V3-VALP-H10 Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | | | |
|--|--|--|--|
|--|--|--|--|

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | | N/A |

C.8.4.4.2 OBJ-PJ05-W2-35-V3-VALP-H12 Results

OBJ-PJ05-W2-35-V3-VALP-H12

Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | | N/A |

C.8.4.5 HUMAN PERFORMANCE – TRUST

C.8.4.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

| OBJ-PJ05-W2-35-V3-VALP-H14 Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | | | |
|--|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | | N/A |

C.8.4.5.2 OBJ-PJ05-W2-35-V3-VALP-H15 Results

| OBJ-PJ05-W2-35-V3-VALP-H15 Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|--|--|
|---|--|--|--|

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | | N/A |

C.8.4.6 SAFETY

C.8.4.6.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): <ul style="list-style-type: none"> • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | | N/A |

C.8.4.6.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

| OBJ-PJ05-W2-35-V3-VALP-S09 Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g: <ul style="list-style-type: none"> • Communication • Visualisation system Other systems in the MRTM | | N/A |

C.8.4.6.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results

| OBJ-PJ05-W2-35-V3-VALP-S10 Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|--|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | | N/A |

C.8.5 Unexpected Behaviours/Results

See chapter C.12.5.

C.8.6 Confidence in Results of Validation Exercise

See chapter C.12.6.

C.8.7 Conclusions

See chapter C.12.7.

C.8.8 Recommendations

See chapter C.12.8.

C.9 EXE-2.3.1 INDRA/HungaroControl RTS Validation

C.10 Summary of the Validation Exercise EXE-2.3.3-INDRA Plan

C.10.1 Validation Exercise description, scope

The operational scope of this real-time simulation includes simultaneous ATS provided to four Norwegian other and small size aerodromes from two MRTMs by one ATCO per RTM and a Supervisor. The scope is fully in line with the context set out in the PJ05-35 Validation Plan (i.e. Solution PJ.05.35 will address the concept of 4 different aerodromes handled within an RTC, with up to 3 aerodromes per MRTM. Exercises addressing this aspect will use a minimum of 2 MRTMs to distribute 4 aerodromes to a limit of 3 in one MRTM).

The objective was to assess i) the dynamic and flexible allocation of aerodromes to MRTMs in nominal and non-nominal situations while maintaining operations at the aerodromes and ii) the supervisor role in the RTC with regard to planning the dynamic allocation of aerodromes. The traffic volume was set to approximately 20-30 mov/h/MRTM in the RTS to simulate a traffic peak and to fit the objectives of the exercise. The cut-off value for a split was “more than 6 simultaneous movements”.

The evaluation mostly focused on situational awareness, workload, usability and the potential safety issues related to flexible allocation.

The simulation lasted for two weeks and took place between 22th November- 13th December 2021. As there was no simulation on the second week, the Open Day could be organised without disturbing the actual measured simulations.

Six ATCOs participated in the exercise: five civilian and one military controller. The civil ATCOs are also members of the core team of the Hungarian remote tower project and most of them have also participated in the PJ05-02 Wave 1 simulations, thus have significant experience in the (multi) remote tower environment.

The ATCOs covered the roles of Clearance Delivery, Ground Controller and Tower Runway Controller for up to three aerodromes simultaneously.

The validation platform used by HungaroControl was INDRA RTWR IBP platform delivered by INDRA NAVIA.

C.10.2 Summary of Validation Exercise EXE-2.3-INDRA Validation Objectives and success criteria

| SESAR Solution Validation Objective | SESAR Solution Success criteria | Coverage and comments on the coverage of SESAR Solution Validation Objective in Exercise 2.3.3 | Exercise Validation Objective | Exercise Success criteria |
|---|---------------------------------|--|-------------------------------|---------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-010 | Fully covered questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-020 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-030 | Fully covered Debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H01 | CRT-PJ05-W2-35-V3-VALP-H01-040 | Fully covered debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-010 | Fully covered questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-020 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-030 | Fully covered Debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02-040 | Fully covered debrief | as solution | as solution |
| HUMAN PERFORMANCE – WORKLOAD | | | | |

| | | | | |
|----------------------------|--------------------------------|--------------------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04-010 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04-020 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H05 | CRT-PJ05-W2-35-V3-VALP-H05-010 | Fully covered questionnaire, debrief | as solution | as solution |

HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H06 | CRT-PJ05-W2-35-V3-VALP-H06-010 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07-010 | Fully covered Debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H08 | CRT-PJ05-W2-35-V3-VALP-H08-010 | Fully covered Workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H09 | CRT-PJ05-W2-35-V3-VALP-H09-010 | Fully covered Debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H10 | CRT-PJ05-W2-35-V3-VALP-H10-010 | Fully covered Debrief, workshop | as solution | as solution |

HUMAN PERFORMANCE – USABILITY and UTILITY

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-010 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-020 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-050 | Fully covered debrief, workshop | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--------------------------------------|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-060 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-070 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11-080 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-010 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-020 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-030 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H12 | CRT-PJ05-W2-35-V3-VALP-H12-050 | Fully covered questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H14 | CRT-PJ05-W2-35-V3-VALP-H14-010 | Fully covered debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H18 | CRT-PJ05-W2-35-V3-VALP-H18-010 | Fully covered questionnaire, debrief | as solution | as solution |

SAFETY

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-010 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-020 | Fully covered questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04-030 | Fully covered debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S05 | CRT-PJ05-W2-35-V3-VALP-S05-010 | Fully covered Questionnaire | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|--|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-S06 | CRT-PJ05-W2-35-V3-VALP-S06-010 | Fully covered Questionnaire | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S07 | CRT-PJ05-W2-35-V3-VALP-S07-010 | Fully covered Questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S08 | CRT-PJ05-W2-35-V3-VALP-S08-010 | Fully covered Questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S09 | CRT-PJ05-W2-35-V3-VALP-S09-010 | Fully covered Questionnaire, debrief, workshop | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S10 | CRT-PJ05-W2-35-V3-VALP-S10-010 | Fully covered Questionnaire, debrief, workshop | as solution | as solution |
| CAPACITY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | CRT-PJ05-W2-35-V3-VALP-CA1.010 | Fully covered debrief, workshop | as solution | as solution |
| COST EFFICIENCY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | CRT-PJ05-W2-35-V3-VALP-CE1.010 | Fully covered, workshop | as solution | as solution |

C.10.3 Summary of Validation Exercise EXE-2.3-INDRA Validation scenarios

The real-time simulation included 4 different Norwegian aerodromes. The exercise contained 2 MRTMs, each capable of handling up to 3 aerodromes simultaneously, with a 20-30 movements/hour and up to 6 simultaneous movements. The goal was to manage aerodromes in a flexible way to provide a continuous service at each aerodrome according to requested traffic levels. In order to achieve as much as possible balance of the ATCOs workload caused by the traffic requests, aerodromes could be transferred between the MRTMs and moved within the MRTM flexibly.

A supervisor role was also part of the scenarios. The supervisor position was used to monitor present workload of the MRTMs, support ATCOs as well as plan future allocation of aerodromes to MTMs based on specific parameters such as expected traffic load and traffic complexity. The supervisor assisted the ATCOs and could initiate a transfer of an aerodrome from one MRTM to another.



Figure: Validation setup with two MRTMs, two ATCOs and one supervisor

The following scenarios were created:

| Scenario ID | N° AD | MRTMs | Ads per MRTM | Supervisor | Operational mode | Event | Split/Merge |
|-------------|-------|-------|--------------|------------|------------------|--|-------------|
| SCN 1 | 4 | 2 | Up to 3 | Yes | Normal | None | Yes |
| SCN 2 | 4 | 2 | Up to 3 | Yes | Normal | IMC and different RWY conditions in one AD | Yes |
| SCN 3 | 4 | 2 | Up to 3 | Yes | Degraded | Loss of visual surveillance in one AD | Yes |
| SCN 4 | 4 | 2 | Up to 3 | Yes | Abnormal | AC emergency (landing gear problem, no fire) | Yes |

Table 22: Validation scenarios in EXE-05-W2-35-V3-2.3.3 HC RTS

The team of six ATCOs have been split into two groups and validated in subsequent weeks. The ATCOs were rotated across the positions thus could provide complete feedback. The scenarios they have seen have been counterbalanced to minimise the learning effect.

The following table presents the first group's scenario table.

| Group 1 | | | | | |
|---------|-------|--------------|---------|---------|---------|
| | | 1 | 2 | 3 | 4 |
| 9:00 | 9:30 | TRN sessions | SCN 4/1 | SCN 1/1 | SCN 2/2 |
| 9:30 | 10:00 | | | | |
| 10:00 | 10:30 | | Q+B | Q+B | Q+B |

Founding Members

| | | | | | |
|-------|-------|-------------|-------------|-------------|------------------|
| 10:30 | 11:00 | | SCN2/3 | SCN4/2 | SCN4/3 |
| 11:00 | 11:30 | | | | |
| 11:30 | 12:00 | | Q+B | Q+B | Q+B |
| 12:00 | 12:30 | Lunch break | Lunch break | Lunch break | Lunch break |
| 12:30 | 13:00 | | | | |
| 13:00 | 13:30 | SCN 1/3 | SCN 3/1 | SCN2/1 | Final debriefing |
| 13:30 | 14:00 | | | | |
| 14:00 | 14:30 | Q+B | Q+B | Q+B | |
| 14:30 | 15:00 | SCN 3/2 | SCN1/2 | SCN3/3 | |
| 15:00 | 15:30 | | | | |
| 15:30 | 16:00 | Q+B | Q+B | Q+B | |
| 16:00 | 16:30 | Debriefing | Debriefing | Debriefing | |

Table 23. Scenario table for Group 1

The table below shows the second group's scenario chart.

| Group 2 | | | | | |
|---------|-------|--------------|-------------|-------------|------------------|
| | | 1 | 2 | 3 | 4 |
| 9:00 | 9:30 | TRN sessions | SCN 3/3 | SCN2/1 | SCN4/3 |
| 9:30 | 10:00 | | Q+B | Q+B | Q+B |
| 10:00 | 10:30 | | SCN 1/2 | SCN4/2 | SCN 3/1 |
| 10:30 | 11:00 | | Q+B | Q+B | Q+B |
| 11:00 | 11:30 | | | | |
| 11:30 | 12:00 | Lunch break | Lunch break | Lunch break | Lunch break |
| 12:00 | 12:30 | | | | |
| 12:30 | 13:00 | SCN2/2 | SCN2/3 | SCN 3/2 | Final debriefing |
| 13:00 | 13:30 | | | | |
| 13:30 | 14:00 | Q+B | Q+B | Q+B | |
| 14:00 | 14:30 | SCN 1/1 | SCN4/1 | SCN 1/3 | |
| 14:30 | 15:00 | Q+B | Q+B | Q+B | |
| 15:00 | 15:30 | | | | |
| 15:30 | 16:00 | Debriefing | Debriefing | Debriefing | |
| 16:00 | 16:30 | | | | |

Table 24. Scenario table for Group 2

C.10.4 Summary of Validation Exercise EXE-2.3-INDRA Validation Assumptions

| Identifier | Title | Description | Justification | Impact on Assessment |
|-------------------------------|---------------------|---|---|----------------------|
| ASM-EXE-PJ05-W2-35-V3-2.3.3-1 | Coupled Frequencies | Frequencies of the three airports will be coupled to one, resulting no switching needed by the ATCO to select them. | The traffic can be managed in a safe and adequate manner. | High |

Table 25: Validation Assumptions overview

C.11 Deviation from the planned activities

Due to COVID-19 the majority of the ATCOs' vaccines was not approved in Norway, which led to the need to gather an almost completely new set of ATCOs. Only a few ATCOs applied for the simulation, thus we had 6 ATCOs instead of the 9 we originally planned with. This reduced the duration of the simulation to 2 weeks.

The only inconvenience during the simulation was a technical shortcoming where the Voice Communication System did not get transferred to the other MRTM together with the other system elements (e.g. radar, strip bays, video panorama). The technical staff assisted the ATCOs during the split&merge to minimize the inconvenience.

C.12 Validation Exercise EXE-2.3.3-INDRA Results

C.12.1 ATCO - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|---|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Situation awareness was at an acceptable level when providing ATS to 3 aerodromes in parallel according to the SASHA-Q scores.</p> <p>ATCOs were aware which aircraft they were communicating with and which a/c or vehicle belonged to which aerodrome.</p> <p>However, the system did not support situation awareness during the split or when the ATCOs wanted to flexibly switch the airports within the MRTM (for further details see CRT-PJ05-W2-35-V3-VALP-H02.030)</p> | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | <p>ATCOs were able to prioritise tasks. According to their feedback, they were ahead of traffic and could organise their work as they wanted. Giving away their other aerodrome was generally not their top priority during an emergency, although there were some exceptions. Regardless of the</p> | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|--------------------------------|--|--|-----------------------------|
| | | | | timings, the aerodrome with emergency aircraft always stayed with them and the other(s) were split. | |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>Whenever the ATCO received/gave away an aerodrome due to the split and merge (or changed the setup of the MRTM via flexible allocation), there was a short period when most of them lost their situational awareness. It was because of the way the head-down system behaved: the radar maps shifted to a different place on the display with a changing view. To make matters worse, the MET displays remained in the previous positions.</p> <p>This caused major confusion and temporary loss of SA. Essentially the situation awareness ATCOs built for themselves via the head-down display got massively impacted during such a change. It took some time to set the air situation display and the MET windows after the split/merge.</p> | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with | ATCOs could maintain their situational awareness in spite of the four different Norwegian airports. They expressed the | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| | | | different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | need for an indication of cardinal directions on the visual panorama. | |
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | The system supported the RTC team in establishing and maintaining their situational awareness, and the system worked as expected during the split, supporting the teamwork between MRTMs too. | OK |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | According to the results ATCOs workload was always at acceptable level. Although the workload increased certain times, especially during the split and merge process, it only lasted for a couple of minutes. ATCOs preferred to work in a 2:2 aerodrome distribution. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The amount of communication was judged to be acceptable. | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of the ATCOs indicate that the procedures adequately support efficient task performance. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of the ATCOs indicate that the procedures adequately supported efficient task performance. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | ATCOs all agree that providing ATC for the selected aerodromes was feasible, including the number of simultaneous movements. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal | Based on the feedback the phraseology is acceptable for the ATCO in normal and | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|---|-----------------------------|
| | providing ATS to multiple aerodromes | | operating conditions and degraded modes | abnormal operating conditions and degraded modes | |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The HMI supported the SUP to identify peak traffic periods and initiate the split and merge process. On the ATCO side however, the HMI's radar map layout and the EFS bay changed to accommodate the new aerodrome, but the MET window remained at the same position which led to confusion. The same happened even if the ATCOs just wanted to switch the places within the MRTM, without any split. | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | No team errors were observed during the simulation. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | Essential information were missing from the Video Wall, i.e. wind data, PTZ and cardinal directions. The InNOVA contained the most crucial information, however, the design was not the most efficient (i.e. timeline). Also, | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|--------------------------------------|--------------------------------|--|---|-----------------------------|
| | providing ATS to multiple aerodromes | | | after an aerodrome switch event, the radar map has shifted to an odd coordinate position, the EFS layout changed, yet the MET window remained at the same position, so the layout had to be re-arranged and that took valuable time. | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Most of the ATCOs (66.6%) agree with the InNOVA being user-friendly. However, there were functions they had difficulties with. Similarly, the two-button design of the mic was unfamiliar and not intuitive, which paved the way for unnoticed errors. | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The system behaviour during split and merge increased the potential for human error by not moving the MET window together with the radar map and EFS bay. This has led to the event when a MET window was next to a different aerodrome's EFS bay, causing confusion. The handheld mic with its two-button layout also led to errors. | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | The timeline used as a short-term planning tool was not preferred. ATCOs turned to the strips instead as it contained discrete and more precise data. | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | The majority of ATCOs (83.3%) were aware which aerodrome was placed to which positions of the system | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | It was unanimously agreed that it was clear which aerodrome was transferred between the MRTMs. The Supervisor made sure that ATCOs were aware which aerodromes will be affected by the split. | OK |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | The majority of ATCOs (83.3%) find the technical system’s performance during split and merge reliable enough to establish trust. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Knowledge, skill and experience requirements are identified per actor group | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Training needs have been discussed for both ATCO and SUP. | OK |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between | CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none">In the vicinity of the aerodromeIn the runway areaOn the manoeuvring area | The majority of ATCOs find that they are able to identify and solve potential conflicts in a timely manner <ul style="list-style-type: none">In the vicinity of the aerodromeIn the runway areaOn the manoeuvring area | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| | MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> • Unstable approaches • Bird strikes • Aircraft not vacating RWY as expected | The majority of ATCOs find that they are able to identify and solve potential hazardous situations in a timely manner, although not a representative set of these situations was validated. | POK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | The majority of ATCOs (83.3%) find that they are able to distinguish with which aircraft, vehicle at which aerodrome they are communicating with | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | The majority of ATCOs find that they were not inducing more conflicting situations than in the reference scenario, and over-the-shoulder observations confirmed this. | OK |
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | The majority of ATCOs (100%) find that they are able to foresee traffic at his/her MRTM at short term in order to avoid overloads | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|---|---|-----------------------------|
| | flexible allocation of aerodromes between MRTMs | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | <p>ATCO is able to identify and manage abnormal situations (e.g.):</p> <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | The majority of ATCOs (83.3%) find that they are able to identify and manage abnormal situations (aircraft emergency due to landing gear problem) | POK |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when | CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g.):</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other airport systems / infrastructure | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|---|---|-----------------------------|
| | working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system | The majority of ATCOs find that they are able to a technical failure in the MRTM affecting the operation at one or more aerodromes affecting the visualisation system (total loss of the visualization of one aerodrome in an MRTM) | POK |
| CAPACITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | The predefined cut-off point in terms of simultaneous movements seemed reasonable for the ATCOs. They were comfortable proving ATS to multiple remote towers but preferred the 2:2 aerodrome distribution to the 3:1 option. | OK |
| COST EFFICIENCY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | ATCOs agree that they could provide 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes. | OK |

Table 26: ATCO - Validation Results for Exercise 1

C.12.2 ATCO - Analysis of Exercise Results per Validation objective

C.12.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

C.12.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Situation awareness was at an acceptable level when providing ATS to 3 aerodromes in parallel according to the SASHA-Q scores.</p> <p>ATCOs were aware which aircraft they were communicating with and which a/c or vehicle belonged to which aerodrome.</p> <p>However, the system did not support situation awareness during the split or when the ATCOs wanted to flexibly switch the airports within the MRTM (for further details see CRT-PJ05-W2-35-V3-VALP-H02.030)</p> | POK |

One standardized questionnaire (SASHA-Q) and three tailored items were used after each run. The SASHA-Q questionnaire addresses SA in six items on a 0-6 scale with 6 indicating the best SA (unless it is a reversed item). Here, we provide the final SASHA score that combines the six items.

SASHA-Q: The total mean score was above the centre of the scale ($M = 5.4$, $SE = 0.08$), indicating acceptable to good SA. No critical scores were achieved, with a minimum of 3.6. When broken down into scenarios and positions, the lowest mean score was 5.11 in MRTM1 during the Monitor failure scenario. This is also where the lowest score can be found, and it is linked to two items, where the ATCO gave a high score to the items “I was surprised by an event I did not expect” and “I started to focus on a single problem.” Such a feedback is not surprising for a scenario that contained an unexpected event.

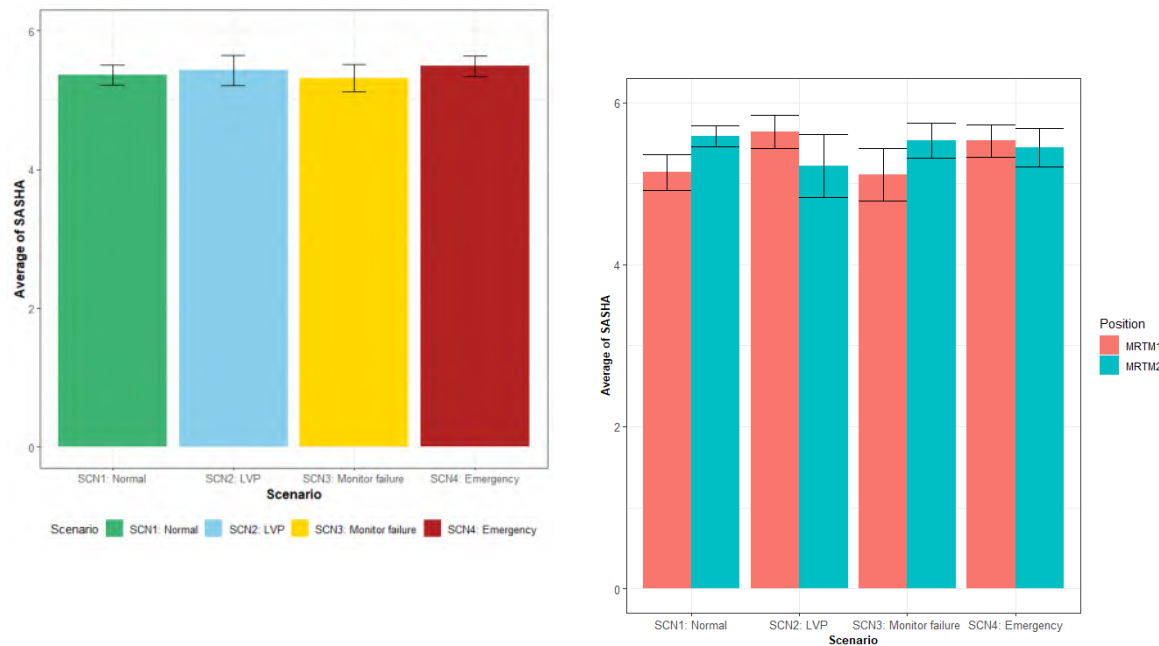
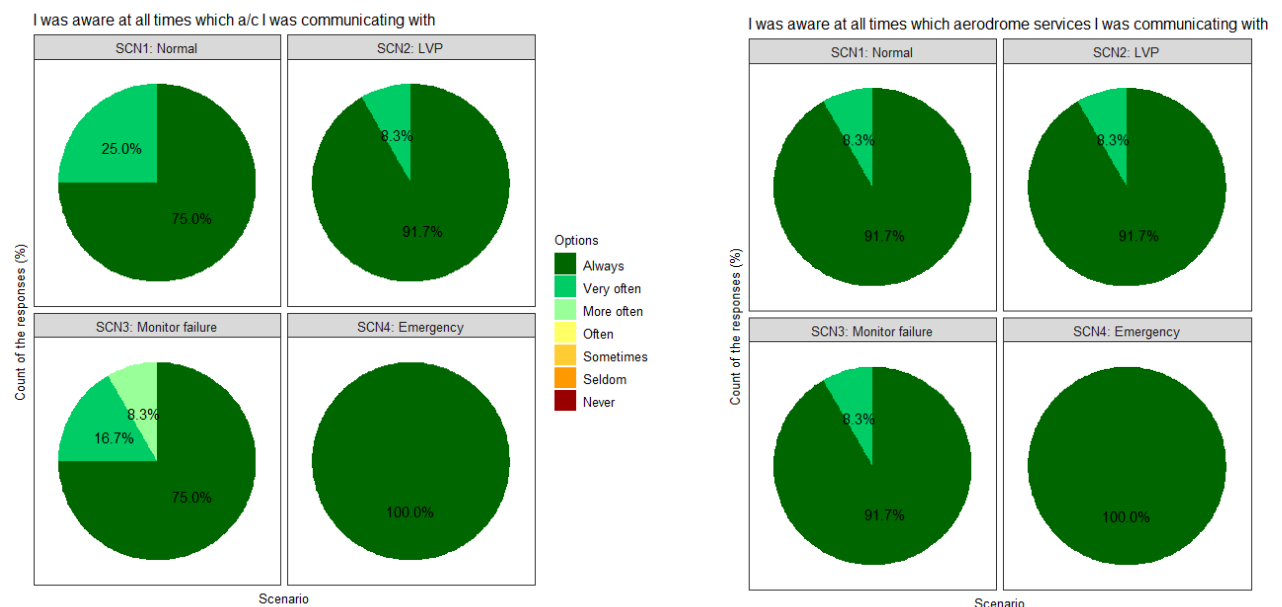


Figure: SASHA-Q mean scores, broken down by Scenarios and Positions. The error bars represent the standard error.

Tailored questions: The items stated “I was aware at all times which a/c or vehicle I was communicating with.”, “I was aware at all times which aerodrome services I was communicating with.”, “I was aware at all times which a/c or vehicle belonged to which aerodrome.” The feedback indicates that ATCOs could generally maintain a sufficient SA for all aerodromes.



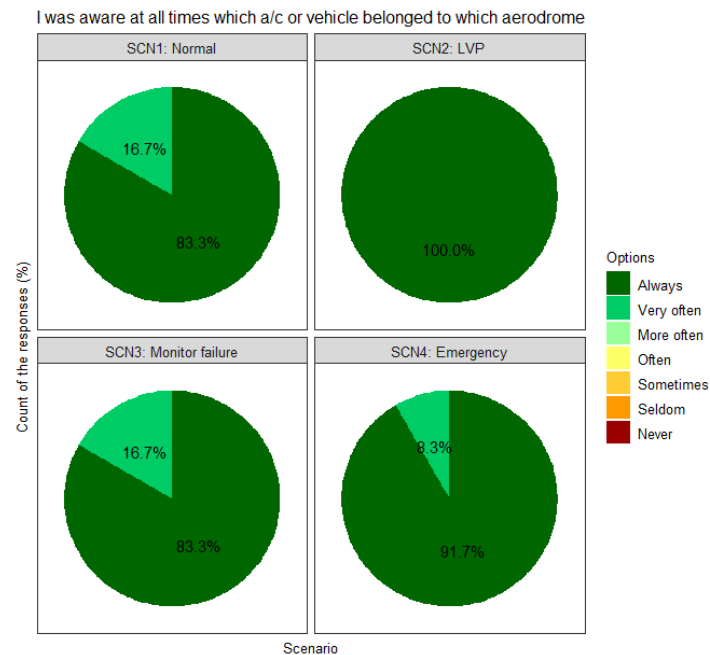


Figure: Pie charts related to the three questions regarding communication and situational awareness.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs were able to prioritise tasks. According to their feedback, they were ahead of traffic and could organise their work as they wanted. Giving away their other aerodrome was generally not their top priority during an emergency, although there were some exceptions. Regardless of the timings, the aerodrome with emergency aircraft always stayed with them and the other(s) were split. | OK |

Task prioritisation has been addressed by the SASHA-Q questionnaire, which has two items dedicated to anticipating future events.

Question 1: “I was ahead of traffic” is related to the prediction of the evolution of the traffic. Question 4: “I was able to organise my work as I wanted” is more closely linked to task prioritization and managing time. The figures below show that the mean values are at acceptable level, even when they are broken down into scenarios and MRTMs.

Furthermore, the emergency scenario was created to see how ATCOs handle a situation where one aerodrome requires full attention and urgent actions. Based on the **observations**, ATCOs always

Founding Members

prioritised the aerodrome in emergency, and most of them were reluctant to immediately split and give away the second aerodrome. Instead they waited for the emergency situation to unfold, and gave away the other aerodrome when they had spare capacity. There were individual differences in regards to calling the APP or the firefighters first.

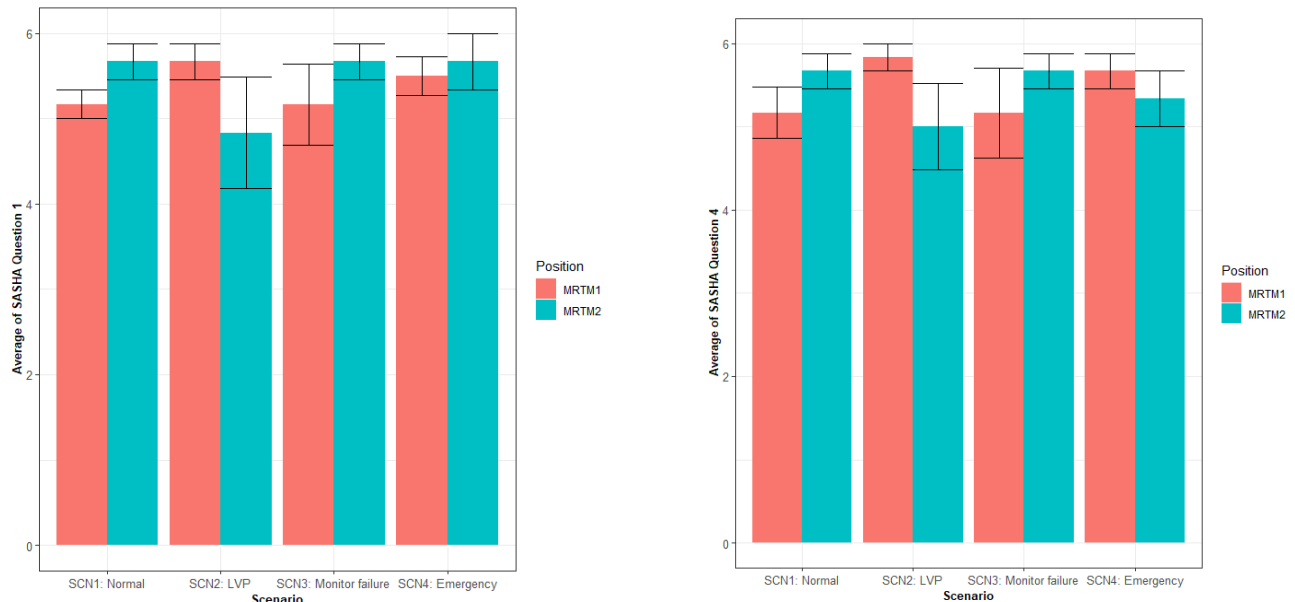


Figure: Average scores of two of the SASHA-Q items related to anticipating future events and are linked to task prioritisation.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>Whenever the ATCO received/gave away an aerodrome due to the split and merge (or changed the setup of the MRTM via flexible allocation), there was a short period when most of them lost their situational awareness. It was because of the way the head-down system behaved: the radar maps shifted to a different place on the display with a changing view. To make matters worse, the MET displays remained in the previous positions.</p> <p>This caused major confusion and temporary loss of SA. Essentially the situation awareness ATCOs built for themselves via the head-down display got massively impacted during such a</p> | POK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | change. It took some time to set the air situation display and the MET windows after the split/merge. | |

Tailored questions and open-ended questions have been designed to address the adequacy of the HMI in supporting situation awareness. This success criteria has a strong link to usability thus the detailed results will be discussed in the respective sections (OBJ-PJ05-W2-35-V3-VALP-H11 & H18).

However, one of the key finding was related to the situation awareness influenced by the system behaviour. If we think about situational awareness as the “picture” that is built on the mental model i.e. the end-users’ understanding of how a system works, then it is safe to say that **their mental model did not match the conceptual model** (i.e. the designer’s understanding of how the system works). ATCOs shared their struggles in the questionnaires and also during debriefing.

Whenever the ATCO received/gave away an aerodrome due to the split and merge (or changed the setup of the MRTM via flexible allocation), there was a short period when most of them lost their situational awareness. It was because of the way the head-down system behaved: the radar maps jumped to a different place on the display with a changing view. To make matters worse, the MET displays remained in the previous positions. This caused major confusion and temporary loss of SA. Essentially the situation awareness ATCOs built for themselves via the head-down display got massively impacted during such a change. It took some time to set the air situation display and the MET windows after the split/merge.

Some of the responses are cited below:

- “I can temporarily loose SA when the system splits/merges the workplaces, or the location of the airports, and the radar windows on the touchpanel rotate. In addition met information won't move, which makes the situation even worse.”
- “After switching the airports in the MRTM the MET window stays in place while everything else moving as expected.”
- “Split/merge process must not interfere with the existing situational awareness of the ATCO, it should give time to build up the extra SA for the new airport and traffic, while keeping the existing setup.”

During debriefings it was recommended to create default radar map settings for the various configurations to ensure that the strip bays and MET windows won't cover the radar map of the airport. Furthermore, it was unanimously agreed to link the MET windows to the strip bays- otherwise the ATCO may mistake one airport's MET window for another airport's MET data. It was a common solution in one ATCO group that the ATCOs who gave away an aerodrome kept it in look only mode till they get familiar with the new situation.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | ATCOs could maintain their situational awareness in spite of the four different Norwegian airports. They expressed the need for an indication of cardinal directions on the visual panorama. | OK |

This success criteria was addressed by one post-simulation question. The majority (83.4%) agreed that they were capable to adapt to the changing sets of aerodromes in the MRTM. As the four Norwegian airports were new to the ATCOs, they mentioned that they needed three-four days (depending on ATCO group) to feel perfectly comfortable in the simulated environment.

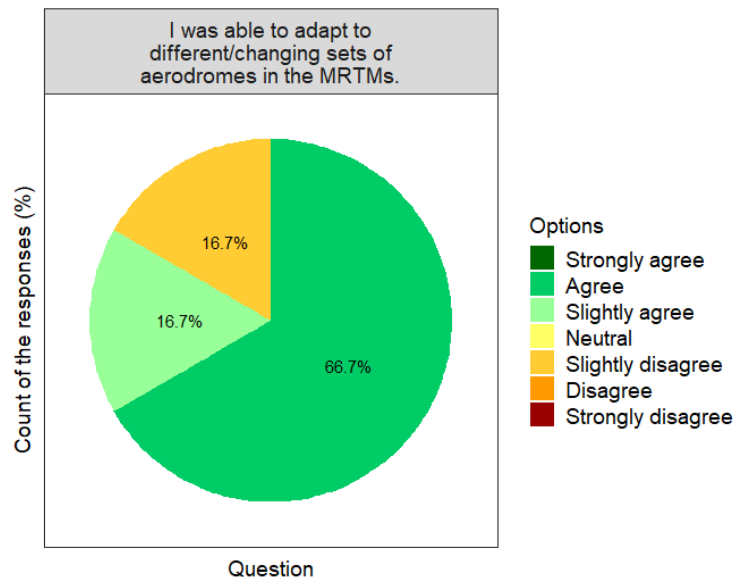


Figure: Feedback received on ability to adapt to the changing set of aerodromes

As a recommendation however, ATCOs expressed the need for an indication of cardinal directions (i.e. North, South, East, West) on the video wall to further enhance their situational awareness in such different environments.

C.12.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | The system supported the RTC team in establishing and maintaining their situational awareness, and the system worked as expected during the split, supporting the teamwork between MRTMs too. | OK |

One post-simulation question and three debriefing questions were used to address this success criteria.

The majority (83.4%) agreed agree that the system behaved as accepted during the split and merge process. When there was a time to split, it was usually the ATCOs' tasks to initiate the transfer on the HMI. They still kept the aerodrome on the CWP in a 'look only' mode until the receiving ATCO confirmed the takeover. As previously mentioned, it was a common practice in one ATCO group that the ATCOs who gave away an aerodrome kept it in look only mode till they get familiar with the new situation.

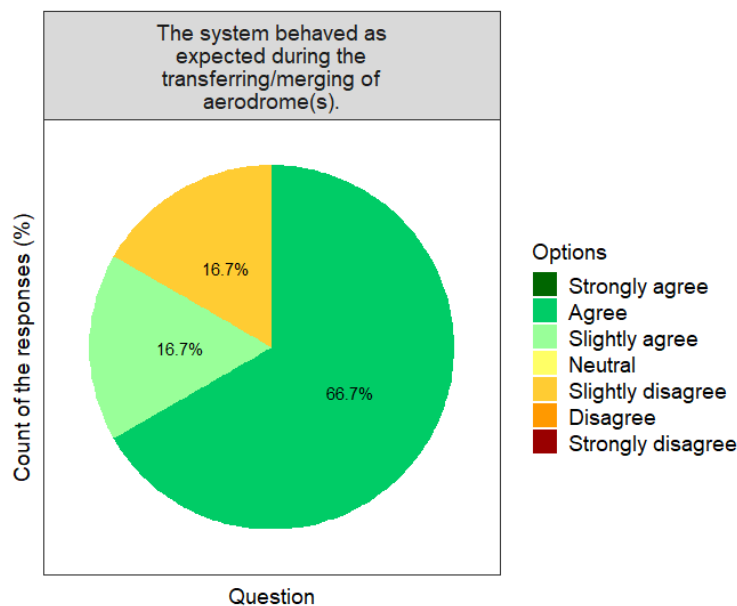


Figure: Feedback received on the system behaviour during split and merge

The debriefing provided the opportunity to bring up the teamwork between the ATCOs and the SUP, and how the technical system supported them in their tasks. The participants explained that as a SUP, they checked their SUP planning tool first, then oftentimes went over to the MRTMs to confirm the expected traffic on their EFS. Based on this data they decided about the split. They still waited around

–sometimes they helped in the split process by passing on the traffic information and runway direction to the receiving ATCO-, but mostly to confirm that the workload levels got balanced between the MRTMs.

C.12.2.2 HUMAN PERFORMANCE – WORKLOAD

C.12.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

OBJ-PJ05-W2-35-V3-VALP-H04

Assess ATCO workload when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | According to the results ATCOs workload was always at acceptable level. Although the workload increased certain times, especially during the split and merge process, it only lasted for a couple of minutes. ATCOs preferred to work in a 2:2 aerodrome distribution. | OK |

One standardized questionnaire (Bedford Workload Scale) and four tailored questions were used after each run. The Bedford Scale is a uni-dimensional rating scale designed to identify operator's spare mental capacity while completing a task. The single dimension is assessed using a hierarchical decision tree that guides the operator through a ten-point rating scale, each point of which is accompanied by a descriptor of the associated level of workload.

Bedford Workload Scale: The total mean score was below the “satisfactory” cut-off line ($M = 2.96$, $SE = 0.2$). When broken down into the scenarios and positions, the values were still within the acceptable range (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). No critical scores were achieved, with a maximum of 6.

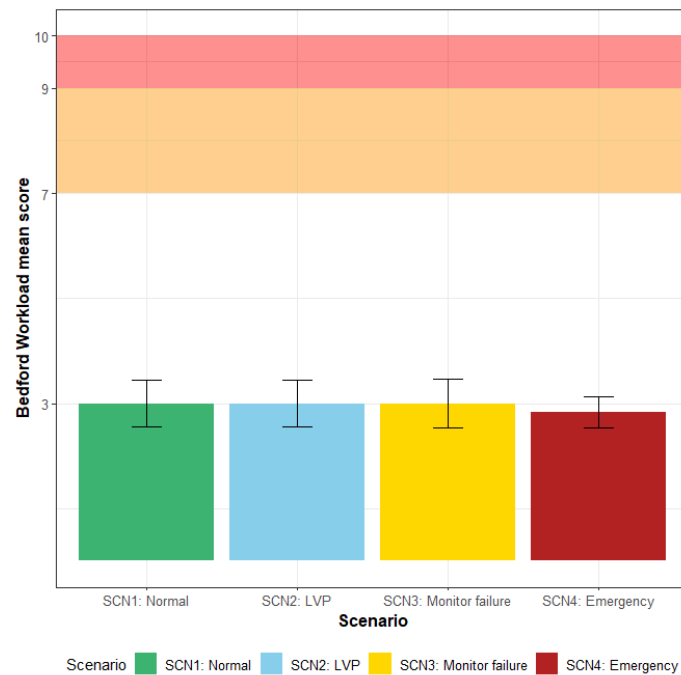


Figure: Mean scores of the Bedford Workload Scale, broken down into scenarios. The error bars represent the standard error.

By taking a closer look at the MRTMs, it is evident that participants in MRTM1 had higher workloads in most of the cases (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). Admittedly, this MRTM was directly exposed to most of the experimental manipulations (e.g. emergency aircraft, technical malfunction), and the other MRTM was there to alleviate the extra load. However, oftentimes the scenario evolved and MRTM1 also received aerodrome from MRTM2.

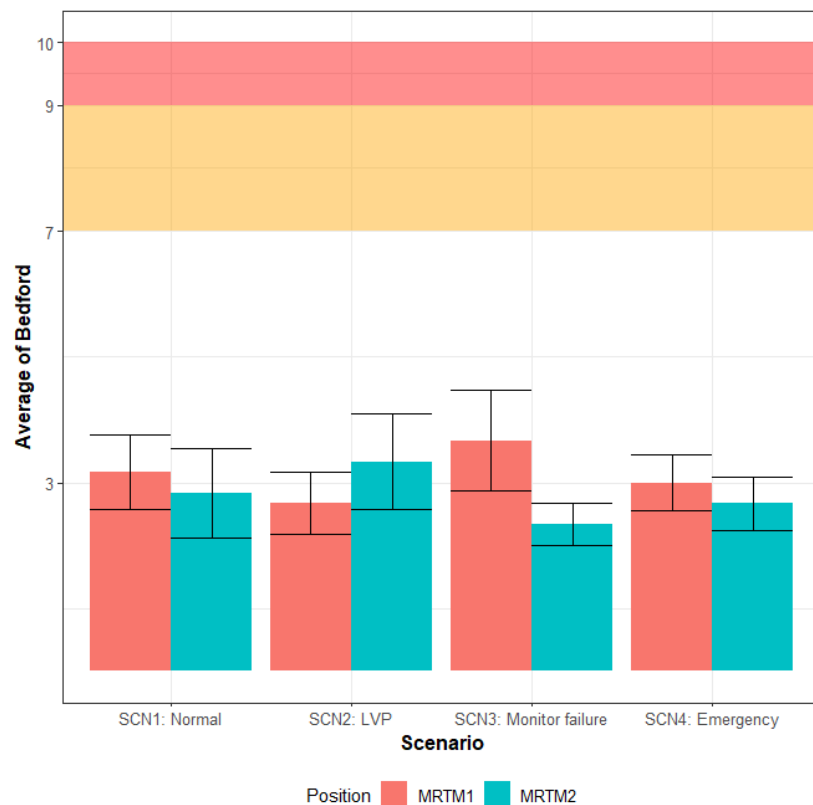


Figure: Mean scores of Bedford Workload Scale, broken down into Scenarios and Position. The error bars represent the standard error.

Tailored: ATCOs also elaborated on the reasons why their workload was high at times. These were the ones mentioned most often:

- “Adding a new aerodrome always increases workload. First, to manage the system, then to build up new situational awareness. It’s not just about the traffic situation, but the new layout of the HMI as well. After a couple of minutes, I felt comfortable again.”
- The HMI did not support efficient split and merge (see CRT-PJ05-W2-35-V3-VALP-H02.030). The radar map shifted to an odd position, yet the MET window stayed at the same place, creating an even more pronounced confusion.
- Unexpected split and merge
- Emergency scenario (i.e. landing gear problem)

The first two points are also reflected in the scores given to the following two questions.

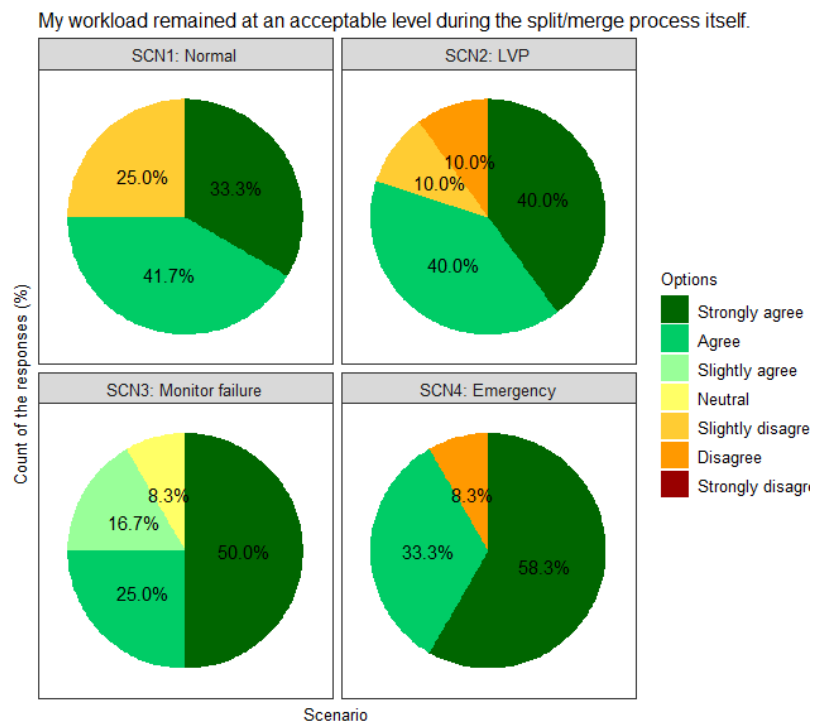


Figure: The distribution of scores given to the workload-specific question regarding the split and merge process. There is more variation in the scores, which is related to the HMI behaviour during the split.

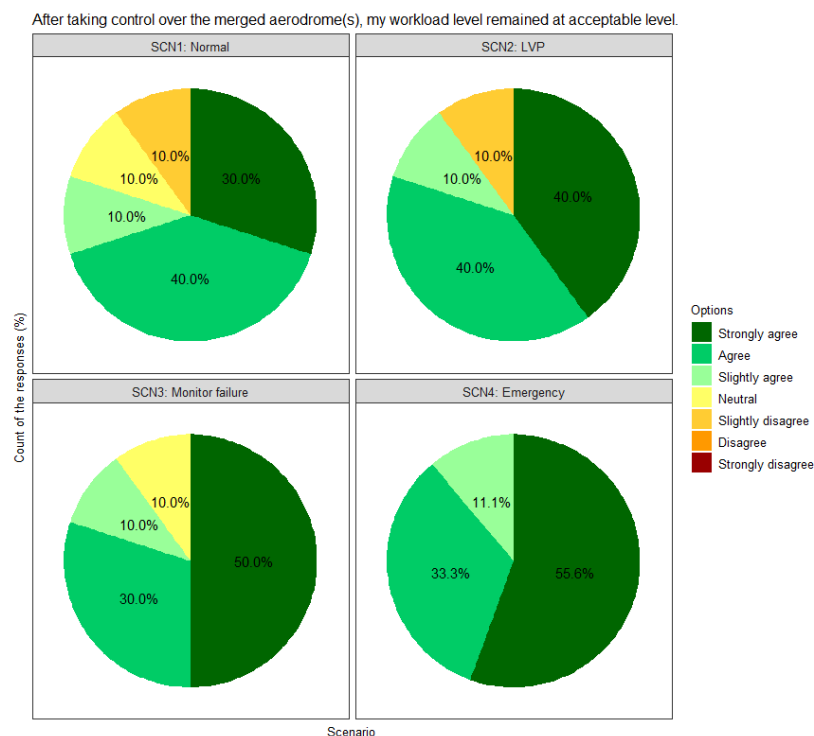


Figure: The distribution of scores in relation to the workload levels after the split and merge process.

Debriefing: ATCOs unanimously agreed that the distribution of 2:2 aerodromes across the two MRTMs was optimal in order to balance the workload. According to the exercise plan, it was assumed that only one aerodrome will be moved in the high traffic load intervals. Interestingly, SUPs instead decided to swap aerodromes in order to avoid a 3:1 distribution. ATCOs also agreed that changing of two aerodromes between two MRTMs is not optimal, split and merge process should affect one aerodrome at a time.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The amount of communication was judged to be acceptable. | OK |

One customized post-run question was used to address this success criteria. According to **Fehler! Verweisquelle konnte nicht gefunden werden.**, ATCOs agree that the amount of communication was acceptable. This is also in line with the results gained from the Bedford Workload Scale.

The amount of communication (air and ground frequency) was acceptable.

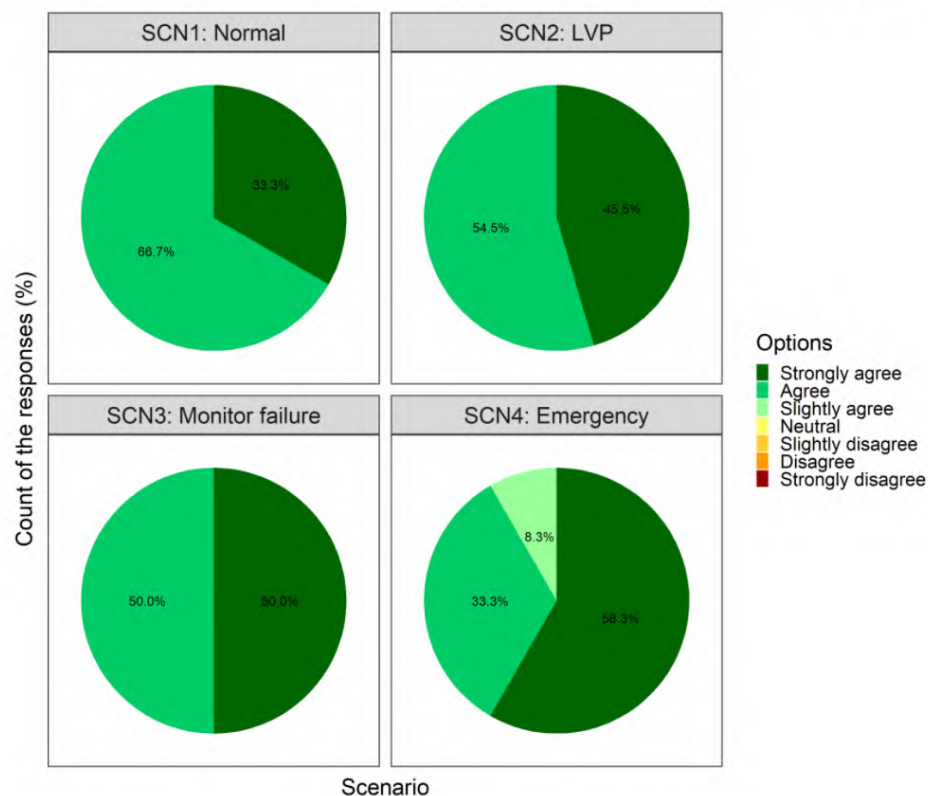


Figure: Feedback received for the communication success criteria

C.12.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

C.12.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of the ATCOs indicate that the procedures adequately support efficient task performance. | OK |

Tailor-made questions: Four post-simulation questions were used to address this success criteria.

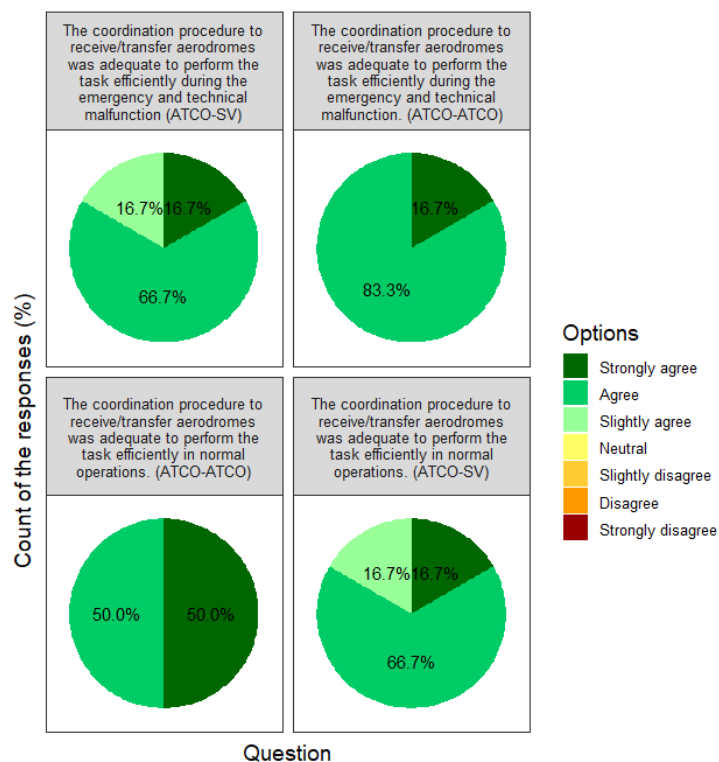


Figure: Feedback distribution received for the coordination procedures between ATCO-ATCO and ATCO-SUP.

C.12.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

OBJ-PJ05-W2-35-V3-VALP-H07

Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of the ATCOs indicate that the procedures adequately supported efficient task performance. | OK |

See previous success criteria.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | ATCOs all agree that providing ATC for the selected aerodromes was feasible, including the number of simultaneous movements. | OK |

Tailor-made questions: Five questions were designed to address the feasibility of providing ATS to the number of tested aerodromes. According to **Fehler! Verweisquelle konnte nicht gefunden werden.**, ATCOs confirm the feasibility and acceptability.

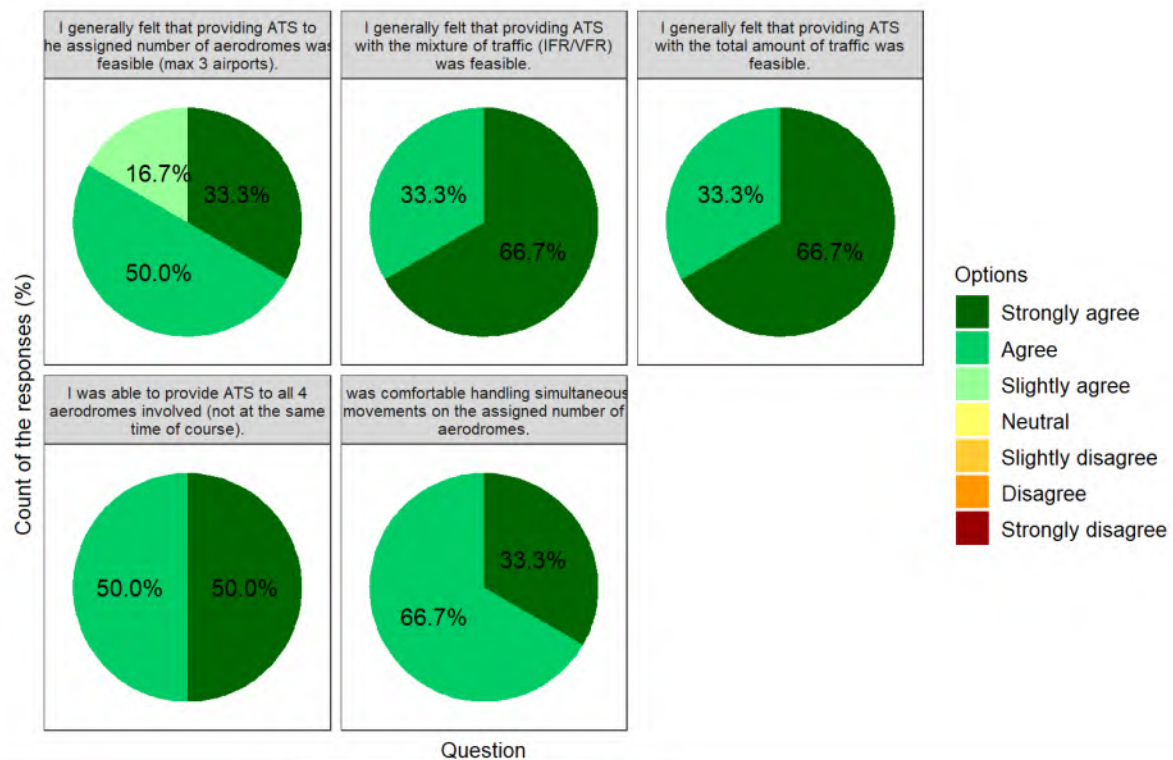


Figure: Feedback received for the questions related to feasibility of providing ATS to the assigned number of aerodromes.

C.12.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | Based on the feedback the phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | OK |

Tailor-made question: One post-simulation question was created to address this success criteria. According to the figure below, it is safe to say that phraseology was adequate in all of the tested conditions.

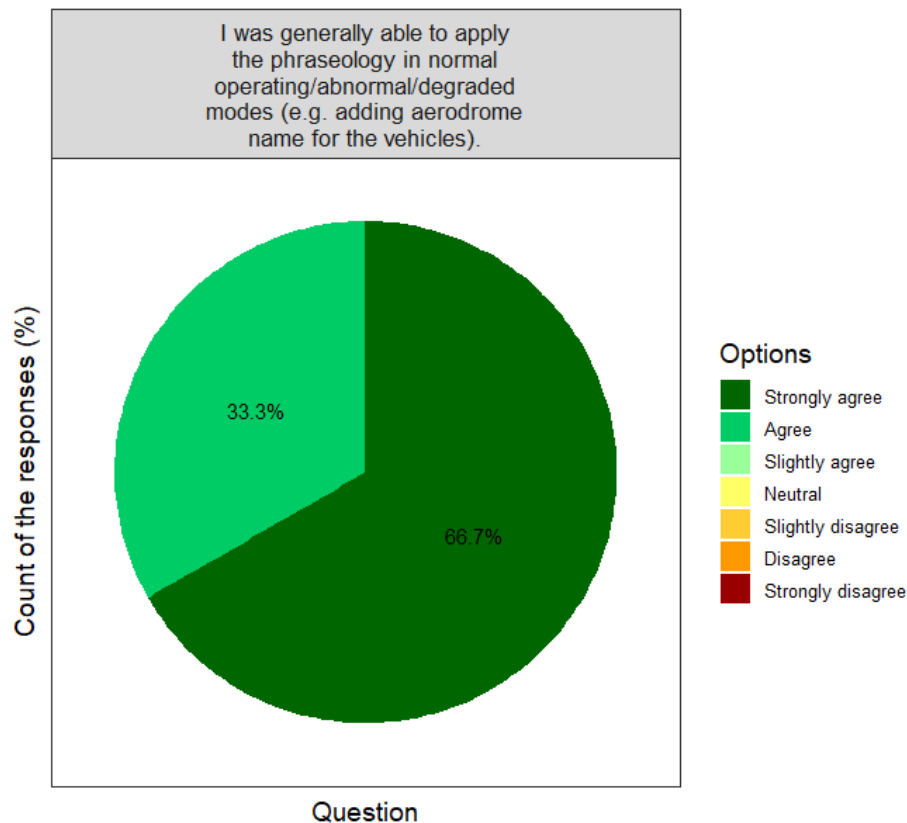


Figure: Feedback received for the phraseology.

C.12.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

C.12.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

Assess that human-machine interface supports the team in carrying out their tasks

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | The HMI supported the SUP to identify peak traffic periods and initiate the split and merge process. On the ATCO side however, the HMI's radar map layout and the EFS bay changed to accommodate the new aerodrome, but the MET window remained at the same position which led to confusion. The same happened even if the ATCOs just wanted to | POK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | switch the places within the MRTM, without any split. | |

Tailored questions: Three items were designed to address the flexible allocation for the ATCO role-whether the system worked according to their mental model and whether they could position the aerodromes in the MRTM to fit their needs. As the middle pie chart in **Fehler! Verweisquelle konnte nicht gefunden werden.** shows, flexible allocation was not preferred due to system behaviour (see CRT-PJ05-W2-35-V3-VALP-H02.030 for more detail). Because the HMI got mixed up once ATCOs had modified the layout of the MRTM, they decided to keep aerodromes where they originally appeared on the screens. Thus it was often the case that a bigger aerodrome was displayed on a smaller screen on the Visual Panorama. However, ATCOs suggested that they rather have this setup than having their head-down display mixed up, which negatively affected their situational awareness.

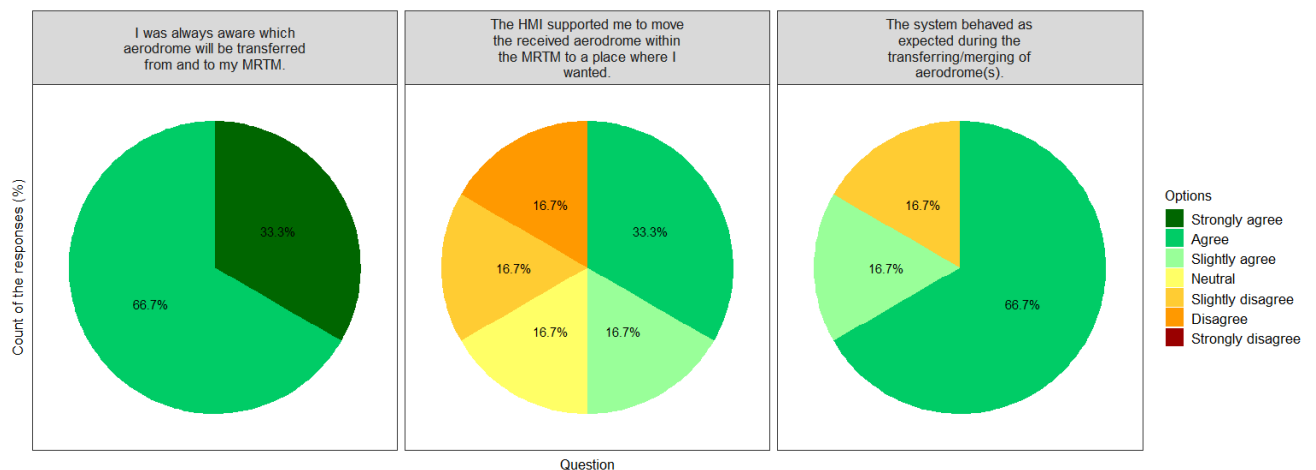


Figure: Results received for the HMI related questions, specifically to the split and merge and flexible allocation

Tailored questions: Two questions were created to address the same topic from the SUP point of view. This set of questions targeted a SUP timeline and planning tool which they used to identify the busy periods and probe new configurations with the what-if function. Based on **Fehler! Verweisquelle konnte nicht gefunden werden.** and the thoughts added to the open-ended questions, it is safe to say that the what-if function would be a key tool for the Supervisors in the future. Some recommendations were made for future improvement, i.e. to ensure that the yellow marked periods accurately show the real traffic peaks, and also indicate the length of the peak.

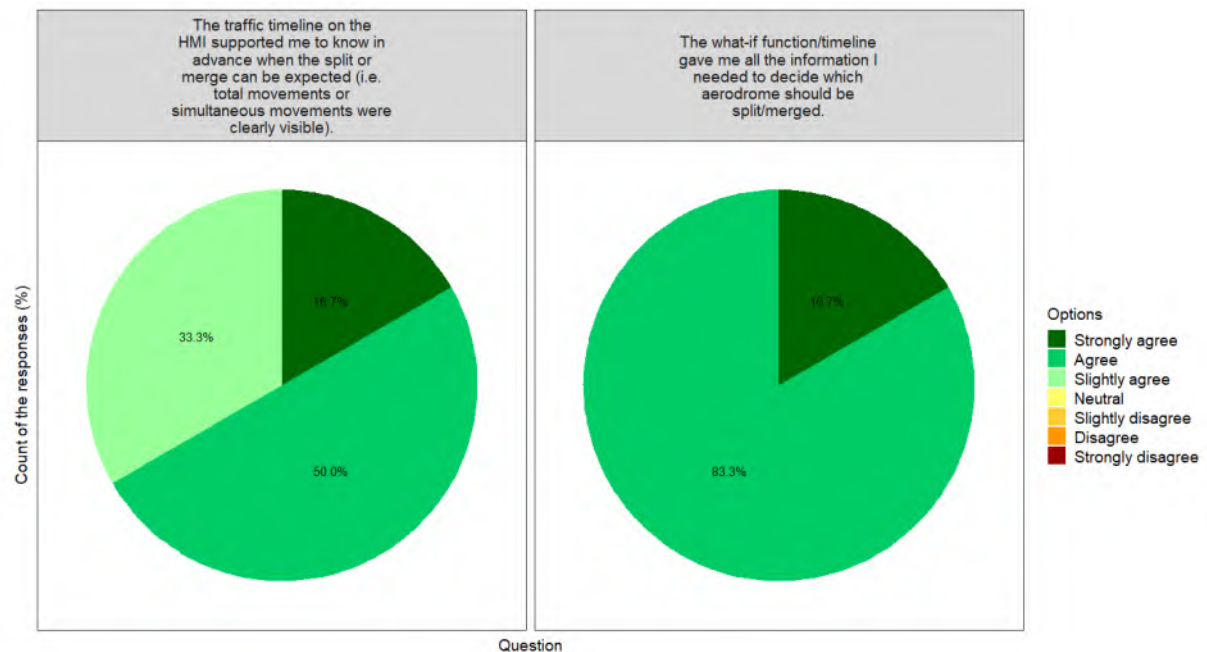


Figure: The feedback received for the SV's planning tool show positive results

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | No team errors were observed during the simulation. | OK |

No team errors were observed during the simulation. There was once a case where a SUP mistakenly swapped the aerodromes when actually he wanted to open up a new MRTM in his software, but it was mainly due to unfamiliarity with the system.

C.12.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | Essential information were missing from the Video Wall, i.e. wind data, PTZ and cardinal directions. The InNOVA contained the most crucial information, however, the design was not the most efficient (i.e. timeline). Also, after an aerodrome switch event, the radar map has shifted to an odd coordinate position, the EFS layout changed, yet the MET window remained at the same position, so the layout had to be re-arranged and that took valuable time. | POK |

Tailored questions: The four questions shown in the pie charts below were designed to address this success criteria. First, we were interested to know whether the system provided all the necessary information for the ATCOs to build their “picture”. If so, the next logical question was whether they could access the relevant information easily. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, there were some missing information on the Video Wall. The following recommendations were made:

- MET data (wind is essential, RVR would also be good in LVP)
- PTZ (for zooming)
- Cardinal directions (i.e. north, south, east, west)

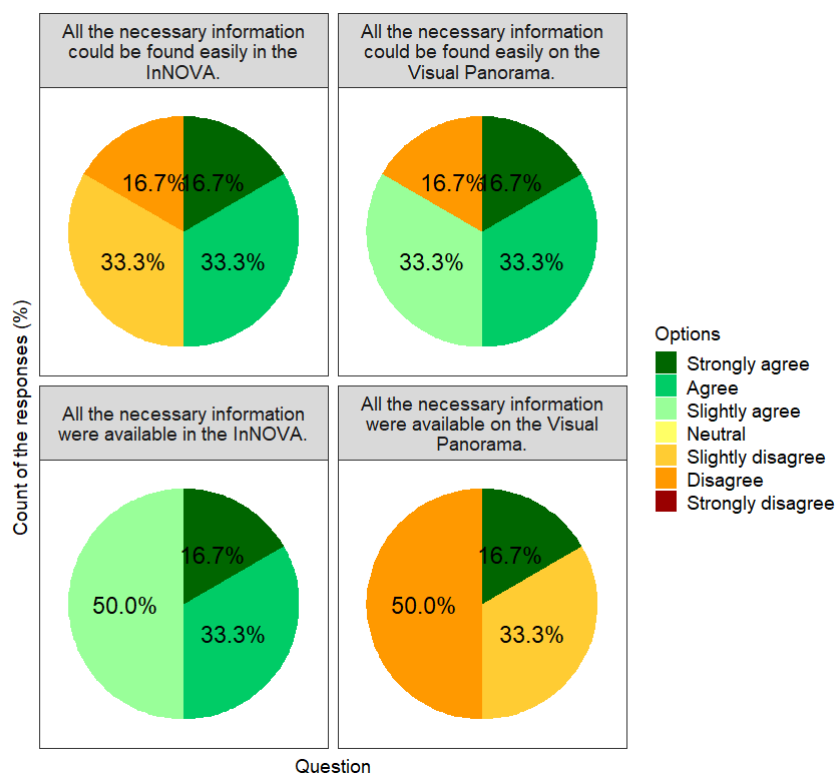


Figure: The distribution of the feedback in relation to the information availability and easy access.

With regards to InNOVA, the MET data in the strip bay was also missed. Some ATCOs pointed out that the design would make more sense if the system was split horizontally rather than vertically, so the radar map layout would be aligned with EFS bay layout. Furthermore, the information on the arrivals was not as efficiently presented as it could have been, thus the timeline was oftentimes switched off. Other than that, the majority of the feedback points to the unusual behaviour of the system during the airport switches.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Most of the ATCOs (66.6%) agree with the InNOVA being user-friendly. However, there were functions they had difficulties with. Similarly, the two-button design of the mic was unfamiliar and not intuitive, which paved the way for unnoticed errors. | POK |

Tailored questions: There were two tailor-made questions regarding the interaction with the InNOVA system and the VCS/handheld device. **Fehler! Verweisquelle konnte nicht gefunden werden.** indicates

that many of the ATCOs regarded the interaction with the InNOVA as user-friendly, however, there were those instances when they wanted to swap the aerodromes and the whole HMI got mixed-up (see CRT-PJ05-W2-35-V3-VALP-H02.030 for more detail).

The function that was key to efficient split & merge and worked very well was the split function itself. ATCOs could use this window without noticeable issues, and it was clear when an aerodrome was in an active or look only mode. The pen function to write on the strips was also highly praised.

That said, the functions ATCOs had difficulties with were the followings:

- Could not use drag and drop for each strip, drag and drop did not work precisely
- There was only one method for strip highlighting
- Runway blocking took way too many clicks
- The ground bay should not contain aircraft that only received their ATC clearance (i.e. are not moving) and flights that are already taxiing. Flights with ATC Clearance should be in a separate bay, which would be even more essential in high traffic load.

With regards to the VCS and handheld device, it is important to separate these two things (which unfortunately the question below did not). Due to a technical limitation the VCS did not join the other systems during the split and merge and the technical staff had to manually switch the VCS to the other MRTMs. The handheld mic was another matter- most of the ATCOs pointed out that it was strange to have two buttons for A/G and G/G communication, placed below each other. Haptic differentiation was difficult, thus some errors were observed.

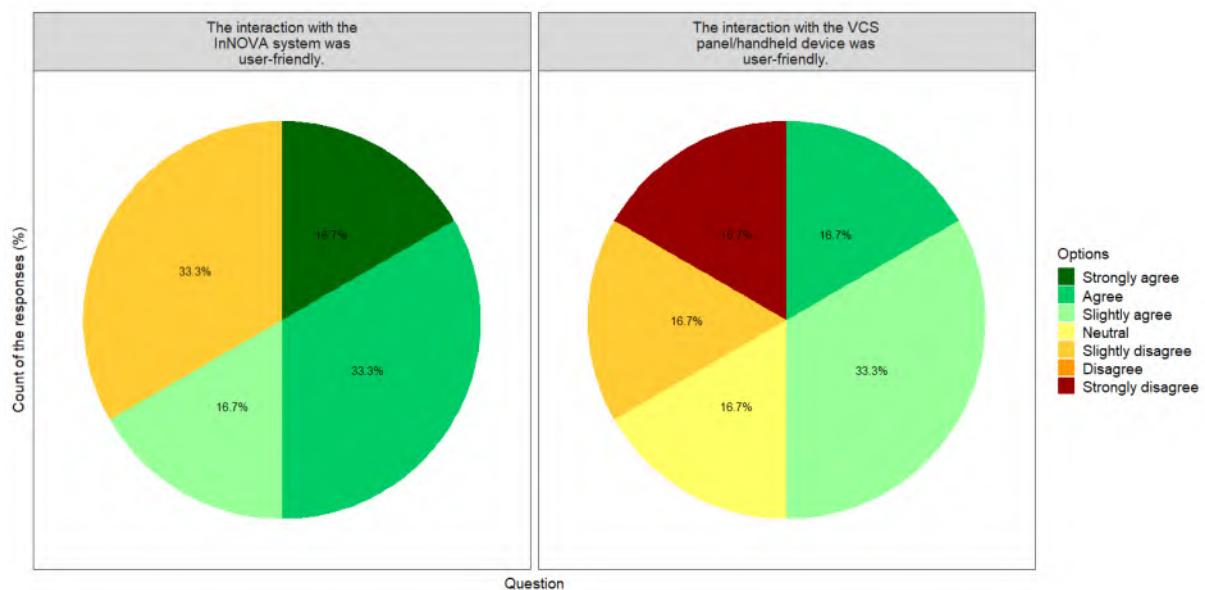


Figure: Feedback received for the interaction experience with the InNOVA and VCS.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The system behaviour during split and merge increased the potential for human error by not moving the MET window together with the radar map and EFS bay. This has led to the event when a MET window was next to a different aerodrome's EFS bay, causing confusion. The handheld mic with its two-button layout also led to errors. | POK |

Debriefing and open-ended questions in the post-simulation questionnaire: In accordance with the previously explained behaviour of the system during aerodrome switches, the MET window always remained at the same position, whilst everything else (EFS bay, radar maps) changed on the head-down display. This led to confusion about which MET window was related to which aerodrome, significantly increasing the potential for error i.e. providing the wrong MET info to an aircraft.

As mentioned in CRT-PJ05-W2-35-V3-VALP-H11.020, the two button design for the handheld mic was also confusing and led to errors. ATCOs reported a total of 5 such instances, however, sometimes they haven't even realised that they were pushing the wrong button as both coupled frequencies were channelled to the same pseudo pilot.



Figure: ATCO in MRTM2 with the hand-held microphone. The mic had two buttons under each other, with the same surface and shape, so haptic differentiation was difficult.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | The timeline used as a short-term planning tool was not preferred. ATCOs turned to the strips instead as it contained discrete and more precise data. | POK |

Tailored questions: This validation addressed only the short-term planning tool. One post-simulation question was created to address the usability of the timeline.

As shown on **Fehler! Verweisquelle konnte nicht gefunden werden.** ATCOs did not favour the timeline that was intended to be the short term planning tool. According to the feedback, they preferred discrete data over interval data representation. Most of the ATCOs even turned it off. Instead they used the strips for short-term planning as those were more precise. Some ATCOs suggested a more refined design for the EFS (e.g. adding the a/c type).

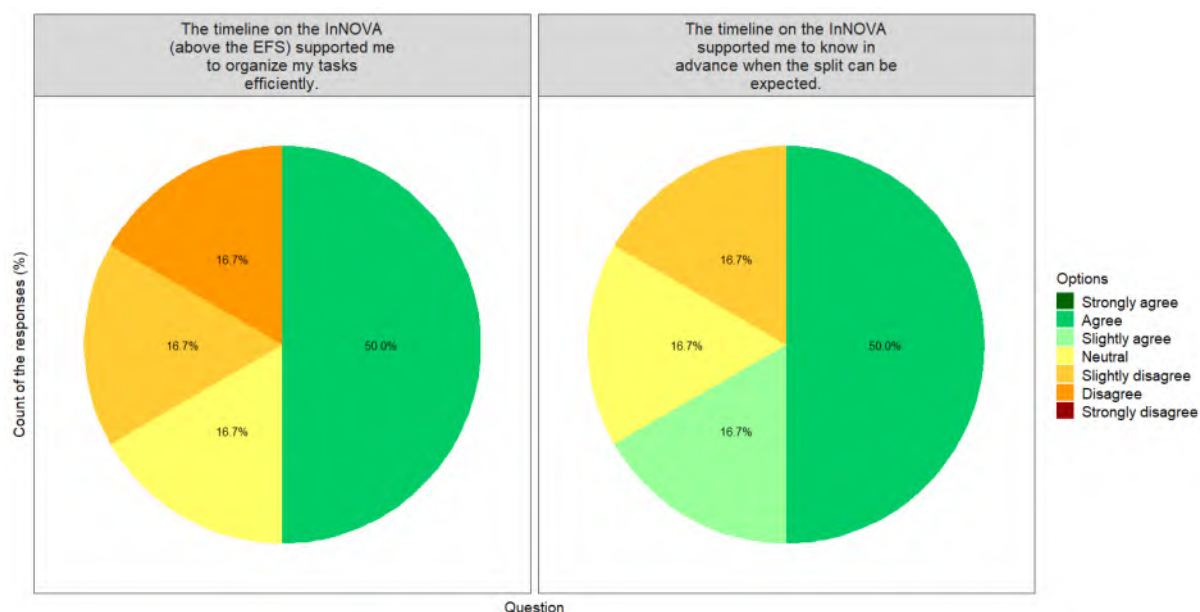


Figure: Feedback received for the usability of the ATCO timeline

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | The majority of ATCOs (83.3%) were aware which aerodrome was placed to which positions of the system | OK |

Tailored questions: This success criteria was addressed with one post-simulation question. As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.**, the majority of ATCOs (83.3%) were aware which aerodrome was placed to which positions of the system.

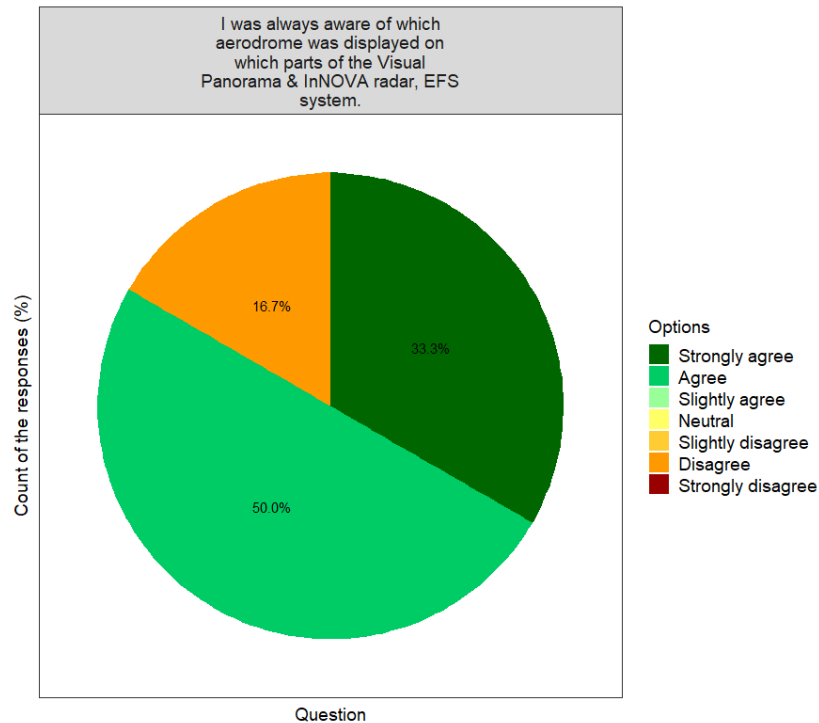


Figure: Feedback received for the awareness of the aerodrome positions in the system

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | It was unanimously agreed that it was clear which aerodrome was transferred between the MRTMs. The Supervisor made sure that ATCOs were aware which aerodromes will be affected by the split. | OK |

Tailored questions: This success criterion was addressed with one post-simulation question. As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.**, it was unanimously agreed that it was clear which aerodrome was transferred between the MRTMs. The Supervisor was monitoring the expected traffic on the SUP timeline and if his decision was to split, the Supervisor always announced which aerodromes will be affected. ATCOs either coordinated themselves the change, or the Supervisor jumped in to help and passed on the traffic information and runway direction to the receiving ATCO.

C.12.2.5 HUMAN PERFORMANCE – TRUST

C.12.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

Assess ATCO trust in support systems when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | The majority of ATCOs (83.3%) find the technical system's performance during split and merge reliable enough to establish trust. | OK |

Tailored questions: A specific question has been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, the majority of ATCOs (83.3%) find the technical system's performance during split and merge reliable enough to establish trust.

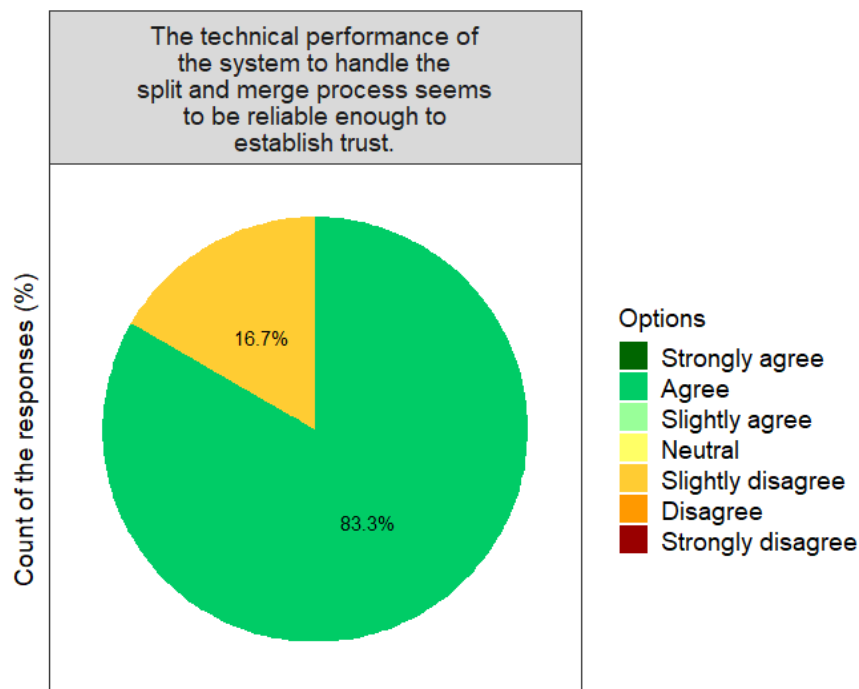


Figure: Feedback on the trust in the technical performance of the system

C.12.2.6 HUMAN PERFORMANCE – Transition Factors

C.12.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Knowledge, skill and experience aspects have been discussed. | OK |

Debriefing: This topic has been touched upon during the debriefing sessions. As previously mentioned, the Hungarian ATCOs did not have experience with the Norwegian airports before. Three of them have been part of the SESAR 2020 Wave 1 PJ05-02 validations, and three of the ATCOs are also Supervisors at Budapest TWR. It is also important to bear in mind that the civilian ATCOs at HungaroControl are used to providing ATS at Budapest, which is a medium-sized airport. Furthermore, as INDRA run validation with Avinor just a few months before this RTS, the observed differences between the two

groups came up quite frequently. One of these main differences was related to the background of the end-users. ATCOs coming from a larger aerodrome were more at ease with the simulated environment than those ATCOs or AFISO coming from a smaller aerodrome.

Some ATCOs mentioned that it hurt their pride that an aerodrome has been taken away from them, even though they felt that they could have continued to provide ATS for that one as well. This is why it should be borne in mind that the split and merge is there for optimising workload. Only the Supervisor has all the RTC-related information in his/her possession, so ATCOs should not question his/her decision.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Training needs have been discussed for both ATCO and SUP. | OK |

Debriefing: This topic has been touched upon during the debriefing sessions. As previously mentioned, the Hungarian ATCOs did not have experience with the Norwegian airports before. They received theoretical training one month before the simulation which was repeated just before the hands-on training. This practical training preceded the measured runs and lasted for ~1.5 hours.

After four days ATCOs shared that they needed this time to get comfortable with the simulated environment (four airports and the system). It is important to bear in mind that the civilian ATCOs at HungaroControl are used to providing ATS at Budapest, which is a medium-sized airport. Therefore they felt that it may have been easier for them to adjust to the simulated traffic level- albeit it wasn't too high for their standards-, then for someone who comes from a small aerodrome with 1-2 VFRs/day.

In terms of training on the system, it is easier to get accustomed to a system which was tailored to the given context of use. The system used in this validation was designed to the needs of the Avinor end-users. Whilst the behaviour of the system may have been intuitive for that group of users, the same design did not meet the mental model of the Hungarian ATCOs.

C.12.2.7 SAFETY

C.12.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | <p>The majority of ATCOs find that they are able to identify and solve potential conflicts in a timely manner</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area <p>On the manoeuvring area</p> | OK |

Tailored questions: Specific questions (A1-A15) have been created to address this success criteria. As Fehler! Verweisquelle konnte nicht gefunden werden. presents:

- In case of 8 questions (A2, A3, A4, A5, A6, A9, A10, A12), 100% of the participating ATCOs stated that they are able to execute the questioned tasks with the system. Comments concerning these questions are the following:
 - A3 and A4 – conflict detection and resolution in the vicinity of the aerodrome were mainly based on radar
 - A5 – the ground bay in EFS was taking traffic from issuing en-route clearance till line-up, and it was too difficult
- In case of 5 questions (A7, A8, A11, A14, A15), 83% of the participating ATCOs stated that they are able to execute the questioned tasks with the system, while the others stated “partially” or “not applicable”. Comments concerning these questions are the following:
 - A7 – Missing PTZ function, labels on the visual screen would be useful
 - A8 – ATCOs were not completely familiar with A/D layout
 - A11 – PTZ would help
 - A15 – RVR info was missing, there was no change in weather, it would have been interesting to see how ATCOs can recognize this change

- In case of 2 questions (A1, A13), 67% of the participating ATCOs stated that they are able to execute the questioned task with the system, while the others stated “partially” or “not applicable”. Comments concerning these questions are the following:
 - A1 – missing PTZ function, EFS was time-consuming, setting the radar picture took long time
 - A13 – In case of LVP, it is not possible without ground radar

Generally, it was a common feedback that binocular function (PTZ functionality) would be necessary, and EFS system was not efficient. Although the comment of A13 mentions that detection and handling of runway incursions is not possible without ground radar in LVP, other comments and debriefing session feedbacks have not confirmed that it would be different from PJ.05.02 solution in any way.

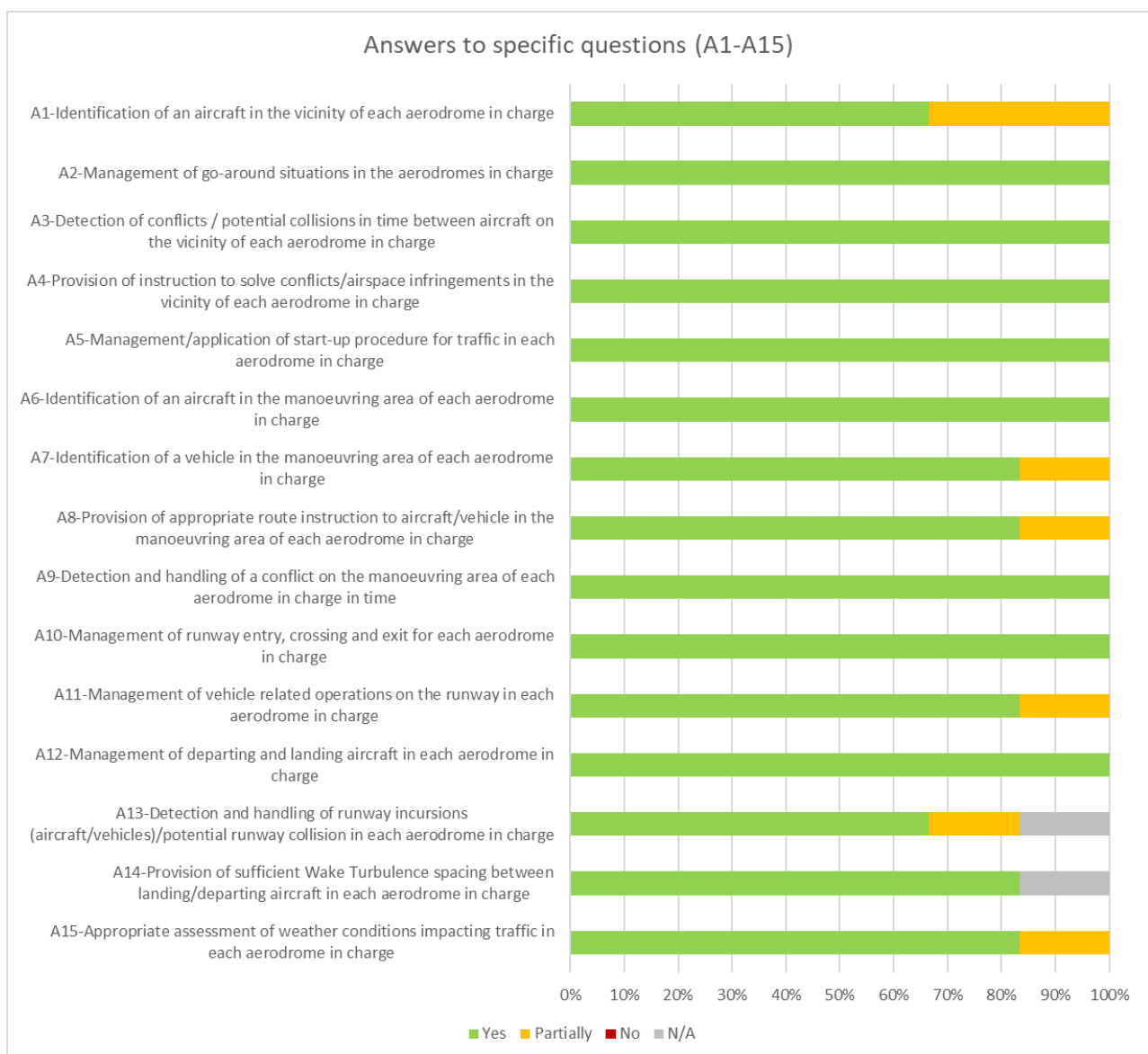


Figure: Feedback on ATCO ability to identify and solve potential conflicts in a timely manner

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | <p>ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.):</p> <ul style="list-style-type: none"> • Unstable approaches • Bird strikes <p>Aircraft not vacating RWY as expected</p> | <p>The majority of ATCOs find that they are able to identify and solve potential hazardous situations in a timely manner, although not a representative set of these situations was validated.</p> <p><i>Note: The POK status of the criteria is due to the fact that only one type of hazardous scenario has been tested, thus the results may not be sufficiently generalizable for all the events listed in the Success Criterion.</i></p> | POK |

Tailored questions: Specific questions (A16 and A18) have been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of question A16, 83% of the participating ATCOs stated that they are able to execute the questioned tasks with the system, while the others stated “not applicable”, and in case of question A18, 67% of the participating ATCOs stated that they are able to execute the questioned task with the system, while the others stated “not applicable”

On the other hand, the number of these kind of situations was limited in the validation exercises. Potential hazardous situations were induced by vehicles in the validation scenarios (e.g. a vehicle not vacating RWY as expected, a vehicle that was following another one entered the RWY without ATC clearance).

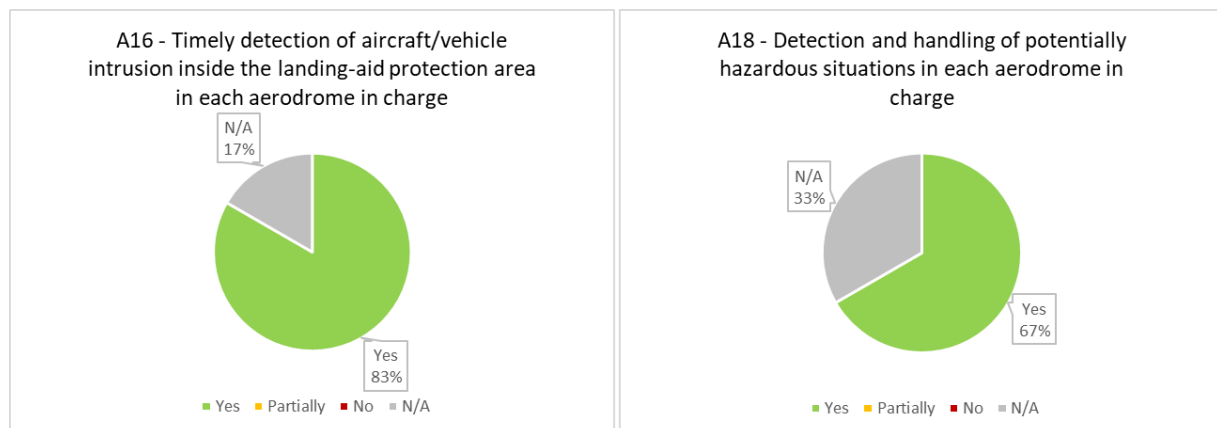


Figure: Feedback on ATCO ability to identify and solve potential hazardous situations in a timely manner

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | The majority of ATCOs (83.3%) find that they are able to distinguish with which aircraft, vehicle at which aerodrome they are communicating with | OK |

Tailored questions: Specific questions (A20 and A21) have been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of both questions, 83% of the participating ATCOs stated that they are able to execute the questioned tasks with the system, while the others stated “partially”.

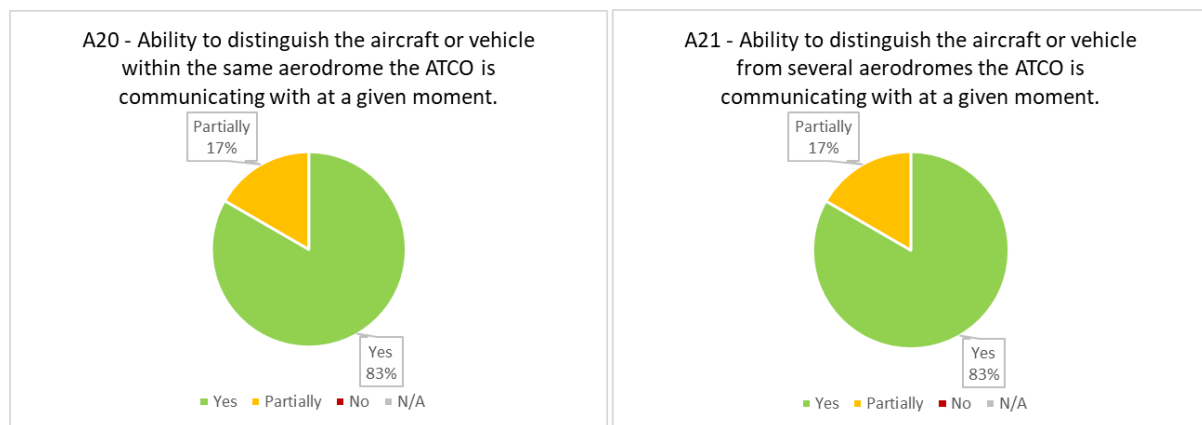


Figure: Feedback on ATCO ability to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with

Debriefing: This topic has been touched upon during the debriefing sessions. ATCO feedbacks highlighted that they were able to distinguish with which aircraft, vehicle at which aerodrome they were communicating with, but due to high number of similar callsigns, it was not always easy and quick. A frame with different colours for each aerodrome (visual presentation, air surveillance window, EFS) would be very useful, and the utilization of squelch indication should be also considered. Physical appearance of air and ground radio buttons should be different to avoid confusion.

Results detailed at CRT-PJ05-W2-35-V3-VALP-H04.020 also support these findings.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | The majority of ATCOs find that they were not inducing more conflicting situations than in the reference scenario, and over-the-shoulder observations confirmed this. | OK |

Tailored questions: A specific question (A27) has been created to address this success criteria. The answers for this question are the following:

- An ATCO lost his situational awareness during split/merge process
- There would be no time for the supervisor to walk and assist in an emergency, so special tools should be provided for the supervisor to get into the situation (visual, voice, radar information without ATCO disturbance)
- During split/merge, the air situation display management was not user friendly, it took too much time to set the radar information for all aerodromes in charge

Debriefing: This topic has been touched upon during the debriefing sessions. According to ATCO feedbacks, the number of conflicting situations induced by the ATCO was not higher than in the reference scenario. Over-the-shoulder observation also confirmed this statement.

C.12.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | The majority of ATCOs (100%) find that they are able to foresee traffic at his/her MRTM at short term in order to avoid overloads | OK |

Tailored questions: A specific question (A19) has been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of question A16, 100% of the participating ATCOs stated that they are able to execute the questioned task with the system.

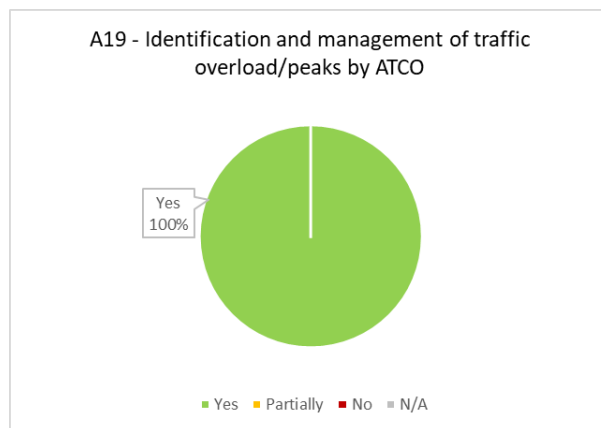


Figure: Feedback on ATCO ability to foresee traffic at his/her MRTM at short term in order to avoid overloads

In spite of this, results detailed at CRT-PJ05-W2-35-V3-VALP-H11.060. should be considered. According to HP questionnaires and debriefing sessions, the timeline used as a short-term planning tool was not preferred. ATCOs turned to the strips instead as it contained discrete and more precise data, but they were able to foresee traffic based on strip information.

C.12.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

| OBJ-PJ05-W2-35-V3-VALP-S06 Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> Aircraft emergency Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport | The majority of ATCOs (83.3%) find that they are able to identify and manage abnormal situations (aircraft emergency due to landing gear problem). <i>Note: The POK status of the criteria is due to the fact that only one type of abnormal scenario has been tested, thus the results may not be sufficiently generalizable for all the abnormal events listed in the Success Criterion.</i> | POK |

Tailored questions: Specific questions (A17 and A23) have been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of both questions, 83% of the participating ATCOs stated that they are able to execute the questioned tasks with the system, while the others stated “not applicable” in case of A17, and “partially” in case of A23.

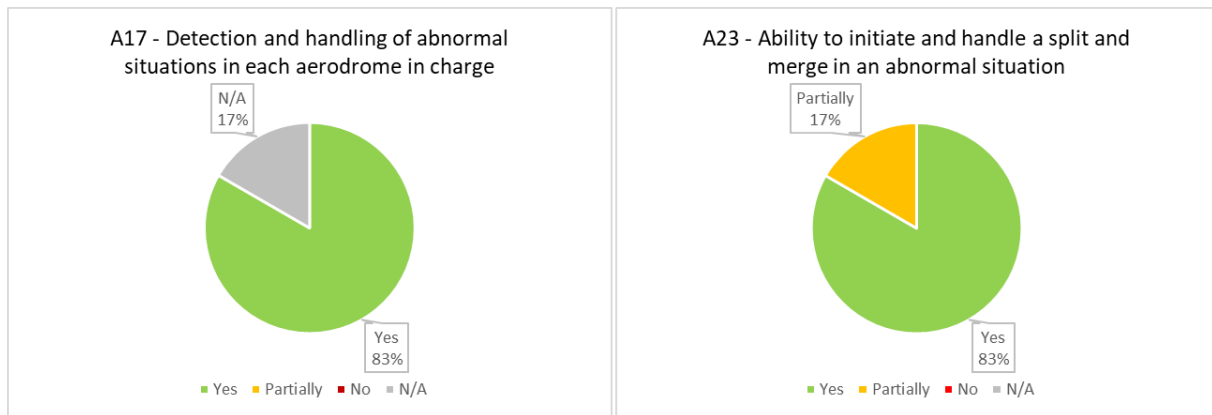


Figure: Feedback on ATCO ability to identify and manage abnormal situations

Debriefing: This topic has been touched upon during the debriefing sessions. According to ATCO feedbacks, the emergency situation (aircraft emergency due to landing gear problem) was manageable, although it is important that the aerodrome(s) which are not affected with the emergency situation should always be split as soon as possible, and the ATCO should not wait for additional information on the emergency to predict the expected workload, because such a situation can quickly escalate, which would make split process more challenging. It is recommended to apply this as an obligatory rule.

C.12.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results

OBJ-PJ05-W2-35-V3-VALP-S07

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> Communication Visualisation system <p>Other airport systems / infrastructure</p> | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system | <p>The majority of ATCOs find that they are able to a technical failure in the MRTM affecting the operation at one or more aerodromes affecting the visualisation system (total loss of the visualization of one aerodrome in an MRTM)</p> <p><i>Note: The POK status of the criteria is due to the fact that only one type of technical failure scenario has been tested, thus the results may not be sufficiently generalizable for all the degraded mode events listed in the Success Criterion.</i></p> | POK |

Tailored questions: Specific questions (A25 and A26) have been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of both questions, 83% of the participating ATCOs stated that they are able to execute the questioned task with the system, while the others stated “partially”. Comments concerning these questions are the following:

- A25 – A mandatory procedure should be defined for situations like that
- A26 – “It should be the ATCO's responsibility to choose the appropriate time window for the split”.



Figure: Feedback on ATCO ability to detect and recover from a technical failure occurring at one of the airports

C.12.2.8 CAPACITY

C.12.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

Founding Members

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | The predefined cut-off point in terms of simultaneous movements seemed reasonable for the ATCOs. They were comfortable providing ATS to multiple remote towers but preferred the 2:2 aerodrome distribution to the 3:1 option. | OK |

Tailor-made questions and debriefings: As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.** related to CRT-PJ05-W2-35-V3-VALP-H07.030, the majority of ATCOs agree that they can provide ATS to 3 aerodromes at the same time, and that the traffic level and complexity was optimal, if not a little too low for their liking. In terms of the simultaneous movements and cut-off point for split, the defined “more than 6” seemed reasonable for the ATCOs, although maybe a little too low-similarly to the overall traffic load. Important to note is that in our validation and system configuration, both the VFRs and IFR counted as “1” in the score, so the timeline essentially showed the expected traffic load and not the traffic complexity. Although the ATCOs did mention this as a potential shortcoming, they did not really see the added benefit of increasing the VFR score to e.g. “1.5”.

Perhaps not surprisingly, SUPs and ATCOs preferred to change the setup from 3:1 aerodrome distribution to 2:2 when possible. This made the workload more balanced across MRTMs.

C.12.2.9 COST EFFICIENCY

C.12.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | ATCOs agree that they could provide 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes. | OK |

Tailor-made questions and debriefings: As discussed in CRT-PJ05-W2-35-V3-VALP-H07.030, ATCOs were comfortable providing ATS to 3 aerodromes at the same time (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). They had also no issues with having four aerodromes to “choose from”, which is even more impressive considering that those aerodromes were foreign ones which they may have never heard of. It is important to note though that the participating civilian ATCOs have

experience in working at Budapest TWR, which is a medium-sized aerodrome. Thus they were at ease with this setup, especially when the MRTM was busy with traffic.

C.12.3 Supervisor - Summary of Validation Exercise Results

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|---|--|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The mean scores of the China-Lake metric suggest that SUPs’ situational awareness was at acceptable level. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | Every participant agreed that the HMI supported their situational awareness and decision-making process. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | | N/A |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in | Supervisor’s reported an acceptable level of workload, even during the split and merge process. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|--|--------------------------------|--|--|-----------------------------|
| | of ATS to multiple aerodromes | | an RTC with a flexible allocation of aerodromes between MRTMs | | |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors reported that they were able to efficiently support ATCOs in non-nominal situations, and were also able to make decisions about the split. However, they also expressed some of the difficulties they faced as first-time RTC Supervisors. | OK |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | Participating ATCOs unanimously agree that the SUP roles and responsibilities are clear and acceptable in an RTC environment. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Participating ATCOs unanimously agree that the assigned number of aerodromes could be handled efficiently from the SUP position. | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of ATCOs did not report anything missing from the SUP system. There was one idea however that is worth to consider, i.e. to have a quick access for view only of any airport, so that the SUP in an RTC environment could follow an emergency situation without bothering the ATCO in the MRTM. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Whilst the utility of the SUP planning tool is unquestionable, there were some issues with the reliability of the timeline data. The interaction with the system was regarded as intuitive. | POK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | The number of errors made in the simulation was negligible and was due to the unfamiliarity with the system. | OK |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | The reliability of the information provided by the timeline should be further improved, as it was not always precise. | POK |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Knowledge, skill and experience requirements are identified per actor group | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | No special training need was identified for the SUP role. | OK |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): | The majority of SUPs (83,3%) find that they are able to support an ATCO in abnormal | POK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|---|-----------------------------|
| | conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | situations (aircraft emergency due to landing gear problem) | |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> Communication Visualisation system Other systems in the MRTM | The majority of SUPs (83,3%) find that they are able to detect and manage technical failures occurring in one module of the RTC (total loss of the visualization of one aerodrome in an MRTM) | POK |
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | The majority of SUPs find that they are able to foresee traffic with supervisor planning tool to safely manage RTC operations | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|-------------------------|----------------------------|----------------------|-------------------|-------------------|-----------------------------|
| | aerodromes between MRTMs | | | | |

Table 27: Supervisor - Validation Results for Exercise 1

C.12.4 Supervisor - Analysis of Exercise Results per Validation objective

C.12.4.1 HUMAN PERFORMANCE – SITUATION AWARENESS

C.12.4.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

OBJ-PJ05-W2-35-V3-VALP-H01

Assess SUP situation awareness when working in an RTC

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | The mean scores of the China-Lake metric suggest that SUPs' situational awareness was at acceptable level. | OK |

Post-run standardized questionnaire: The China-Lake situational awareness scale has been used to address the SUP's SA score. The metric is essentially an inverse version of the Bedford Workload Score and was used instead of the SASHA-Q, as the China-Lake does not contain questions that are too specific for ATCO positions and tasks.

Fehler! Verweisquelle konnte nicht gefunden werden. shows that Supervisor's situational awareness was at satisfactory level. They were either sitting behind their computer and were monitoring the SUP's planning tool, or they were assisting the ATCOs during the split & merge.

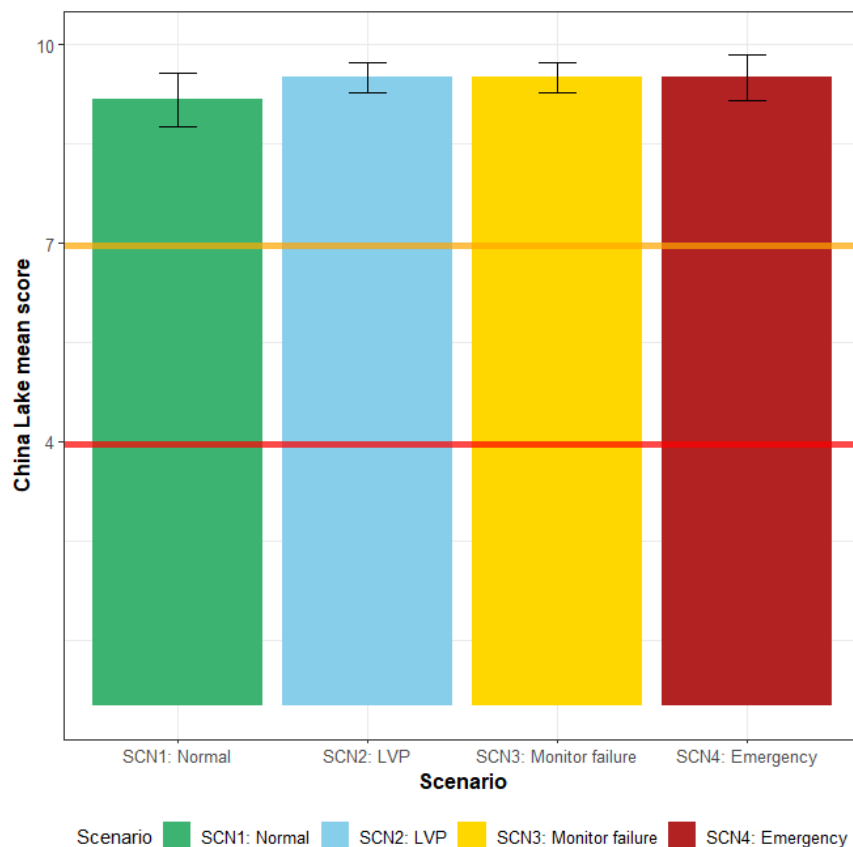


Figure: Mean scores of the China-Lake Situational Awareness scale, broken down into Scenarios.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | Every participant agreed that the HMI supported their situational awareness and decision-making process. | OK |

Tailor-made questions: Two questions have been prepared to address this success criteria. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows that i) the timeline was useful in supporting SUP's to see when an overload was expected, and ii) the what-if planning tool helped them to identify

the optimal sectorisation. The participating controllers proposed to further improve the timeline as it was not always correct, and that the actual overload period was not sufficiently transparent.

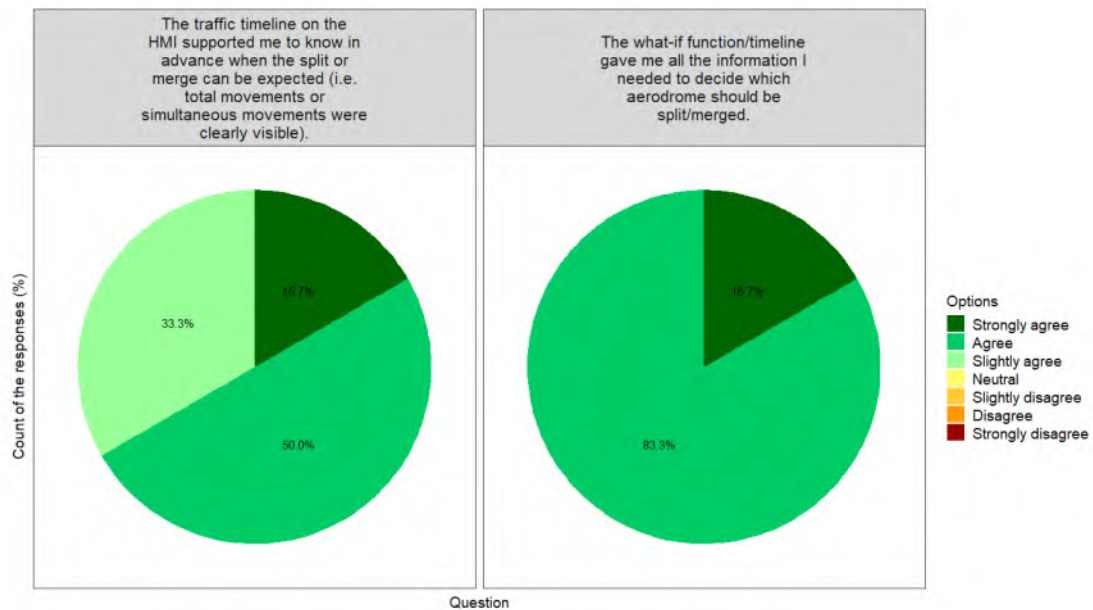


Figure: Feedback on the HMI support for the SUP

Another idea which relates to SA was that “the SUP position should have a quick access for a view only radar+visual+voice function of any airport. In an emergency situation there would be no time to walk to the MRTM position (also leaving the others without SUP is not an option) so there should be a way for the SUP to get as much information as possible about the situation without putting extra workload on the ATCO”.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | | N/A |

C.12.4.2 HUMAN PERFORMANCE – WORKLOAD

C.12.4.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

OBJ05-W2-35-V3-VALP-H05**Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes**

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisor's reported an acceptable level of workload, even during the split and merge process. | OK |

Post-run standardized questionnaire: The Bedford Workload Scale have been used to address the workload level of the Supervisors. As **Fehler! Verweisquelle konnte nicht gefunden werden.** shows, the SUPs' mean workload is within satisfactory level. The highest score was 4, and it was reported after the emergency scenario.

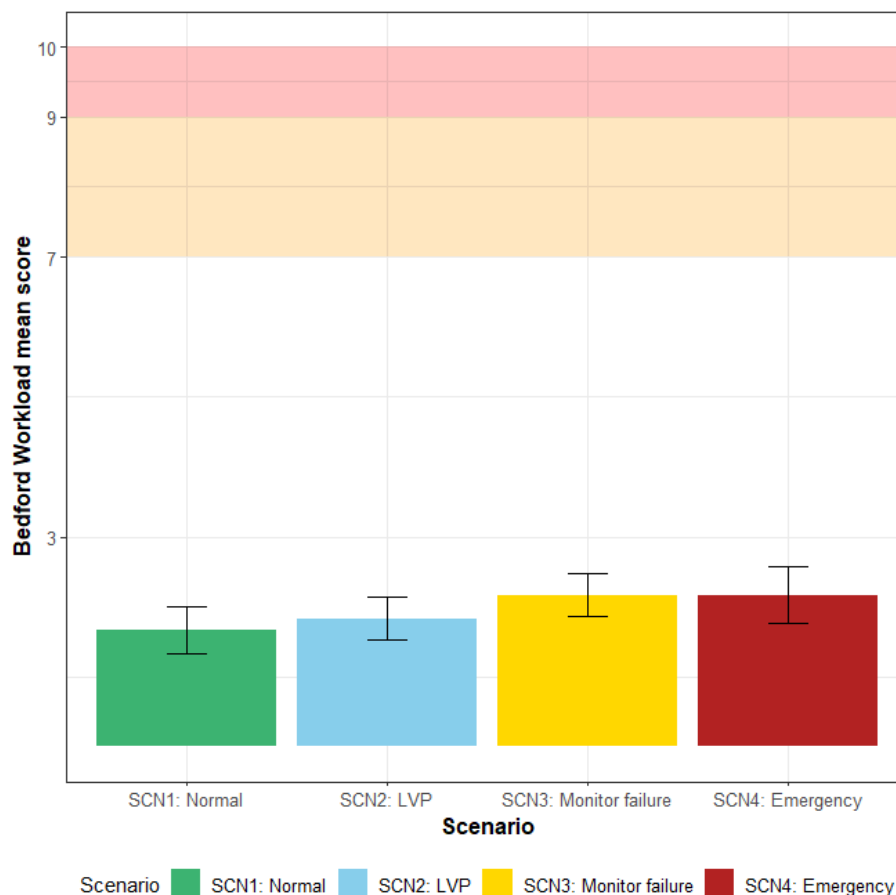


Figure: Mean scores of Bedford Workload Scale, broken down into Scenarios. The error bars represent the standard error.

Tailor-made question: The pie chart below shows the feedback received for the split and merge event. Based on the data it seems that the Supervisors' workload remained at acceptable level during the

split. In SCN1 a Supervisor explained that due to technical problem the splitting was difficult, hence the orange colour. Otherwise they mentioned that they only made the decision to split, and the ATCOs were the ones who coordinate this between themselves.

My workload remained at an acceptable level during the split/merge process itself.

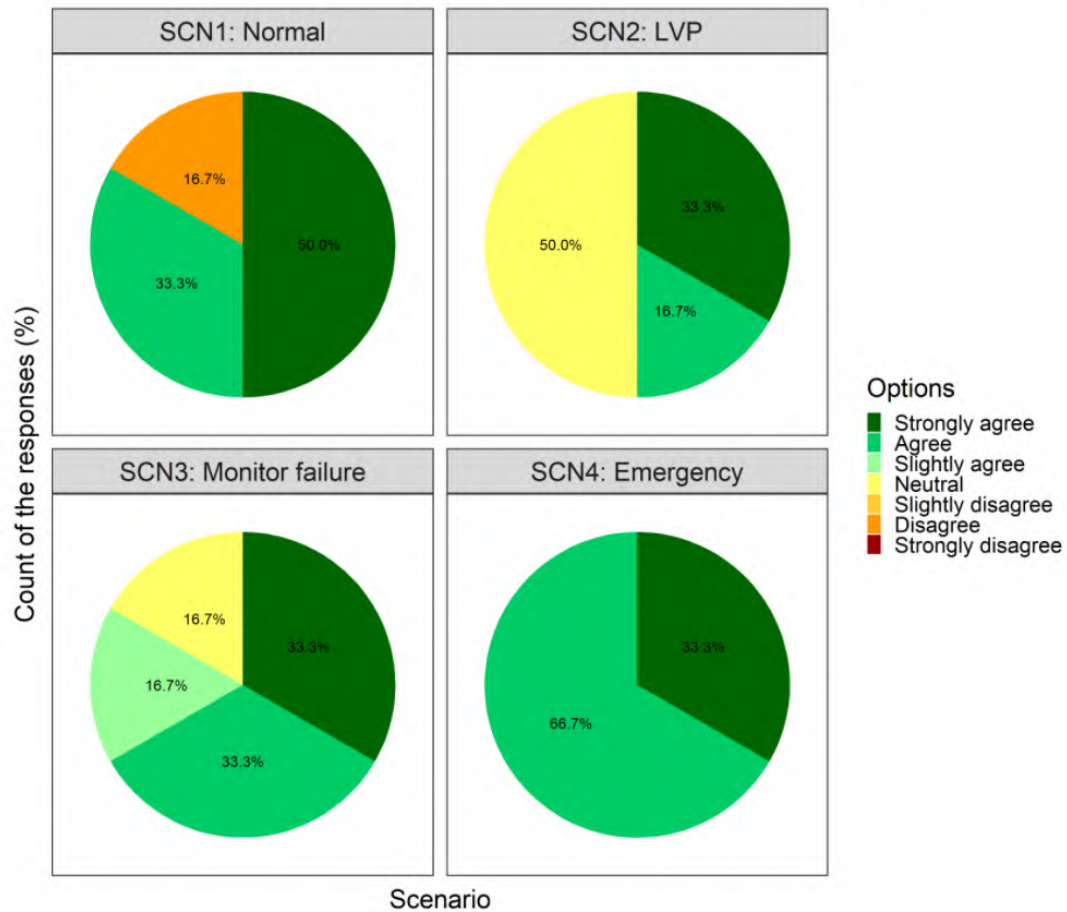


Figure: Feedback received on the workload experienced during the split and merge, from SUP perspective.

C.12.4.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

C.12.4.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

OBJ-PJ05-W2-35-V3-VALP-H09

Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | Supervisors reported that they were able to efficiently support ATCOs in non-nominal situations, and were also able to make decisions about the split. However, they also expressed some of the difficulties they faced as first-time RTC Supervisors. | OK |

Tailor-made questions: Two questions were designed to address this complex success criteria, as seen on the pie chart below. We wanted to know whether the Supervisor's could sufficiently support the ATCOs in especially non-nominal events. Based on the feedback it is clear that Supervisor's agree that they could efficiently help the ATCOs in such cases.

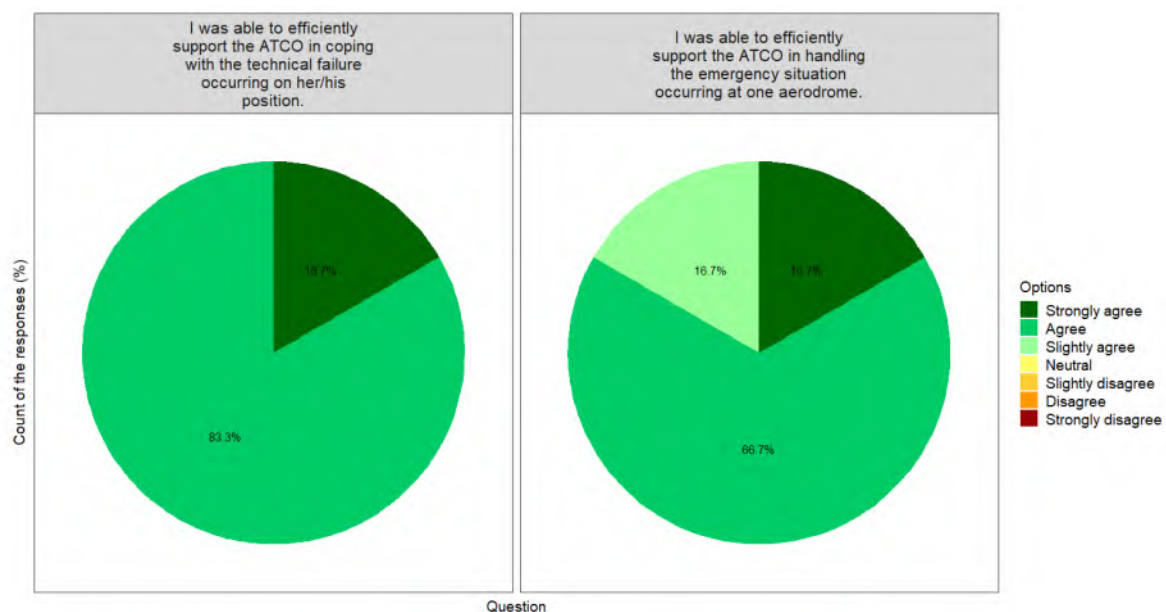


Figure: Feedback on the support SUPs gave the ATCOs during non-nominal conditions.

To complement the non-nominal situations with general experiences, they also opened up about some of the difficulties they faced in the SUP role:

- “To precisely identify the peaks. I needed to analyse the data provided by the system, because the yellow marked periods were not real peaks in most cases.”

- “To stay in my place and not to take part physically in the situation. Maybe bigger distances between the positions and direct phone lines would have solved this issue.”
- “To make ATCOs understand the need of splitting”- This is line with what is explained in the Transition factors objective, CRT-PJ05-W2-35-V3-VALP-H15.010.

C.12.4.4 HUMAN PERFORMANCE – USABILITY and UTILITY

C.12.4.4.1 OBJ-PJ05-W2-35-V3-VALP-H10 Results

OBJ-PJ05-W2-35-V3-VALP-H10

Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | Participating ATCOs unanimously agree that the SUP roles and responsibilities are clear and acceptable in an RTC environment. | OK |

Tailor-made questions: Two questions have been created to address this success criteria, as shown in the pie chart below. According to the results, ATCOs understood the responsibilities that this RTC SUP role introduces.

As mentioned in the previous section, it was a bit unusual for them to step back and do not get involved in an unexpected situation. Also, sectorisation is a task that is not part of the current Budapest TWR Supervisor’s responsibilities. Importantly, one participant made the following observation:

- “For the SUP position, the roles should be defined because different interaction would be expected from a big center SUP and from a 2-3 airport multi remote center.”

The consequent implications on the transition factors are detailed in CRT-PJ05-W2-35-V3-VALP-H15.010.

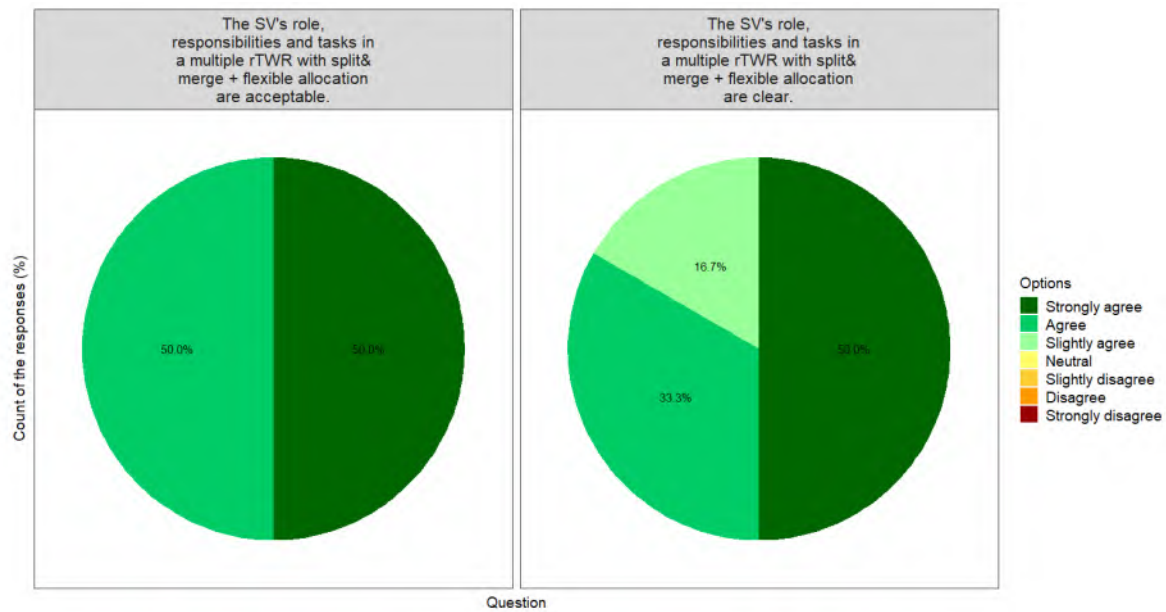


Figure: Feedback received on the Supervisor's roles and responsibilities

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Participating ATCOs unanimously agree that the assigned number of aerodromes could be handled efficiently from the SUP position. | OK |

Debriefing: The group debriefing provided the opportunity to cover the feasibility aspect of the solution. They had no issues with the assigned number of clusters of aerodromes (i.e. four aerodromes distributed across 2 MRTMs), especially with having the SUP planning tool that they could play around with and create sectorisations.

C.12.4.4.2 OBJ-PJ05-W2-35-V3-VALP-H12 Results

OBJ-PJ05-W2-35-V3-VALP-H12

Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | The majority of ATCOs did not report anything missing from the SUP system. There was one idea however that is worth to consider, i.e. to have a quick access for view only of any airport, so that the SUP in an RTC environment could follow an emergency situation without bothering the ATCO in the MRTM. | OK |

The SUP system and planning tool provided information on the traffic load and simultaneous traffic load within the pre-defined time windows. The threshold was marked with red, and the peak periods were highlighted with a yellow box. ATCO endorsements were also part of the system. There was no functionality to calculate and display workload specifically.

Tailored questions: As already reported in CRT-PJ05-W2-35-V3-VALP-H18.010, two questions were created to address the SUP tool from information needs point of view. According to **Fehler! Verweisquelle konnte nicht gefunden werden.** and the thoughts added to the open-ended questions it is safe to say that the what-if function would be a key tool for the Supervisors in the future. Some recommendations were made for future improvement, i.e. to ensure that the yellow marked periods accurately show the real traffic peaks, and also indicate the length of the peak by adding a slider or any alternative solution.

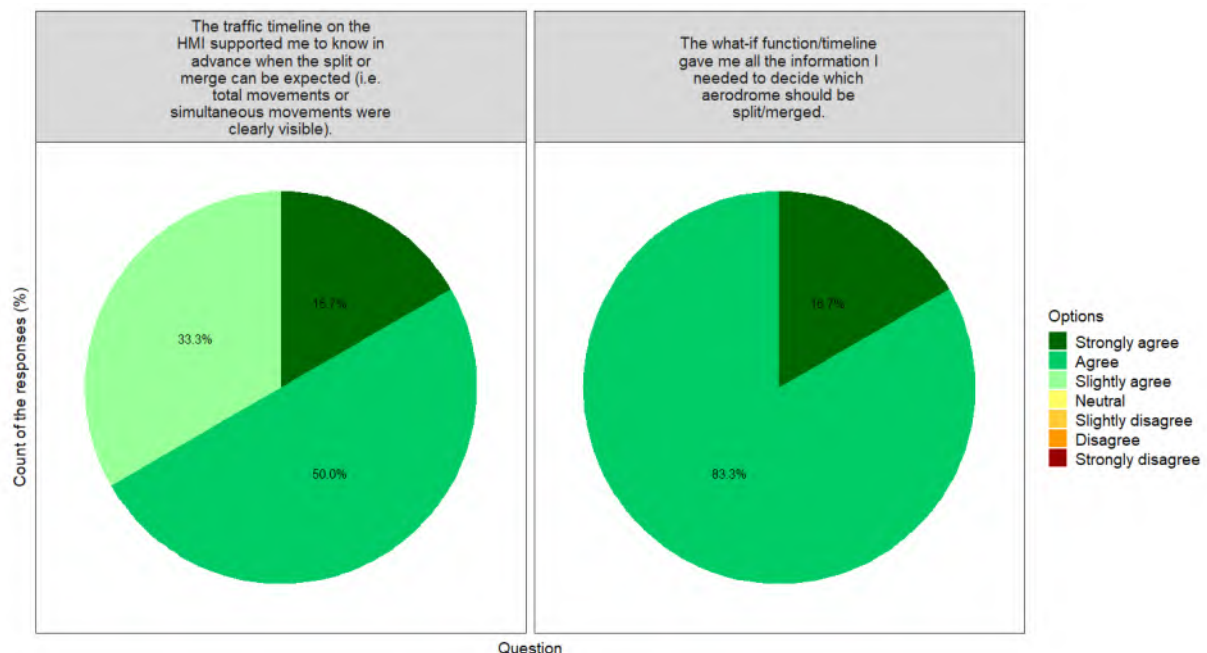


Figure: Feedback received for the information needs of the SUP role

As already mentioned in the Situational awareness section, an idea was put forward for the SUP position:

- “The SUP position should have a quick access for a view only radar+visual+voice function of any airport. In an emergency situation there would be no time to walk to the MRTM position (also leaving the others without SUP is not an option) so there should be a way for the SUP to get as much information as possible about the situation without putting extra workload on the ATCO”.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Whilst the utility of the SUP planning tool is unquestionable, there were some issues with the reliability of the timeline data. The interaction with the system was regarded as intuitive. | POK |

Standardized and tailor-made questions: SATI and two specific questions were integrated into the post-validation questionnaire to get feedback on the usability of the SUP system. SATI is a standardized EUROCONTROL questionnaire which mainly targets the Trust in ATC automation tools, but has several items related to usability too.

As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.**, ATCOs agreed that the SUP planning tool was useful and that they felt confident when they were working with the system. As mentioned earlier, the timeline was not always precise thus the Supervisors often went over to the MRTMs to check the strip data. It is important to highlight that the second ATCO group used a slightly upgraded SUP planning tool, so the feedback of the two ATCO groups are slightly different accordingly.

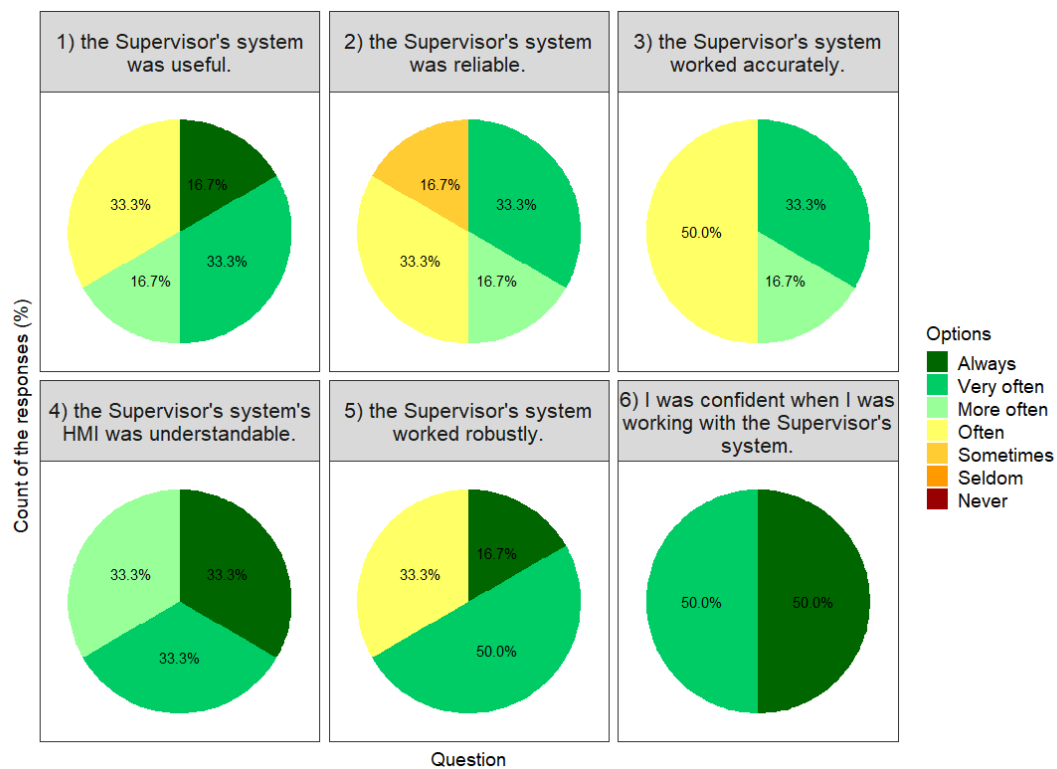


Figure: Feedback received for the SATI questionnaire from the supervisor role.

The timeline was regarded as very useful in a SUP role, as already discussed in CRT-PJ05-W2-35-V3-VALP-H12.010.

The interaction with the SUP system was also highly praised. As seen on **Fehler! Verweisquelle konnte nicht gefunden werden.**, participants unanimously agreed that interacting with the system was intuitive. Some errors were observed, but it was in the first periods when the system was still unfamiliar for the ATCOs.

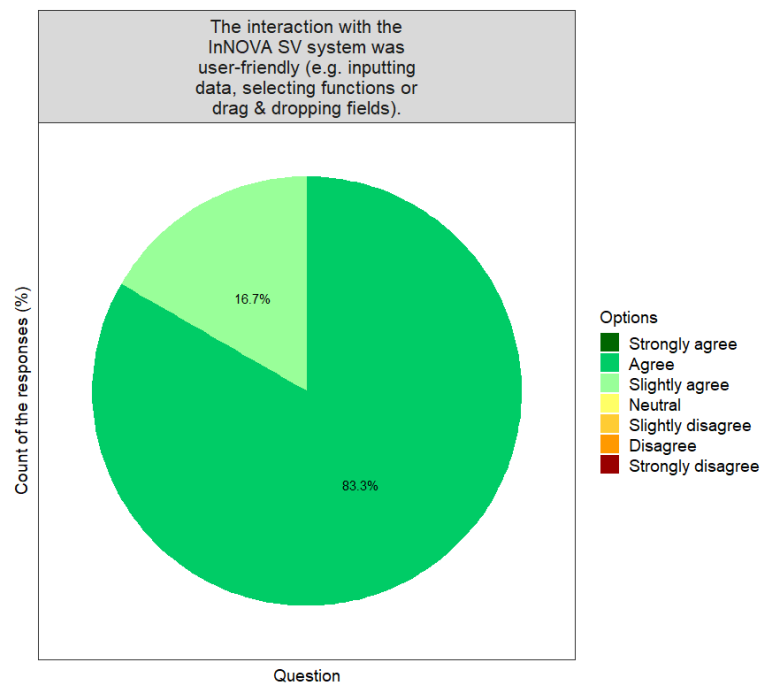


Figure: Feedback received on the usability of the SUP system

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | The number of errors made in the simulation was negligible and was due to the unfamiliarity with the system. | OK |

Tailor-made questions: According to the questionnaire there was one time when a Supervisor mistakenly turned off and switched on the airports in one of the active MRTMs, when in fact he wanted to open MRTM4 (dummy MRTM) in the planning tool. This error was made due to the unfamiliarity with the system.

C.12.4.5 HUMAN PERFORMANCE – TRUST

C.12.4.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

| OBJ-PJ05-W2-35-V3-VALP-H14 Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | The reliability of the information provided by the timeline should be further improved, as it was not always precise. | POK |

In the previous objective the results on the SATI (Trust in ATC Automation tools) questionnaire have already been presented. Based on **Fehler! Verweisquelle konnte nicht gefunden werden.**, the reliability of the information provided by the timeline should be further improved, which is further attested by the comments ATCOs provided as recommendation for system development.

C.12.4.5.2 OBJ-PJ05-W2-35-V3-VALP-H15 Results

| OBJ-PJ05-W2-35-V3-VALP-H15 Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|--|--|
|---|--|--|--|

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Knowledge, skill and experience aspects have been discussed, but nothing significant has been identified. | OK |

Debriefing: This topic has been touched upon during the debriefing sessions. As previously mentioned, the Hungarian ATCOs did not have experience with the Norwegian airports before. Three of them have been part of the SESAR 2020 Wave 1 PJ05-02 validations, and three of the ATCOs are also Supervisors at Budapest TWR.

Some ATCOs also mentioned that it hurt their pride that an aerodrome has been taken away from them, even though they felt that they could have continued to provide ATS for that one as well. Thus ATCOs should bear in mind that the split and merge is there for optimising workload. Only the Supervisor has all the RTC-related information in his/her possession, so ATCOs should not question his/her decision.

In terms of the role of the SUP, the first group pointed out that sectorisation is not part of the (HungaroControl) Tower Supervisor's current duties, so this task was a little unusual. They also suggested that motivation and affinity are the key skills and requirements for becoming a Centre SUP. The SUP should be confident in "ordaining" the split, yet s/he should explain the reason for a split briefly just as a SUP would do in ACC, so that ATCOs also understand that it is due to e.g. a predicted traffic levels and not due their performance. As one of the participating ATCO put it, by so doing the SUP would not "trample on the ATCO's feelings".

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | No special training need was identified for the SUP role. | OK |

C.12.4.6 SAFETY

C.12.4.6.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations(e.g): <ul style="list-style-type: none"> Crash on an airport or its vicinity Fire on an airport Unplanned closure of an airport ATCO overload in one or more MRTM of the RTC | The majority of SUPs (83,3%) find that they are able to support an ATCO in abnormal situations (aircraft emergency due to landing gear problem). <i>Note: The POK status of the criteria is due to the fact that only one type of abnormal scenario has been tested, thus the results may not be sufficiently generalizable for all the abnormal events listed in the Success Criterion.</i> | POK |

Tailored questions: Specific questions (S3 and S5) have been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of both questions, 83% of the participating ATCOs stated that they are able to execute the questioned task with the system, while the others stated "not applicable" in case of S3, and "partially" in case of S5. A comment stated that "the SUP suggested the split or made the call to split".

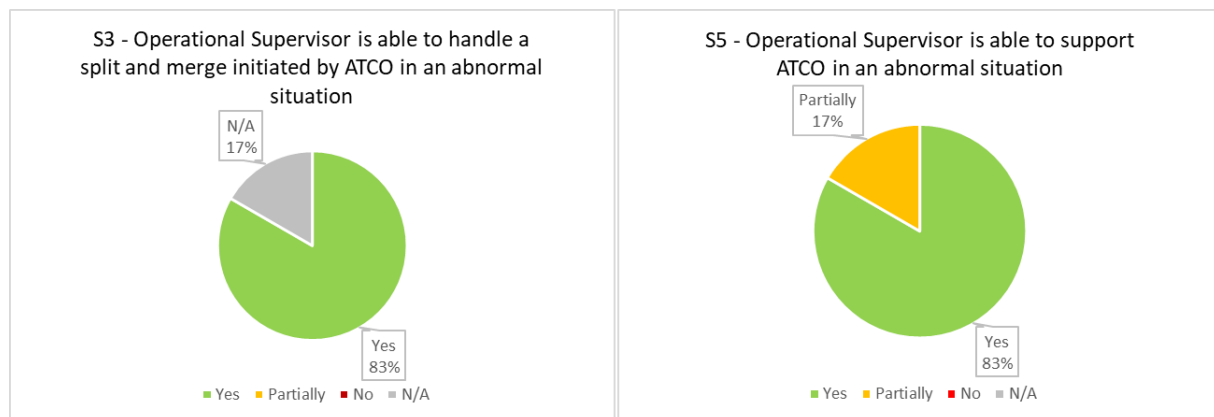


Figure: Feedback on supervisor's ability to support an ATCO in abnormal situations

Debriefing: This topic has been touched upon during the debriefing sessions. As previously mentioned, in an RTC, the supervisor has limited information on specific MRTMs, and it could decrease the efficiency of support provided to the ATCO in abnormal situations. According to ATCO feedback, there would not be enough time for the supervisor to go to the affected MRTM and assist in an emergency situation, so special tools should be provided to get into the situation as soon as possible (visual, voice, radar information) without ATCO disturbance.

C.12.4.6.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

| OBJ-PJ05-W2-35-V3-VALP-S09 Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|---|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to e.g:</p> <ul style="list-style-type: none"> Communication Visualisation system <p>Other systems in the MRTM</p> | <p>The majority of SUPs (83,3%) find that they are able to detect and manage technical failures occurring in one module of the RTC (total loss of the visualization of one aerodrome in an MRTM).</p> <p><i>Note: The POK status of the criteria is due to the fact that only one type of technical failure has been tested, thus the results may not be sufficiently generalizable for all the degraded model events listed in the Success Criterion.</i></p> | POK |

Tailored questions: Specific questions (S4 and S6) have been created to address this success criteria. As Fehler! Verweisquelle konnte nicht gefunden werden. presents, in case of both questions, 83% of

the participating ATCOs stated that they are able to execute the questioned task with the system, while the others stated “not applicable” in case of S4, and “partially” in case of S6.

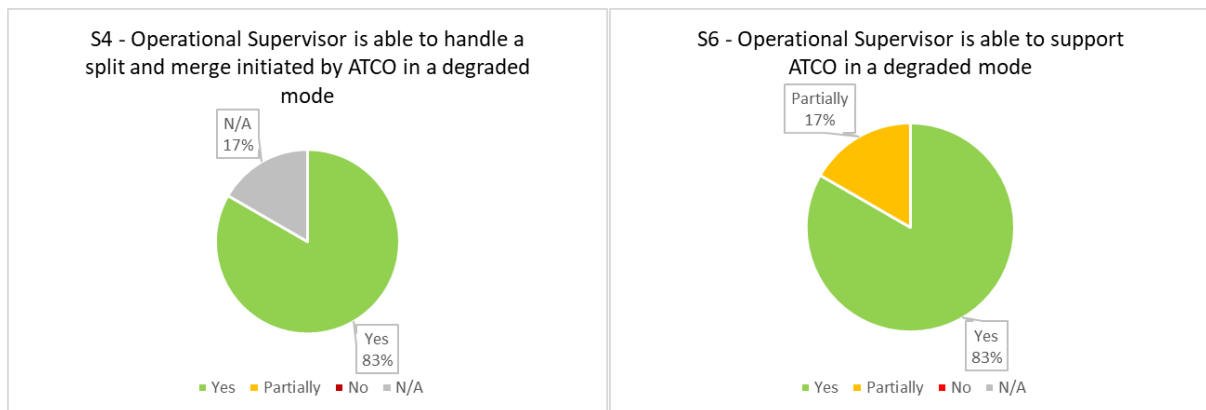


Figure: Feedback on supervisor’s ability to detect and manage technical failures occurring in one module of the RTC

C.12.4.6.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results

| OBJ-PJ05-W2-35-V3-VALP-S10 Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | The majority of SUPs find that they are able to foresee traffic with supervisor planning tool to safely manage RTC operations | OK |

Tailored questions: Specific questions (S1 and S2) have been created to address this success criteria. As **Fehler! Verweisquelle konnte nicht gefunden werden.** presents, in case of question S1, 100% of the participating SUPs stated that they are able to execute the questioned task with the system, and in case of question S2, 83% of the participating SUPs stated that they are able to execute the questioned task with the system, while the others stated “partially”. Comments concerning these questions are the following:

- S1 – System predicted peaks needed further investigation as these were not precise enough
- S2 – Only to initiate and supervise the split/merge

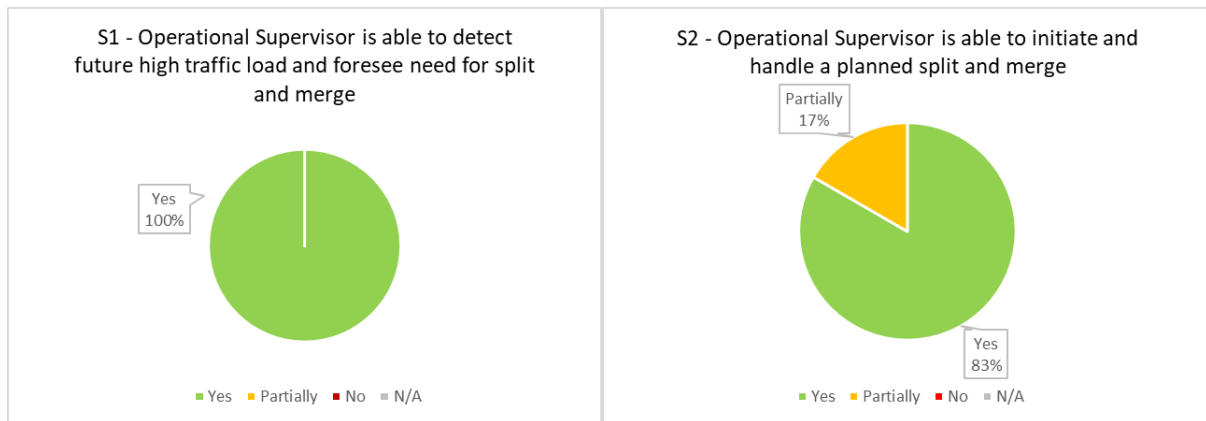


Figure: Feedback on supervisor's ability to foresee traffic with supervisor planning tool to safely manage RTC operations

Debriefing: This topic has been touched upon during the debriefing sessions. According to SUP feedback, the SUP tool supports prediction, but it is not accurate enough, the added value in complex traffic is lower. As it was mentioned earlier, the second ATCO group used a slightly upgraded SUP planning tool, so the feedback of the two ATCO groups are slightly different accordingly.

Findings of CRT-PJ05-W2-35-V3-VALP-H12.010 support these statements.

C.12.5 Unexpected Behaviours/Results

The only inconvenience during the simulation was a technical shortcoming where the Voice Communication System did not get transferred to the other MRTM together with the other system elements (e.g. radar, strip bays, video panorama). The technical staff assisted the ATCOs during the split&merge to minimize the inconvenience. In addition, there was an unplanned total loss of the whole videowall in Scenario 4, when the ATCO (MRTM1) provided air traffic control for two aerodromes (Bodø and Røst). Visual presentation for Bodø came back after a few seconds, while in case of Røst, it took approximately 15 seconds. MRTM2 prepared for taking over Røst, but finally it was not necessary.

Nevertheless, the validation set-up and experimental procedure were adequate for the validations, because all relevant functionalities were assessable. In conclusion, the exercise has fulfilled its purpose and highly contributed to the identification of areas of further improvement of the concept.

C.12.6 Confidence in Results of Validation Exercise

C.12.6.1 Level of significance/limitations of Validation Exercise Results

The order of scenarios was counter-balanced, with the exception of SCN 4 and 3 (emergency and technical malfunction) always being the last ones. This was chosen because SCN 4 and SCN3 were assumed to be more challenging than the other scenarios and ATCOs' experience with the MRT concept and system should be at a high level in order to apply the necessary procedures.

Operational procedures for the simulation were at a similar level than in PJ05-02: coordination with approach was implemented, but communication means with the airport management were limited to the ground frequency. Importantly, the ground frequencies were coupled across the aerodromes, which was against the HP requirement defined for PJ05-02¹. This deviation was intentional: this Garex VCS did not yet take into account the HP design REQ² defined at the end of PJ05-02, i.e. if ATCOs wanted to transmit to individual aerodromes, it would have required a lot of clicks. In PJ05-02 a different type of VCS HMI was validated which showed only three buttons, mapped to the respective aerodromes. That intuitive design could not be replicated here on short notice, so we used only one button on the handheld mic to talk on the coupled ground frequency. This is a definite limitation, however, it does not pose any risks on the interpretation of the results.

The simulator was placed in a relatively small room, thus the Supervisor was sitting quite close to the two MRTMs. Thus some of the SUPs were inclined to leave their position and stand behind the ATCOs

¹ REQ-05.00-SPRINTEROP-CO03.0006: The ATCO shall, for the surface movement control service (communications for the control of vehicles other than aircraft on manoeuvring areas at controlled aerodromes), be able to transmit to individual aerodromes.

² REQ.05.00_HPdesign_10: The ground frequency push buttons have to be integrated in the CWP in a way that they are easily distinguishable between airports (e.g if airports are represented side by side the push buttons shall be respectively located on each side).

or circle in the room. The SUP responsibilities required in the different settings could vary as explained in CRT-PJ05-W2-35-V3-VALP-H10.010. Thus due to this validation setting, the results are representative to smaller RTCs, as described in the PJ05-35 Validation Plan, section 3.1 Validation Plan context³.

C.12.6.2 Quality of Validation Exercises Results

The results are based on ATCOs' subjective opinions and have been collected by means of questionnaires and documented debriefings. Data collection and analysis were adequately monitored and are considered to be of good quality. Questionnaires were filled in by the participants on laptops following each validation run and the completeness of the answers was checked and assured by the system. The timing of questionnaires and debrief sessions were appropriately planned and carried out capturing the recollections of the ATCOs'.

C.12.6.3 Significance of Validation Exercises Results

The operational significance of the validation exercise results can be considered acceptable since the operational environment was appropriate for V3 level and was accepted as such by the ATCOs'. On the ATCO's side the only shortcoming was the system behaviour during aerodrome switch. From the SUP point of view, the timeline should be more precise. Other than those, the validation was of high quality. The mixture of the ATCOs' experience (from different airports, both civilian and military, 5 with single remote tower experience) increases the significance of the results through the different perspectives on multiple remote tower operations. One thing of note however, most of the participating ATCOs have background in providing ATS at Budapest (and working for two runways simultaneously), thus their performance and opinions may differ from those who have experience with a small aerodrome (e.g. Avinor exercise).

C.12.7 Conclusions

A.1.1.1. Conclusions on concept clarification

The Real Time Simulation addressed a setup with two measured MRTMs, each providing the capability to allocate 3 aerodromes at a time within each MRTM. The validations are focusing on evaluation of human performance and safety aspects. There were 4 aerodromes in the simulation, which were flexibly allocated to the MRTMs based on SUP decision (or on ATCO request), supported by the SUP Planning tool. Each MRTM had a slightly different aerodrome configuration in each run, and it was quite frequent that SUPs swapped aerodromes between the MRTMs in order to keep the 2:2 aerodrome distribution.

The SUP had the responsibility to decide when to split based on the information he gathered from the SUP Planning tool, but the exact timing of the split was defined by the ATCO taking into consideration

³ Validation Plan, section 3.1: "Solution PJ.05.35 will address the concept of 4 different aerodromes handled within an RTC, with up to 3 aerodromes per MRTM. Exercises addressing this aspect will use a minimum of 2 MRTMs to distribute 4 aerodromes to a limit of 3 in one MRTM."

the traffic and other relevant circumstances. The SUP always carefully analysed the situation and monitored the outcome of the split. ATCOs coordinated the split between themselves, although sometimes the SUP jumped in to help them. This may not be feasible in a bigger-sized RTC, where there is a bigger distance between the SUP CWP and the MRTMs.

Based on the results, ATCOs had no issues with the flexible allocation as a concept- they did not mind that one aerodrome could take different positions on the Visual Panorama, although they did not use it frequently between splits/merges. Naturally, ATCOs needed a few seconds to build up situational awareness for the new aerodrome and manage the coordination. The only thing that has impacted SA rather negatively was the head-down display behaviour when moving around the aerodromes (see next section).

A.1.1.1. Conclusions on technical feasibility

Many of the technical features needed for the assessment were available in the simulation environment and in the passive shadow mode to draw a conclusion on technical feasibility.

The SUP Planning tool proved to be very useful and therefore feasible for this and future validation exercises, with minor revisions.

On the ATCO's side however, the HMI's radar map layout and the EFS bay changed to accommodate the split and merge, but the MET window remained at the same position which led to confusion. The same happened even if the ATCOs just wanted to switch the places within the MRTM, without any split. Thus a user-friendly flexible allocation was not supported by the system, and ATCOs were hesitant to move around the aerodromes within the MRTM in the fear of temporarily losing their situational awareness.

A.1.1.1. Conclusions on performance assessments

Conclusions related to Human Performance, Safety, Capacity and Cost Efficiency are described in detail in section **Fehler! Verweisquelle konnte nicht gefunden werden.** and **Fehler! Verweisquelle konnte nicht gefunden werden..**

C.12.8 Recommendations

Concept-related:

- For the SUP position, the roles should be clearly defined because different interaction would be expected from a big center SUP and from a 2-3 airport multi remote tower center SUP.
- Split should happen in a lower traffic period, when the ATCOs have spare capacity for the handover process and to build up the situational awareness.
 - The Supervisor should induce the split as s/he is the one who has the overview of the predicted traffic load.
 - It should be the ATCOs' responsibility to manage the handover between themselves, thus they timing of the split should be coordinated between SUP and ATCOs (i.e. receiving one).
 - Handover checklist should be created and applied.

- In case of an emergency, the other aerodrome(s) should be given away to make sure that the ATCO can fully focus on the non-nominal situation. It is better to split as soon as possible, and not to wait for additional information on the emergency to predict the expected workload, because such a situation can quickly escalate, which would make split process more challenging.

System-related:

ATCO InNOVA:

- The system behaviour should be user friendly during an aerodrome switch (i.e. between and within MRTM).
 - The MET window should be linked to the EFS bay i.e. it should move together with the EFS and radar map during an aerodrome change.
 - Presets could be defined for the aerodrome radar maps, and also individual ATCO presets could be created. This could reduce the time to re-arrange the HMI elements and would also mitigate the risk that the new setup will cover important information on the radar map. Individual ATCO presets provide a quickly available, familiar layout for the ATCOs in every aerodrome configuration.
- The look-only function was extremely useful and should be part of the system configuration.
- Wind information should be integrated into the top bar (i.e. next to the airport name).
- Squelch indication and coloured frames would be useful to easily distinguish where the call is coming from.
- The ground bay should not contain aircraft that just received their ATC Clearance.
- The runway closure should require less clicks.

SUP system:

- SUP position should have a quick access for a „view only” radar+visual+voice function of any airport. In an emergency situation there would be no time to walk to the MRTM position (also leaving the others without SUP is not an option) so there should be a way for the SUP to get as much information as possible about the situation without putting extra workload on the ATCO
- The timeline should be more precise, by marking the real simultaneous traffic based on updates from actual data. The predicted duration of the overload periods should also be more transparent.

Visual panorama:

- The following information should be on the video wall:
 - MET data (wind is essential, RVR would also be good in LVP)
 - PTZ (for zooming)
 - Cardinal directions (i.e. north, south, east, west)
- ATCOs should be able to move aerodromes also to the C-slot (upper right side), even if there are only two aerodromes.

Communication:

ATCOs should be able to transmit to individual aerodromes (G/G comm) in an intuitive and efficient manner. This could be achieved by having the ground frequency push buttons integrated in the CWP in a way that they are easily distinguishable between airports (e.g if airports are represented side by side the push buttons shall be respectively located on each side).

Appendix D Validation Exercise EXE-2.4-ENAV Report

D.1 Summary of the Validation Exercise EXE-05-W2-35-V3-2.4-ENAV Plan

D.1.1 Validation Exercise description, scope

The validation exercise focuses on providing remotely Air Traffic Services from an RTC with the dynamic allocation of up to 3 small environment airports between two MRTMs and contribute to the OI Step SDM-0210 'Highly Flexible Allocation of Aerodromes to Remote Tower Modules'.

A single ATCO per each Module covers the roles of Clearance Delivery, Ground Controller and Tower Runway Controller simultaneously.

AN RTC Supervisor dynamically allocates the airports between MRTMs, supported by a planning tool.

Human Performance, Safety and Cost Efficiency analysis is conducted to evaluate the ATCOs ability to provide simultaneous ATS in a safe and efficient manner.

The ENAV RTC Test Bed located at ENAV Training Centre in Forlì, integrating IDS AIRNAV and TECHNO SKY systems is used to perform a Real Time Simulation in airport operational environment.

D.1.2 Summary of Validation Exercise EXE-05-W2-35-V3-2.4-ENAV Validation Objectives and success criteria

The following table provides the Exercise Validation Objectives/ Success Criteria and the planned coverage of Solution Validation Objectives/Success Criteria.

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|---|---|--------------------------------|---|----------|-------------------------------|---------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP- | Majority of SUPs state that they can prioritise tasks | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|---|--------------------------------|--|----------|-------------------------------|---------------------------|
| | | H01.020 | | | | |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|---|---|--------------------------------|--|---|-------------------------------|---|
| | | | aerodromes between MRTMs | | | |
| HUMAN PERFORMANCE – WORKLOAD | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an | Partial (simulated case only for abnormal and degraded modes) | As solution | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal conditions, in |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|--|--------------------------------|--|---|-------------------------------|--|
| | | | RTC with a flexible allocation of aerodromes between MRTMs | | | case of aircraft emergency and in case of failure of the communication or visualization system when working in an RTC with a flexible allocation of aerodromes between MRTMs |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCOs acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS to the assigned number of aerodromes | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3- | Assess usage of the ATCO phraseology when providing ATS | CRT-PJ05-W2-35-V3- | The phraseology is acceptable for the ATCO in normal and abnormal operating | Partial (simulated case only for abnormal | As solution | The phraseology is acceptable for the ATCO in normal |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|--|--------------------------------|--|---|-------------------------------|--|
| VALP-H08 | to multiple aerodromes | VALP-H08.010 | conditions and degraded modes | and degraded modes) | | operating conditions, in case of aircraft emergency and in case of failure of the communication or visualization system |
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | Partial (simulated case only for abnormal and degraded modes) | As solution | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal operating conditions, in case of aircraft emergency and in case of failure of the system when working in an RTC with a flexible allocation of aerodromes between MRTMs |
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|---|---|--------------------------------|---|----------|-------------------------------|---------------------------|
| | ATS to multiple aerodromes | | clear, consistent, stable and acceptable. | | | |
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Full | As solution | As solution |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|--|----------------------|--------------------------------|---|-------------------------------|-------------------------------|---|
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | Partial (simulated case only) | As solution | Majority of ATCOs confirm adequate usability of alarms for emergency situation |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | Full | As Solution | As Solution |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | Partial | As solution | ATCOs confirm the adequacy of the usability and utility of flight list traffic forecast and prioritisation function integrated in the EFPS system for the next action to be performed |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP- | Majority of ATCOs confirm there is no confusion about which aerodrome are transferred between the MRTMs. | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|---|--------------------------------|--|-------------------------------|-------------------------------|---|
| | | H11.080 | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts | Partial (simulated case only) | | Majority of Supervisors confirm adequate usability and utility of alarms and alerts for the SUP planning tool and emergency situation |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|---|--------------------------------|--|-------------------------------|-------------------------------|--|
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | Full | As solution | As solution |
| HUMAN PERFORMANCE – TRUST | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | Partial | As solution | ATCOs trust the functionality of the automated task prioritisation for the next action to be performed integrated in the EFPS system |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | Partial (simulated case only) | As solution | ATCOs trust in reliability of alarms and alerts for emergency situations |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|---|--------------------------------|--|----------|-------------------------------|---------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Full | As solution | As solution |
| SAFETY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between | CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none">In the vicinity of the aerodromeIn the runway areaOn the manoeuvring area | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|--|--------------------------------|--|-------------------------------|-------------------------------|---|
| | MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | Full | As solution | As solution |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | Full | As solution | As solution |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | Partial (simulated case only) | As solution | ATCO is able to identify and manage abnormal situations of Aircraft emergency |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible | CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting (e.g.): <ul style="list-style-type: none"> • Communication • Visualisation system | Partial (simulated case only) | As solution | ATCO is able to detect and recover from a technical failure in the MRTM affecting Communication or Visualisation system |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|---|--------------------------------|--|-------------------------------|-------------------------------|--|
| | allocation of aerodromes between MRTMs | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S08.010 | <p>Supervisor is able to support an ATCO in abnormal situations(e.g):</p> <ul style="list-style-type: none"> • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport • ATCO overload in one or more MRTM of the RTC | Partial (simulated case only) | As solution | Supervisor is able to support an ATCO in abnormal situations of emergency flight |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S09.010 | <p>Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to(e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other systems in the MRTM | Partial (simulated case only) | As solution | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to Communication or Visualisation system |
| OBJ-PJ05-W2- | Assess Supervisor capability to | CRT-PJ05-W2-35- | SUP is able to foresee traffic with supervisor planning tool to safely | Full | As solution | As solution |

| | Validation Objective | Criteria ID | Validation Criteria | Coverage | Exercise Validation Objective | Exercise Success criteria |
|----------------------------|--|--------------------------------|--|----------|-------------------------------|--|
| 35-V3-VALP-S10 | support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | V3-VALP-S10.010 | manage RTC operations | | | |
| COST EFFICIENCY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | Full | As solution | ATCO can provide ATS to 3 aerodromes at a time in an RTC of 3 aerodromes |

Table 28: Validation Objectives addressed in Validation EXE-05-W2-35-V3-2.4-ENAV

D.1.3 Summary of Validation Exercise EXE-05-W2-35-V3-2.4-ENAV Validation scenarios

The validation scenarios are consistent with the use cases described in the SPR-INTEROP/OSED and related to the sub-operating environment 'Small Airports' as categorized in the SESAR 2020 Classification Schema, that means airports with IFR annual movements between 15.000 and 40.000.

Detailed information describing reference and solution scenarios (nominal and non-nominal) is reported in the following sections.

A.4.1.13 Reference Scenario(s)

In current day operations, provision of simultaneous remote ATS to multiple airports by one ATCO is not yet deployed in real operational environment. Nevertheless, the previous work done in SESAR 2020 Wave1 dedicated to Multiple Remote Tower, has delivered results determining Solution PJ05-02 validated at V3 maturity level in W1 as a reference for Solution 35 regarding Multiple Remote Tower Modules.

In line with that, the reference scenarios are mainly based on MRTMs with a fixed allocation of the airports, that allows the ATCO to maintain situational awareness for 2 small airports (corresponding to the PJ.20 Operating environment description for 'Small Environment Airport') simultaneously, with up

to 20 movements/hour total of all airports and 4 to 6 simultaneous movements, including mix of IFR, VFR and vehicles.

The RTC Supervisor role and the related support tool are not considered in the reference scenario.

Taking into account the scope of the validation exercise, airports information and traffic information are shown in the following table and charts.

| | Airport A | Airport B | Airport C |
|--|------------------------------|----------------------|----------------------------|
| Airport name (AIP) | Brindisi/Casale (LIBR) | Lamezia Terme (LICA) | Treviso/Sant'Angelo (LIPH) |
| RWY designators and length | 13/31 3048 m 05/23 1793 m | 10/28 3017 m | 7/25 2420 m |
| Number of taxiways | 18 | 9 | 2 |
| Airspace classification | D | D | D |
| IFR movements per year (2019) actual figures | 19937 | 22179 | 21689 |

Table 29 ENAV Aerodrome description



Figure 12 - RTC and aerodromes location

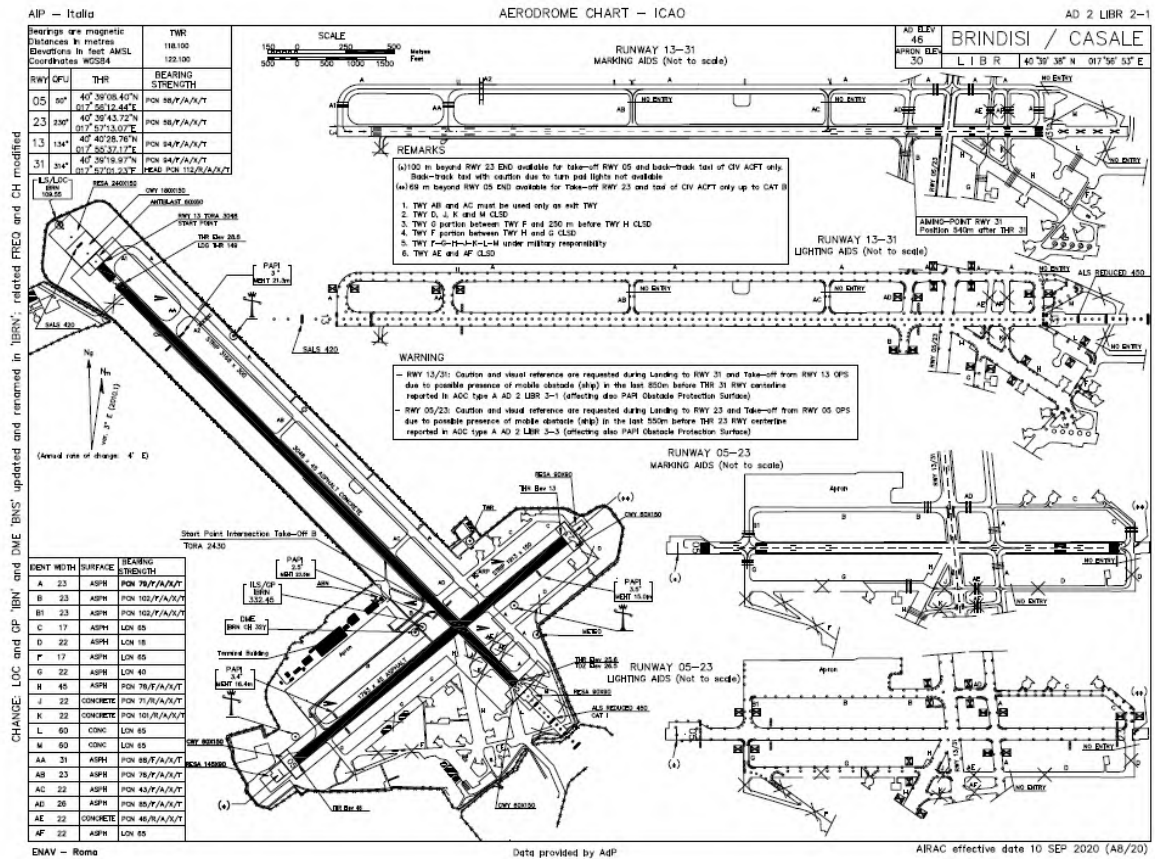


Figure 13 - Brindisi/Casale aerodrome chart

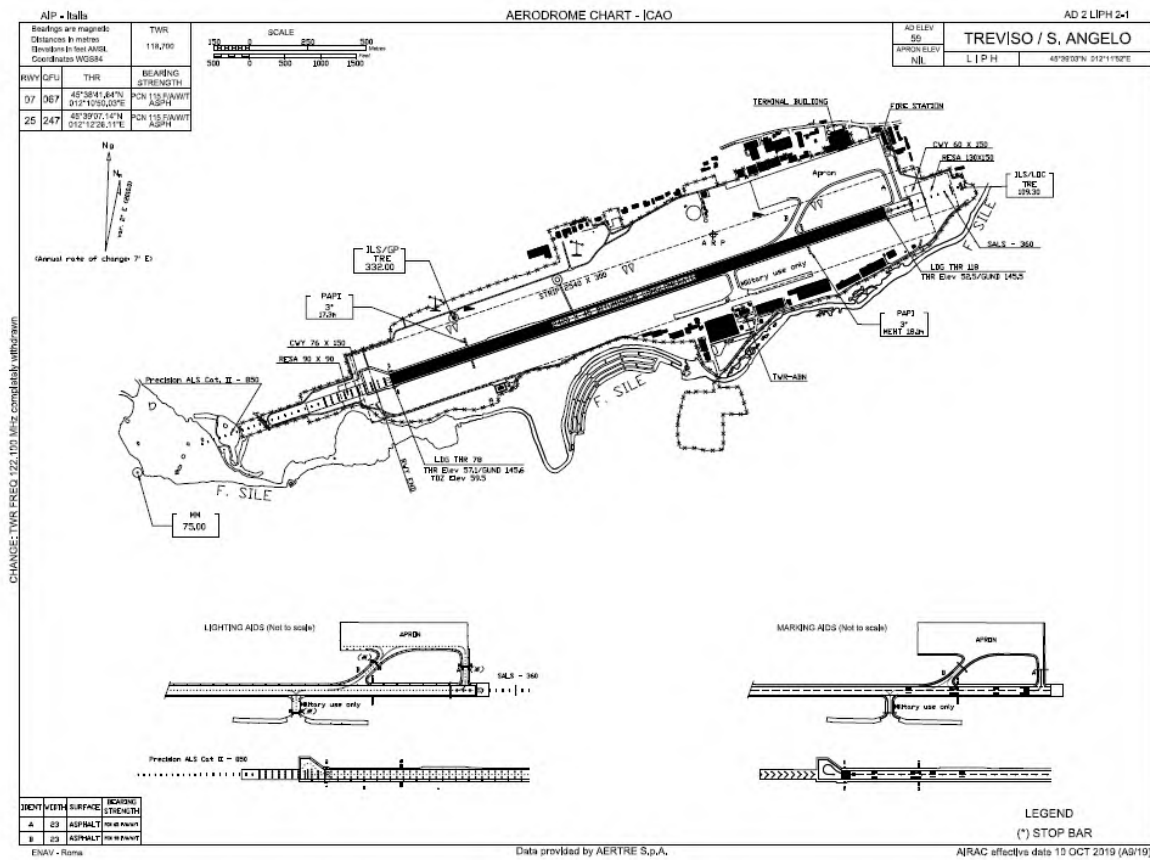


Figure 14 - Treviso/Sant'Angelo aerodrome chart

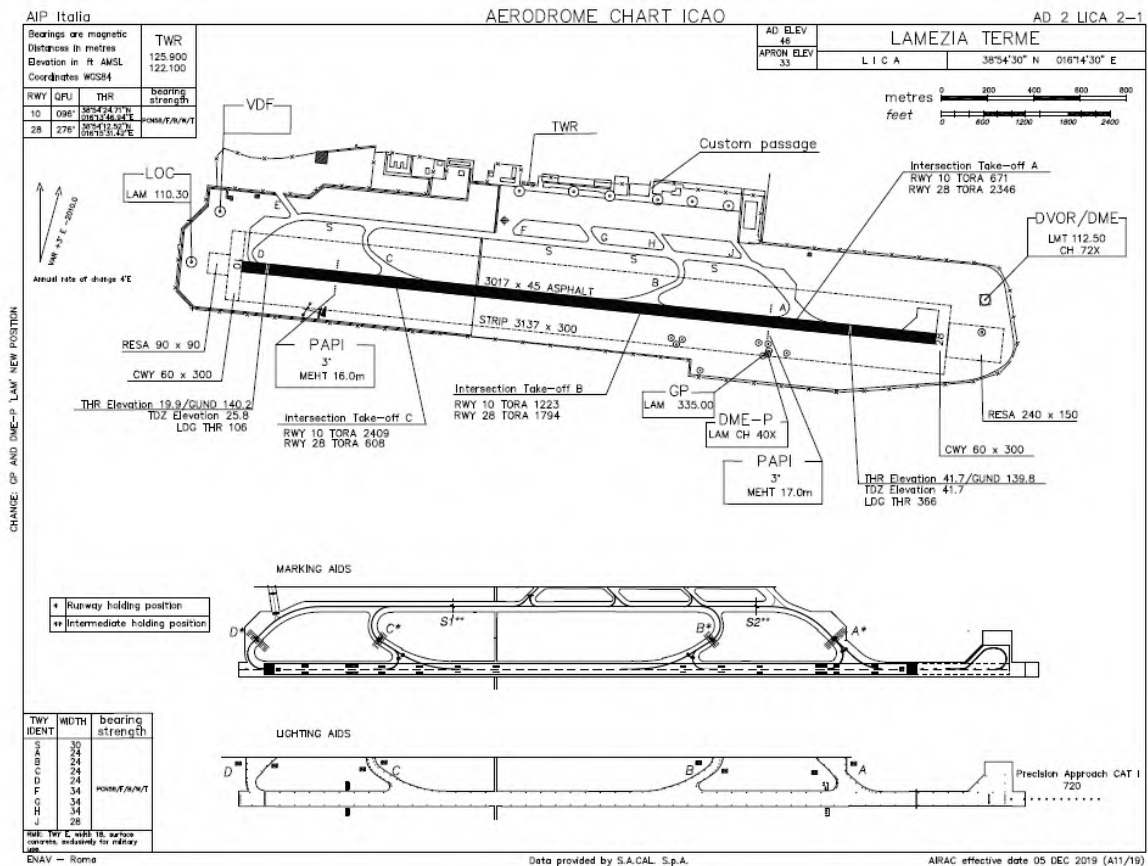


Figure 15 - Lamezia Terme aerodrome chart

Reference scenario is used to compare the solution scenarios results. More than one reference scenario was run in order to get a consistent comparison of the several solution scenarios with different experimental conditions. A table with more detailed information is reported in the following section.

A.4.1.14 Solution Scenario(s)

The main characteristics of the solution scenarios are mainly based on:

- 3 small environment airports allocated to the RTC:
 - Brindisi (LIBR), Lamezia Terme (LICA), Treviso (LIPH)
- RTC with 2 MRTMs (a single ATCO per each Module)
- Traffic volume with max 30 movements/hour and up to 6 simultaneous movements (IFR + VFR + vehicles), total of all aerodromes
- AN RTC Supervisor position with another ATCO designated to cover the Supervisor role supported by a planning tool for dynamic allocation of the airports.
- Dynamic allocation of 3 airports between two MRTMs

- each module with the capability to allocate and to manage up to 3 airports simultaneously
- some scenarios was run with up to 3 airports allocated to one module (at a certain time, 1 module with 3 airports allocated and 1 module with no airports)

Airports and traffic information are the same as the reference scenario and are reported in the previous section.

A.4.1.15 Validation scenarios parameters

The following table reports an overview of some experimental conditions, in line with the parameters characteristics reported in the section 4.4.2 to be covered by the exercises. Some conditions are still under definition and not included in the table.

| SCN | Operational modes | Traffic distribution per AD | Traffic complexity | Time of day | Visibility conditions | Transfer (split/merge) | Air Surveillance | Note |
|------|------------------------|--|-----------------------------------|-------------|-------------------------------|------------------------|-----------------------------------|---|
| REF1 | Nominal | two aerodromes with majority of traffic | Mainly IFR traffic (>75%) | Daytime | Low visibility for LIPH (fog) | NO | Yes for LICA, LIPH No for LIBR | |
| REF2 | Nominal | one aerodrome with majority of traffic) | Mainly VFR traffic (>75%) | Daytime | | NO | Yes for LICA, LIPH No for LIBR | |
| REF3 | Nominal | two aerodromes with majority of traffic | VFR 45% IFR 45% Vehicles10% | Daytime | | NO | Yes for LICA, LIPH No for LIBR | |
| SOL1 | Nominal | two aerodromes with majority of traffic | Mainly IFR traffic (>75%) | Daytime | Low visibility for LIPH (fog) | YES | Yes for LICA, LIPH No for LIBR | |
| SOL2 | Nominal | one AD with majority of traffic | Mainly VFR traffic (>75%) | Daytime | | YES | Yes for LICA, LIPH No for LIBR | |
| SOL3 | Nominal | two aerodromes with majority of traffic | VFR 45% IFR 45% Vehicles10% | Daytime | | YES | Yes for LICA, LIPH No for LIBR | |
| SOL4 | Abnormal/ Emergency | two aerodromes with majority of traffic | Mainly IFR traffic (>75%) | Daytime | | YES | Yes for LICA, LIPH No for LIBR | Aircraft declaring emergency on Treviso Airport |

| | | | | | | | | |
|------|----------------------|--|---------------------------------|---------|--|-----|--|--|
| SOL5 | Degraded/ Failure | two aerodromes with majority of traffic | Mainly IFR traffic (>75%) | Daytime | | YES | Yes for LICA, LIPH No for LIBR | M2 OTW Failure |
| SOL6 | Degraded/ Failure | two aerodromes with majority of traffic | Mainly IFR traffic (>75%) | Daytime | Low visibility for LIPH (fog) | YES | Yes for LICA, LIPH No for LIBR | M1 and M2 OTW Failure recovered after few minutes but with 1 screen lost on M1 |

Table 30 - Scenarios parameters overview

D.1.4 Summary of Validation Exercise EXE-05-W2-35-V3-2.4-ENAV Validation Assumptions

| Identifier | Title | Description | Justification | Impact on Assessment |
|---------------------------|---------------------------|---|---|----------------------|
| ASM-PJ05-W2-35-EXE2.4-001 | ATCO endorsements | ATCOs are endorsed for all the (single) aerodromes allocated to the RTC | In order to cover the exercise scope and properly validate the concept, it is assumed that the involved ATCOs can hold endorsements for all the different airports within the RTC | High |
| ASM-PJ05-W2-35-EXE2.4-002 | Training and competencies | All Controllers have appropriate training and competencies. | In order to properly validate the concept it is important that the controllers are familiar with the operating environment and all the tools/functionalities. | High |

| | | | | |
|---------------------------|----------------------------------|--|---|--------|
| ASM-PJ05-W2-35-EXE2.4-003 | Technical management/supervision | APT and TWR Systems supervision entrusted to technical staff | Technical supervision of all the system within the RTC is needed and it is considered worthwhile the entrusting to designated technical personnel | Medium |
|---------------------------|----------------------------------|--|---|--------|

Table 31: Validation Assumptions overview

D.2 Deviation from the planned activities

An additional Degraded / Failure mode scenario was added to the experimental plan: SOL6.

D.3 Validation Exercise EXE-05-W2-35-V3-2.4-ENAV Results

Context of the Assessment and Methodology

The simulation exercise took place from the 4th of April to the 15th of April with 3 simulation days dedicated to train the test subjects and 7 days dedicated to the execution of the simulation scenarios.

Furtherly, 2 preparatory days aimed at testing from operational point of view the platforms and the simulating environment took place on the 24th and 25th of March 2022.

Five test subjects were involved in the exercise with different roles, experience and background in order to expose the concept to a wide range of ATCOs' representatives:

- 2 ATCOs, who in their operational life fulfil the role of TMA/ACC supervisors , were employed as RTC supervisors in the simulation;
- 3 ATCOs, who in their operational life fulfil the role of responsible of airport rostering and training, were employed as MRTM ATCO in the simulation. They currently work on different airport environments encompassing big size airport with multiple runways and regional airports so that different points of view could be collected.

The ATCOs' age is between 36 and 57 with a working experience between 11 and 38 years.

The following figure gives an idea of the agenda organization:

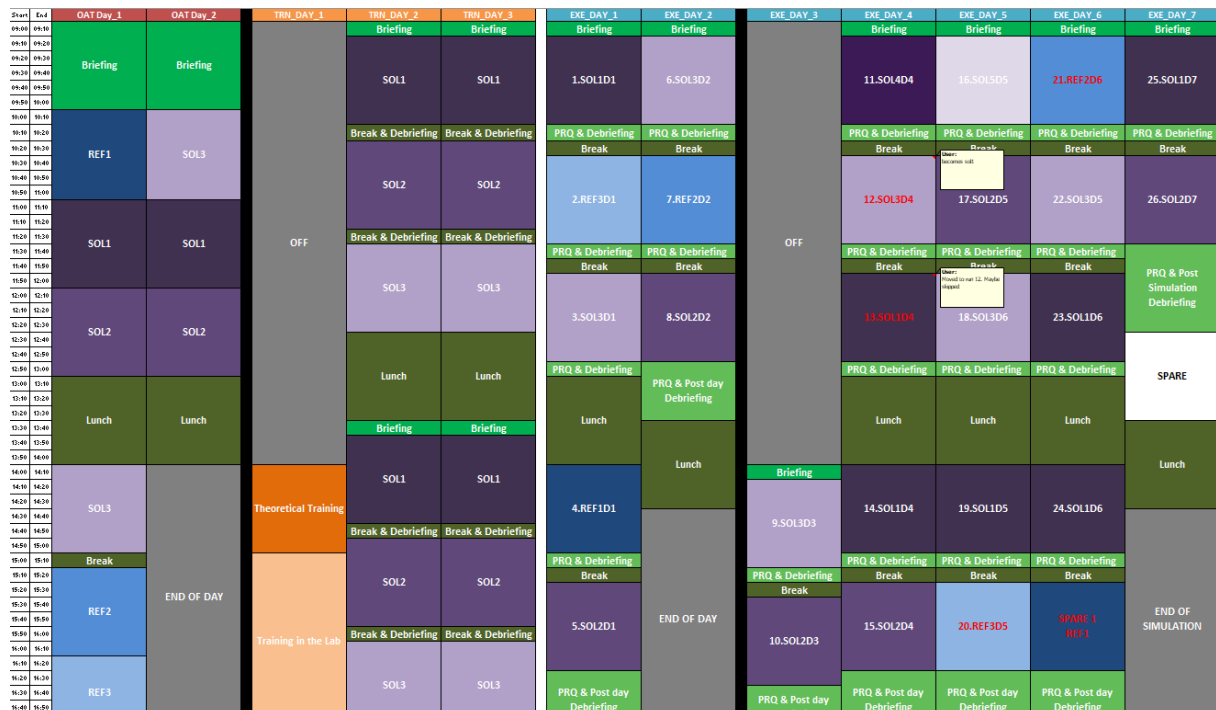


Figure: Simulation Organization

The first day of training was dedicated to the familiarization with the concept under assessment and the platforms. The other 2 training days were dedicated to train the ATCOs on the specific solution scenarios to mitigate the effect of lack of familiarities with the experimental environment and the test airports.

A total number of 25 runs were executed during the 7 simulation days. The aim was to collect data for reference scenarios, for solution scenarios and abnormal and degraded mode scenarios in order to support a comparative assessment between the different scenarios. As the experimental conditions foresaw 3 main variables in terms of traffic conditions, as explained in section A.1.3, the experimental plan has been organised in order to perform at least 1 reference scenario for each traffic conditions, a certain number of solution scenarios keeping the same traffic conditions and 3 solution scenarios dedicated to abnormal and degraded mode of operations.

For each solution and reference scenario 2 RTM ATCOs were employed; while for the solution scenario 1 RTC SUP was also employed, for the reference scenario no RTC SUP was involved being the reference scenario an RTC without flexible allocation. So, the agenda was organised such that the ATCOs and SUP roster foresaw a maximum of 2 consecutive working hours happening for each ATCOs/SUP to give at least 1 hour of relief during the simulation days at each ATCO. Also, to avoid a learning effect, the reference and solution scenarios were balanced among all the 7 simulation days, giving more slots dedicated to test the new solution to expose the ATCOs and SUPs as much as possible to the new concept.

The ATCOs rotated among the 2 modules to experiment both the RT module positions, even if the allocation of airports was flexible and established by the SUP during the solution scenarios according to his judgement of the expected workload for the 2 modules, supported in this task by the supervisor planning tool.

During the simulation days it was judged useful to also experiment 2 “default” views for the OTW, standing for both OTW settings the opportunity to always rotate the visual presentation on the available 360° of the entire panorama:

- 120° ;
- 180° .

At the beginning, the 120° view was chosen for its low compression on the monitors, but it required more interactions with PTZ to see the entire RWY of the displayed airports;°) the 180° view, on the other hand, allowed the entire RWY to be seen on the monitors, so requiring less interactions with PTZ. In both cases, a 360° panoramic view was enabled by a dedicated control panel.

Measures have been employed during the RTS to assess the success criteria and prove the validation objectives. In respect with these criteria, the analysis provided a response about the observed differences between the reference and the solution scenarios.

The RTS HP and Safety analysis process is organised in the following different steps:

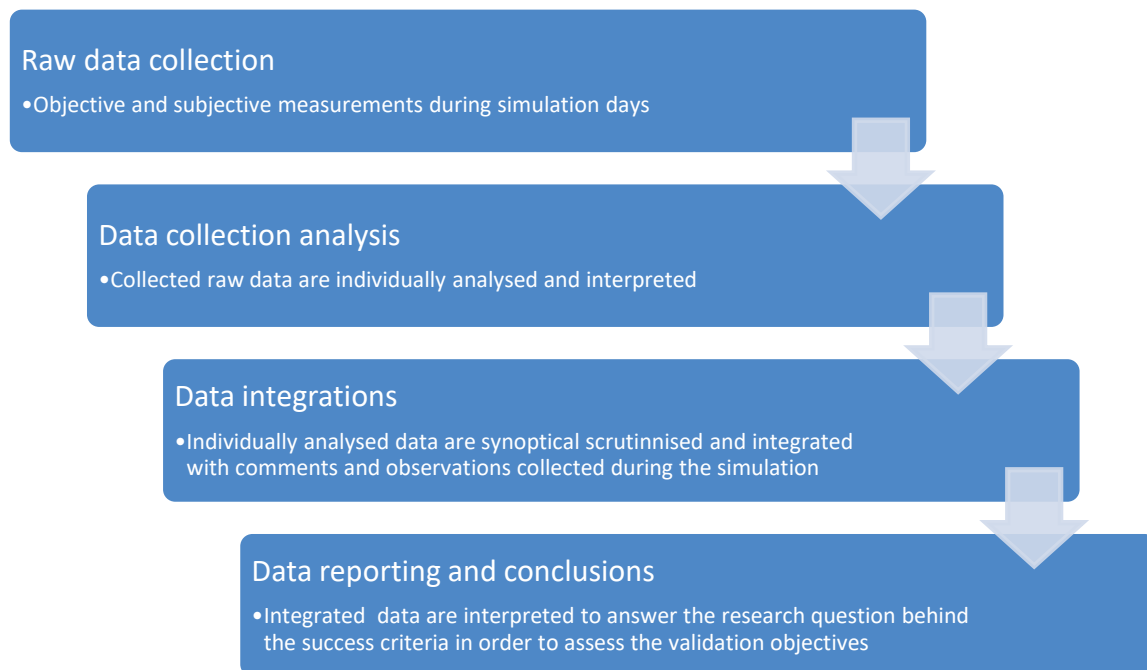


Figure: RTS HP and Safety analysis process

Raw data collection has been performed during the simulation execution through questionnaires, debriefings, interviews, observations and system data recordings as summarised below:



Figure: Data collection methods

Post run questionnaire was provided to the involved ATCOs at the end each run to in order to collect subjective HP and SAF data in relation to the specific run; a post run debriefing and interview was then conducted to collect run specific comments and to clarify possible observed points by HP and SAF experts. Post simulation questionnaire and final debriefing were finally conducted to collect overall view of involved test subjects about on the concept under assessment.

As already mentioned, supervisors were not involved in the reference scenario, so when the results are presented in next sections no reference data will be presented.

Data collected through questionnaires, observations, debriefing and system data recordings have then been categorised per scenarios and position calculating the mean value and standard deviation for them.

Finally, data have been aggregated in order to compare answers provided for different experimented scenarios and among simulated position to achieve the following comparative assessment (the table provides also the number of run for each experimental condition):

| Number of Reference Scenario runs | Number of relevant solution scenarios runs | Comment |
|-----------------------------------|--|--|
| 1 REF 1 with 120° OTW | 1 SOL 1 with 120° OTW | Due to time constraint, it was not possible to achieve 3 SOL 1 at 120° and priority was given to the other 2 scenarios as more critical in terms of experimental conditions (Traffic Sample). Also, Abnormal and Failure mode scenarios were run on SOL1 experimental conditions with the only change of no Fog on Treviso airport |
| 1 REF 1 with 180° OTW | 3 SOL 1 with 180° OTW | |
| 1 REF 2 with 120° OTW | 3 SOL 2 with 120° OTW | |
| 1 REF 2 with 180° OTW | 3 SOL 2 with 180° OTW | |
| 1 REF 3 with 120° OTW | 3 SOL 3 with 120° OTW | |
| 1 REF 3 with 180° OTW | 3 SOL 3 with 180° OTW | |
| | 1 SOL 1 with 120° OTW Failure mode | Temporal failure of both modules OTW, Loss of 1 screen on M1 – No Fog on Treviso Airport |
| | 1 SOL 1 with 180° OTW Failure mode | Failure of M2 OTW – No Fog on Treviso Airport |
| | 1 SOL 1 with 180° OTW Abnormal mode | Aircraft Emergency on Treviso airport – No Fog on Treviso Airport |

Table 32 Experimental Plan Comparative Assessment

In order to validate the investigated RTC with flexible allocation of airports between modules, concepts under evaluation in terms of human performance, safety and cost efficiency of the following areas have been investigated. The picture also provides the employed tools to assess the indicators:

| | |
|---|------------------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS • Assess <i>SUP situation awareness</i> when working in a RTC • Assess <i>ATCO situation awareness</i> when providing ATS to multiple aerodromes • Assess <i>team situation awareness</i> when providing ATS to multiple aerodromes | China Lake Customised questions |
| HUMAN PERFORMANCE – WORKLOAD • Assess <i>ATCO workload</i> when providing ATS to multiple aerodromes • Assess <i>Supervisor workload</i> when supporting the provision of ATS to multiple aerodromes | Bedford Customised questions |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES • Assess <i>ATCOs acceptance of operating methods</i> when providing ATS to multiple aerodromes • Assess <i>ATCO acceptance of roles and responsibilities</i> when providing ATS to multiple aerodromes • Assess <i>usage of the ATCO phraseology</i> when providing ATS to multiple aerodromes • Assess <i>Supervisors acceptance of operating methods</i> when supporting provision of ATS to multiple aerodromes • Assess <i>Supervisor acceptance of roles and responsibilities</i> when supporting provision of ATS to multiple aerodromes | CARS Customised questions |
| HUMAN PERFORMANCE – USABILITY and UTILITY • Assess that <i>human-machine interface</i> supports the team in carrying out their tasks • Assess <i>usability and utility of ATCO human machine interface</i> when providing ATS to multiple aerodromes • Assess <i>usability and utility of Supervisor human machine interface</i> when supporting provision of ATS to multiple aerodromes | Customised SUS questions |
| HUMAN PERFORMANCE – TRUST • Assess <i>ATCO trust</i> in support systems when providing ATS to multiple aerodromes • Assess <i>Supervisor trust</i> in support systems when supporting provision of ATS to multiple aerodromes • Early assessment of <i>transition factors</i> in a RTC with a flexible allocation of aerodromes between MRTMs | Customised SATI questions |
| SAFETY • Assess <i>ATCO capability</i> to provide ATC services in a safe manner when working in a RTC with a flexible allocation of aerodromes between MRTMs under all conditions • Assess <i>Supervisor capability</i> to support the ATCO in all conditions when working in a RTC with a flexible allocation of aerodromes between MRTMs | Customised questions |
| CEF • Assess the <i>staff required</i> for providing ATS to multiple aerodromes | Customised questions |

Figure: Scope of the assessment

Objective and subjective data collected during the simulation are the main source of information, which give the initial start to the whole results analysis.

The questionnaires data have been graphically plotted according to the following criteria:

- SUP Post Simulation questionnaire
 - Number of answers respect to the recorded responses levels
- SUP Post Run questionnaire
 - Average value per solution scenario and combined average value for all the solution scenarios, as the employed out of the window views had no effect on the supervisor position, no detailed view have been provided. Also, Supervisors were not employed in the reference scenarios and thus no data have been measured in this case
 - Answers distribution respect to the recorded responses levels
- ATCO Post Simulation questionnaire
 - Number of answers respect to the recorded responses levels
- ATCO Post Run questionnaire
 - Average value per experimental conditions, reference and solution scenarios detailed for each out of the window experimented view;
 - Average value per experimental conditions, reference and solution scenarios
 - Average value per reference and solution scenarios
 - Answers distribution respect to the recorded responses levels per reference and solution scenarios (where applicable as some questions were relevant only for the solution scenarios)

The average values also include the safety related scenarios that will be furtherly assessed in the dedicated safety objectives and criteria. Nevertheless, they were included in the HP analysis considering the HP results of these scenarios are not far from the overall trend and thus they do not affect the HP analysis and provides more robustness to the analysis.

D.3.1 ATCO - Summary of Validation Exercise Results

| Validation Exercise 2.4 Validation Objective ID | Validation Exercise 2.4 Validation Objective Title | Exercise Validation | Validation Exercise 2.4 Success Criterion ID | Validation Exercise 2.4 Success Criterion | Exercise 2.4 Success | Sub-operating environment | Exercise Results | #01 | Validation | Validation Exercise 2.4 Validation Objective Status |
|---|---|-------------------------------|--|--|--------------------------------|---------------------------|--|-----|------------|---|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | | Small airports | Majority of ATCOs rated the situational awareness at an acceptable value. Indeed, the measured situational awareness values are all above the tolerable threshold of 5 points except than for the REF3 scenario where the experimental conditions were testing the ATCO exposure to the management of 3 airports without the support of the supervisor and thus without flexible allocation. Anyhow for the solutions scenarios and for the other references | | | OK |

experimented conditions the SA is rated above 8.

| | | | | |
|--------------------------------|---|----------------|--|----|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | Small airports | the ATCOs were generally able to prioritise tasks except in the case of reference scenario 3 which was characterised by the management of 3 airports on one single module without the support of the supervisor and thus without flexible allocation. The test subjects reported a workload so high during the specific scenario that they were not fully able to give priority to the more critical actions. For all the other experimented conditions and scenarios, the provided results are above the tolerable threshold. | OK |
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | Small airports | Even if the overall trend is in the positive area of the answers, the difference between the tolerable threshold and the mean values is not so distant as the other analysed indicators. | OK |

This is to be seen mainly in relation to the employed HMI as all the test subjects suggested improvements, especially in the position of the emergency button and the handover transfer that were located in the border of the head-down display while the ATCOs would have preferred them integrated in the strip bay area. These results are to be interpreted as recommendations for the simulating environment rather than the concept itself and what can be generalised for the concepts is that before the deployment the HMI of the technical system shall be locally assessed and designed in relation to the specific operational environment.

Another possible issue was in relation to the fix position of the airports in the out of the window view and CWP head down display. While in the previous phase of the project it was recommended to keep

fix position for the airports to help the situation awareness, the collected feedback was that the fix position had an opposite effect, especially when the transferred airport was a third airport in the middle fix position: during the transfer allocating the airport in the middle caused a temporary disorientation of the ATCOs that required a few times to recap the exact position of the airports. Despite the suggested improvements, the criteria is judged as met, considering the most of responses provided is on the level six for the solution scenario.

| | | | | | | |
|----------------------------|---|--------------------------------|--|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | The most of the responses are in the tolerable area of the graphs (4 points and above) nevertheless, especially from the supervisor point of view, there might be technical development that could further enhance the team situational awareness. | OK |
|----------------------------|---|--------------------------------|--|----------------|--|----|



Above all the Supervisor tool need to be based on live data which was not the case in the simulation environment due to technical constraints that could not be overcome for time and resources reasons.

Other improvements that were discussed to help the shared situational awareness were in relation to possible technology improvements providing actual Module's information replication. Of course, a local dedicated assessment to consider the benchmark between ergonomics and situational awareness benefits as the supervisors also recommended to avoid to add too many displays in their position.

Other suggested improvements were in relation to the practices and operating procedure already exposed in the previous bullet point.

HUMAN PERFORMANCE – WORKLOAD

| | | | | | | | |
|----------------------------|---|-----------|--------------------------------|--|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess workload when providing ATS to multiple aerodromes | ATCO when | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | Different components of workload were assessed in addition to the overall perceived cognitive workload as it was considered necessary also to assess the planning load, the monitoring load and the coordination load to verify if there was any dimension of the workload that was more demanding and required specific mitigations. The perceived cognitive workload was always at acceptable level, except for the reference scenario in the experimental conditions 3 where the airports were all allocated on one single module without the flexible allocation and support of the supervisor positions. Looking at the overall trend, also observable in the mean value below, a slight reduction of the workload is recorded for the solution scenarios | OK |
|----------------------------|---|-----------|--------------------------------|--|----------------|--|----|



against the reference scenarios thanks to the supervisor role that was able to balance the workload between the modules. The criteria is considered as successfully met considering since the most of the responses is well below the tolerable threshold for the solution scenarios and appointed to the level 3 of the satisfactory workload with enough spare capacity and the different components of the workload were considered satisfactory.

| | | | | |
|--------------------------------|---|----------------|---|----|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | Small airports | Except for reference scenario 3, where even the communication load was not acceptable according to the feedback provided by the participating ATCOs, the communication load was generally acceptable without significant difference between solution and reference scenarios. The | OK |
|--------------------------------|---|----------------|---|----|

criteria is considered as successfully met considering the most of the responses are on level 6 for the solution scenarios

HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

| | | | | | | | |
|----------------------------|--|-----------------|--------------------------------|--|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess acceptance of operating methods when providing ATS to multiple aerodromes | ATCOs of | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal conditions, in case of aircraft emergency and in case of failure of the communication or visualization system when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | Dedicated procedures and checklist were employed during the simulation for the handover, the abnormal and failure modes (such as during emergency) and the participating test subjects strongly recommended to have dedicated procedures and checklist for the deployment as well. | OK |
|----------------------------|--|-----------------|--------------------------------|--|----------------|--|----|

the acceptance was always rated at acceptable level and above the tolerable threshold for the solution scenarios while for the experimented condition of the reference scenario 3 this was not the case. The ATCO did not judge as acceptable to manage 3 aerodromes on one single module without the support of the supervisor

balancing their workload by flexibly assigning the airports between the modules. The acceptability of the frequency of the transfer was judged as adequate too.

The criteria is considered as OK considering the collected results.

| | | | | | | |
|----------------------------|---|--------------------------------|--|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | For the solution scenarios the criteria are judged as successfully met considering the distribution of solution answers are mainly on the level 6 but, even if Roles and responsibilities were judged as feasible in the simulation experience, the test subjects suggested that some responsibilities might be delegated to the supervisor to relief the ATCOs' module; e.g. the coordination with other entities might be delegated to the supervisor rather than the ATCOs. | OK |
| | | CRT-PJ05-W2-35-V3- | Majority of ATCOs confirm the feasibility and acceptability of | Small airports | For the solution scenarios the criteria are judged as successfully met considering | OK |



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|----------------------------|--|--------------------------------|--|----------------|---|----|
| | | VALP-H07.030 | providing ATS services to the assigned number of aerodromes | | the distribution of solution answers are mainly on the level 6. One ATCO somewhat disagree on the feasibility for the management of 3 airports on one single module | |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal operating conditions, in case of aircraft emergency and in case of failure of the communication or visualization system | Small airports | No issues neither specific comments were raised about the current employed phraseology and the criteria was successfully assessed | OK |

HUMAN PERFORMANCE – USABILITY and UTILITY

| | | | | | | |
|----------------------------|---|--------------------------------|---|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | Small airports | ATCOs confirm that the user interface design supports a sufficient level of situation awareness. Even if the overall trend is in the positive area of the answers, the difference between the tolerable threshold and the mean values is not so distant as the other analysed indicators. This is to be seen mainly in relation to the employed HMI as all the test subjects suggested improvements, especially in | OK |
|----------------------------|---|--------------------------------|---|----------------|--|----|

the position of the emergency button and the handover transfer that were located in the border of the head-down display while the ATCOs would have preferred them integrated in the strip bay area. These results are to be interpreted as recommendations for the simulating environment rather than the concept itself and what can be generalised for the concepts is that before the deployment the HMI of the technical system shall be locally assessed and designed in relation to the specific operational environment.

Another possible issue was in relation to the fix position of the airports in the out of the window view and CWP head down display. While in the previous phase of the project it was recommended to keep fix position for the airports to help the situation awareness, the collected feedback was that the fix position had an

opposite effect, especially when the transferred airport was a third airport in the middle fix position: during the transfer allocating the airport in the middle caused a temporary disorientation of the ATCOs that required a few times to recap the exact position of the airports. Despite the suggested improvements, the criteria is judged as met, considering the most of responses provided is on the level six for the solution scenario

| | | | | |
|--------------------------------|---|----------------|--|----|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | Small airports | Even if the criteria is considered successfully met as the overall perception was that human error was not increased in terms of potential and severity respect to the scenario without flexible allocation being the most of the answers above the tolerable threshold of 4, the ATCOs commented that there is the need to always properly balance the workload in order to minimise the impact | OK |
|--------------------------------|---|----------------|--|----|

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|----------------------------|---|--------------------------------|--|---|---|----|
| | | | | on human error, meaning that the team human error potential is acceptable if the workload of the operators is acceptable. | | |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | Small airports | Most of the controllers agreed or somewhat agreed that they had all the required information to complete their tasks. | OK |
| | | | | | They did not raise any issue in relation to the level of information that were provided but they suggested to define proper checklist for the handover, the anormal mode and the degraded mode. | |
| | | | | | The criteria is considered as successfully met considering the provided answers. | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Small airports | Even if the ATCOs suggested improvements in the Electronic Flight Progress Strip System and other systems provided during the experiment, these were not under assessment, being the | OK |

main focus of the exercise the validation of an RTC with flexible allocation of airports between modules. Even if some of these feedback are reported in the objective assessment H01, H02, H04 as possibly affecting the investigated indicators, they are not reported in relation to this H11 objectives being the above mentioned focus (RTC with flexible allocation) the key element of the usability assessment.

The average value of the easy to use answer are within the tolerable threshold even if few cases are below the acceptable value. Indeed, the ATCOs raised that the handover system was not completely easy to use as the button was located in a position difficult to access.

Despite the suggested improvements, most of the ATCOs responses are located

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| | | | above the tolerable threshold. |
| | | | For the post simulation questions, 2 out of the 3 involved ATCOs somewhat agreed that the usability of the MRTM handover system was adequate, while one somewhat disagreed. As for the post simulation, this is not a so strong positive result for the above-mentioned issues during the transfer. |
| | | | About the timing of the handover, there were different perception: 1 ATCO agreed that the handover was timely executed, one somewhat agreed and a last one Neither agreed nor disagreed. |
| | | | Overall, the criteria is considered as ok. |
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability of alarms for emergency situation | Small airports | About the alarms and alerts, there were different perception: 1 ATCO agreed that alarms and alerts were effective and not intrusive, OK |

one somewhat agreed and a last one Neither agreed nor disagreed. The criteria is judged as met being the most of the answers above the tolerable threshold of 4

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|--------------------------------|--|----------------|---|----|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | Small airports | Even if the criteria is considered successfully met as the overall perception was that human error was not increased in terms of potential and severity respect to the scenario without flexible allocation being the most of the answers above the tolerable threshold of 4, the ATCOs commented that there is the need to always properly balance the workload in order to minimise the impact on human error, meaning that the team human error potential is acceptable if the workload of the operators is acceptable. Also, considering what mentioned about the HMI of the transfer system and the emergency communication system (to SUP) improvements are | OK |
|--------------------------------|--|----------------|---|----|

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| | | | | needed in terms of design of the HMI. |
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of flight list traffic forecast and prioritisation function integrated in the EFPS system for the next action to be performed | Small airports | Considering the provided answers in the post run question (The MRTM prioritization system was easy to use), the criteria is considered as successfully met considering as most of the answers are above the tolerable threshold. Despite most of the answers are positive, there are some scenarios that does not reach a satisfactory value. Indeed, during the debriefing, the ATCOs judged it as useful but there was not so much interest in it. It has to be considered, when reading these results, that ATCOs involved in the exercise were not familiar with the EFPS system, so the HMI indication processed by the ATCO Planning Tool algorithm was not always obvious as supporting information. Moreover, the algorithm itself would need to be enriched with as many | OK |

cases as possible in order to be able to perform its task in most situations, perhaps by associating artificial intelligence and machine learning technology with this tool.

| | | | | |
|--------------------------------|--|----------------|--|----|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | Small airports | The criteria is considered as successfully met as the ATCOs were aware of which aerodrome was displayed where. Anyway, some ATCOs suggested during the debriefing to highlight, in the out of the window view, the frame related to the airport where pilots are transmitting. | OK |
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome are transferred between the MRTMs. | Small airports | Questionnaires and debriefing confirmed there was never confusion during the handover about the transferred airports and thus the criteria is considered as successfully met. | OK |

HUMAN PERFORMANCE – TRUST

| | | | | | |
|---|--------------------|---|----------------|--|----|
| Assess ATCO trust in support systems | CRT-PJ05-W2-35-V3- | ATCOs trust the functionality of the automated task | Small airports | No issues raised in relation to the trust of the functionality | OK |
|---|--------------------|---|----------------|--|----|



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|--------------------------------|---|--------------|--|----------------|---|
| OBJ-PJ05-W2-35-V3-VALP-H13 | when providing ATS to multiple aerodromes | VALP-H13.010 | prioritisation for the next action to be performed integrated in the EFPS system | | of the task prioritisation tool. The level of reliability was considered sufficient on the basis of a 7 points post-simulation question where most of the ATCOs somewhat agreed that the tool provided reliable suggestions |
| CRT-PJ05-W2-35-V3-VALP-H13.040 | | | ATCOs trust in reliability of alarms and alerts for emergency situations | Small airports | The level of trust was mainly addressed during the debriefing and no ATCOs raised any issue in relation to the level of trust, especially in relation with the emergency situations that were experimented. The only point raised for the emergency was about the HMI that should be improved |
| CRT-PJ05-W2-35-V3-VALP-H13.080 | | | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | Small airports | The level of trust was mainly addressed during the debriefing and no ATCOs raised any issue in relation to the level of trust. The level of confidence was considered as sufficient |

HUMAN PERFORMANCE – TRANSITION FACTORS



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|----------------------------|---|--------------------------------|--|----------------|---|------|
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Small airports | No final conclusions on skill and recruitment requirements from the collected responses, as not all the answers are aligned on the positive or negative responses for the ATCOs. The overall trend in the discussion was that no real new requirement or skill is needed, but adaptation to the new way of working would be required. | P-OK |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Small airports | Both the supervisors and the ATCOs agreed that the ATCOs and supervisor should be extensively trained to undertake the new role for the supervisor and the new responsibilities for the ATCOs as it can be understood looking at the figure below. | Ok |
| SAFETY | | | | | | |



| | | | | | | |
|----------------------------|---|--------------------------------|---|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> • In the vicinity of the aerodrome • In the runway area • On the manoeuvring area | Small airports | The criteria is considered as successfully met considering the results provided for the OBJ-PJ05-W2-35-V3-VALP-H02 and dedicated questions. There was no simulation of specific conflicts during the simulation days, nevertheless there was no issue raised by ATCOs in the ability of identifying potential conflicts: the ATCOs were even appreciating the conflicting clearances tool which supported the ATCOs in the overload cases in the early identification of clearances in conflict. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | Small airports | ATCOs did not raise any issue in relation with the ability to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | OK |

| | | | | | | | |
|----------------------------|--|--|--------------------------------|---|----------------|--|----|
| | | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | Small airports | The perceived level of safety was acceptable for most of the ATCOs and in all the solution scenarios. Also, no issues were raised about the increase of conflicting situations in the solution scenarios and thus the criteria is considered as successfully met | OK |
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations of Aircraft emergency | Small airports | The criteria was met through a dedicated solution scenario which is solution scenario 4. Level of situation awareness for solution 4 dedicated scenario was considered as good | OK |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC | | CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting Communication or Visualisation system | Small airports | The criteria was met through a dedicated solution scenario which are solution scenario 5 and 6. Level of situation awareness for solution 5 and 6 dedicated scenarios was considered as good | OK |

with a flexible
allocation of
aerodromes
between MRTMs

COST EFFICIENCY

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|------------------------------------|--|--|--|-------------------|---|----|
| OBJ-PJ05- W2-35-V3- VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05- W2-35-V3- VALP- CE1.010 | ATCO can provide ATS to 3 aerodromes at a time in an RTC of 3 aerodromes | Small airports | The ATCOs were questioned about the ability to provide ATS to 3 aerodromes at a time to assess the criteria. Not a conclusive result can be achieved from the provided responses, but based on the H02 and H04 objectives assessment the criteria is considered as successfully met considering the workload and the situation awareness were always maintained at acceptable level in the solution scenarios | OK |
|------------------------------------|--|--|--|-------------------|---|----|

Table 33: ATCO - Validation Results for Exercise 2.4

D.3.2 ATCO - Analysis of Exercise Results per Validation objective

D.3.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

D.3.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Majority of ATCOs rated the situational awareness at an acceptable values. Indeed the measured situational awareness values are all above the tolerable threshold of 5 points except than for the REF3 scenario where the experimental conditions were testing the ATCO exposure to the management of 3 airports without the support of the supervisor and thus without flexible allocation. Anyhow for the solutions scenarios and for the other references experimented conditions the SA is rated above 8. | OK |

The situation awareness was measured in both the post run (through the China lake and ad hoc questionnaires) and post simulation questionnaires (through customised questionnaires). The results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations.

The following plot provides the average value of the measured situation awareness (10 points china lake scale) per kind of scenario, detailing the results also for the 2 experimented out of the window views introduced in the previous chapters.

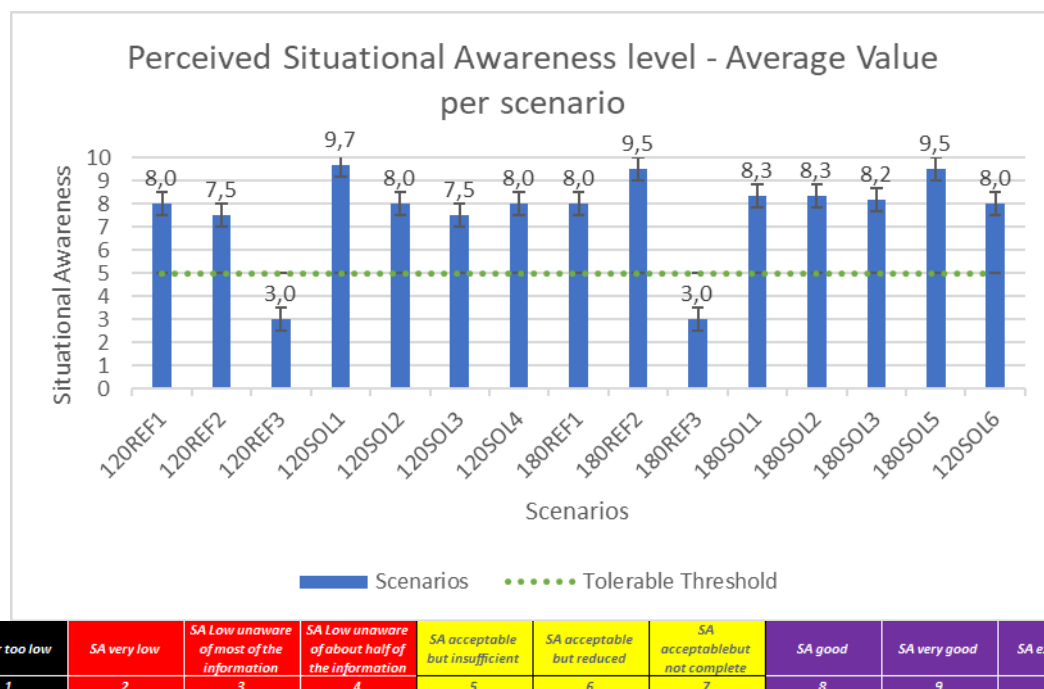


Figure: ATCO - Situational Awareness – Post Run Questionnaire

The results have also been mediated for the references and solutions scenarios experimented. They are reported in the following graph:

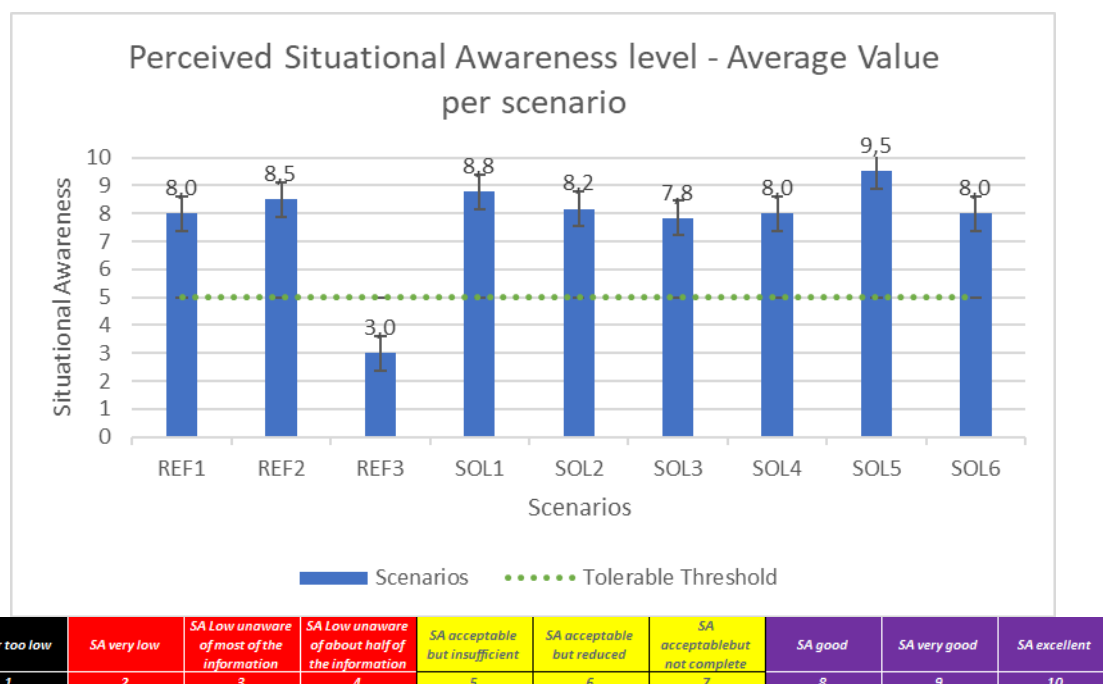


Figure: ATCO - Situational Awareness – Post Run Questionnaire

As it can be observed, the measured situational awareness values are all above the tolerable threshold of 5 points except than for the REF3 where the experimental conditions were testing the ATCO exposure to the management of 3 airports without the support of the supervisor and thus without flexible allocation. For the specific scenario the ATCOs were instructed to stop the run if the workload was considered not anymore sustainable and indeed this scenario was executed twice and in both cases the run was interrupted few minutes before the runs' end. Both the ATCOs, coherently with the provided questionnaire' answers, commented that it was really hard to maintain the situational awareness at acceptable level during all the run. They both rated the situational awareness at level 3 which is in the lower levels. Other comments were: "I have some difficulties to maintain the SA after handover of third airport. I need some seconds to realize the scenario" Anyhow for the solutions scenarios and for the other references experimented conditions the SA is rated above 8 with an overall mean value of 7.2 for the references scenarios and 8.2 for the solutions scenarios, values that are above the tolerable threshold as indicated in the figure below:

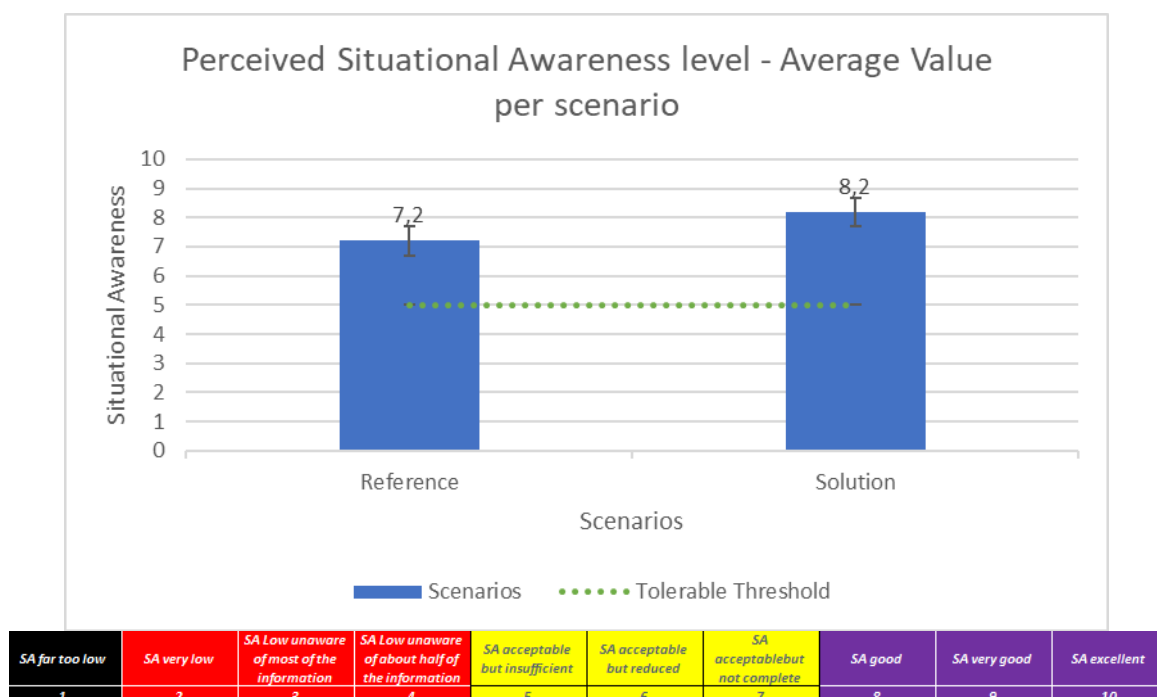


Figure: ATCO - Situational Awareness – Post Run Questionnaire - Average

These results are also in line with what provided in the post – experiment questionnaires reported below for both the reference scenarios and solution scenarios:

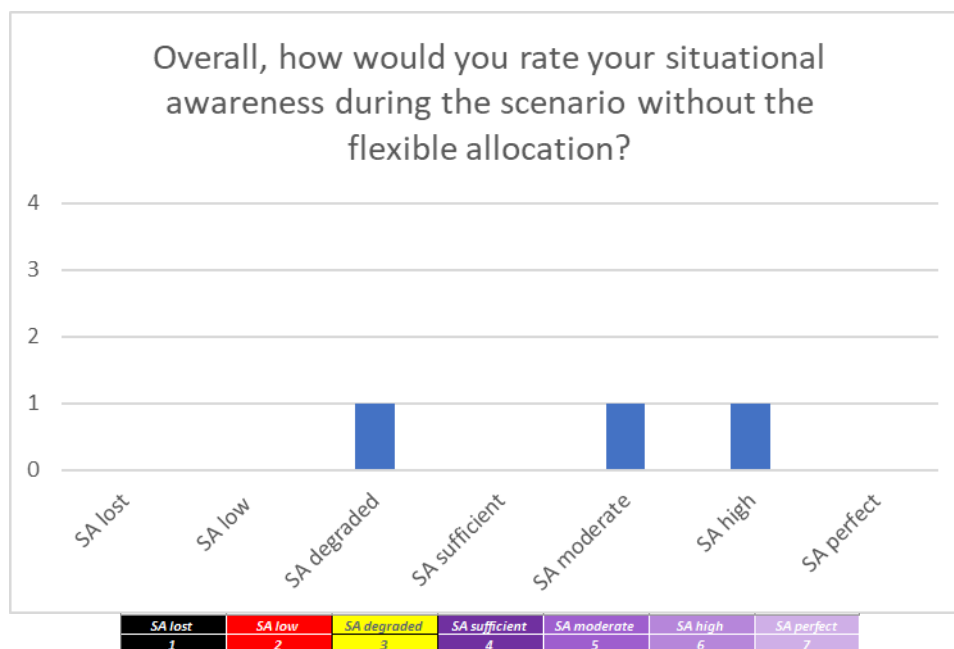


Figure: ATCO - Situational Awareness – Post EXE Questionnaire

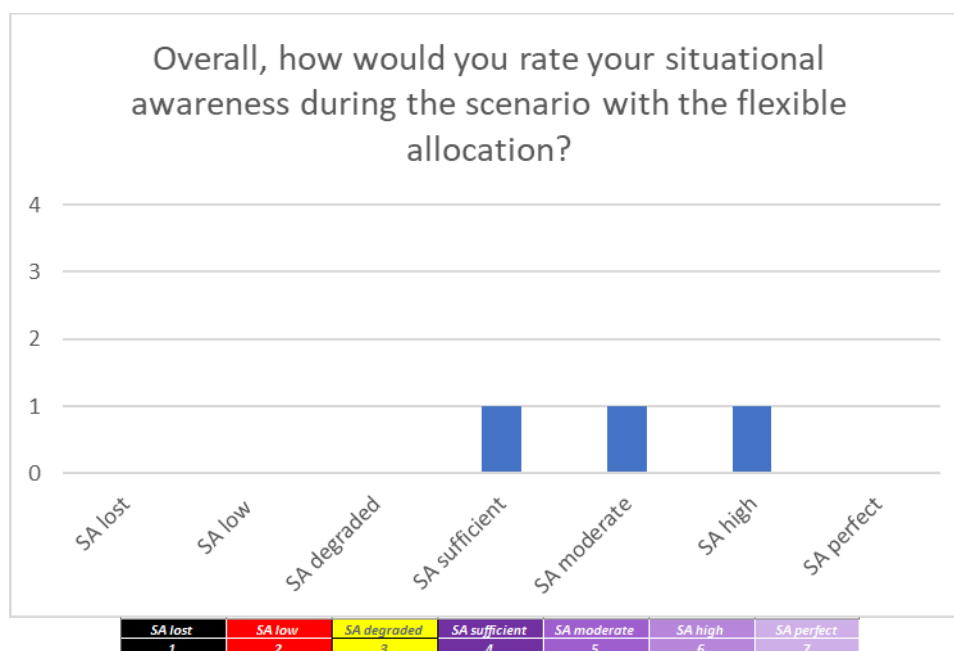


Figure: ATCO - Situational Awareness – Post EXE Questionnaire

While 1 ATCO for the reference scenario reported a degraded level of situation awareness, for the solution scenarios all the three ATCO's responses are above the sufficient level rate of SA. Indeed one ATCO commented that it "Is difficult to maintain the sa for a long time" with 3 airports.

The criteria is judged as met considering the above mentioned results and the below post-run distributions' of answers with the majority of responses attesting a level of situation awareness of 8 points.

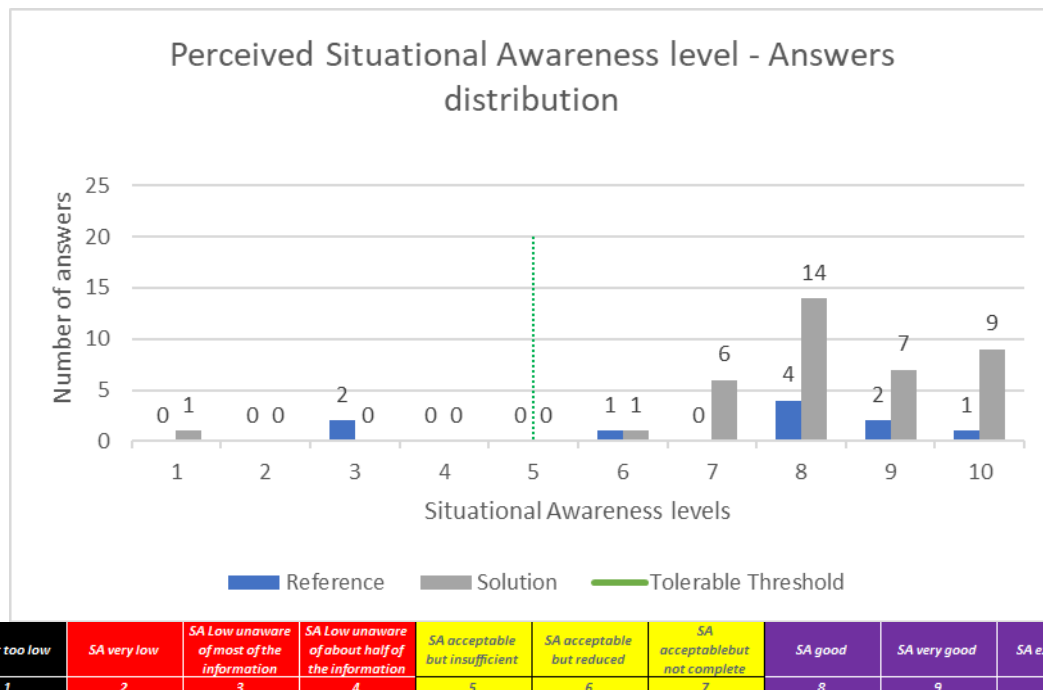


Figure: ATCO - Situational Awareness – Post EXE Questionnaire

Only in one case an ATCO commented a reduced level of situation awareness during the handover, rating the experienced SA level at 6 in the solution scenario with experimental conditions SOL2 and after taking the control of the third airport another ATCO rated it at 7. Both these two cases are to be read in a slight overload due to the handover of the third airport but even if overloaded both the cases are rating the SA above the tolerable threshold, in the SA acceptable area.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | the ATCOs were generally able to prioritise tasks except in the case of reference scenario 3 which was characterised by the management of 3 airports on one single module without the support of the supervisor and thus without flexible allocation. The test subjects reported a workload so high during the specific scenario that they were not fully able to give priority to the more critical actions. For all the other experimented conditions and scenarios, the provided results are above the tolerable threshold. | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|-------------------|--------|
| | | | |

The criteria has been addressed through post run and post simulation 7 points scale questions plotted below:

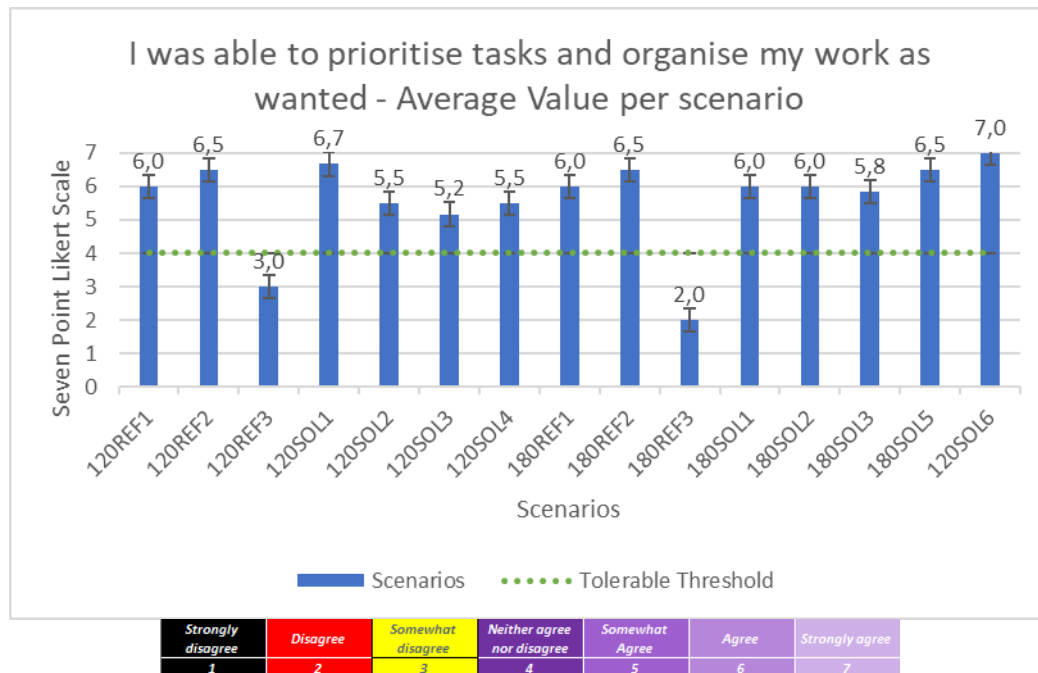


Figure: ATCO – Task prioritization – Post run Questionnaire

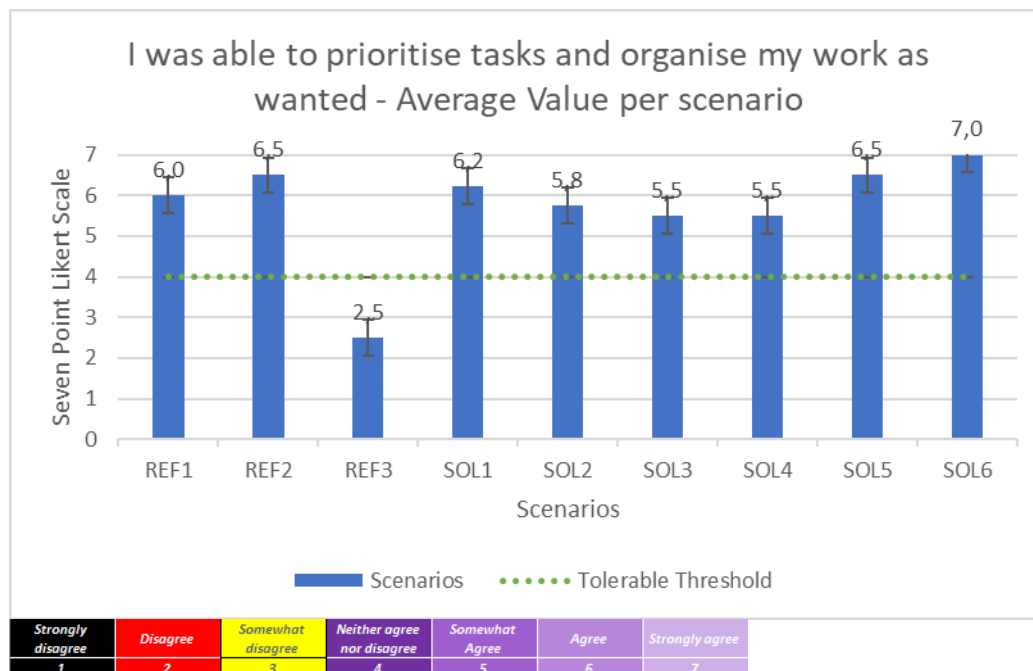


Figure: ATCO – Task prioritization – Post run Questionnaire

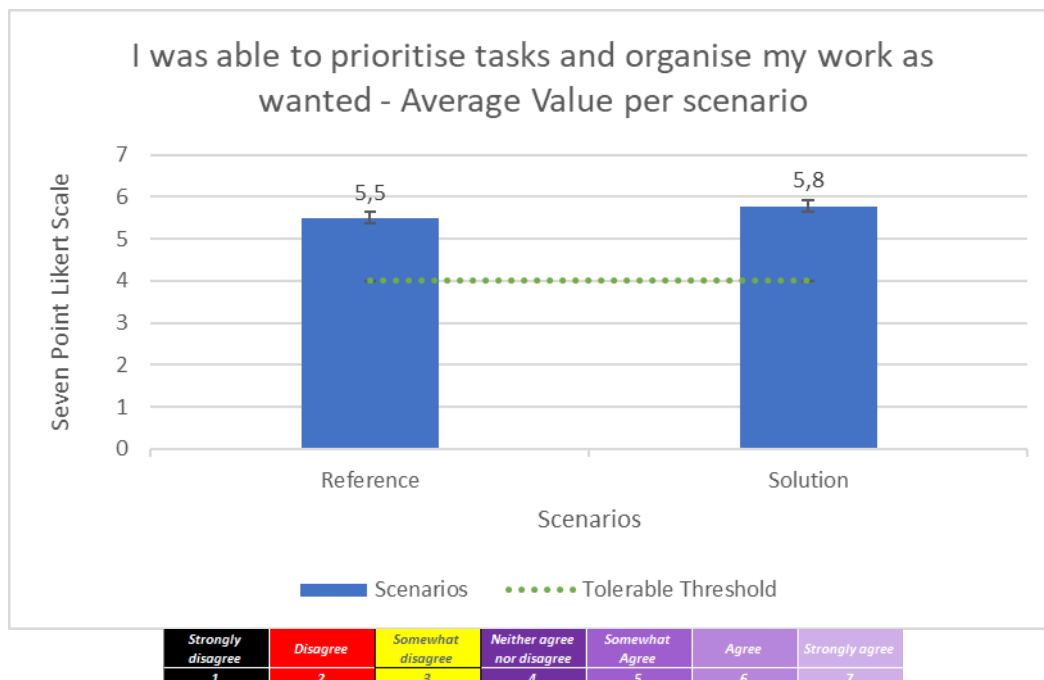


Figure: ATCO – Task prioritization – Post run Questionnaire - Average

As it can be observed in the above provided plots, the ATCOs were generally able to prioritise tasks except in the case of reference scenario 3 which was characterised by the management of 3 airports on one single module without the support of the supervisor and thus without flexible allocation. The test subjects reported a workload so high during the specific scenario that they were not fully able to give priority to the more critical actions. For all the other experimented conditions and scenarios, the provided results are above the tolerable threshold.

The post experiment results were not fully conclusive as the 3 answers are spread among the 3 areas (negative, tolerable and positive) as can be observed in the graph below:

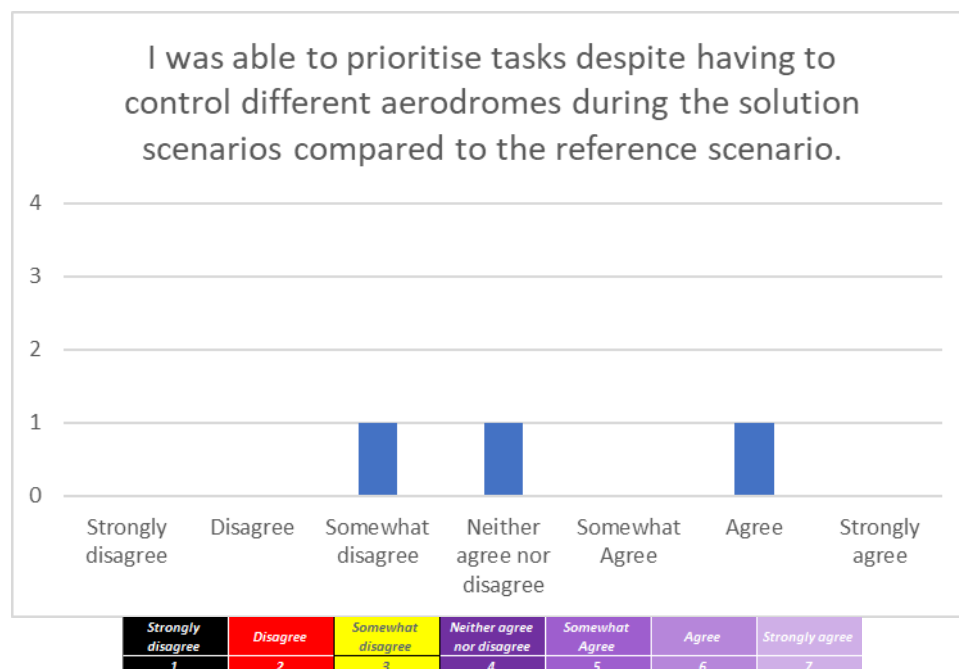


Figure: ATCO – Task prioritization – Post EXE Questionnaire

Indeed, the ATCO that answered “Neither agree nor disagree” also commented that “During reference with three airports was difficult to maintain the correct tasks and priorities”.

Anyway, the criteria is judged as successfully met considering the distributions of the answers provided below: majority of ATCOs responses is on the positive level six for the solutions scenarios.

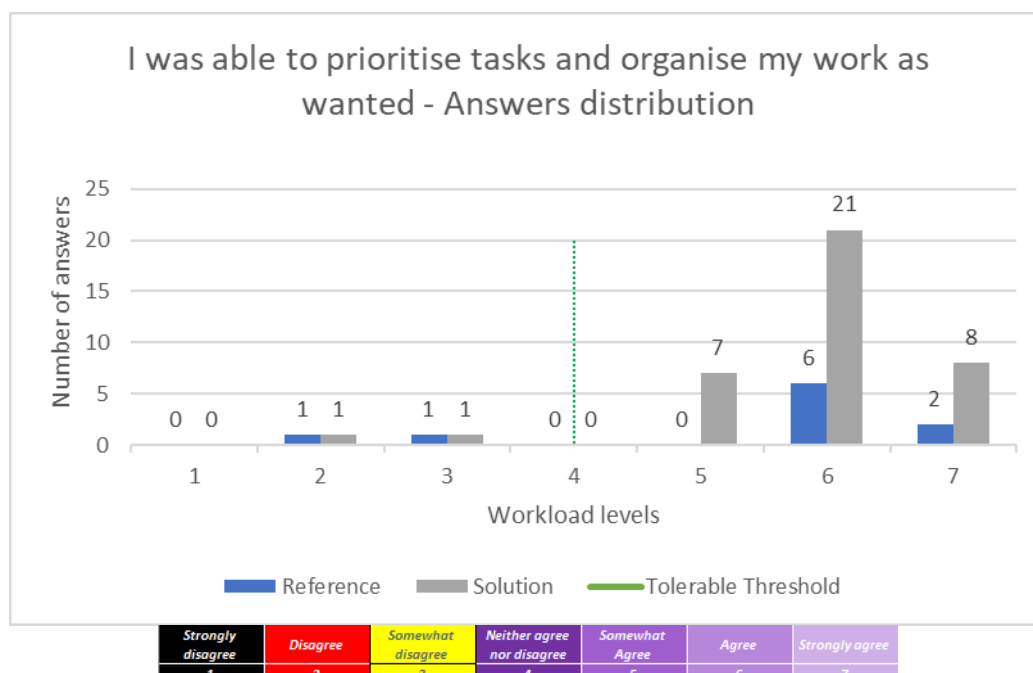


Figure: ATCO – Task prioritization – Post EXE Questionnaire

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>Even if the overall trend is in the positive area of the answers, the difference between the tolerable threshold and the mean values is not so distant as the other analysed indicators. This is to be seen mainly in relation to the employed HMI as all the test subjects suggested improvements, especially in the position of the emergency button and the handover transfer that were located in the border of the head-down display while the ATCOs would have preferred them integrated in the strip bay area. These results are to be interpreted as recommendations for the simulating environment rather than the concept itself and what can be generalised for the concepts is that before the deployment the HMI of the technical system shall be locally assessed and designed in relation to the specific operational environment.</p> <p>Another possible issue was in relation to the fix position of the airports in the out of the window view and CWP head down display. While in the previous phase of the project it was recommended to keep fix position for the airports to help the situation awareness, the collected feedback was that the fix position had an opposite effect, especially when the transferred airport was a third airport in the middle fix position: during the transfer allocating the airport in the middle caused a temporary disorientation of the ATCOs that required a few times to recap the exact position of the airports. Despite the suggested improvements, the criteria is judged as met, considering</p> | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | the most of responses provided is on the level six for the solution scenario. | |

The criteria has been addressed in a 7 points scale ad hoc question that is analysed in the following plots:

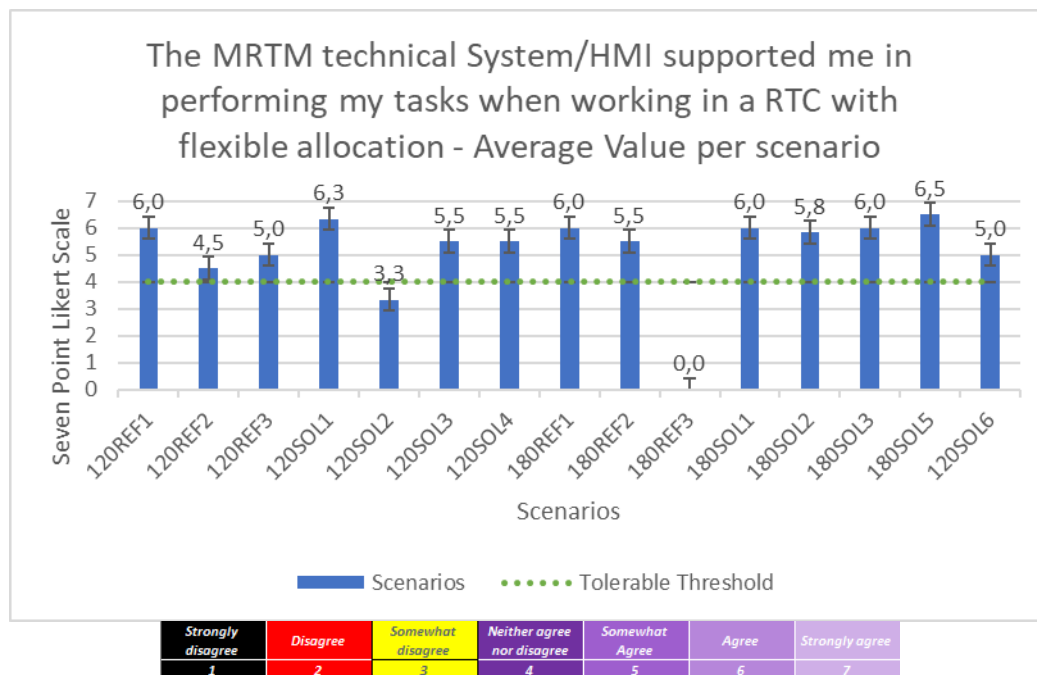


Figure: ATCO – HMI support – Post Run Questionnaire

Even if the overall trend is in the positive area of the answers, there is one point below the tolerable threshold and the difference between the threshold and the mean values is not so distant as the other analysed indicators. This is to be seen mainly in relation to the employed HMI as all the test subjects suggested improvements, especially in the position of the emergency button and the handover transfer that were located in the border of the head-down display while the ATCOs would have preferred them integrated in the strip bay area. Also, the ATCOs complained about the number of status of the electronic flight progress system bay and the movements of the transfer between the strip bays that was not fully aligned to their day to day system. Indeed the comments were:

- “PEA buttons to be placed in a better position (eg. Near the strip bay)”
- “Strip bay not completely functional for my needs”

These results are to be interpreted as recommendations for the simulating environment rather than the concept itself and what can be generalised for the concepts is that before the deployment the HMI of the technical system shall be locally assessed and designed in relation to the specific operational environment.

Same results can be observed looking at the both the average values per scenarios and the combined average values for references and solutions scenarios reported below.

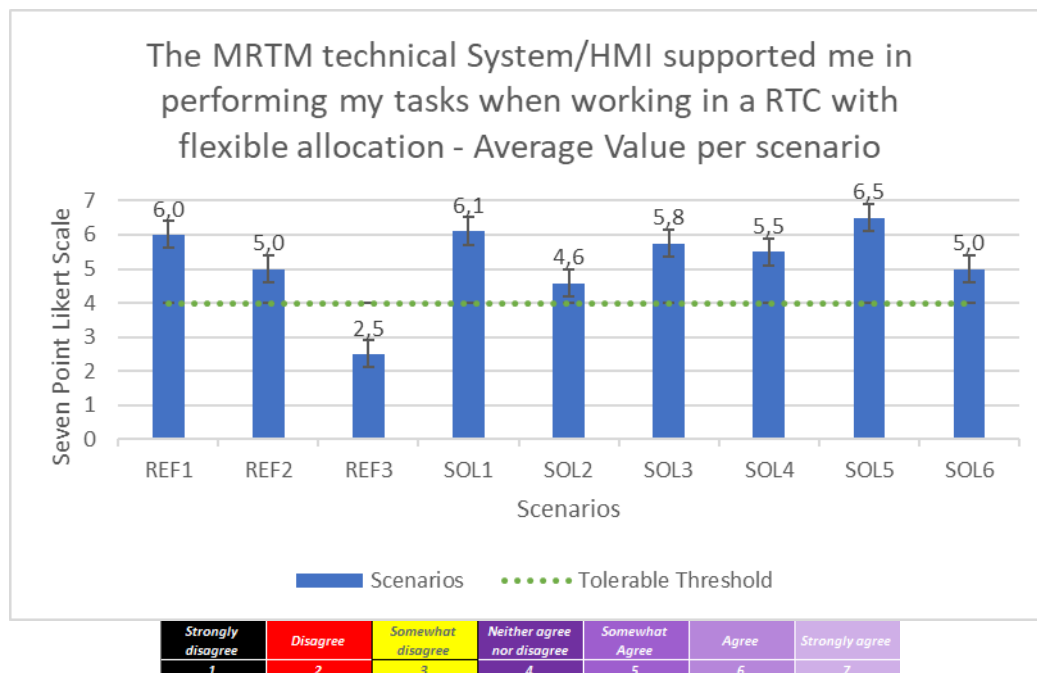


Figure : ATCO – HMI support – Post Run Questionnaire

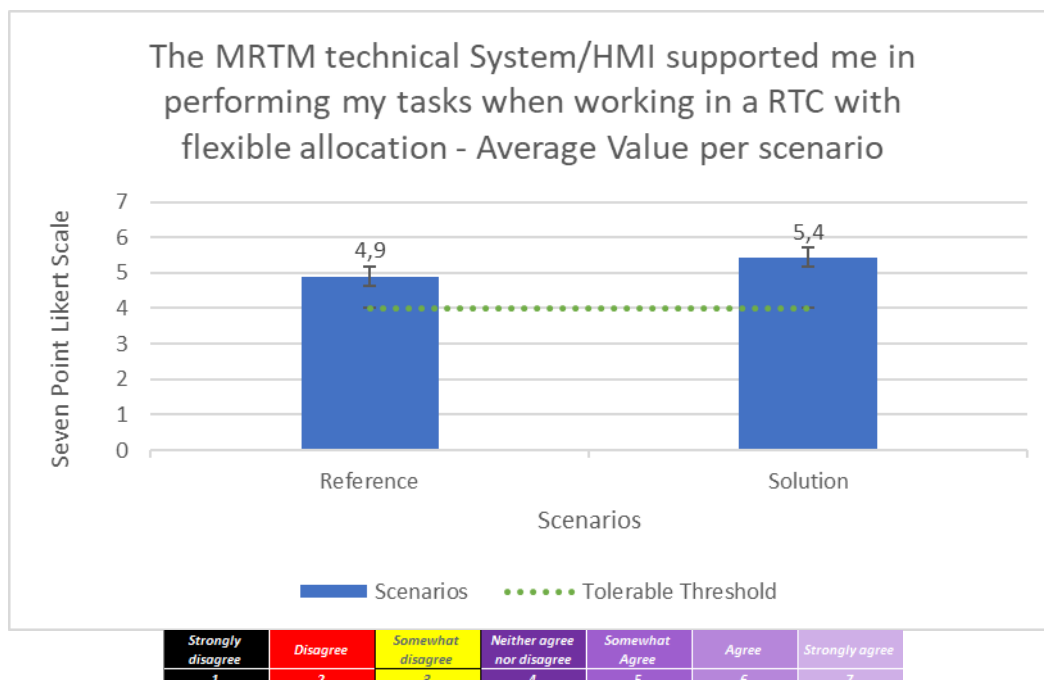


Figure: ATCO – HMI support – Post Run Questionnaire

Another possible issue was in relation to the fix position of the airports in the out of the window view and CWP head down display. While in the previous phase of the project it was recommended to keep fix position for the airports to help the situation awareness, the collected feedback was that the fix position had an opposite effect, especially when the transferred airport was a third airport in the middle fix position: during the transfer allocating the airport in the middle caused a temporary disorientation of the ATCOs that required a few times to recap the exact position of the airports. They would have preferred to receive the transferred airport always occupying the last position in all the screen i.e. on the bottom of the displays for the external view and on the right on the head down CWP displays.

Despite the suggested improvements, the criteria is judged as met, considering the most of responses provided in the plot below is on the level six for the solution scenario.

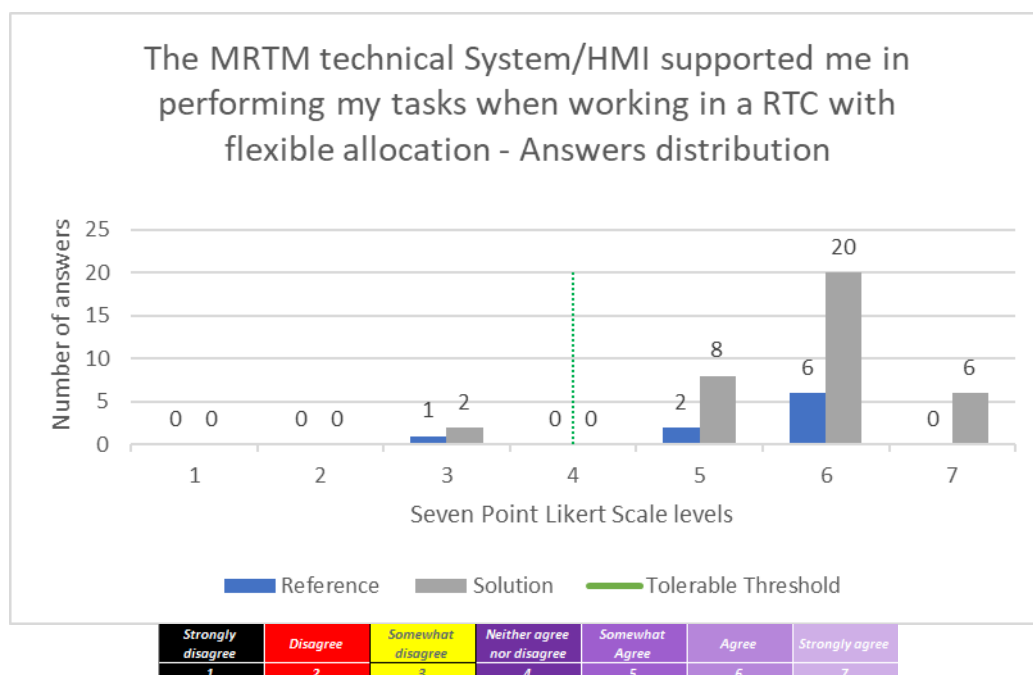


Figure : ATCO – HMI support – Post Run Questionnaire

Other points discussed were in relation to the PTZ and the out of the windows view. Indeed, the ATCOs, especially in the 120° experimented out of the windows view complained about the difficulties in the interaction with the OTW/PTZ functionalities: being the runway not entirely visible in these experimental conditions they needed to frequently rotate the OTW or interact with the PTZ to check the runway clear before departure and landing and the system required several actions, taking time that could have been dedicated to other tasks. Moving to the 180° OTW view experimental condition the situation was improved as they did not need to frequently interact with the visual system.

Anyway ATCOs suggested to implement Picture in Picture system rather than PTZ to enhance the interaction with the system.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | Not addressed | |

D.3.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>The most of the responses are in the tolerable area of the graphs (4 points and above) nevertheless, especially from the supervisor point of view, there might be technical development that could further enhance the team situational awareness.</p> <p>Above all the Supervisor tool need to be based on live data which was not the case in the simulation environment due to technical constraints that could not be overcome for time and resources reasons.</p> <p>Other improvements that were discussed to help the shared situational awareness were in relation to possible technology improvements providing actual Module's information replication. Of course, a local dedicated assessment to consider the benchmark between ergonomics and situational awareness benefits as the supervisors also recommended to avoid to add too many displays in their position.</p> | OK |

OBJ-PJ05-W2-35-V3-VALP-H03**Assess team situation awareness when providing ATS to multiple aerodromes**

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | Other suggested improvements were in relation to the practices and operating procedure already exposed in the previous bullet point. | |

The criteria has been assessed through 7 points scale question in the post simulation questionnaire for both the ATCOs and SUPs position in order to understand the subjective point of view. The results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations.

The following answers were provided by the participating ATCOs.

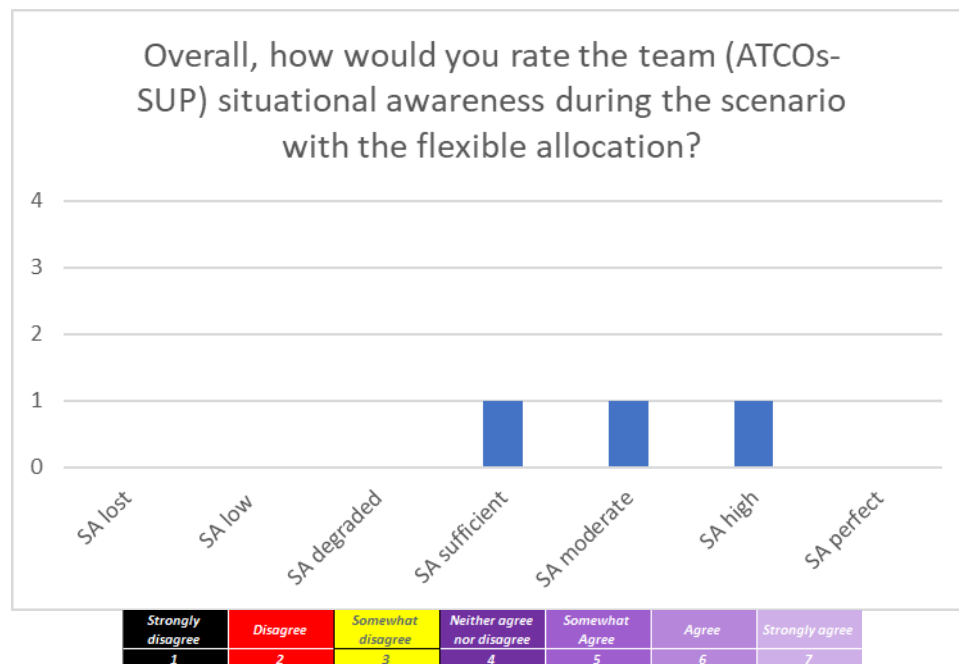


Figure: Team situational awareness– Post EXE Questionnaire - ATCO

The following answers were provided by the participating SUPs.

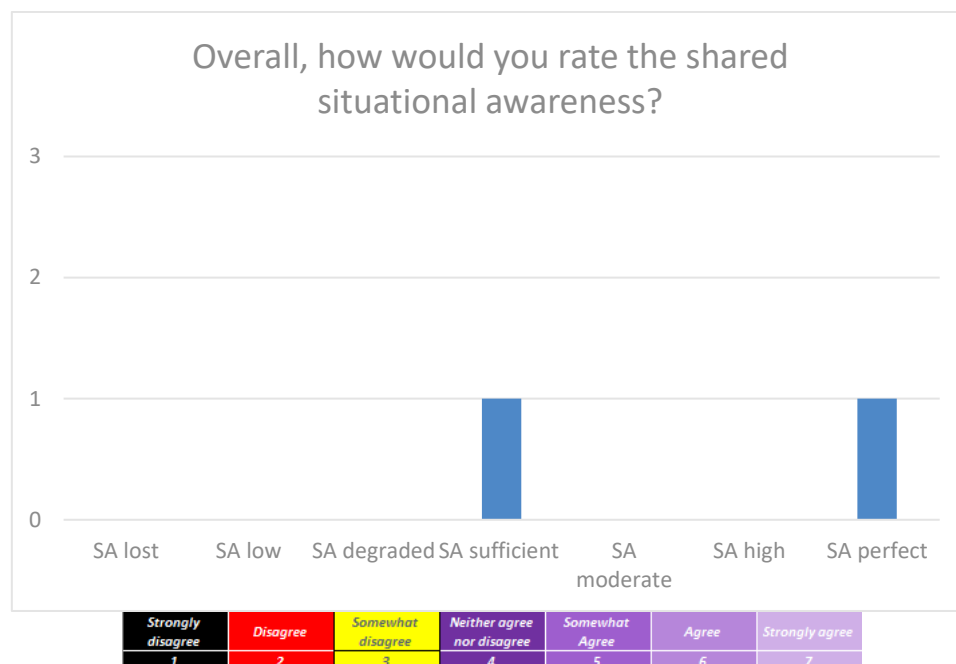


Figure: Shared situational awareness– Post EXE Questionnaire - SUP

Even if the criteria is considered as successfully met considering the most of the above responses are in the tolerable area of the graphs (4 points and above) nevertheless, especially from the supervisor point of view, there might be technical development that could further enhance the team situational awareness.

Above all the Supervisor tool need to be based on live data which was not the case in the simulation environment due to technical constraints that could not be overcome for time and resources reasons.

Other improvements that were discussed to help the shared situational awareness were in relation to possible technology improvements providing actual Module's information replication. Of course, a local dedicated assessment to consider the benchmark between ergonomics and situational awareness benefits as the supervisors also recommended to avoid to add too many displays in their position.

Other suggested improvements were in relation to the practices and operating procedure already exposed in the previous bullet point.

D.3.2.2 HUMAN PERFORMANCE – WORKLOAD

D.3.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

OBJ-PJ05-W2-35-V3-VALP-H04

Assess ATCO workload when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Different components of workload were assessed in addition to the overall perceived cognitive workload as it was considered necessary also to assess the planning load, the monitoring load and the coordination load to verify if there was any dimension of the workload that was more demanding and required specific mitigations. The perceived cognitive workload was always at acceptable level, except for the reference scenario in the experimental conditions 3 where the airports were all allocated on one single module without the flexible allocation and support of the supervisor positions. Looking at the overall trend, also observable in the mean value below, a slight reduction of the workload is recorded for the solution scenarios against the reference scenarios thanks to the supervisor role that was able to balance the workload between the modules. The criteria is considered as successfully met considering since the most of the responses is well below the tolerable threshold for the solution scenarios and appointed to the level 3 of the satisfactory workload with enough spare capacity and the different components of the workload were considered satisfactory. | Ok |

The criteria has been assessed through post run ten points Bedford scale and ad hoc post simulation 7 points scale questionnaires. The results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations.

Different components of workload were assessed in addition to the overall perceived cognitive workload as it was considered necessary also to assess the planning load, the monitoring load and the coordination load to verify if there was any dimension of the workload that was more demanding and required specific mitigations.

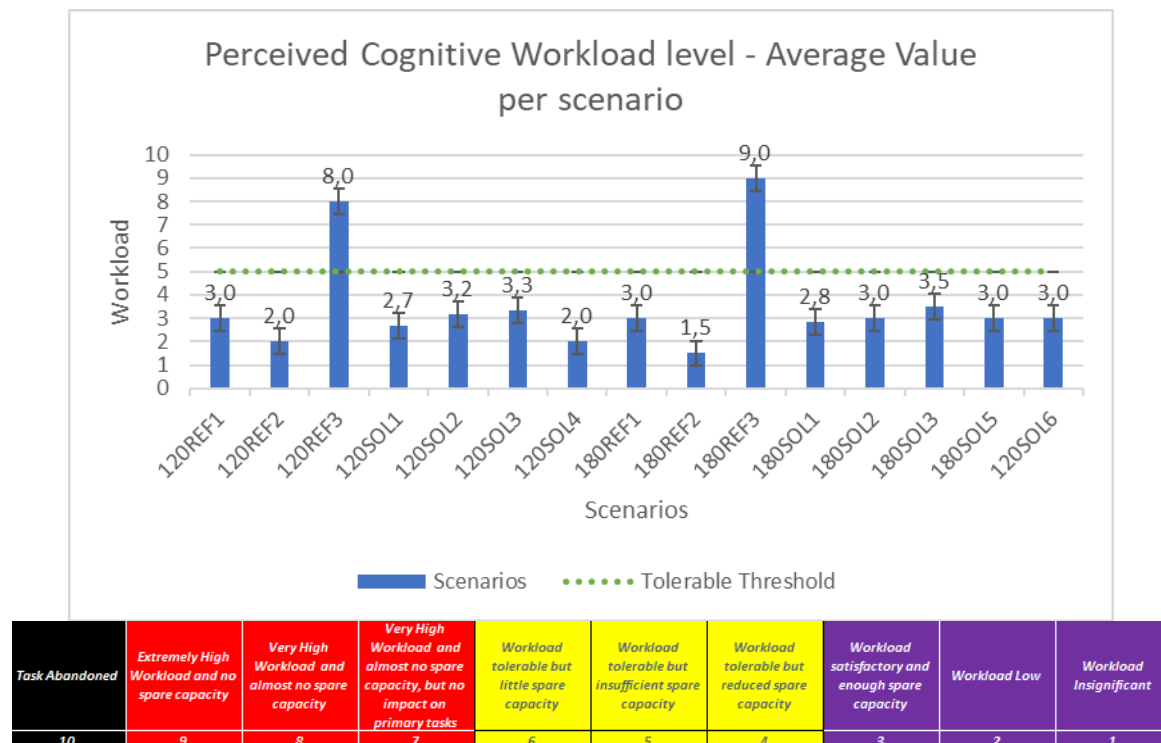


Figure: ATCO Workload – Post Run Questionnaire

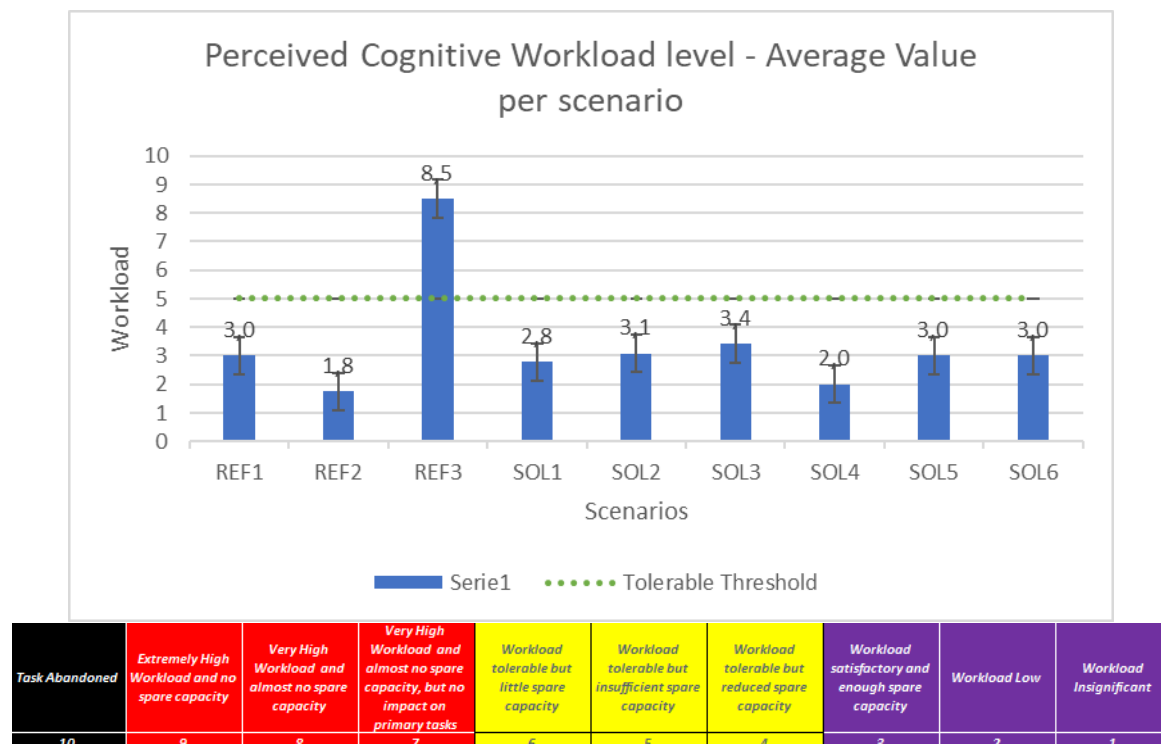


Figure: ATCO Workload – Post Run Questionnaire

As it can be observed from both the above graphs, the perceived cognitive workload was always at acceptable level, except for the reference scenario in the experimental conditions 3 where the airports were all allocated on one single module without the flexible allocation and support of the supervisor positions.

During the run the ATCOs reported a very high workload that generated loss of situational awareness, as already explained for the situational awareness objectives.

Looking at the overall trend, also observable in the mean value below, a slight reduction of the workload is recorded for the solution scenarios against the reference scenarios thanks to the supervisor role that was able to balance the workload between the modules.

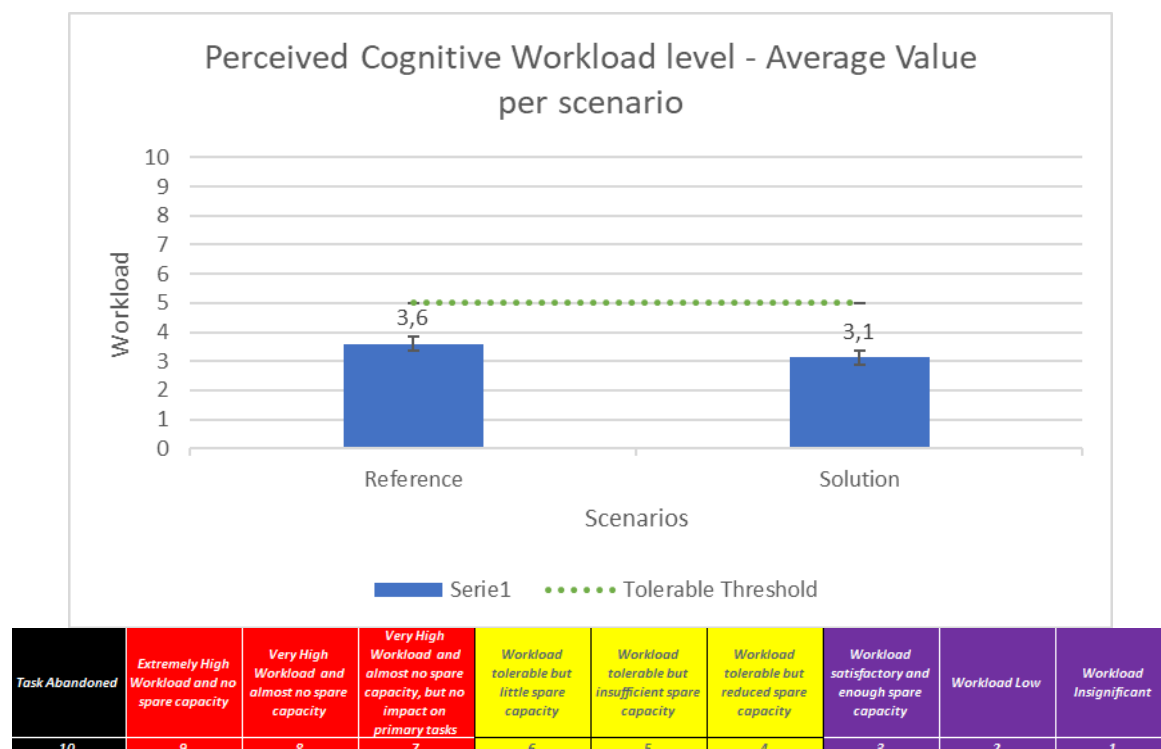


Figure: ATCO Workload – Post Run Questionnaire - Average

This is more evident considering the post simulation questions on workload. Indeed 2 out of the 3 ATCOs rated that the workload was slightly heavy in the scenarios without the flexible allocations on the 7 points scale (in the not tolerable area of the workload) while, as it can be observed in the relevant plots below, 2 out of the 3 ATCOs rated that the workload was acceptable on the same scale for the scenarios with flexible allocation.

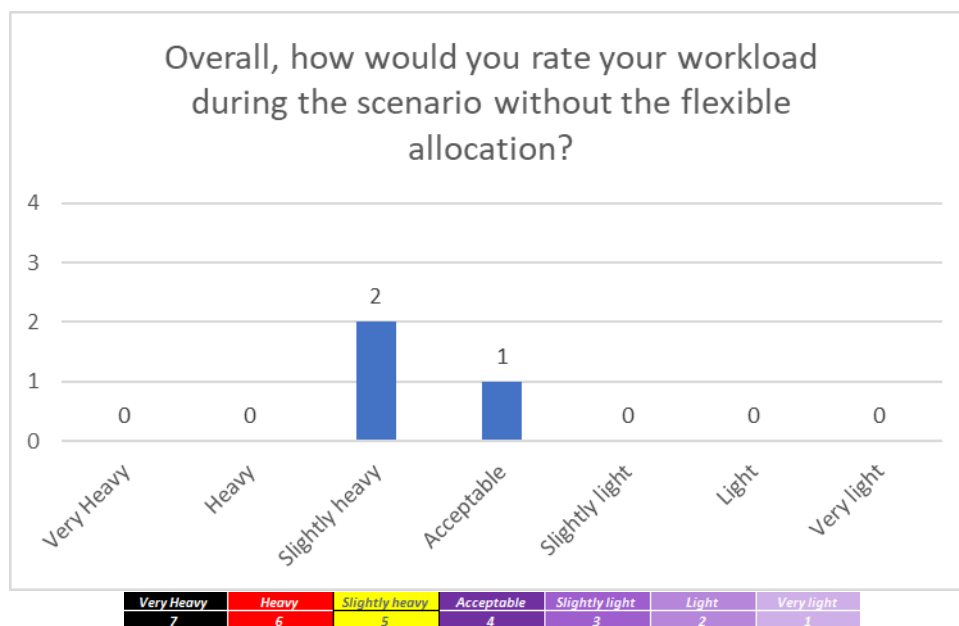


Figure: ATCO Workload – Post EXE Questionnaire -

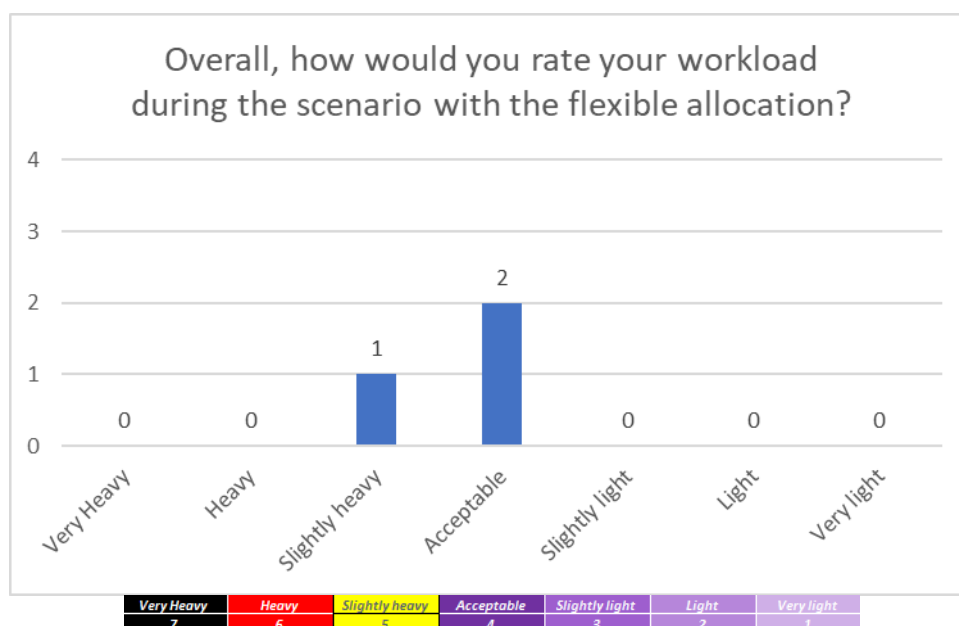


Figure: ATCO Workload – Post EXE Questionnaire -

The criteria is considered as successfully met considering the most of the responses is well below the tolerable threshold for the solution scenarios and appointed to the level 3 of the satisfactory workload with enough spare capacity.

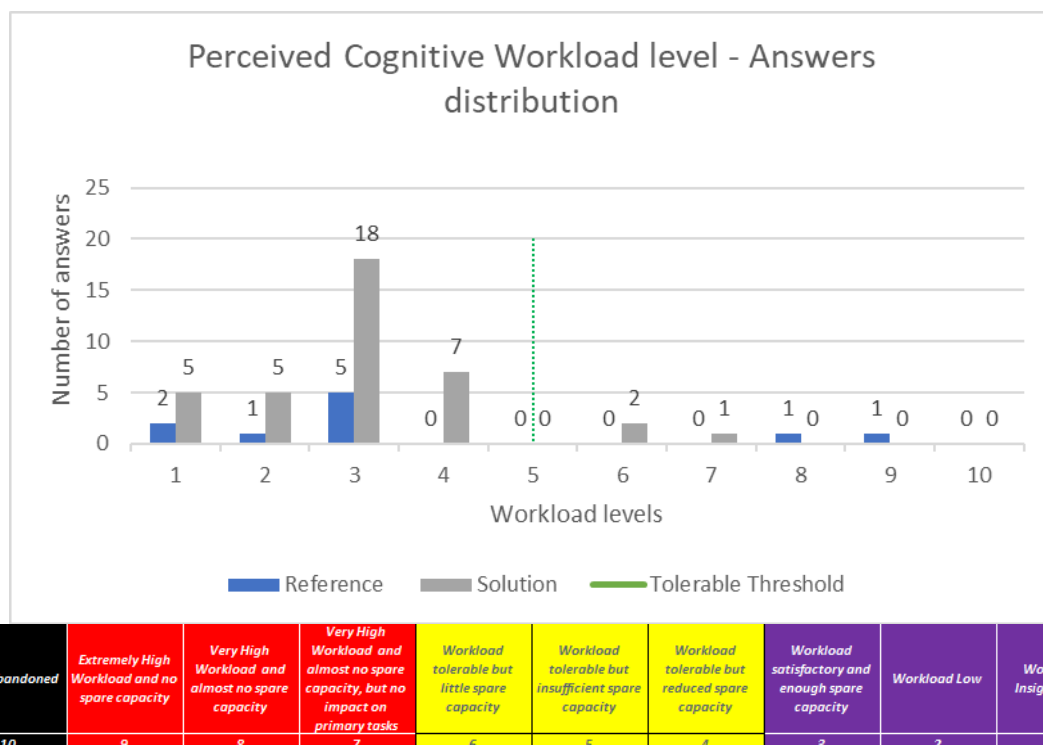


Figure: ATCO Workload – Post Run Questionnaire -

As it can be observed in the plots below, the monitoring workload was always acceptable except that in Reference scenario 3 where the ATCO was experimenting the management of 3 airports on one single module without the support of the supervisor and thus without flexible allocation.

The monitoring load for the specific scenario was considered not acceptable for both the experimented out of the windows view as it was rated on level 3 and level 2 resulting in an average value of 2.5 that is well below the tolerable threshold.

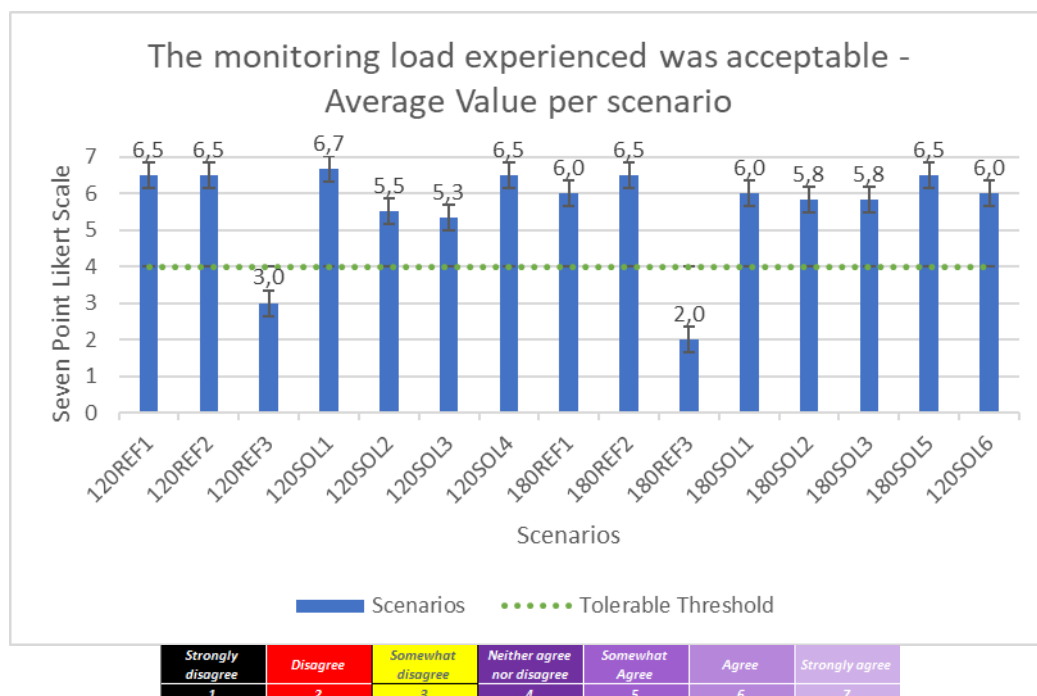


Figure: ATCO Workload – Post Run Questionnaire - Monitoring load

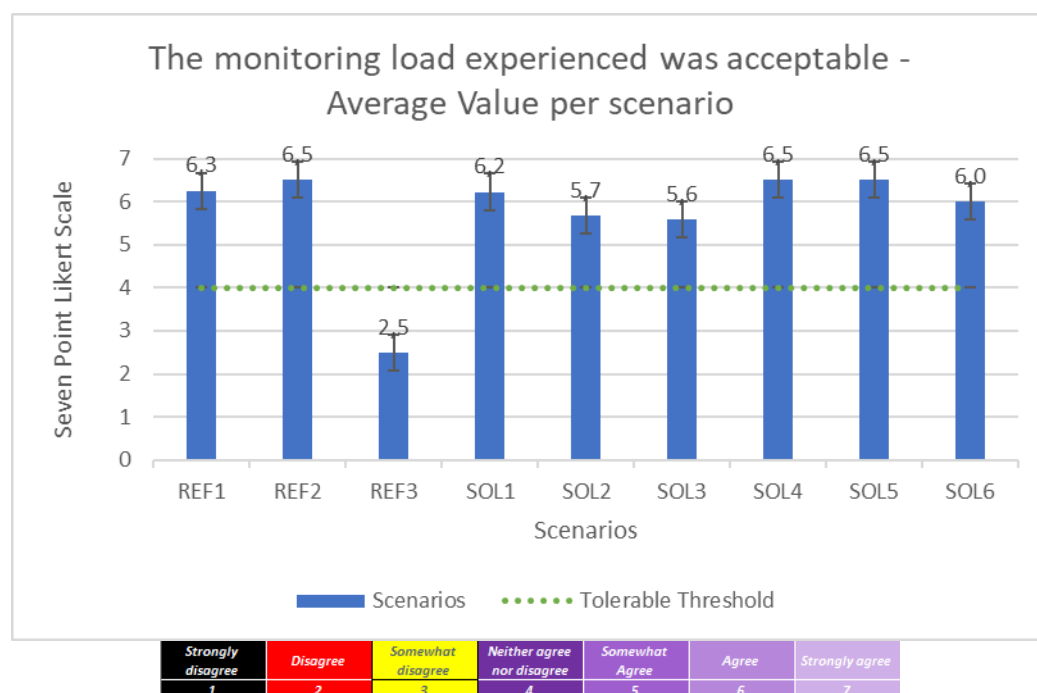


Figure: ATCO Workload – Post Run Questionnaire - Monitoring load

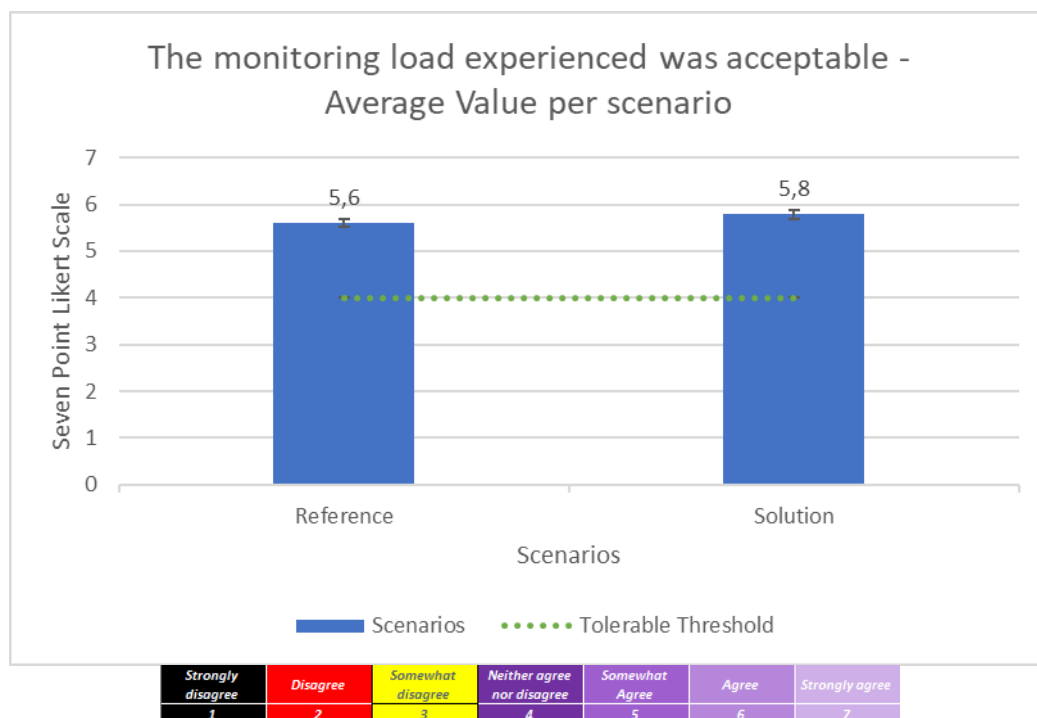


Figure: ATCO Workload – Post Run Questionnaire - Monitoring load - Average

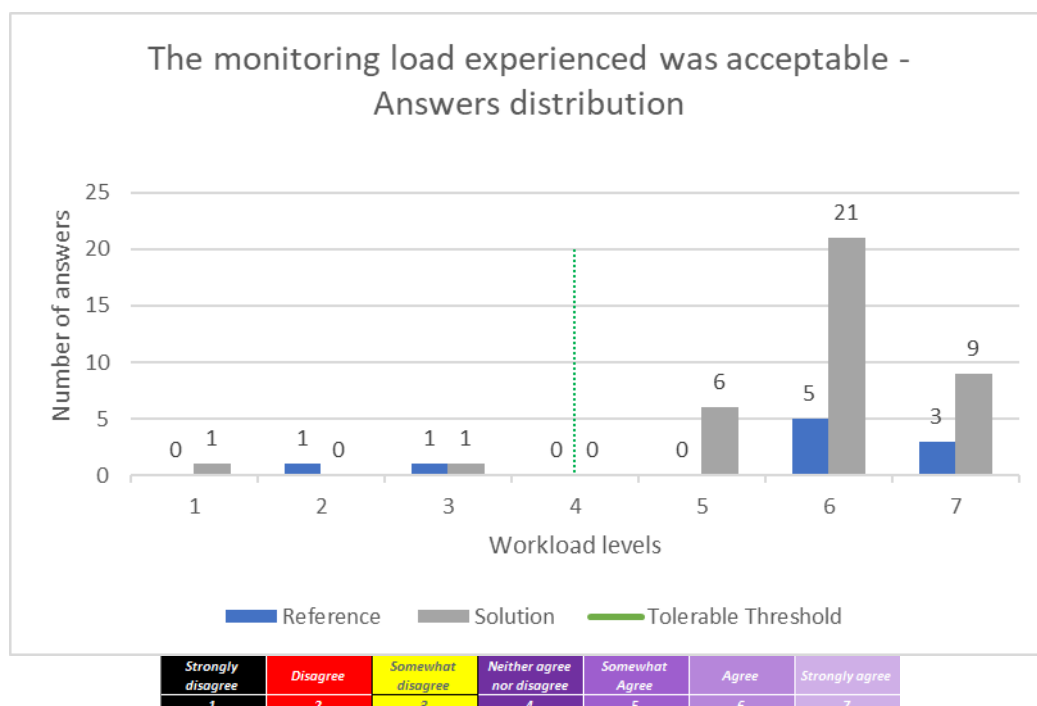


Figure: ATCO Workload – Post Run Questionnaire - Monitoring load

Anyway, for the solution scenario all the recorded answers are in the positive area of the plot responses as visible above.

For the coordination load data were collected only for the solution scenarios since there was no need of coordination for the reference scenarios.

For this component of the workload there was one single case, solution scenario at 120° Out of the windows view where the workload was not considered acceptable and the ATCO commented that “Some coordination talk were inefficient due to aircrafts radio calls”.

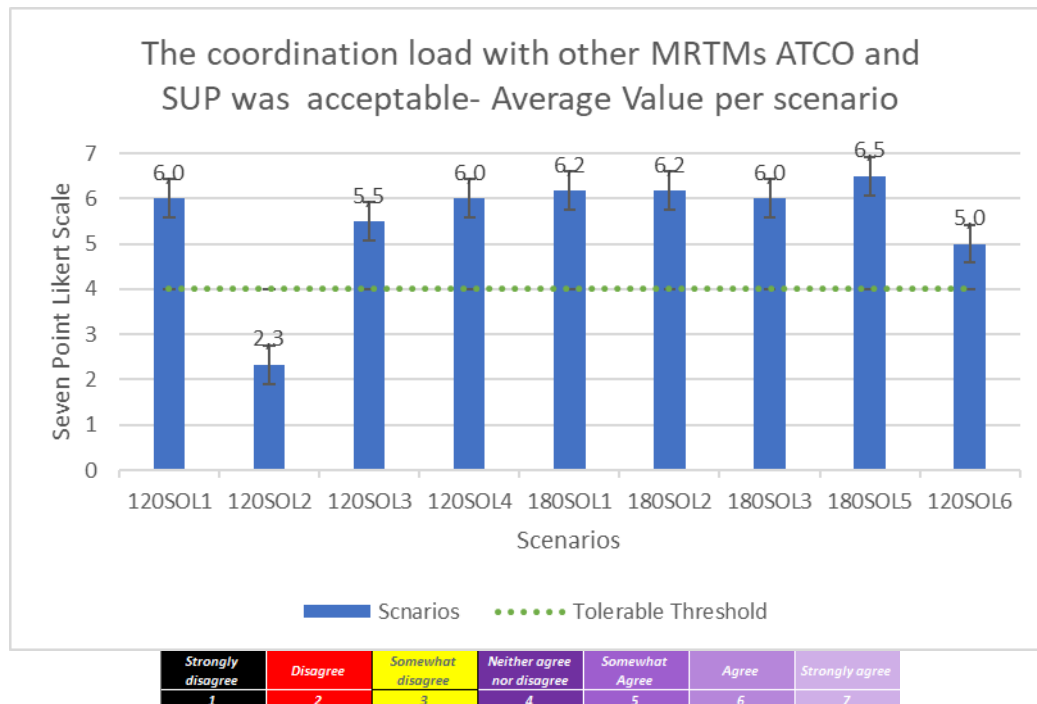


Figure: ATCO Workload – Post Run Questionnaire - Coordination load

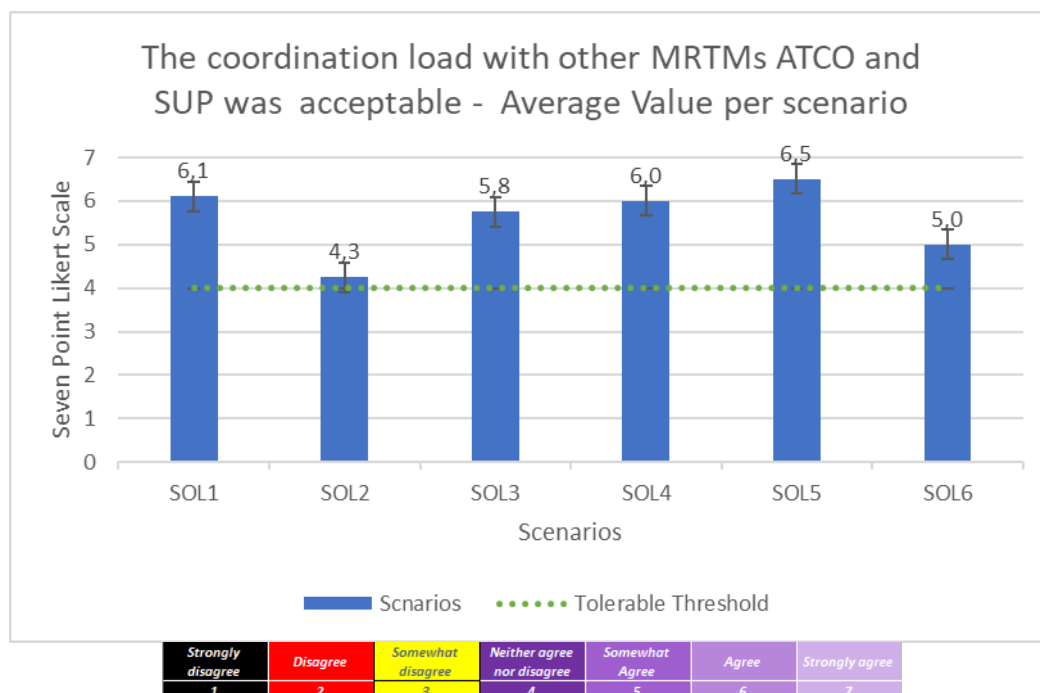


Figure: ATCO Workload – Post Run Questionnaire - Coordination load

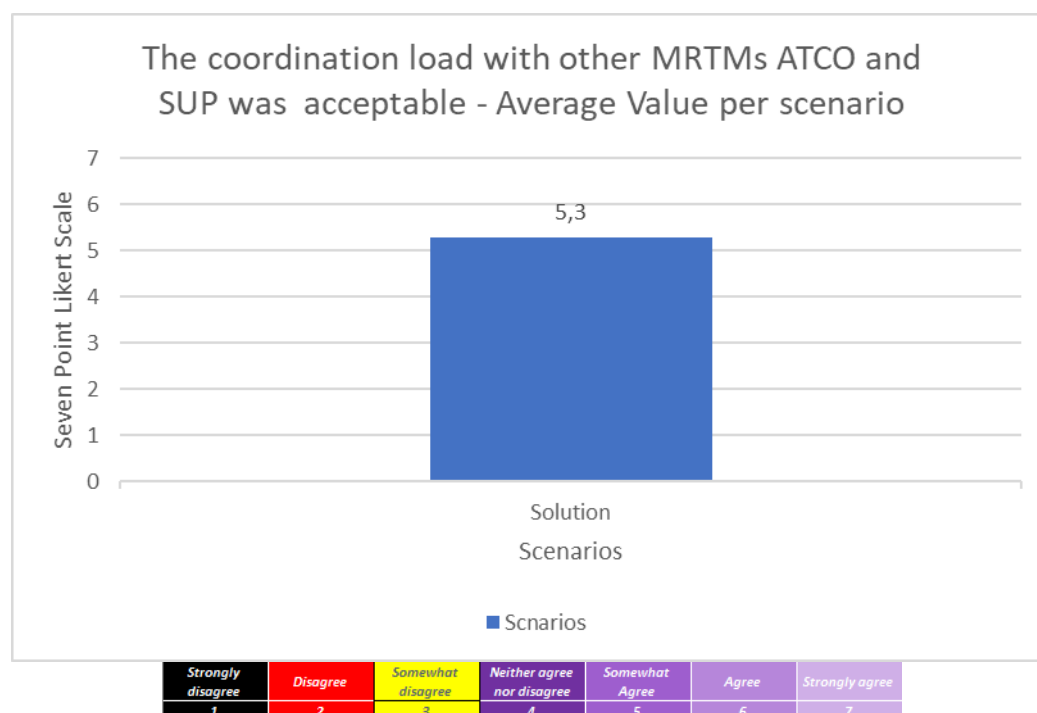


Figure: ATCO Workload – Post Run Questionnaire - Coordination load - Average

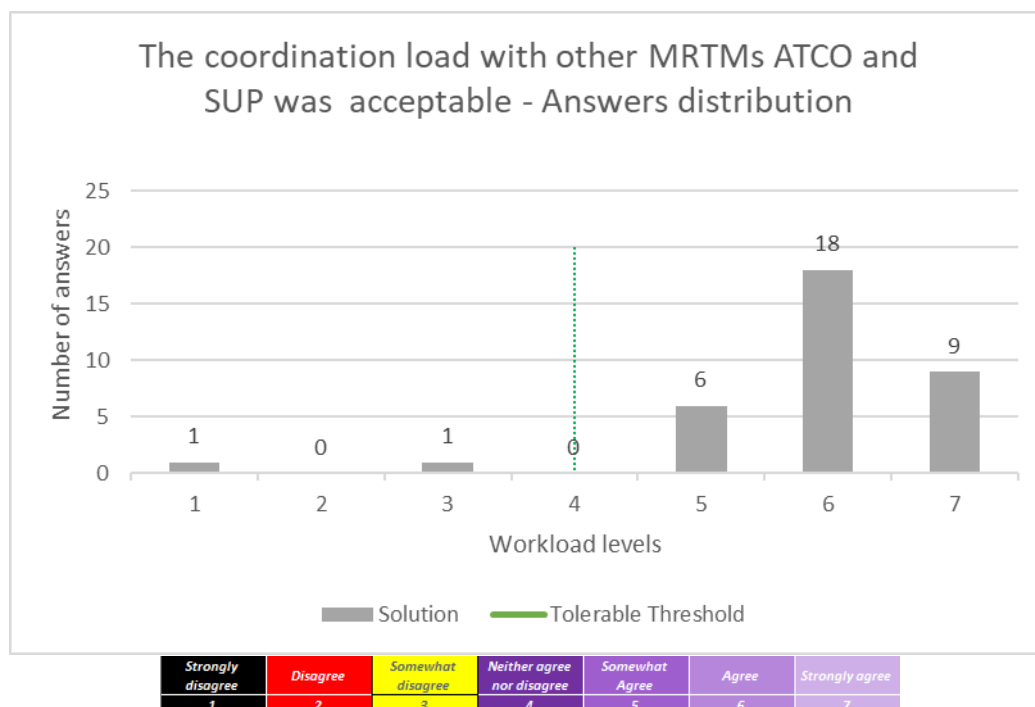


Figure: ATCO Workload – Post Run Questionnaire - Coordination load

Anyway the answers are mainly in the positive area of the responses levels.

For the planning load the same issue as for the monitoring load was recorded. Indeed, the planning load of the reference scenario 3 was not acceptable since there was no support from the supervisor and the ATCO was in charge of providing ATS services to 3 airports.

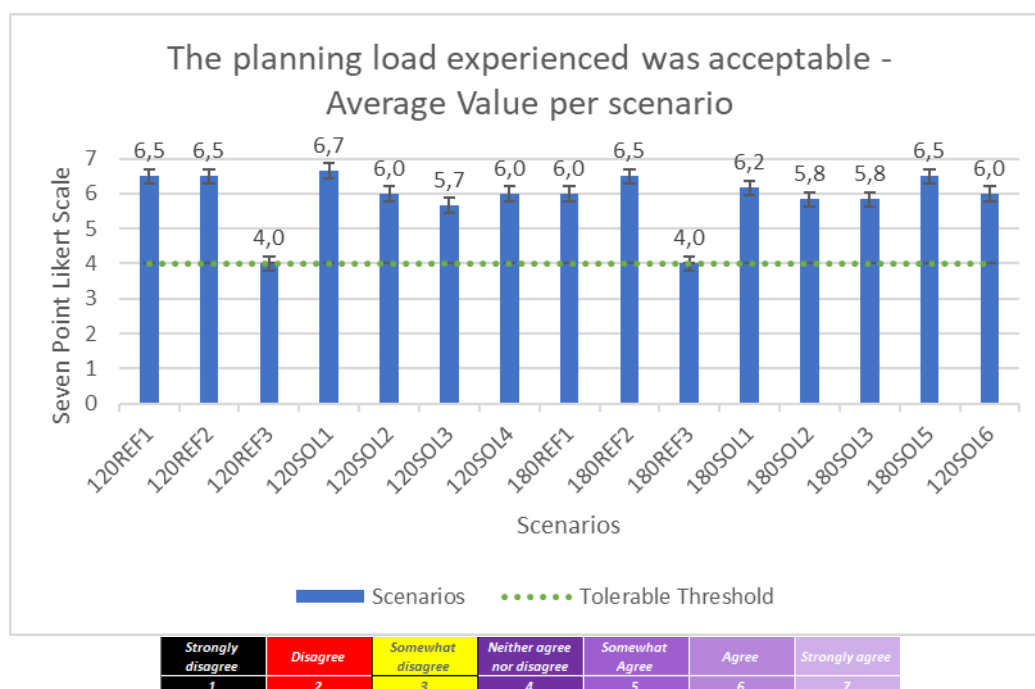


Figure: ATCO Workload – Post Run Questionnaire - Planning load

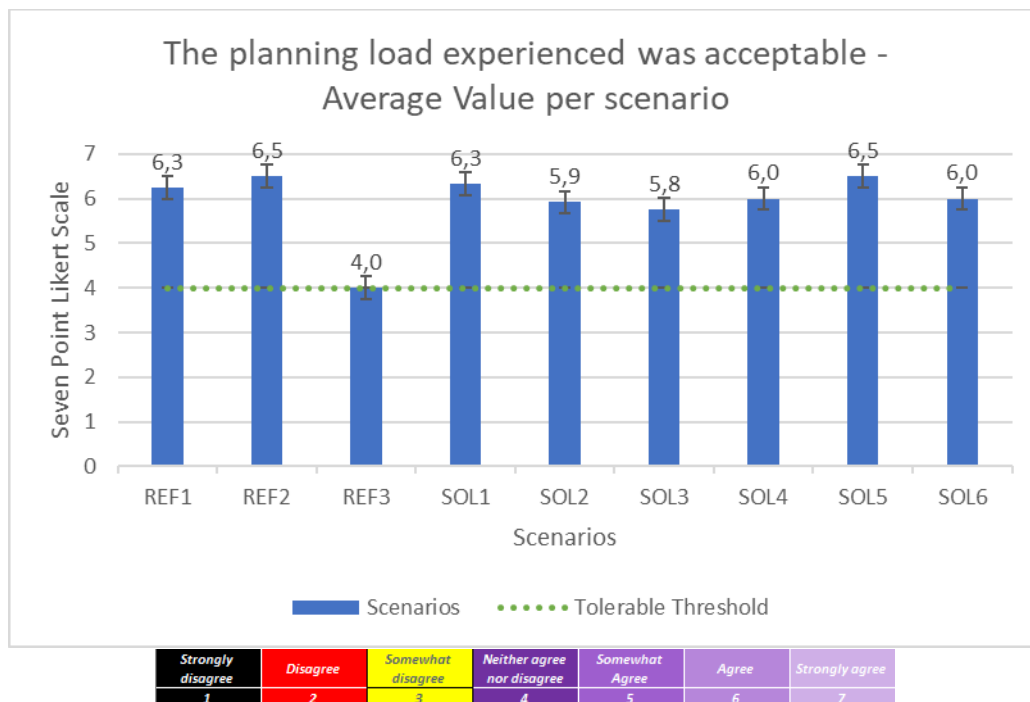


Figure: ATCO Workload – Post Run Questionnaire - Planning load

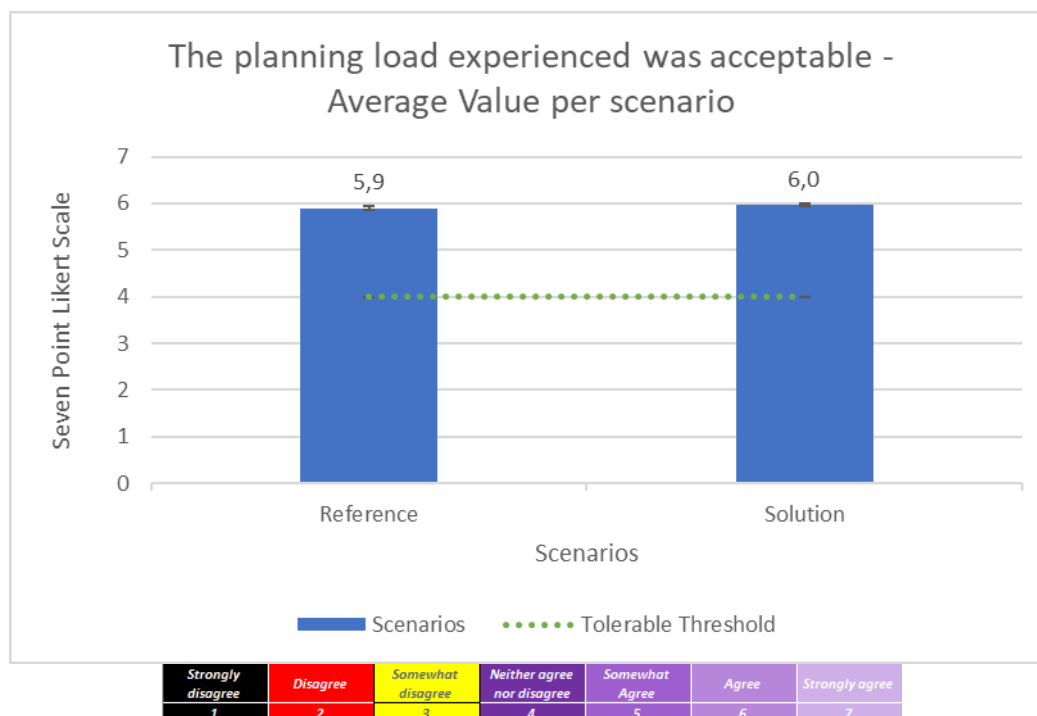


Figure: ATCO Workload – Post Run Questionnaire - Planning load - Average

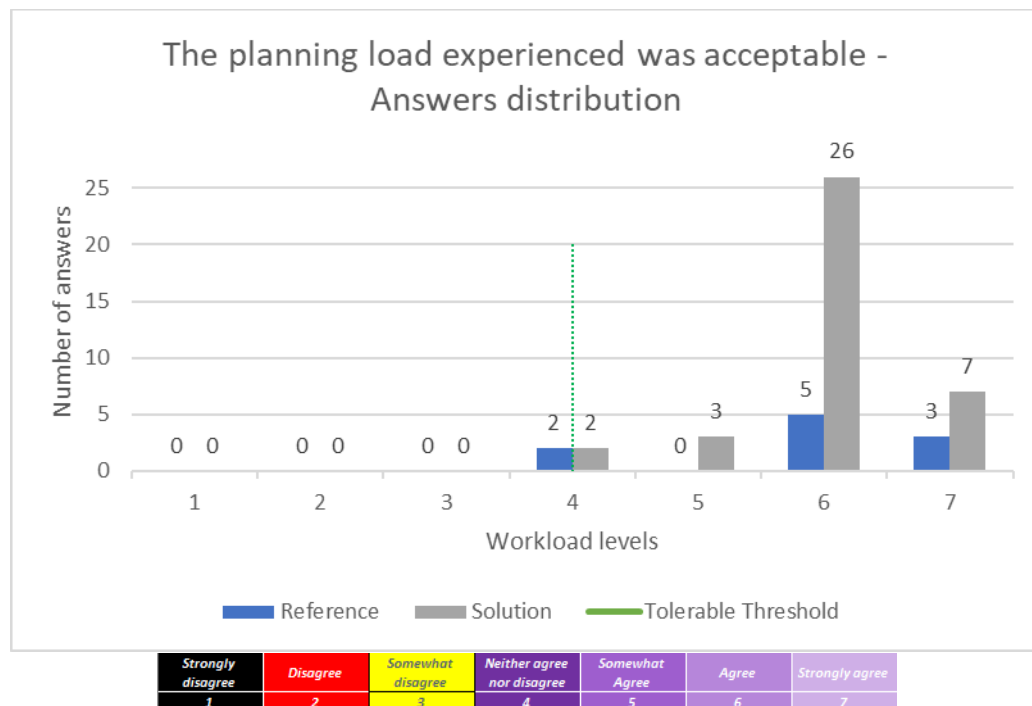


Figure: ATCO Workload – Post Run Questionnaire - Planning load

For the solution scenarios, positive answers were mainly recorded also for the planning load.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | Except for reference scenario 3, where even the communication load was not acceptable according to the feedback provided by the participating ATCOs, the communication load was generally acceptable without significant difference between solution and reference scenarios. The criteria is considered as successfully met considering the most of the responses are on level 6 for the solution scenarios | Ok |

The criteria was assessed through ad-hoc questions in the post run and the responses are analysed in the following graphs (the results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations):

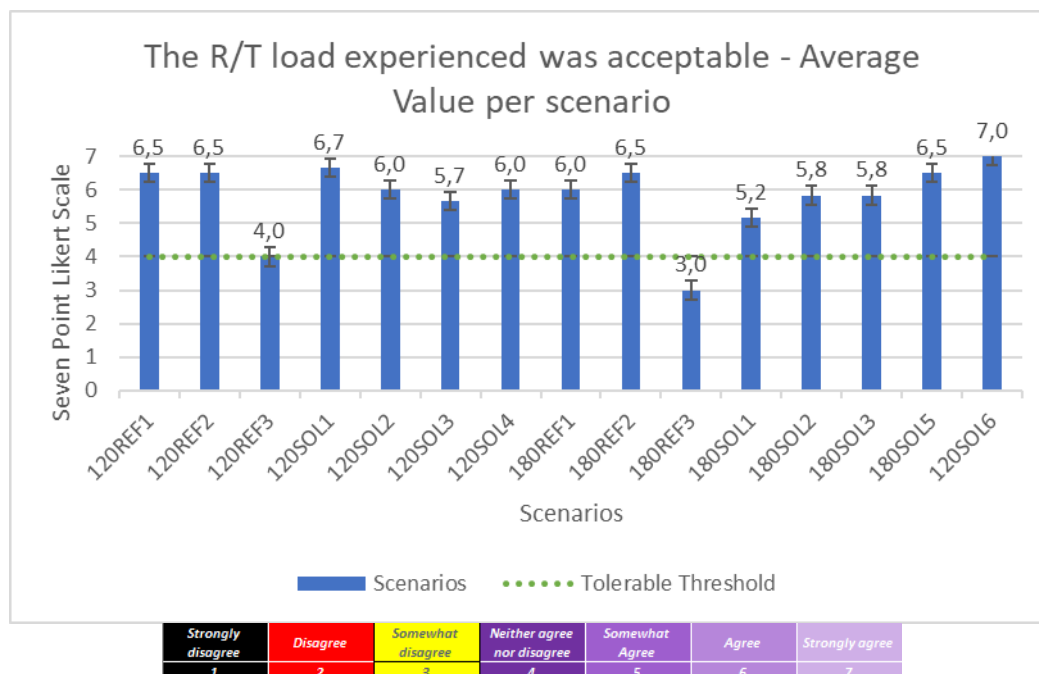


Figure: ATCO Workload – Post Run Questionnaire - R/T load

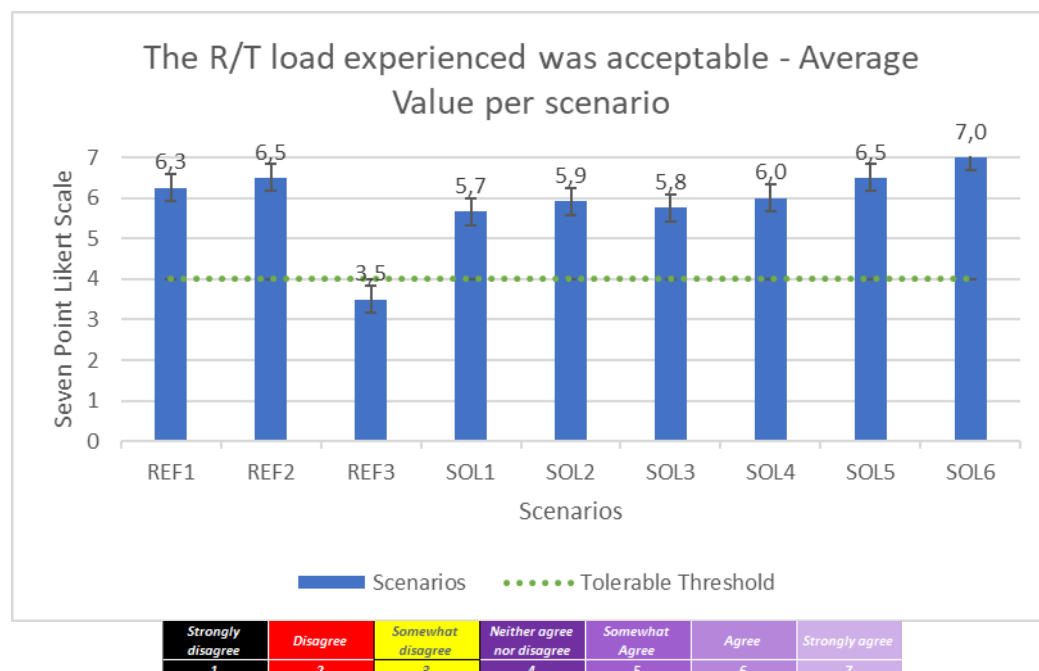


Figure: ATCO Workload – Post Run Questionnaire - R/T load

Except for reference scenario 3, where even the communication load was not acceptable according to the feedback provided by the participating ATCOs, the communication load was generally acceptable without significant difference between solution and reference scenarios, also observable in the following combined average values:

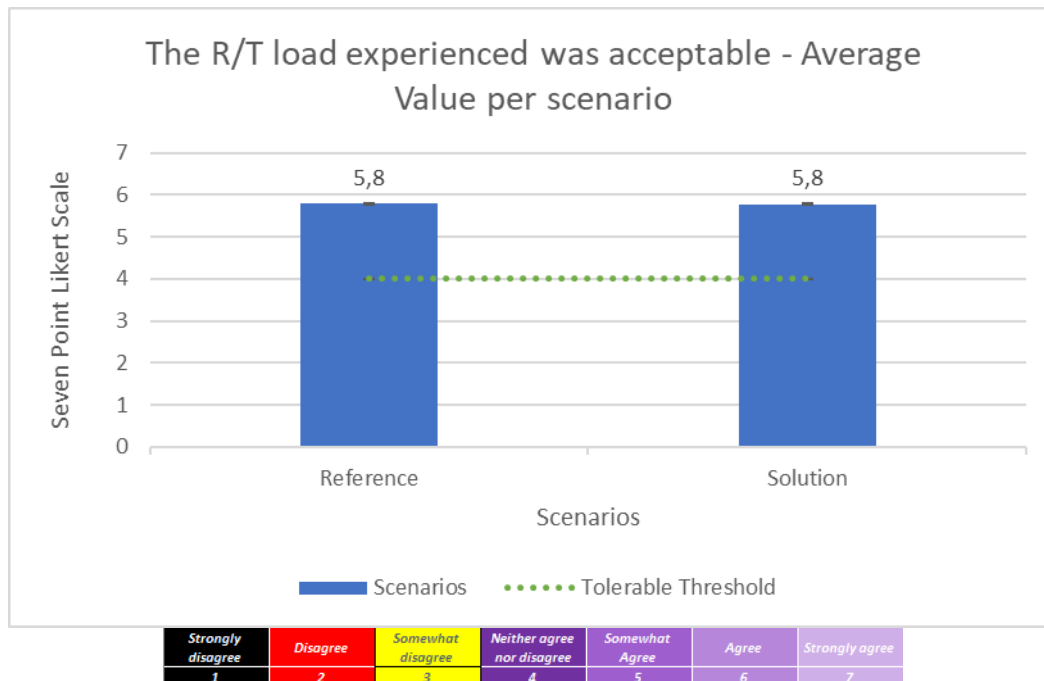


Figure: ATCO Workload – Post Run Questionnaire - R/T load - Average

The criteria is considered as successfully met considering the most of the responses are on level 6 for the solution scenarios which is well above the tolerable threshold.

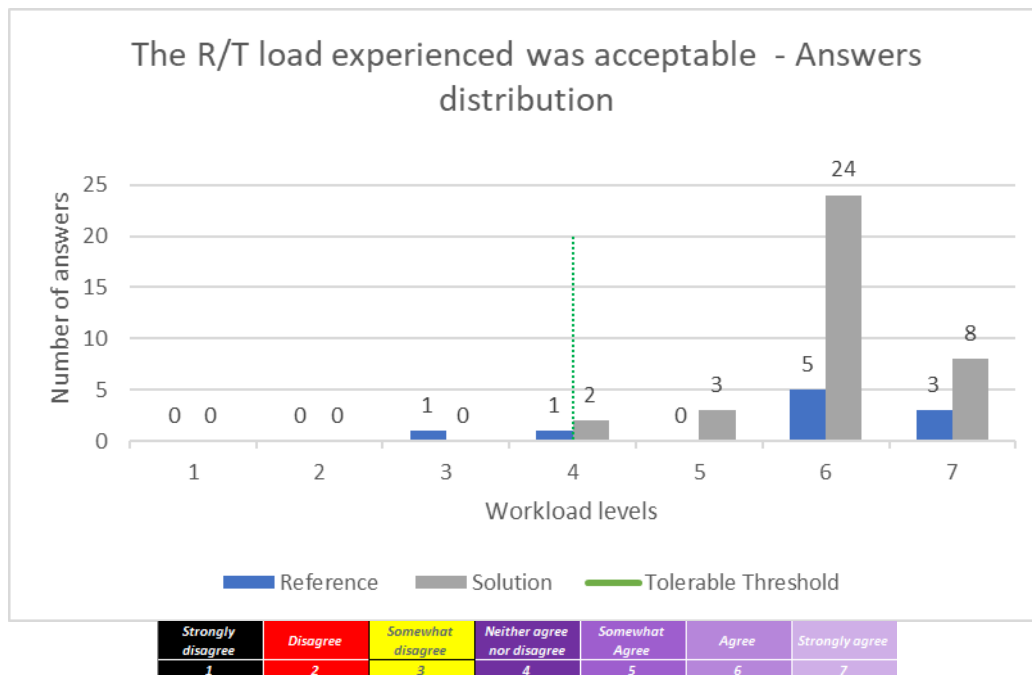


Figure: ATCO Workload – Post Run Questionnaire - R/T load -

The criteria is considered as successfully met

D.3.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

D.3.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal conditions, in case of aircraft emergency and in case of failure of the communication or visualization system when working in an RTC with a flexible allocation of aerodromes between MRTMs | Dedicated procedures and checklist were employed during the simulation for the handover, the abnormal and failure modes (such as during emergency) and the participating test subjects strongly recommended to have dedicated procedures and checklist for the deployment as well. the acceptance was always rated at acceptable level and above the tolerable threshold for the solution | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | <p>scenarios while for the experimented condition of the reference scenario 3 this was not the case. The ATCO did not judge as acceptable to manage 3 aerodromes on one single module without the support of the supervisor balancing their workload by flexibly assigning the airports between the modules. The acceptability of the frequency of the transfer was judged as adequate too.</p> <p>The criteria is considered as OK considering the collected results.</p> | |

The criteria has been assessed through the post simulation questionnaire (complemented by the collected notes of the debriefings and interviews as well as by the conducted observations) and has been successfully met considering the answers provided below are all 3 above the tolerable value of 4. (Neither agree nor disagree).

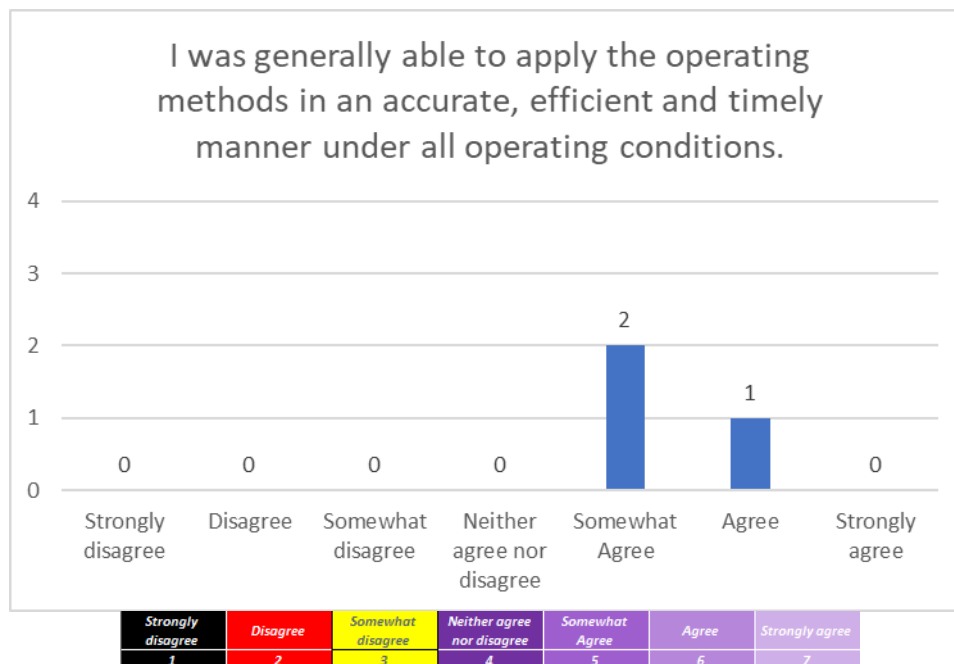


Figure: ATCO Operating method – Post EXE Questionnaire

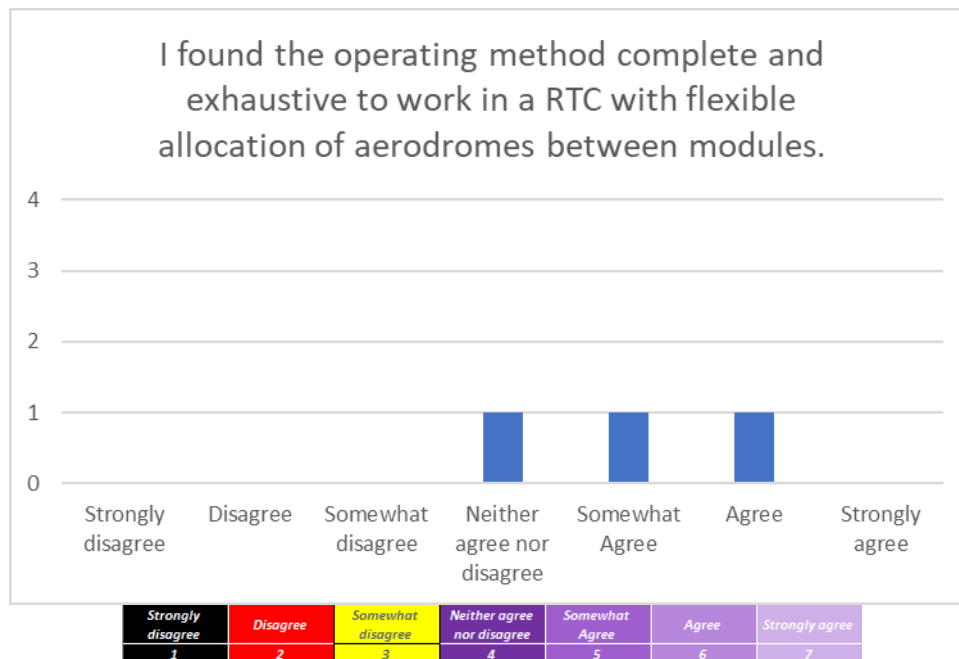


Figure: ATCO Operating method – Post EXE Questionnaire

Dedicated procedures and checklist were employed during the simulation for the handover, the abnormal and failure modes (such as during emergency) and the participating test subjects strongly recommended to have dedicated procedures and checklist for the deployment as well.

Level of acceptance was also rated in the post run questionnaire on the 10 points CARS rate. The results in terms of average are plotted below for the different scenarios:

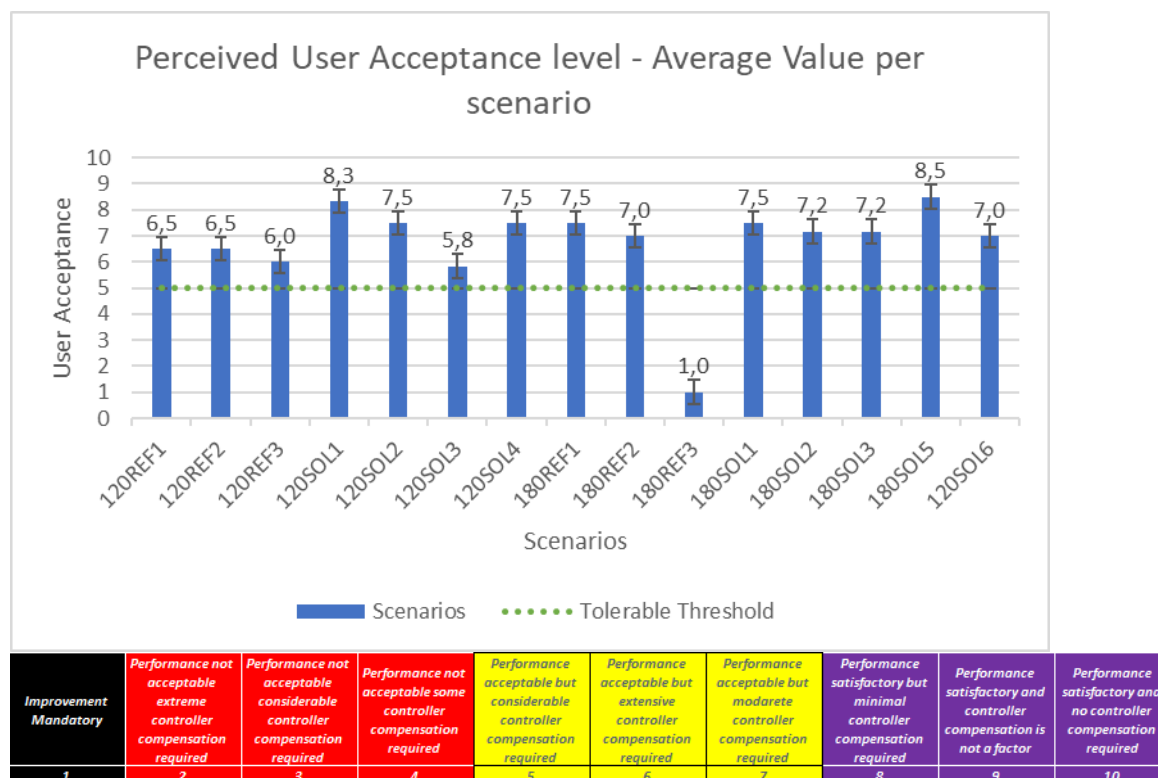


Figure: ATCO User acceptance – Post RUN Questionnaire

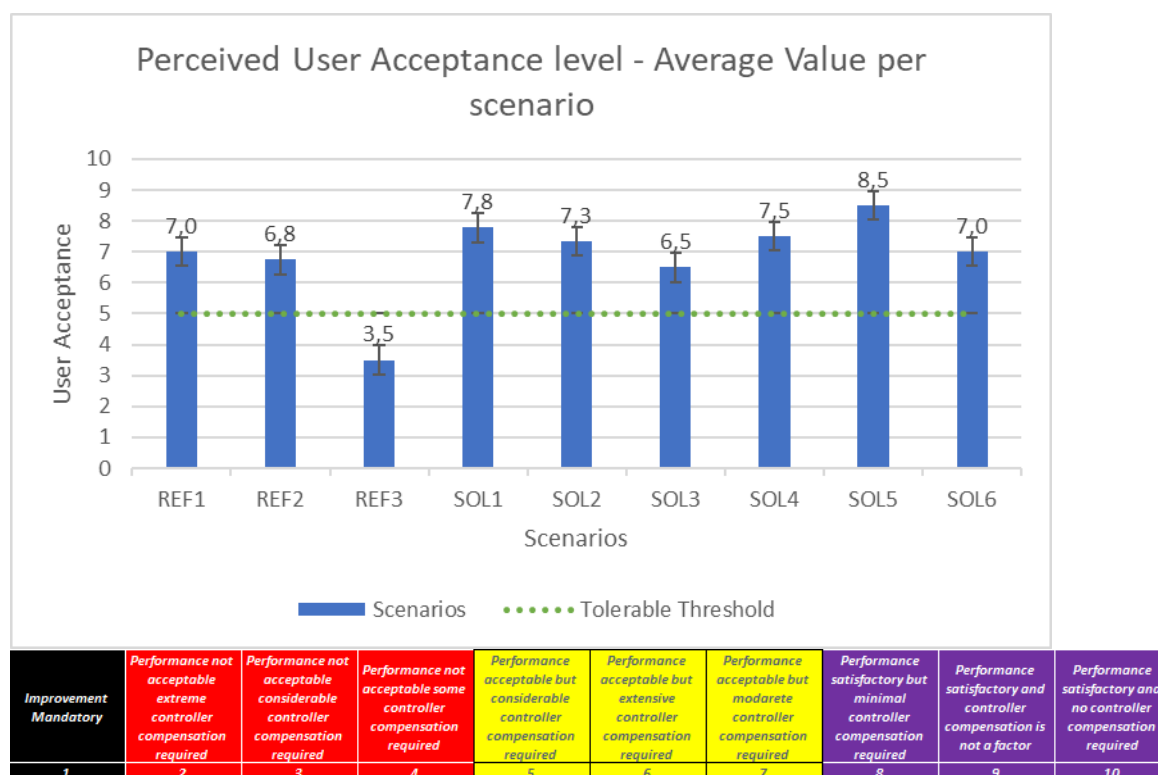


Figure: ATCO User acceptance – Post RUN Questionnaire

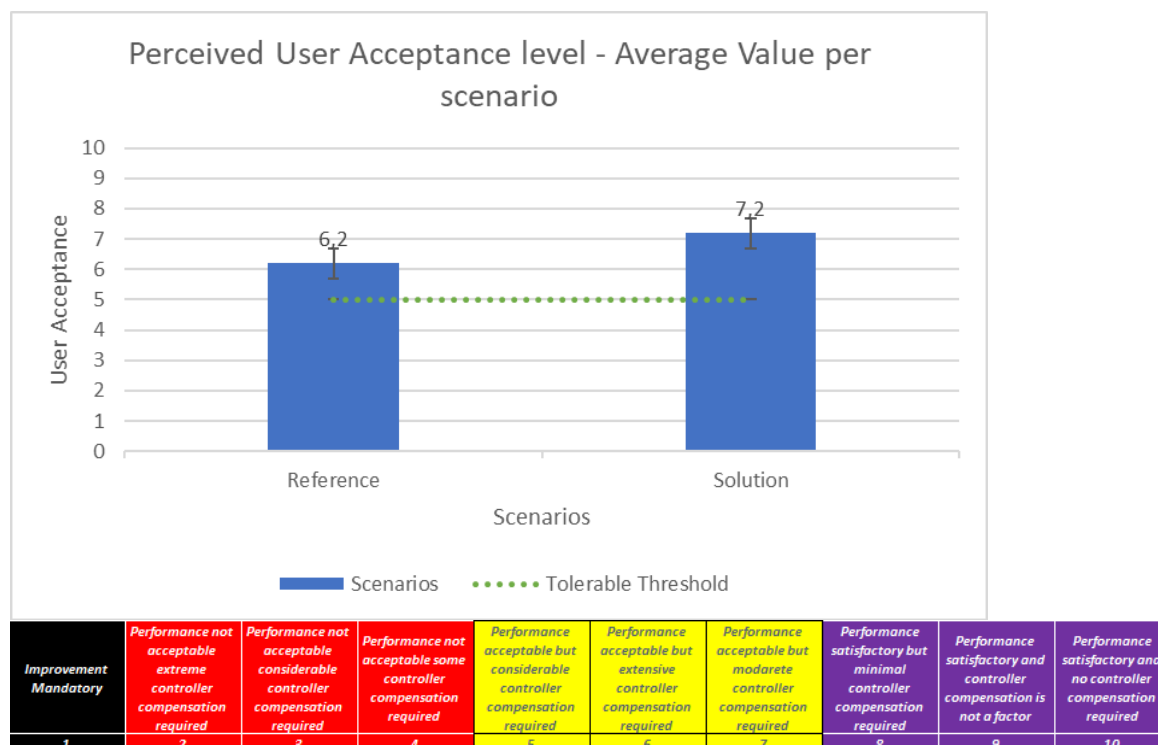


Figure: ATCO User acceptance – Post RUN Questionnaire - Average

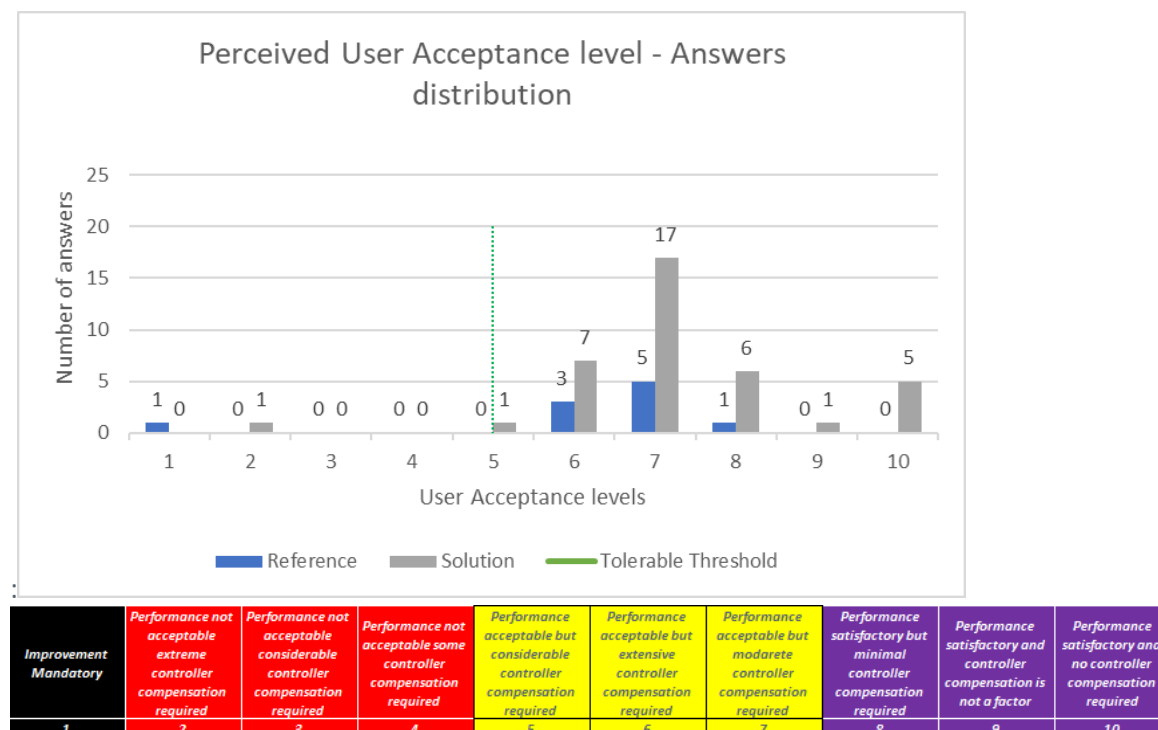


Figure: ATCO User acceptance – Post RUN Questionnaire

As it can be observed in the graphs above, the acceptance was always rated at acceptable level and above the tolerable threshold for the solution scenarios while for the experimented condition of the reference scenario 3 this was not the case. The ATCO did not judge as acceptable to manage 3 aerodromes on one single module without the support of the supervisor balancing their workload by flexibly assigning the airports between the modules.

Finally, the ATCOs were also questioned about the acceptability of the frequency of the transfer which was judged as adequate as summarised in the next post simulation question based on the 7 points scale:

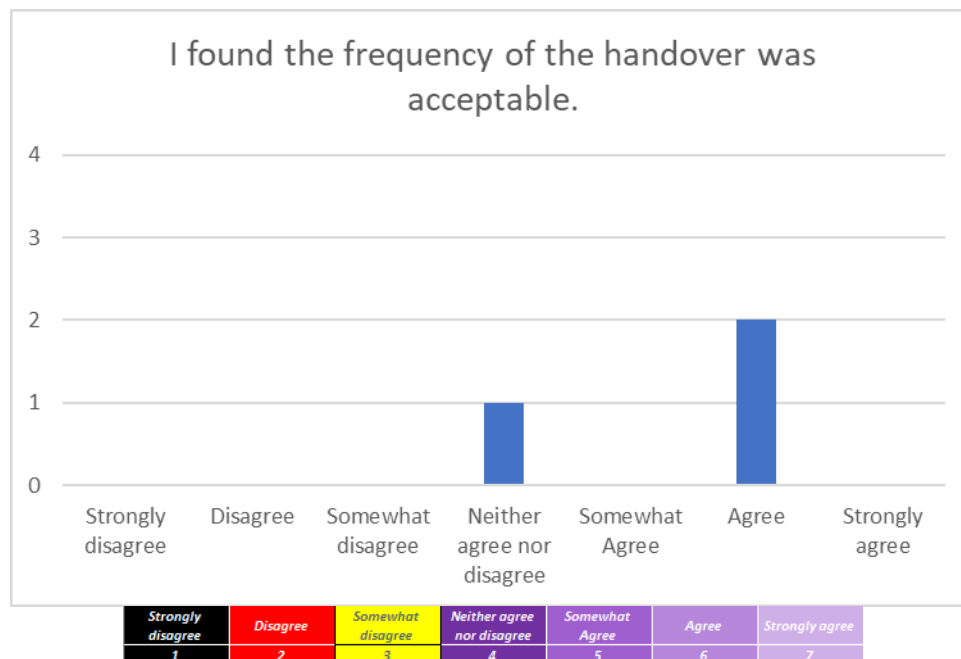


Figure: ATCO Frequency of handover – Post EXE Questionnaire

Indeed 2 of the 3 ATCOs rated the answer on the level 6 which is above the acceptable threshold.

System Logs were analysed to measure the number of handovers for each solution scenario.

The average number of handovers recorded are provided in the following picture:

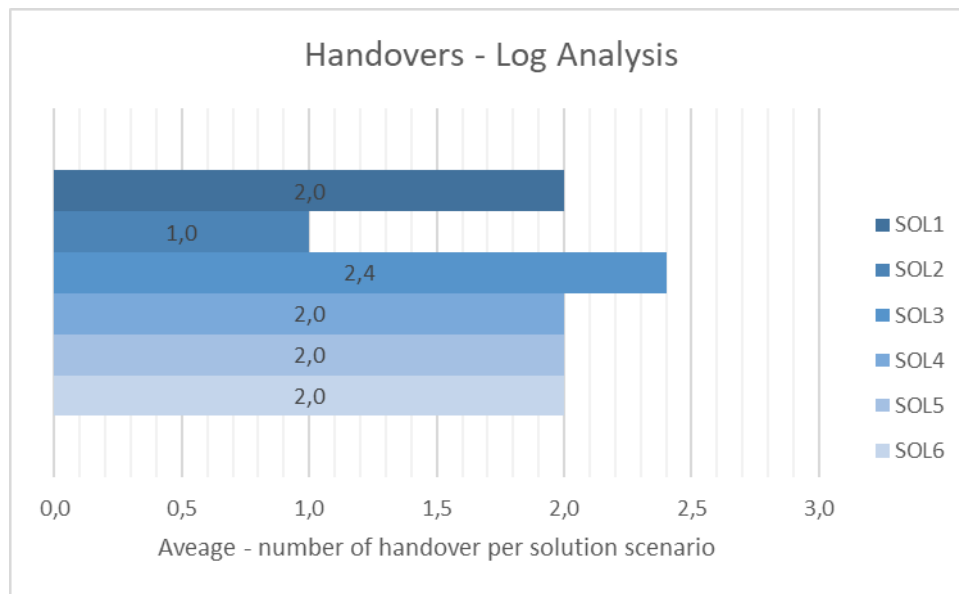


Figure: ATCO Frequency of handover – System Logs analysis

As it can be observed the number of switches is consistent among the scenarios and the SOL3 scenario was the scenario with the most use of the handover. Indeed, the traffic sample of solution 3 had an equivalent load of VFR & IFR and the Supervisor was balancing the workload between the modules to avoid both overload and low load periods. Solution 2, which foresaw the most traffic as VFR, did not require so much balancing of workload.

Solution 4, 5 and 6 were safety related scenarios.

The criteria is considered as OK considering the collected results.

D.3.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

OBJ-PJ05-W2-35-V3-VALP-H07

Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | For the solution scenarios the criteria are judged as successfully met considering the distribution of solution answers are mainly on the level 6 but, even if Roles and responsibilities were judged as feasible in the simulation experience, the test subjects suggested that some responsibilities might be delegated to the supervisor to relief the ATCOs' | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| | | module; e.g. the coordination with other entities might be delegated to the supervisor rather than the ATCOs. | |
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | For the solution scenarios the criteria are judged as successfully met considering the distribution of solution answers are mainly on the level 6. One ATCO somewhat disagree on the feasibility for the management of 3 airports on one single module as it can be observed in the following graph | Ok |

Both the criteria have been investigated in post simulation questionnaire and post run questionnaires through 7 points scale questions as well as during the debriefing. The results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations.

As it can be observed in the following plots, the roles and the possibility of providing ATS services to the assigned number of airports were found feasible in the solution scenarios:

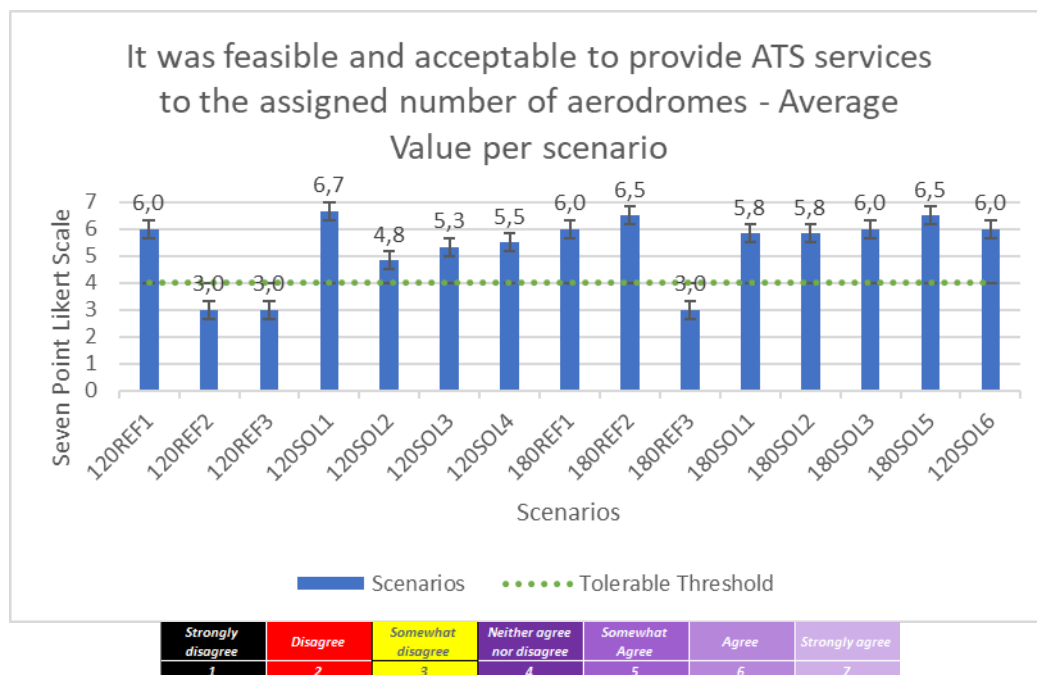


Figure: ATCO Number of assigned aerodromes – Post RUN Questionnaire

For the reference scenarios, especially for REF3 and REF2 experimental conditions not really positive results have been measured, especially in the OTW view based on the 120°. In fact, in reference 3 there was no flexible allocation and 3 airports were assigned to 1 single module during all the run and this was judged not feasible for long period considering the runs were both interrupted few minutes before the end. The REF2 experimental conditions were testing traffic mainly VFR that are the most critical one and without the supervisor supporting the flexible allocation and the balancing of workload between airports it was judged difficult to manage the allocated airports.

Also, the OTW view at 120° required more interactions with the system as already explained in previous sections.

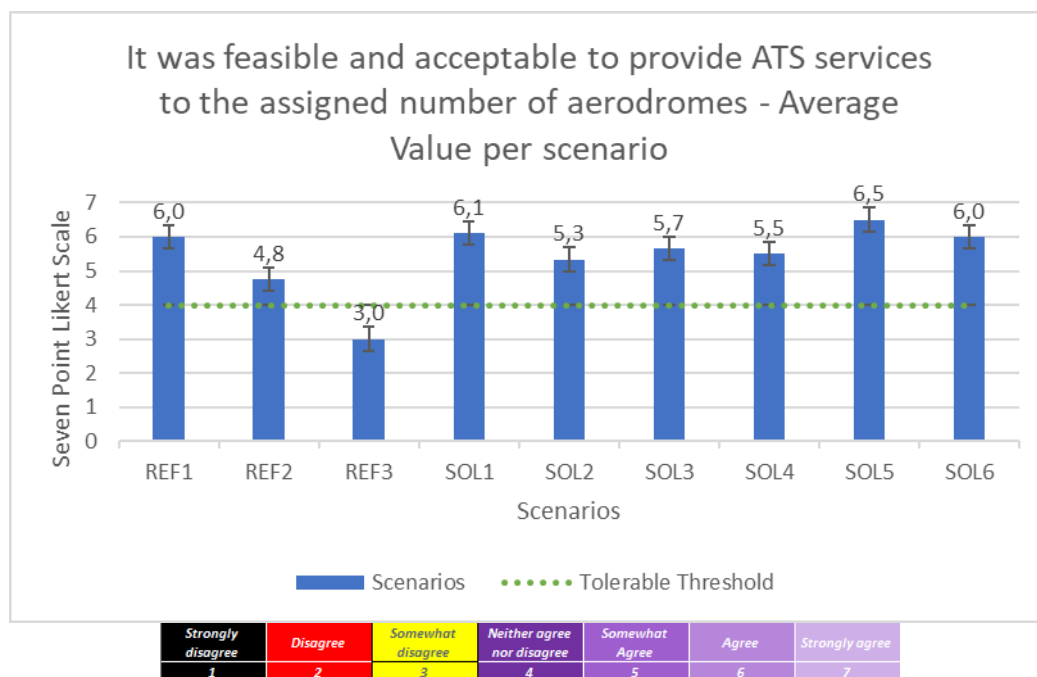


Figure: ATCO Number of assigned aerodromes – Post RUN Questionnaire

This is also visible in the following overall mean value plots, where it's clear that for the solution scenarios the result is farer from the tolerable threshold respect to the reference scenarios.

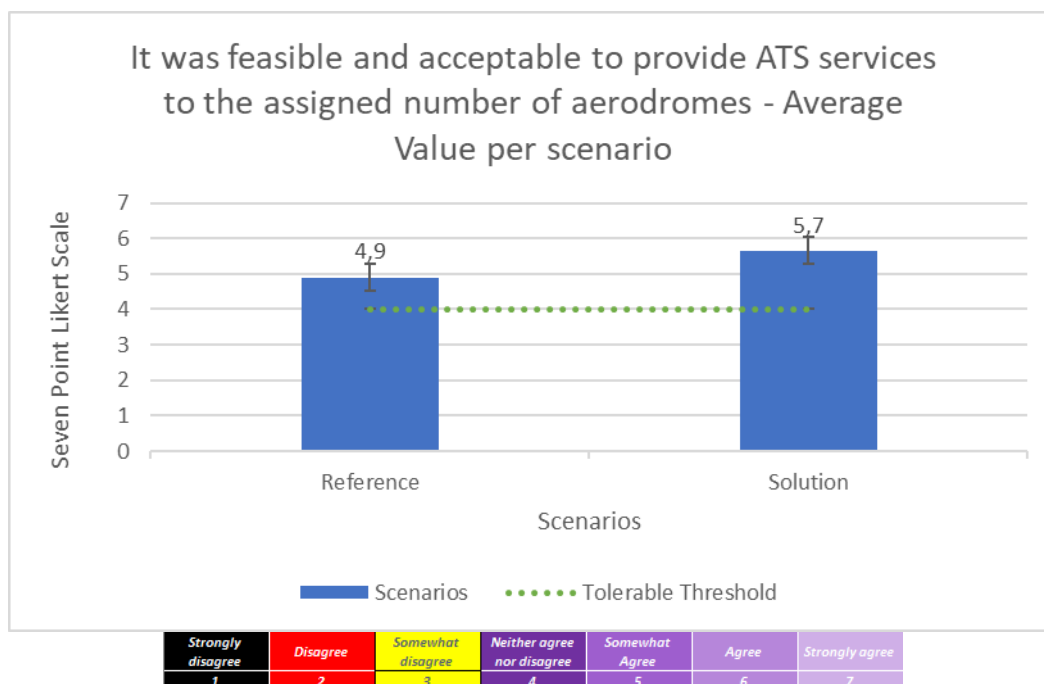


Figure: ATCO Number of assigned aerodromes – Post RUN Questionnaire - average

For the solution scenarios the criteria are judged as successfully met considering the distribution of solution answers are mainly on the level 6 as visible in the following plot:

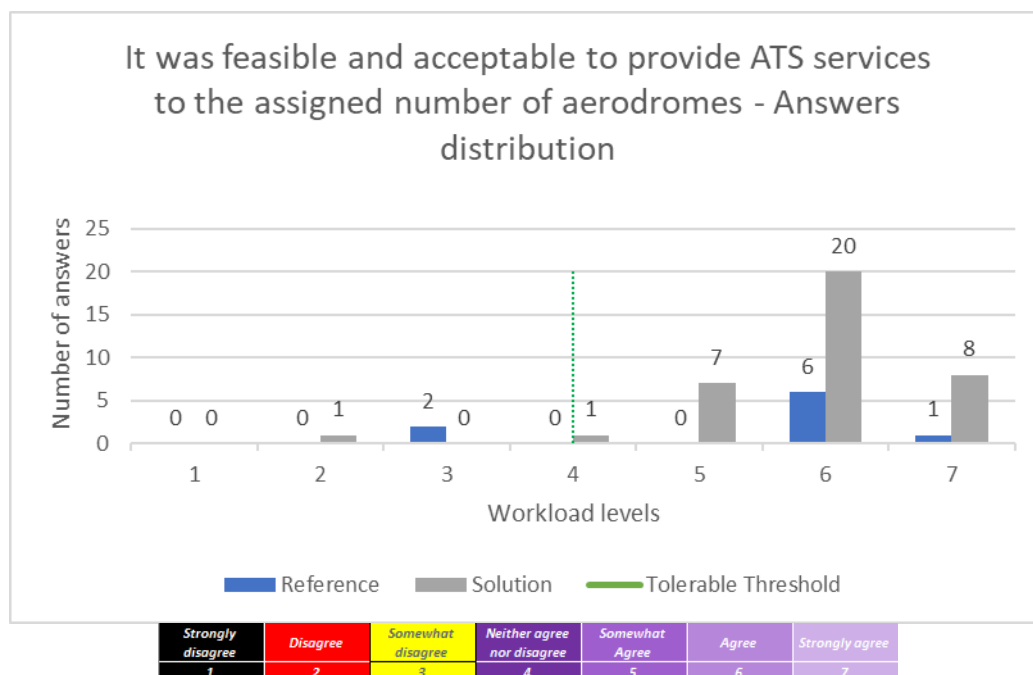


Figure: ATCO Number of assigned aerodromes – Post RUN Questionnaire

Same results for 2 airports on one single remote tower module is also observable in the post simulation question below:

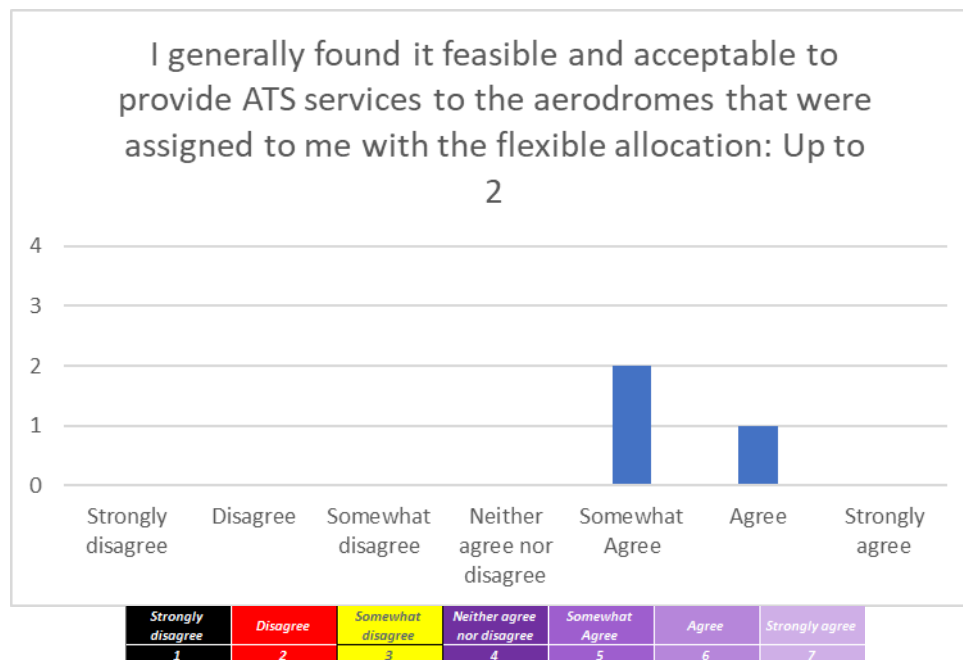


Figure: ATCO Number of assigned aerodromes – Post EXE Questionnaire

One ATCO somewhat disagree on the feasibility for the management of 3 airports on one single module as it can be observed in the following graph:

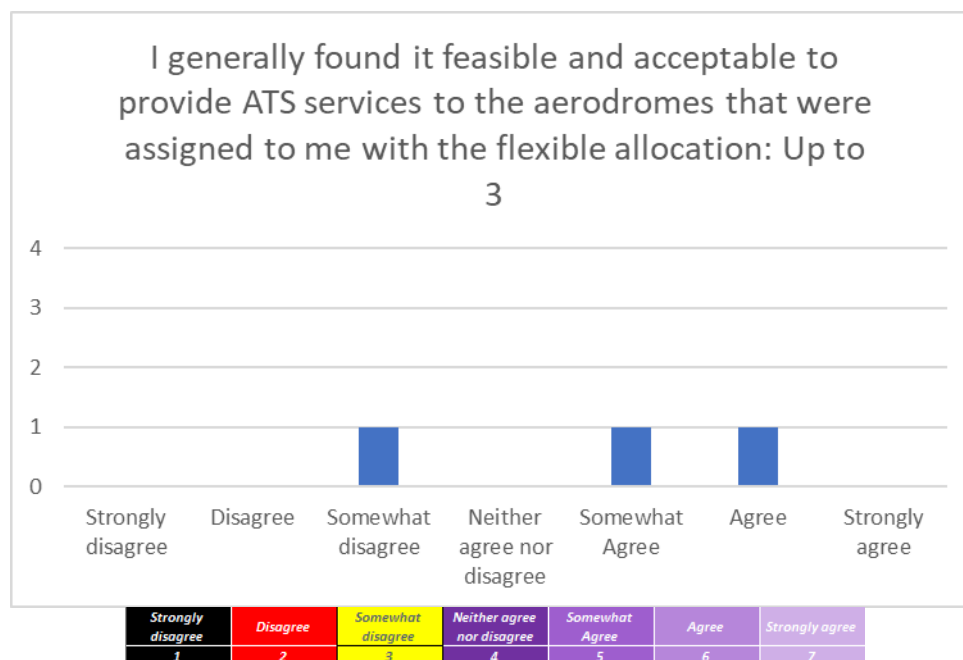


Figure: ATCO Number of assigned aerodromes – Post EXE Questionnaire

Anyway, the most of responses were also positive and this needs to be read in light of the support provided by the supervisor in the balancing of the workload between the 2 modules.

Finally, some feedbacks were also provided in relation to the roles and responsibilities: even if these were judged as feasible in the simulation experience, the test subjects suggested that some responsibilities might be delegated to the supervisor to relief the ATCOs' module; e.g. the coordination with other entities might be delegated to the supervisor rather than the ATCOs.

D.3.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

| OBJ-PJ05-W2-35-V3-VALP-H08 Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal operating conditions, in case of aircraft emergency and in case of failure of the communication or visualization system | No issues neither specific comments were raised about the current employed phraseology and the criteria was successfully assessed | Ok |

No issues neither specific comments were raised about the current employed phraseology and the criteria was successfully assessed also in the post simulation question reported below:

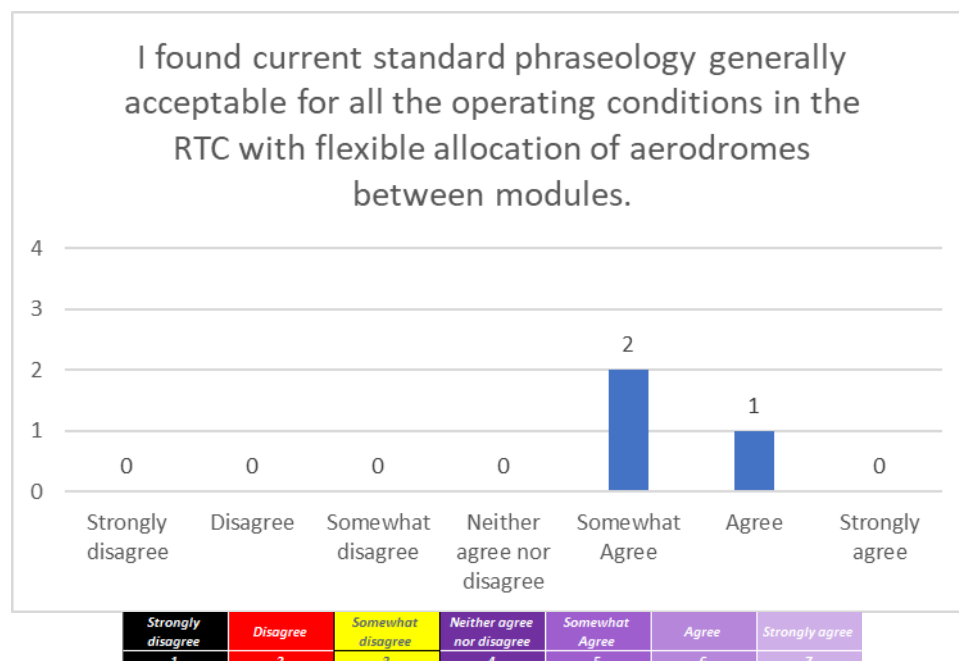


Figure: ATCO Phraseology– Post EXE Questionnaire

The criteria is judged as successfully met considering the above mostly positive results.

D.3.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

D.3.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

Assess that human-machine interface supports the team in carrying out their tasks

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | <p>ATCOs confirm that the user interface design supports a sufficient level of situation awareness. Even if the overall trend is in the positive area of the answers, the difference between the tolerable threshold and the mean values is not so distant as the other analysed indicators. This is to be seen mainly in relation to the employed HMI as all the test subjects suggested improvements, especially in the position of the emergency button and the handover transfer that were located in the border of the head-down display while the ATCOs would have preferred them integrated in the strip bay area. These results are to be interpreted as recommendations for the simulating environment rather than the concept itself and what can be generalised for the concepts is that before the deployment the HMI of the technical system shall be locally assessed and designed in relation to the specific operational environment.</p> <p>Another possible issue was in relation to the fix position of the airports in the out of the window view and CWP head down display. While in the previous phase of the project it was recommended to keep fix position for the airports to help the situation awareness, the collected feedback was that the fix position had an opposite effect, especially when the transferred airport was a third airport in the middle fix position: during the</p> | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | transfer allocating the airport in the middle caused a temporary disorientation of the ATCOs that required a few times to recap the exact position of the airports. Despite the suggested improvements, the criteria is judged as met, considering the most of responses provided is on the level six for the solution scenario. | |

The criteria has been addressed in a 7 points scale ad hoc question:

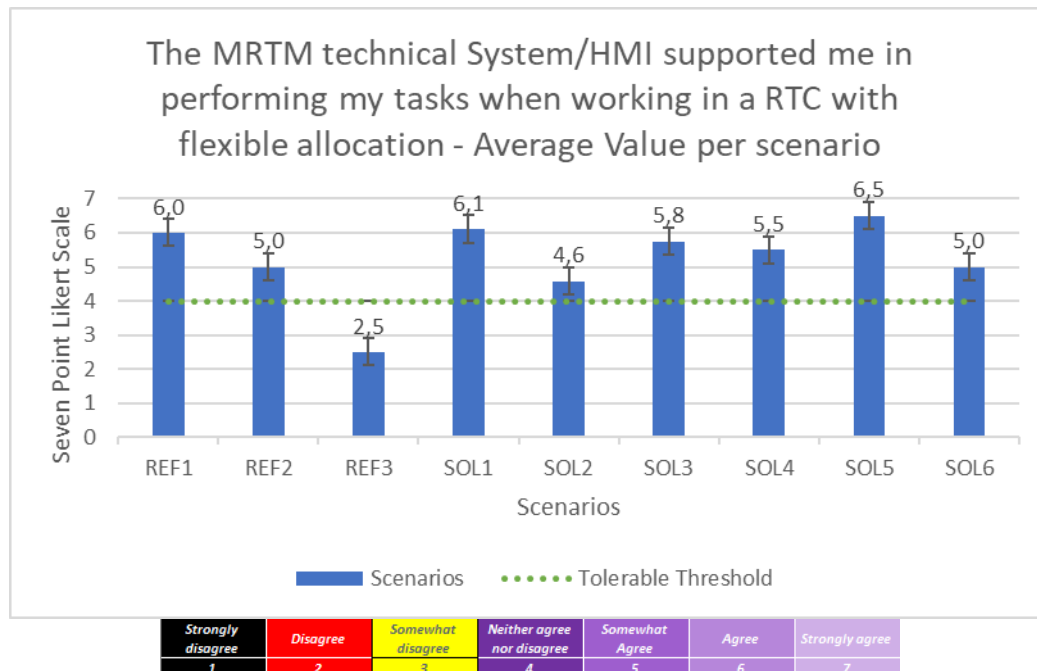


Figure: ATCO – Technical system support– Post Run Questionnaire

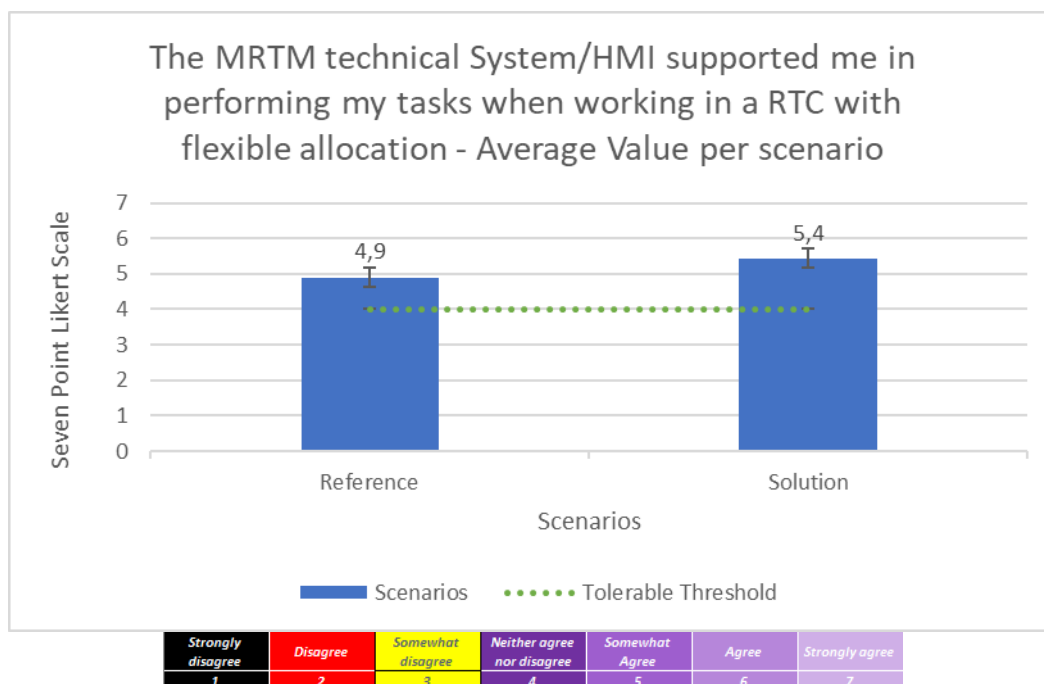


Figure: ATCO – Technical system support – Post Run Questionnaire

Even if the overall trend is in the positive area of the answers, there is one point below the tolerable threshold and the difference between the threshold and the mean values is not so distant as the other analysed indicators. This is to be seen mainly in relation to the employed HMI as all the test subjects suggested improvements, especially in the position of the emergency button and the handover transfer that were located in the border of the head-down display while the ATCOs would have preferred them integrated in the strip bay area. Also, the ATCOs complained about the number of status of the electronic flight progress system bay and the movements of the transfer between the strip bays that was not fully aligned to their day to day system. Indeed the comments were:

- “PEA buttons to be placed in a better position (eg. Near the strip bay)”
- “Strip bay not completely functional for my needs”

These results are to be interpreted as recommendations for the simulating environment rather than the concept itself and what can be generalised for the concepts is that before the deployment the HMI of the technical system shall be locally assessed and designed in relation to the specific operational environment.

Same results can be observed looking at the both the average values per scenarios and the combined average values for references and solutions scenarios reported below.

Another possible issue was in relation to the fix position of the airports in the out of the window view and CWP head down display. While in the previous phase of the project it was recommended to keep fix position for the airports to help the situation awareness, the collected feedback was that the fix position had an opposite effect, especially when the transferred airport was a third airport in the middle fix position: during the transfer allocating the airport in the middle caused a temporary disorientation of the ATCOs that required a few times to recap the exact position of the airports. They would have preferred to receive the transferred airport always occupying the last position in all the

screen i.e. on the bottom of the displays for the external view and on the right on the head down CWP displays.

Despite the suggested improvements, the criteria is judged as met, considering the most of responses provided in the plot below is on the level six for the solution scenario.

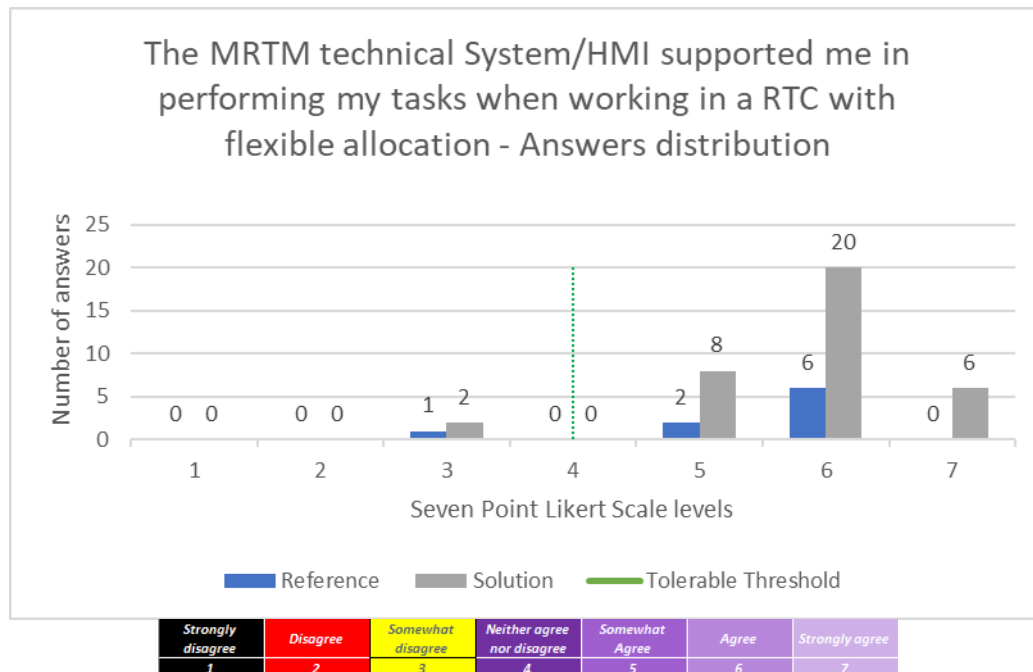


Figure: ATCO – Technical system support – Post Run Questionnaire

Other points discussed were in relation to the PTZ and the out of the windows view. Indeed, the ATCOs, especially in the 120° experimented out of the windows view complained about the difficulties in the interaction with the OTW/PTZ functionalities: being the runway not entirely visible in these experimental conditions they needed to frequently rotate the OTW or interact with the PTZ to check the runway clear before departure and landing and the system required several actions, taking time that could have been dedicated to other tasks. Moving to the 180° OTW view experimental condition the situation was improved as they did not need to frequently interact with the visual system.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | Even if the criteria is considered successfully met as the overall perception was that human error was not increased in terms of potential and severity respect to the scenario without flexible allocation being the most of the answers above the tolerable threshold of 4, the ATCOs | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | commented that there is the need to always properly balance the workload in order to minimise the impact on human error, meaning that the team human error potential is acceptable if the workload of the operators is acceptable. | |

Human error was investigated through post simulation questionnaire in terms of potential for human error and severity of human error in the ATCO post simulation questionnaire, complemented by the collected notes of the debriefings and interviews as well as by the conducted observations.

The ATCOs responses are reported below for both the potential and the severity.

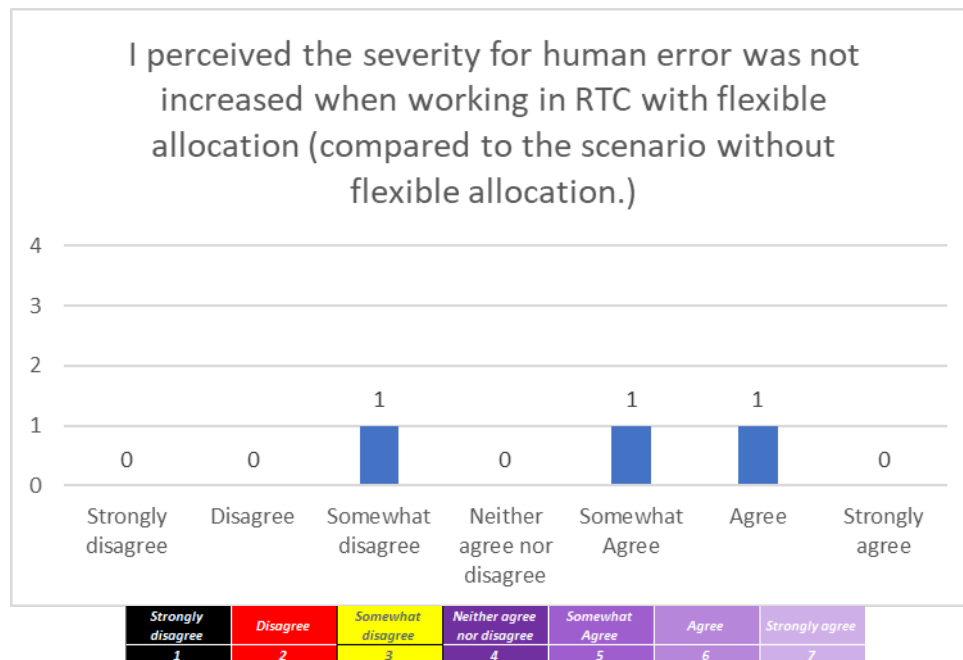


Figure: ATCO Human error– Post EXE Questionnaire

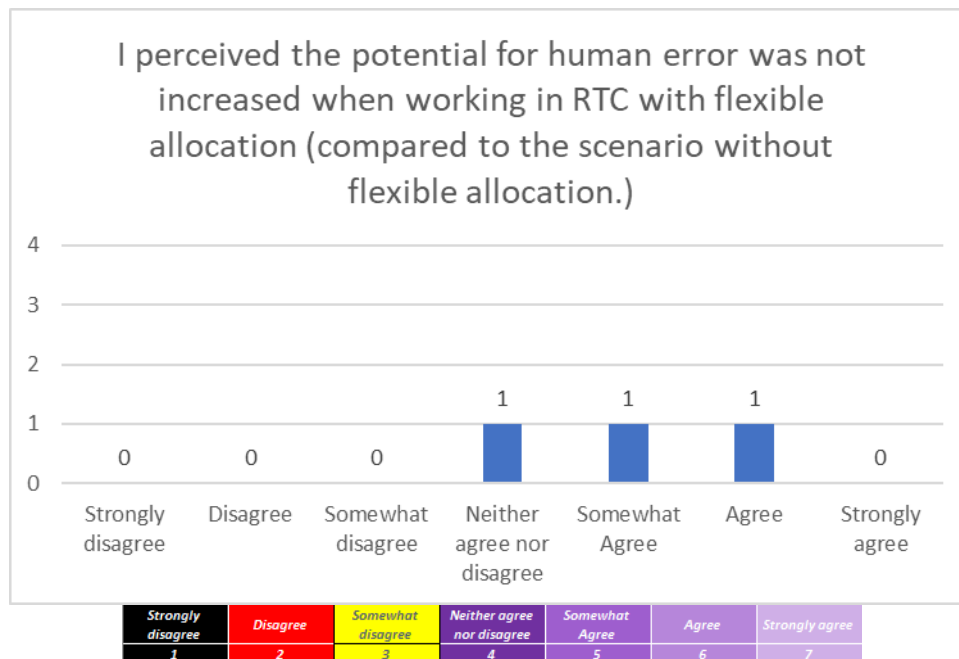


Figure: ATCO Human error– Post EXE Questionnaire

Even if the criteria is considered successfully met as the overall perception was that human error was not increased in terms of potential and severity respect to the scenario without flexible allocation being the most of the answers above the tolerable threshold of 4, the ATCOs commented that there is the need to always properly balance the workload in order to minimise the impact on human error, meaning that the team human error potential is acceptable if the workload of the operators is acceptable.

D.3.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way | <p>Most of the controllers agreed or somewhat agreed that they had all the required information to complete their tasks.</p> <p>They did not raise any issue in relation to the level of information that were provided but they suggested to define proper checklist for the handover, the</p> | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | <p>anormal mode and the degraded mode.</p> <p>The criteria is considered as successfully met considering the provided answers.</p> | |

The criteria was assessed through an ad-hoc question in the post simulation questionnaire on 7 points scale complemented by observations and debriefing notes.

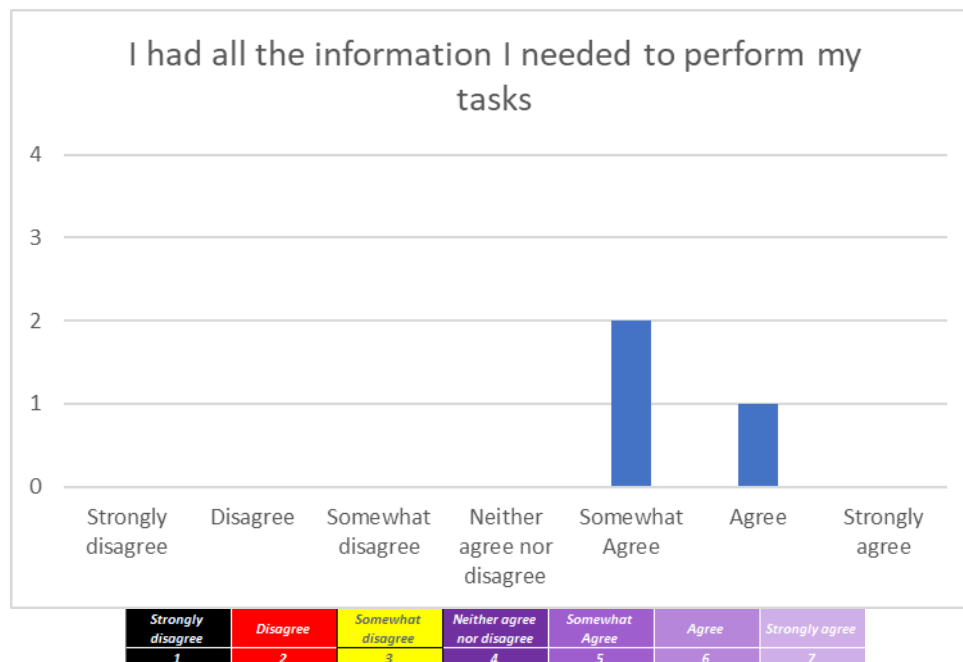


Figure: ATCO Level of Information– Post EXE Questionnaire

Most of the controllers agreed or somewhat agreed that they had all the required information to complete their tasks.

They did not raise any issue in relation to the level of information that were provided but they suggested to define proper checklist for the handover, the anormal mode and the degraded mode.

The criteria is considered as successfully met considering the provided answers.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | Even if the ATCOs suggested improvements in the Electronic Flight Progress Strip System and other systems provided during the experiment, these were not under assessment, being the main focus of the exercise the validation of an RTC | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | <p>with flexible allocation of airports between modules. Even if some of these feedback are reported in the objective assessment H01, H02, H04 as possibly affecting the investigated indicators, they are not reported in relation to this H11 objectives being the above mentioned focus (RTC with flexible allocation) the key element of the usability assessment.</p> <p>The average value of the easy to use answer are within the tolerable threshold even if few cases are below the acceptable value. Indeed, the ATCOs raised that the handover system was not completely easy to use as the button was located in a position difficult to access.</p> <p>Despite the suggested improvements, most of the ATCOs responses are located above the tolerable threshold.</p> <p>For the post simulation questions, 2 out of the 3 involved ATCOs somewhat agreed that the usability of the MRTM handover system was adequate, while one somewhat disagreed. As for the post simulation, this is not a so strong positive result for the above-mentioned issues during the transfer.</p> <p>About the timing of the handover, there were different perception: 1 ATCO agreed that the handover was timely executed, one somewhat agreed and a last one Neither agreed nor disagreed.</p> <p>Overall, the criteria is considered as ok.</p> | |

The criteria was assessed through customised questions from SUS in the post simulation questionnaire and post run questionnaire adapted to a 7 points scale and complemented by observations and debriefing notes.

The results are provided only for the solution scenario as the reference had no handover system.

Even if the ATCOs suggested improvements in the Electronic Flight Progress Strip System and other systems provided during the experiment, these were not under assessment, being the main focus of the exercise the validation of an RTC with flexible allocation of airports between modules. Even if some of these feedback are reported in the objective assessment H01, H02, H04 as possibly affecting the investigated indicators, they are not reported in relation to this H11 objectives being the above mentioned focus (RTC with flexible allocation) the key element of the usability assessment.

As it can be observed for the average value of the easy to use answer, mostly of the responses are in the positive area of the plot, above the tolerable threshold of 4 points.

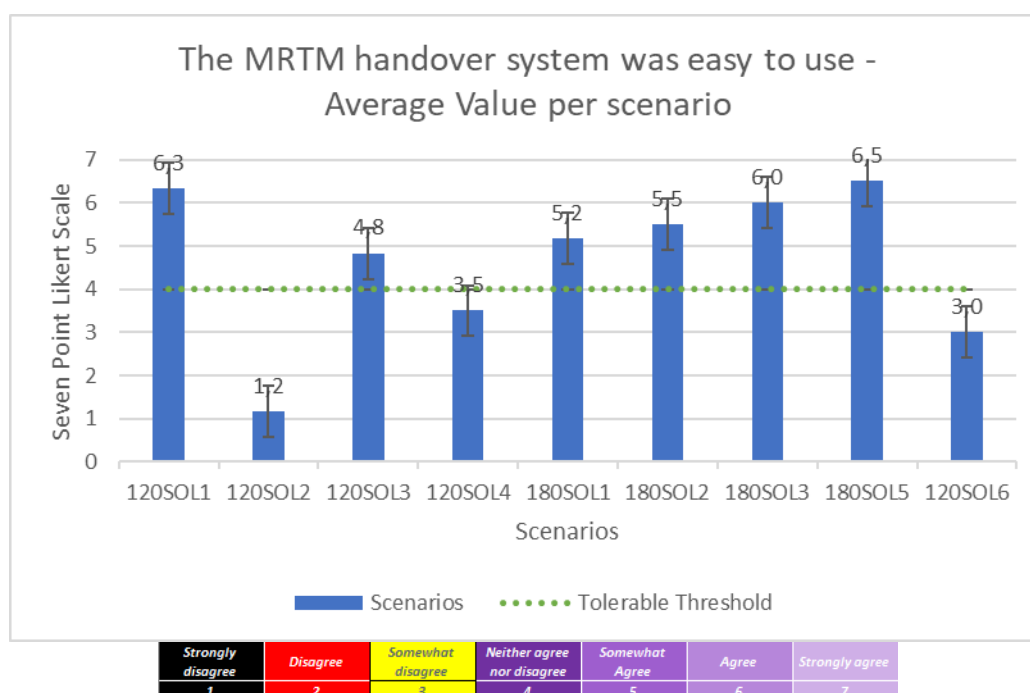


Figure: ATCO Usability– Post RUN Questionnaire

Few cases are below the acceptable value. Indeed, the ATCOs raised that the handover system was not completely easy to use the button was located in a position difficult to access.

This is also visible in the graph provided below:

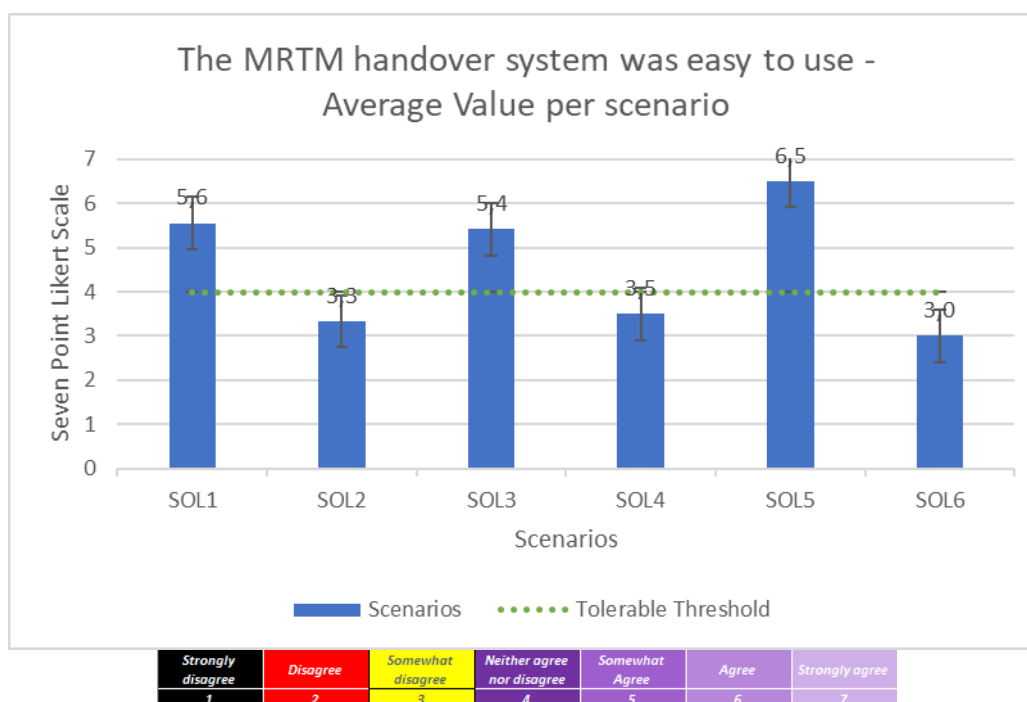


Figure: ATCO Usability– Post RUN Questionnaire

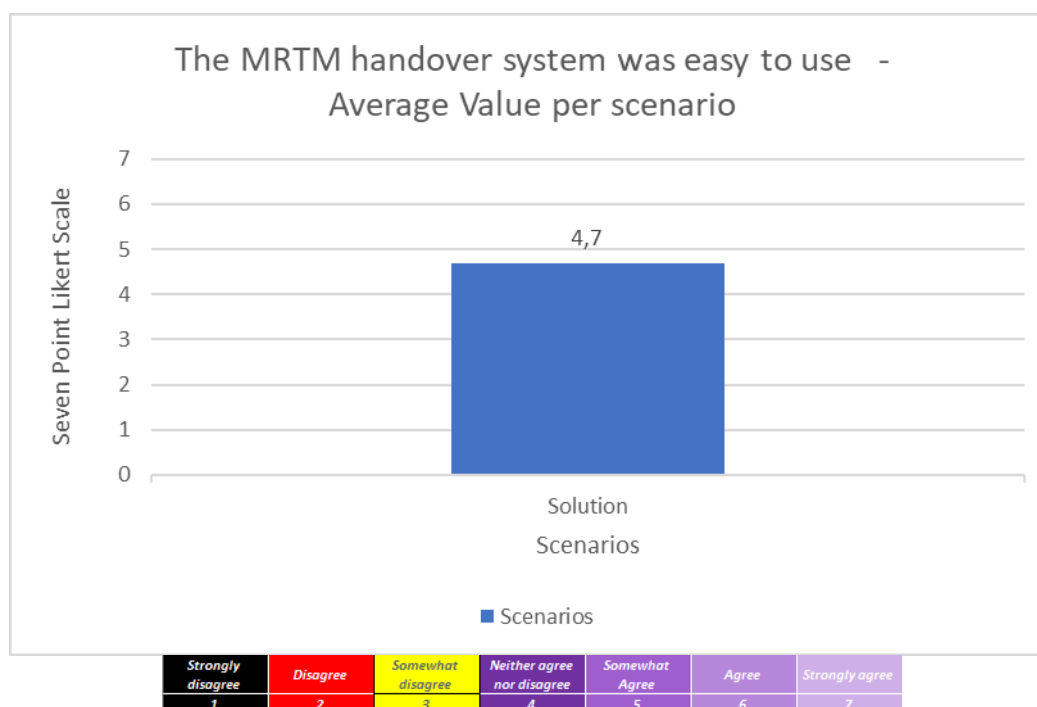


Figure: ATCO Usability– Post RUN Questionnaire

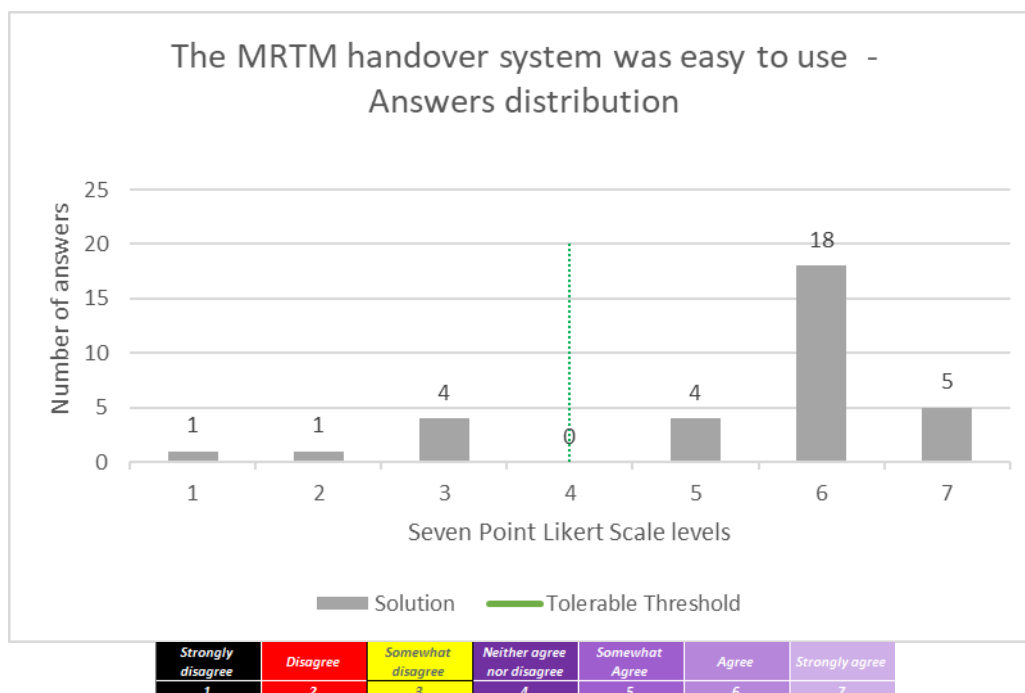


Figure: ATCO Usability– Post RUN Questionnaire

Despite the suggested improvements, most of the ATCOs responses are located above the tolerable threshold, as observable in the plot above.

For the post simulation questions, 2 out of the 3 involved ATCOs somewhat agreed that the usability of the MRTM handover system was adequate, while one somewhat disagreed. As for the post simulation, this is not a so strong positive result for the above-mentioned issues during the transfer.

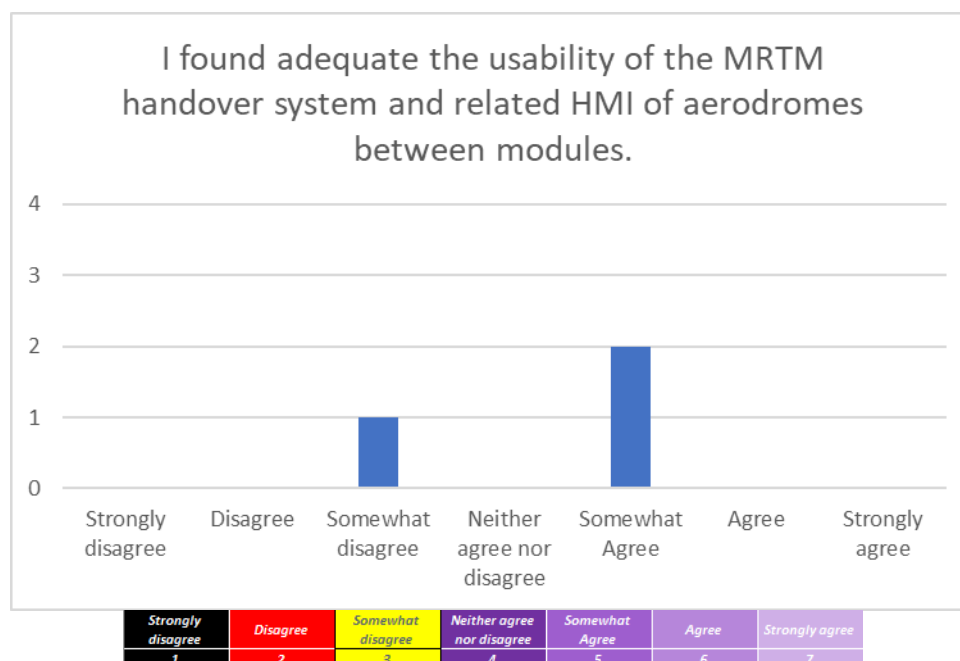


Figure: ATCO Usability– Post RUN Questionnaire

About the timing of the handover, there were different perception: 1 ATCO agreed that the handover was timely executed, one somewhat agreed and a last one Neither agreed nor disagreed.

See the following graph:

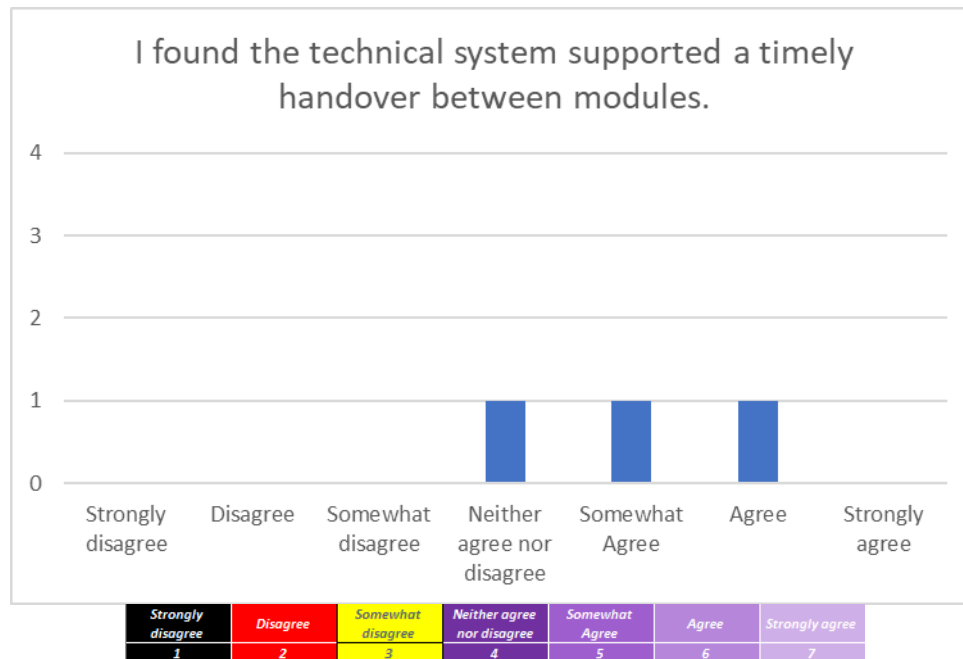


Figure: ATCO Usability– Post EXE Questionnaire

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability of alarms for emergency situation | About the alarms and alerts, there were different perception: 1 ATCO agreed that alarms and alerts were effective and not intrusive, one somewhat agreed and a last one Neither agreed nor disagreed. The criteria is judged as met being the most of the answers above the tolerable threshold of 4 | Ok |

as it can be see in the post simulation 7 points scale question below:

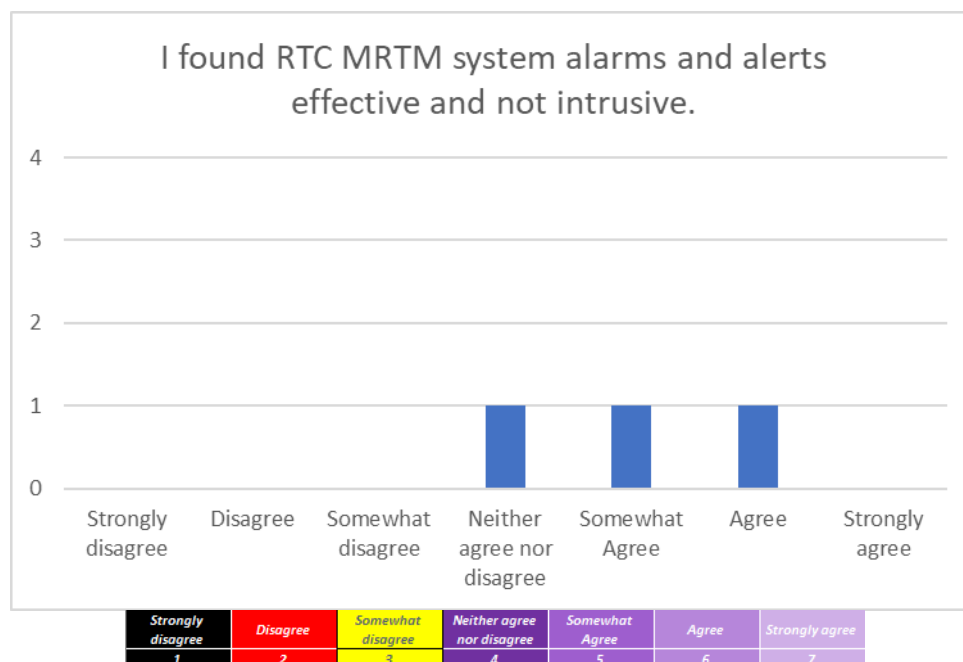


Figure : ATCO Alarms & Alerts– Post EXE Questionnaire

Even if the criteria is judged as met being the most of the answers above the tolerable threshold of 4, the ATCOs raised during the debriefing that the emergency button location and HMI could be improved to avoid any confusion. Indeed, initially the ATCO communicated to the supervisor the emergency (solution 4 experimental condition) on a wrong airport through the CWP dedicated HMI function as it was located too far from the reachable area and was too small.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | Even if the criteria is considered successfully met as the overall perception was that human error was not increased in terms of potential and severity respect to the scenario without flexible allocation being the most of the answers above the tolerable threshold of 4, the ATCOs commented that there is the need to always properly balance the workload in order to minimise the impact on human error, meaning that the team human error potential is acceptable if the workload of the operators is acceptable. Also, considering what mentioned about the HMI of the | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | transfer system and the emergency communication system (to SUP) improvements are needed in terms of design of the HMI. | |

This criteria has been investigated with the same question as for CRT-PJ05-W2-35-V3-VALP-H18.02 and thus the results are copied below.

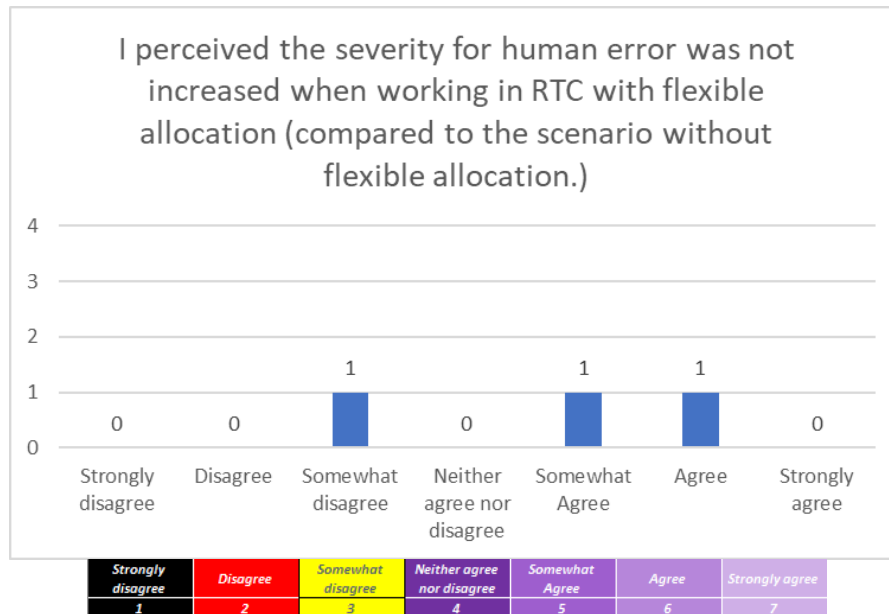


Figure: ATCO Human Error– Post EXE Questionnaire

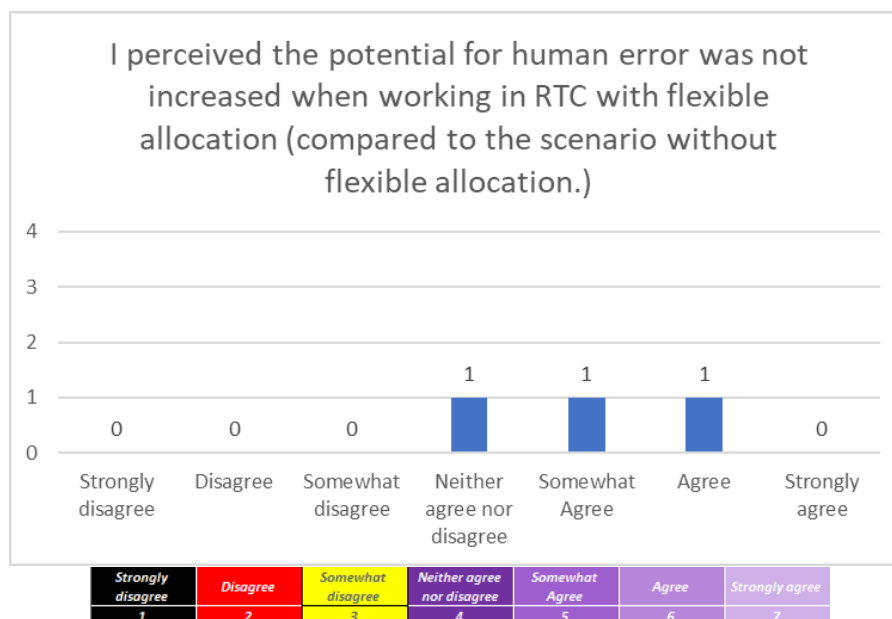


Figure: ATCO Human Error– Post EXE Questionnaire

Even if the criteria is considered successfully met as the overall perception was that human error was not increased in terms of potential and severity respect to the scenario without flexible allocation being the most of the answers above the tolerable threshold of 4, ATCOs commented that there is the need to always properly balance the workload in order to minimise the impact on human error, meaning that the team human error potential is acceptable if the workload of the operators is acceptable.

Also, considering what mentioned about the HMI of the transfer system and the emergency communication system (to SUP) improvements are needed in terms of design of the HMI.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of flight list traffic forecast and prioritisation function integrated in the EFPS system for the next action to be performed | Considering the provided answers in the post run question (The MRTM prioritization system was easy to use), the criteria is considered as successfully met considering as most of the answers are above the tolerable threshold. Despite most of the answers are positive, there are some scenarios that does not reach a satisfactory value. Indeed, during the debriefing, the ATCOs judged it as useful but there was not so much interest in it. It has to be considered, when reading these results, that ATCOs involved in the exercise were not familiar with the EFPS system, so the HMI indication processed by the ATCO Planning Tool algorithm was not always obvious as supporting information. Moreover, the algorithm itself would need to be enriched with as many cases as possible in order to be able to perform its task in most situations, perhaps by associating artificial intelligence and machine learning technology with this tool. | Ok |

The criteria was assessed in the post simulation and post run questionnaires and complemented by debriefing and observations.

Considering the provided answers in the post run question (The MRTM prioritization system was easy to use) provided in the next pictures in terms of average values, the criteria is considered as successfully met considering as most of the answers are above the tolerable threshold.

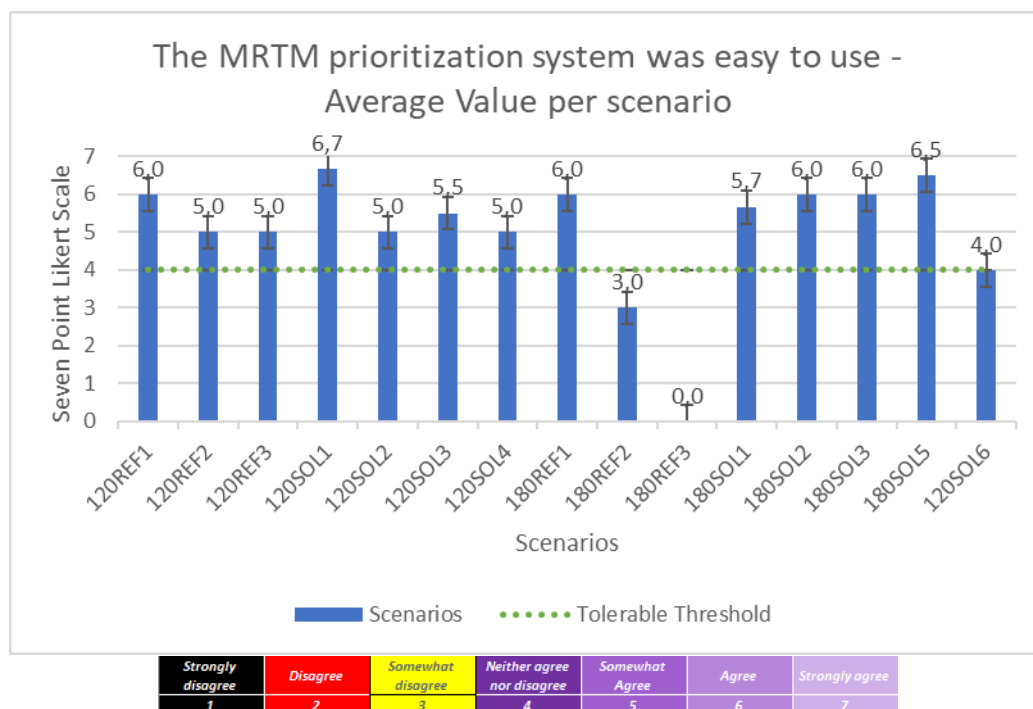


Figure: ATCO – Task Prioritization Tool– Post Run Questionnaire

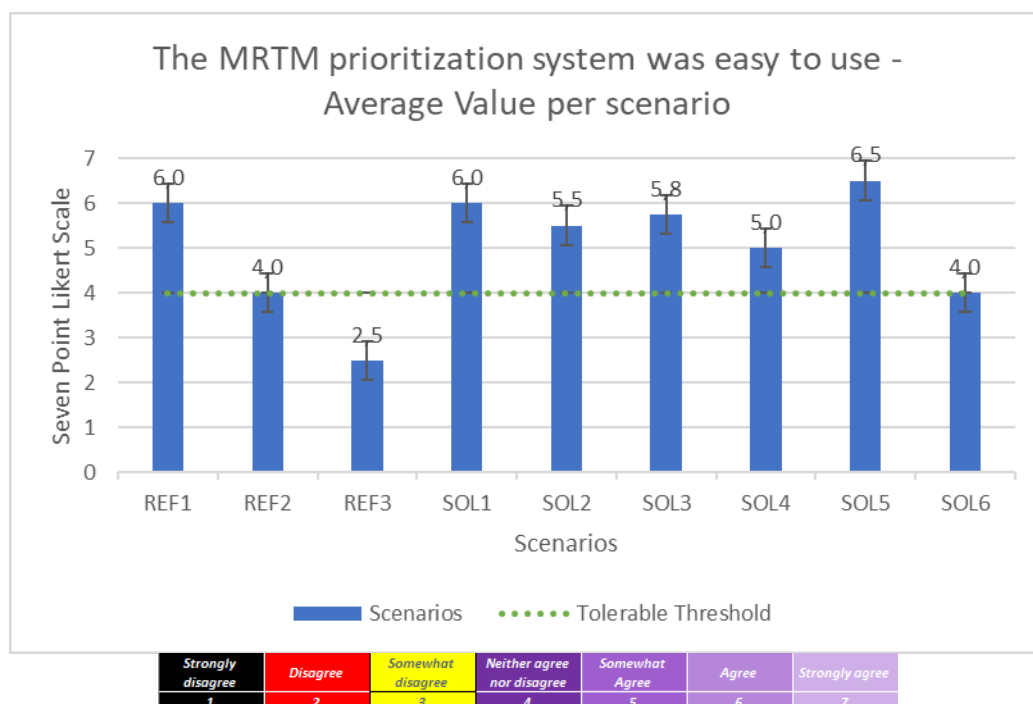


Figure: ATCO – Task Prioritization Tool– Post Run Questionnaire

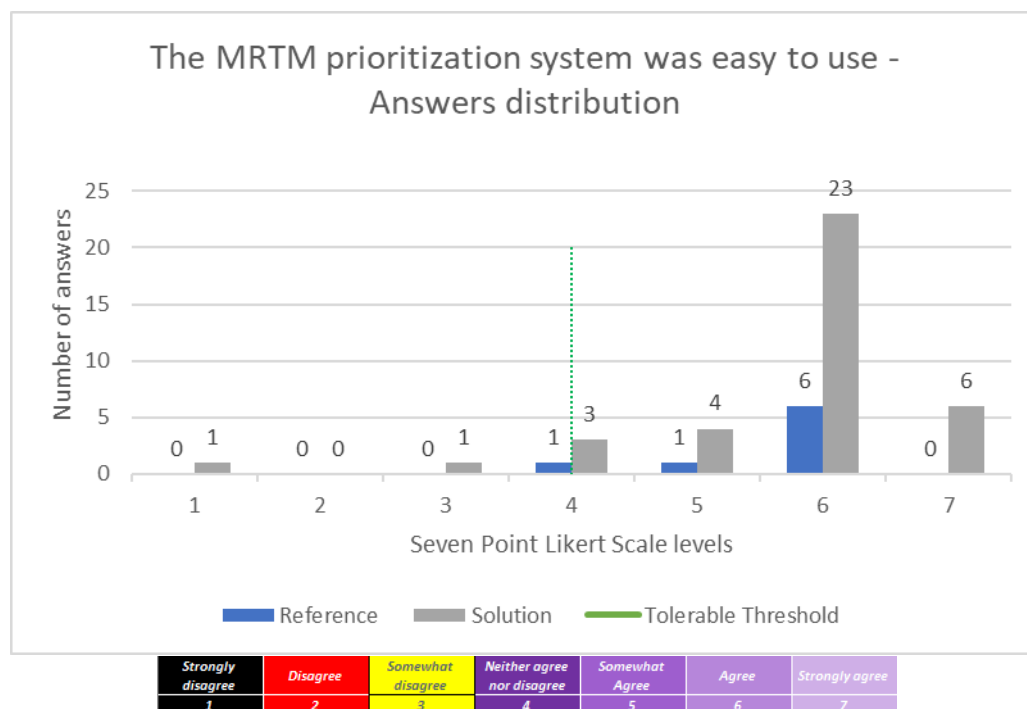


Figure: ATCO – Task Prioritization Tool– Post Run Questionnaire

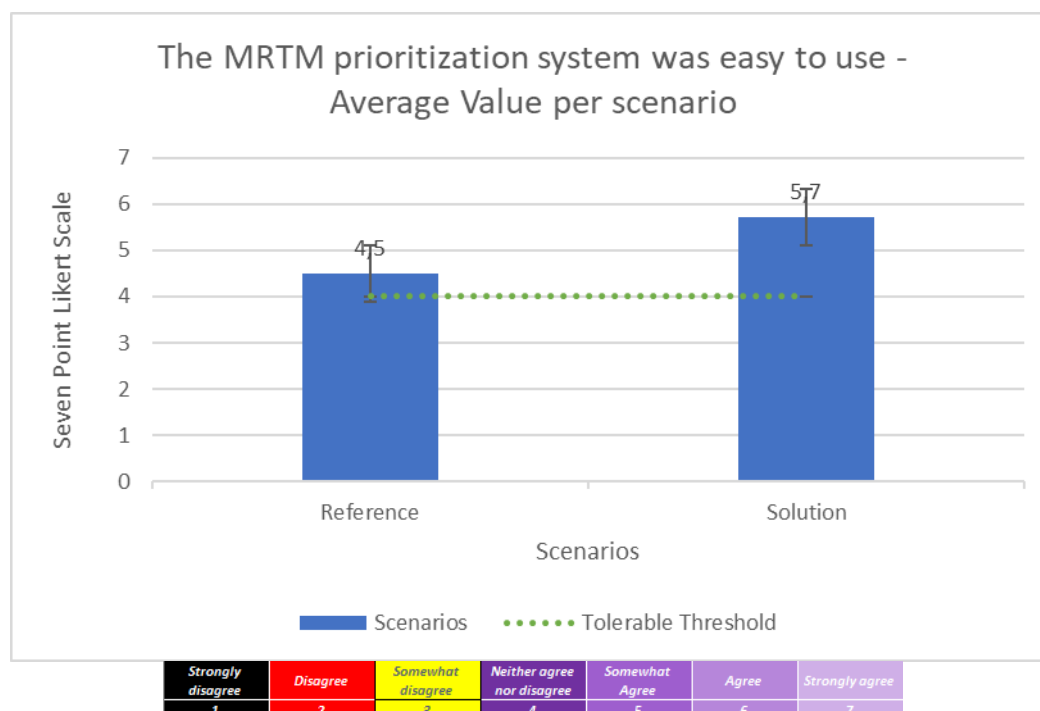


Figure: ATCO – Task Prioritization Tool– Post Run Questionnaire

Despite most of the answers are positive, there are some scenarios that does not reach a satisfactory value. Indeed, during the debriefing, the ATCOs were not really enthusiastic about the provided support and even if they judged it as useful there was not so much interest in it. This comment can also explain the answers to the post simulation questions provided below:

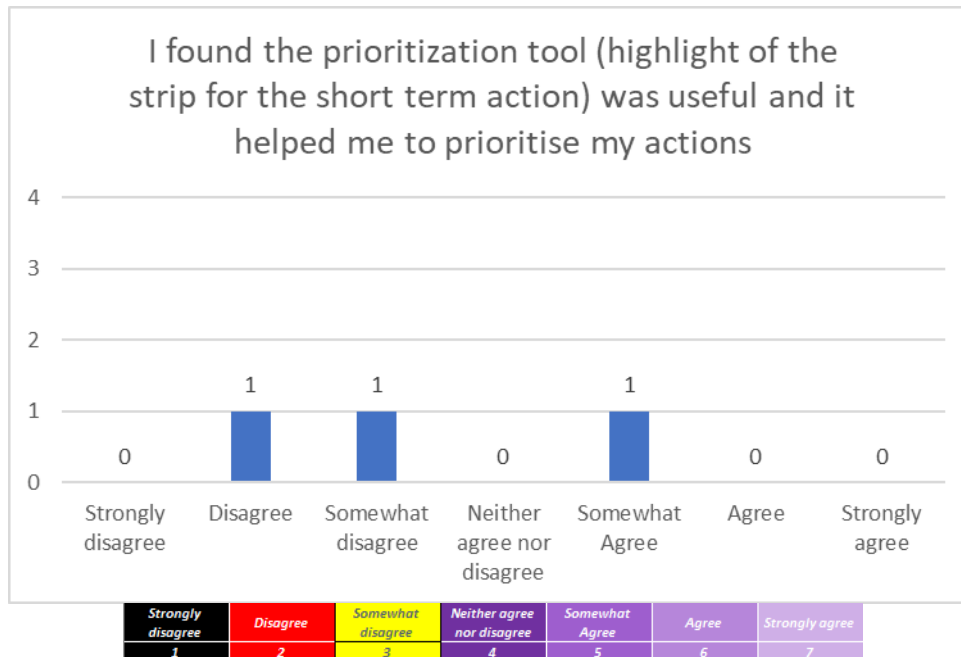


Figure: ATCO – Task Prioritization Tool– Post EXE Questionnaire

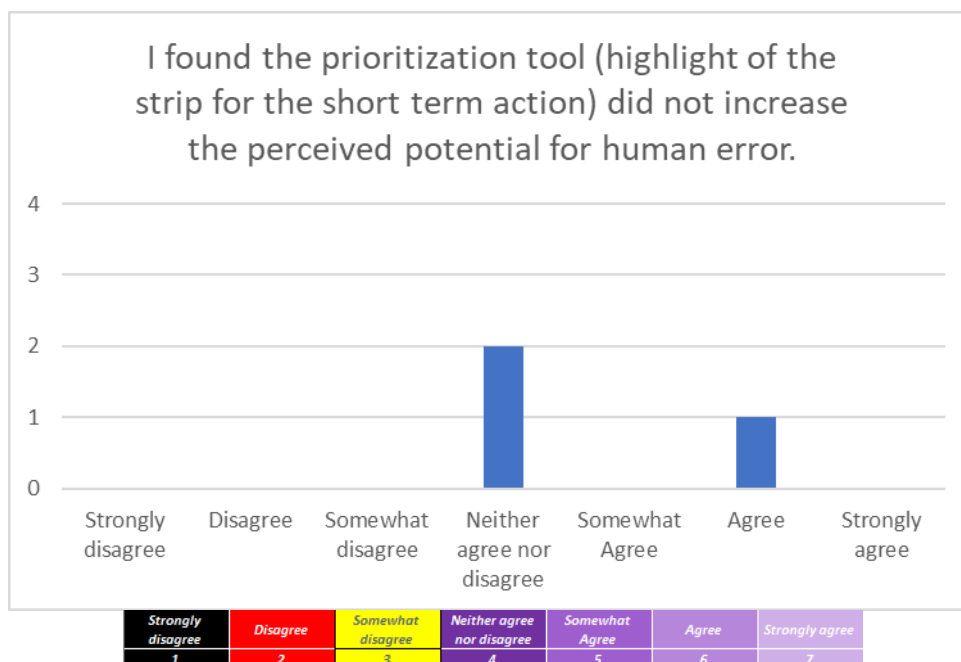


Figure: ATCO – Task Prioritization Tool– Post EXE Questionnaire

It has to be considered, when reading these results, that ATCOs involved in the exercise were not familiar with the EFPS system, so the HMI indication processed by the ATCO prioritization Tool algorithm was not always obvious as supporting information.

Moreover, the algorithm itself would need to be enriched with as many cases as possible in order to be able to perform its task in most situations, perhaps by associating artificial intelligence and machine learning technology with this tool.

Anyway, the criteria is considered as successfully met and recommendations of the above mentioned improvements are recorded.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | The criteria is considered as successfully met as the ATCOs were aware of which aerodrome was displayed where. Anyway, some ATCOs suggested during the debriefing to highlight, in the out of the window view, the frame related to the airport where pilots are transmitting. | Ok |

The criteria is considered as successfully met considering the post simulation question below

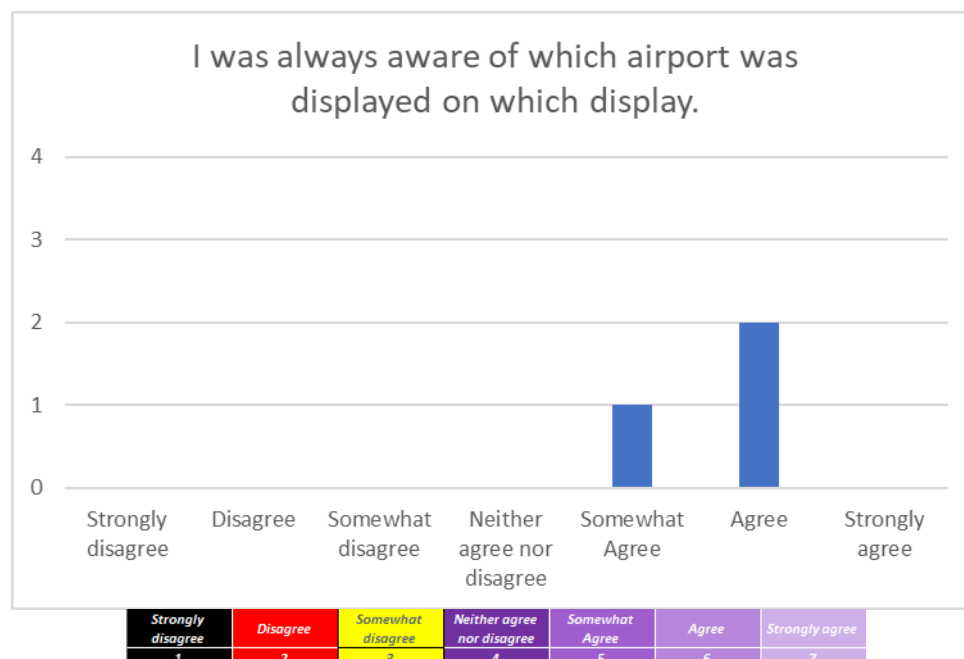


Figure: ATCO – Displayed airports– Post EXE Questionnaire

Anyway, some ATCOs suggested during the debriefing to highlight, in the out of the window view, the frame related to the airport where pilots are transmitting.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs | Questionnaires and debriefing confirmed there was never confusion during the handover about the transferred airports and thus the criteria is considered as successfully met. | Ok |

During the handover procedure, once initiated, the receiving ATCO started monitoring the frequency (of the airport that was going to be transferred) few seconds before the airport was displayed on both visual presentations; the frequency was manually (not automatically) taken over by the receiving module at the end of the handover procedure. Indeed, before the transfer, the receiving ATCO manually set audio module only for receiving (RX) communications related to the airport that was about to be acquired. After transfer, the receiving ATCO needed to manually set audio module for coupling the 'air' frequencies, by clicking TX related to the transferred airport. The sending ATCO manually set his audio module on RX to monitor transferred airport frequency until the acknowledgment of the successful completion of the handover procedure from the receiving ATCO in order to positively close the handover procedure. No issues were raised by ATCOs about the frequency during the handover.

As it can be seen in the following post simulation questions and as it was also confirmed in the debriefing there was never confusion during the handover about the transferred airports and thus the criteria is considered as successfully met.

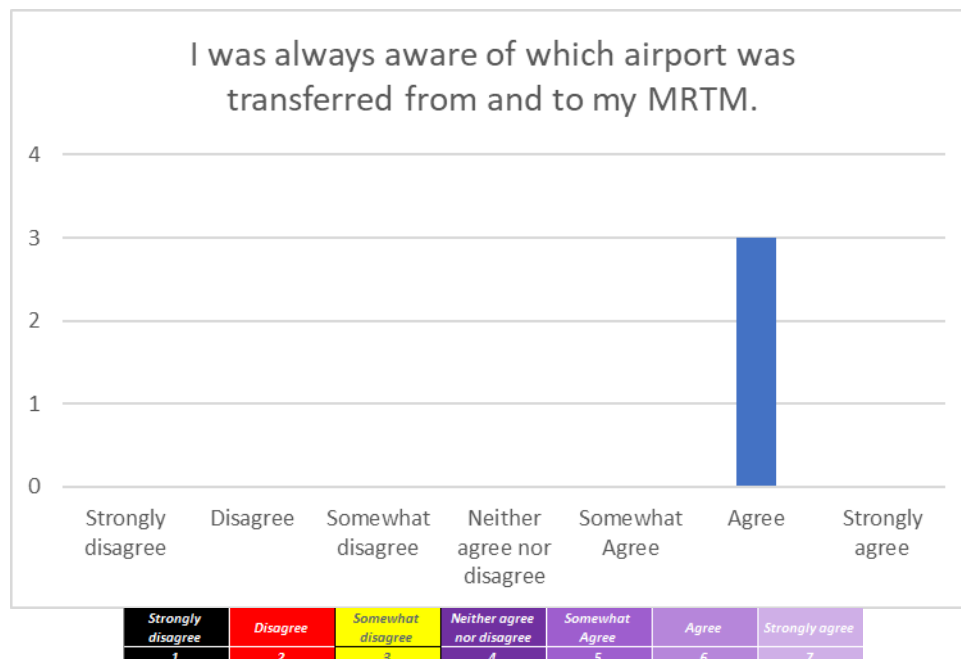


Figure: ATCO – Transferred airports– Post EXE Questionnaire

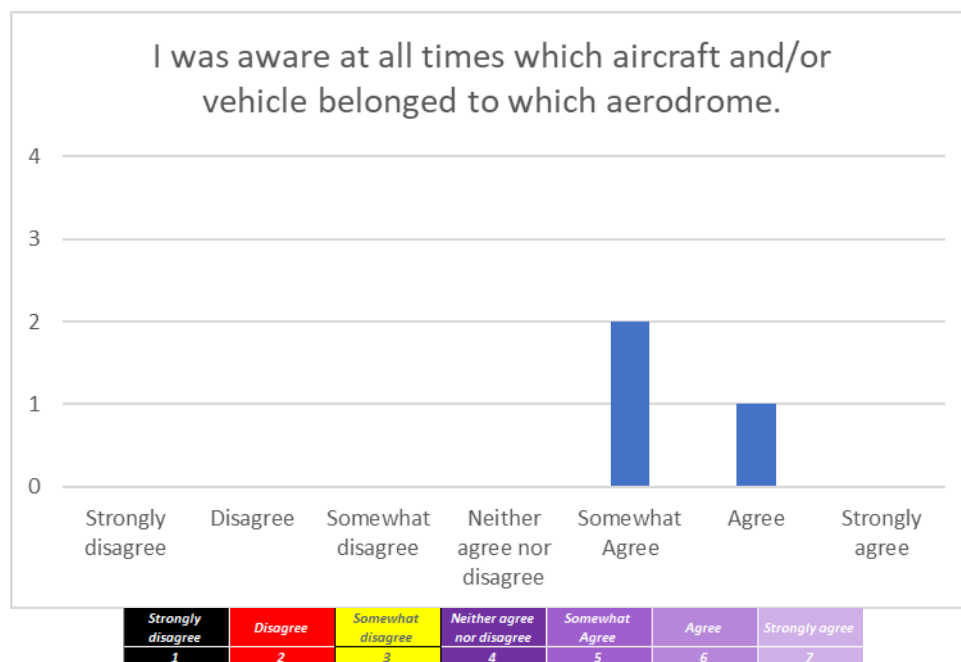


Figure : ATCO – Aircraft/Vehicles– Post EXE Questionnaire

D.3.2.5 HUMAN PERFORMANCE – TRUST

D.3.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

Assess ATCO trust in support systems when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation for the next action to be performed integrated in the EFPS system | No issues raised in relation to the trust of the functionality of the task prioritisation tool. The level of reliability was considered sufficient on the basis of a 7 points post-simulation question where most of the ATCOs somewhat agreed that the tool provided reliable suggestions | Ok |
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust in reliability of alarms and alerts for emergency situations | Not addressed | |
| Criterion ID | Success Criterion | Validation Result | Status |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts for emergency situations | The level of trust was mainly addressed during the debriefing and no ATCOs raised any issue in relation to the level of trust, especially in relation with the emergency situations that were experimented. The only point raised for the emergency was about the HMI that should be improved | OK |

The level of trust was mainly addressed during the debriefing and no ATCOs raised any issue in relation to the level of trust, especially in relation with the emergency situations that were experimented. The only point raised for the emergency was about the HMI that should be improved as mentioned in the previous objectives.

The level of confidence is considered as sufficient on the basis of the following post simulation questions' result on the 7 points scale:

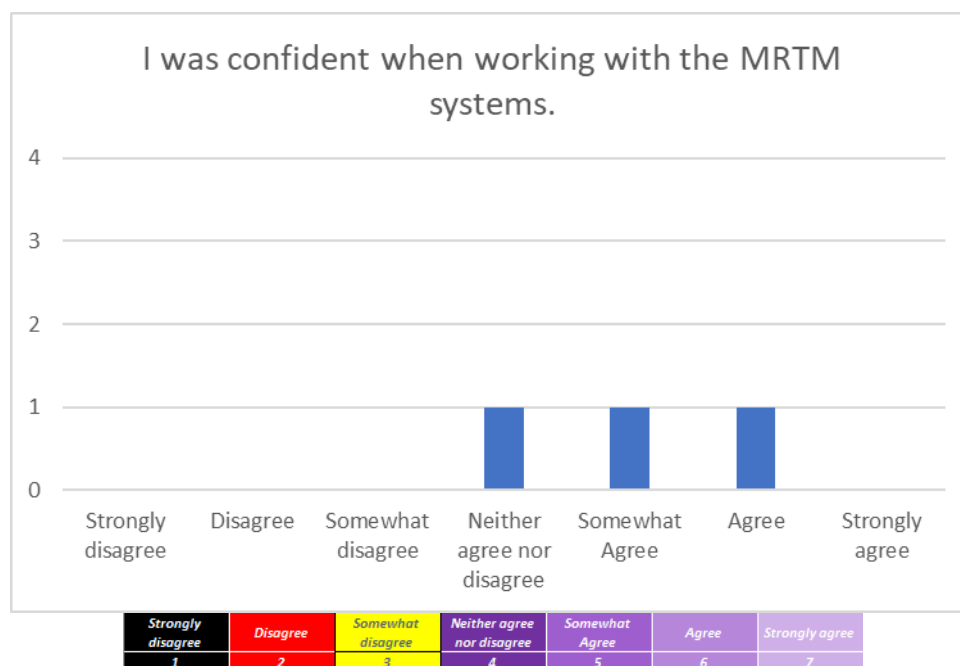


Figure : ATCO – Confidence– Post EXE Questionnaire

The level of reliability is considered as sufficient on the basis of the following post simulation questions' result on the 7 points scale:

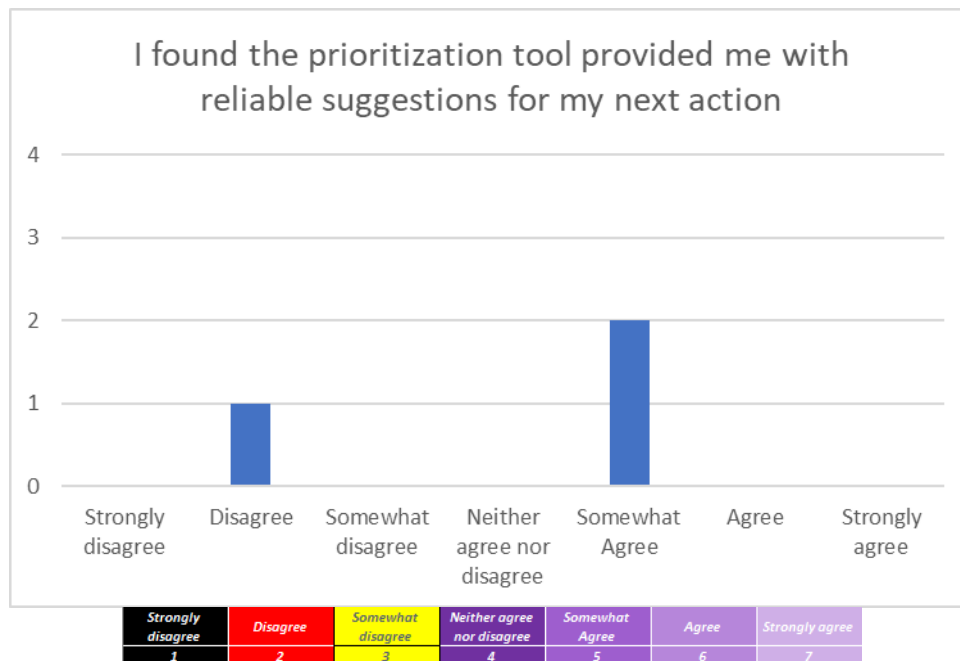


Figure: ATCO – Task Prioritization Tool– Post EXE Questionnaire

The criteria is considered as successfully met.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | The level of trust was mainly addressed during the debriefing and no ATCOs raised any issue in relation to the level of trust. The level of confidence was considered as sufficient | Ok |

The level of trust was mainly addressed during the debriefing and no ATCOs raised any issue in relation to the level of trust on the functionalities of the handover system. Nevertheless, some improvements in the HMI were suggested as already mentioned in the previous objectives.

The level of confidence is considered as sufficient on the basis of the following post simulation questions' result on the 7 points scale:

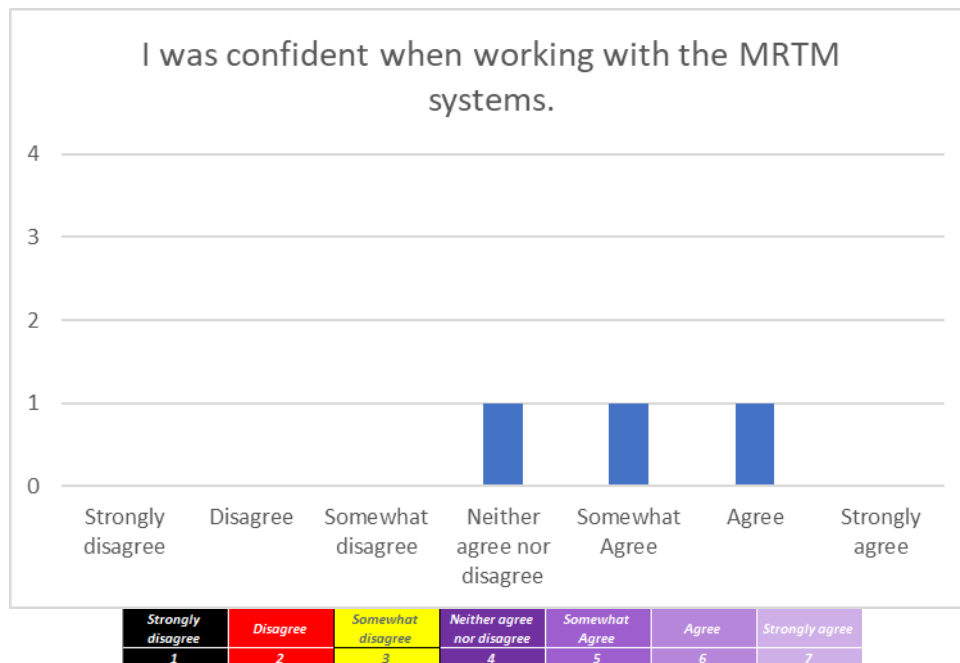


Figure: ATCO – Confidence– Post EXE Questionnaire

The criteria is considered as successfully met

D.3.2.6 HUMAN PERFORMANCE – Transition Factors

D.3.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements identified/consolidated per actor group | No final conclusions on skill and recruitment requirements from the collected responses, as not all the answers are aligned on the positive or negative responses for the ATCOs The overall trend in the discussion was that no real new requirement or skill is needed, but adaptation to the new way of working would be required. | P-OK |

No final conclusions on skill and recruitment requirements from the collected responses, as not all the answers are aligned on the positive or negative responses for the supervisors and the ATCOs (figure below)

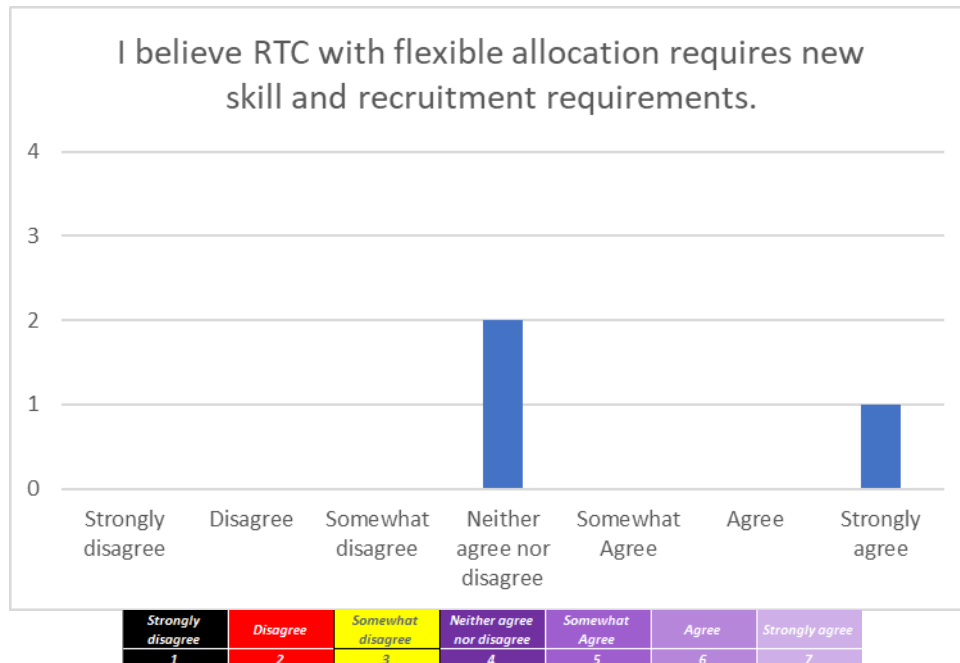


Figure: ATCO – Skill & recruitment– Post EXE Questionnaire

The overall trend in the discussion was that no real new requirement or skill is needed, but adaptation to the new way of working would be required.

The criteria is considered as partially ok

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | All the ATCOs agreed that the ATCOs and supervisor should be extensively trained to undertake the new role for the supervisor and the new responsibilities for the ATCOs as it can be understood looking at the figure below. | Ok |

All the ATCOs (figure below) agreed that the ATCOs and supervisor should be extensively trained to undertake the new role for the supervisor and the new responsibilities for the ATCOs as it can be understood looking at the figure below.

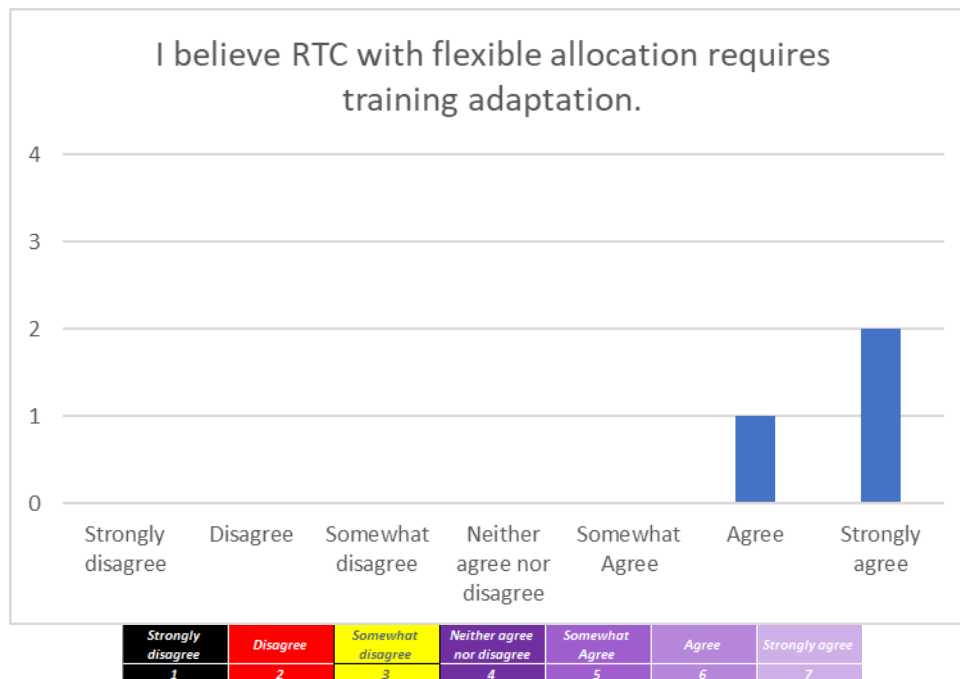


Figure: ATCO – Training– Post EXE Questionnaire

The criteria is considered as successfully met.

D.3.2.7 SAFETY

D.3.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | <p>ATCO is able to identify and solve potential conflicts in a timely manner:</p> <ul style="list-style-type: none"> In the vicinity of the aerodrome In the runway area On the manoeuvring area | The criteria is considered as successfully met considering the results provided for the OBJ-PJ05-W2-35-V3-VALP-H02 and dedicated questions. There was no simulation of specific conflicts during the simulation days, nevertheless there was no issue raised by ATCOs in the ability of identifying potential conflicts: the ATCOs were even appreciating the conflicting clearances tool which supported the ATCOs in the overload | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | cases in the early identification of clearances in conflict. | |

There was no simulation of specific conflicts during the simulation days, nevertheless there was no issue raised by ATCOs in the ability of identifying potential conflicts: the ATCOs were even appreciating the conflicting clearances tool which supported the ATCOs in the overload cases in the early identification of clearances in conflict.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.): <ul style="list-style-type: none"> • Unstable approaches • Bird strikes Aircraft not vacating RWY as expected | Not addressed | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | ATCOs did not raise any issue in relation with the ability to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | OK |

The criteria is considered as successfully met considering the results provided for the OBJ-PJ05-W2-35-V3-VALP-H02 and the ATCO post simulation questions results provided below:

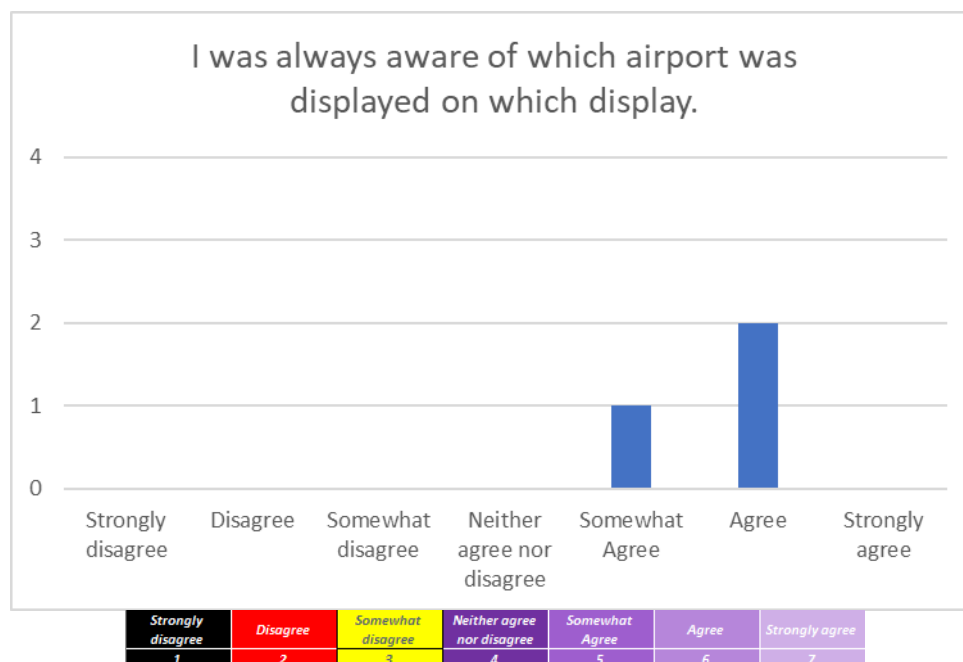


Figure: ATCO – Airports– Post EXE Questionnaire

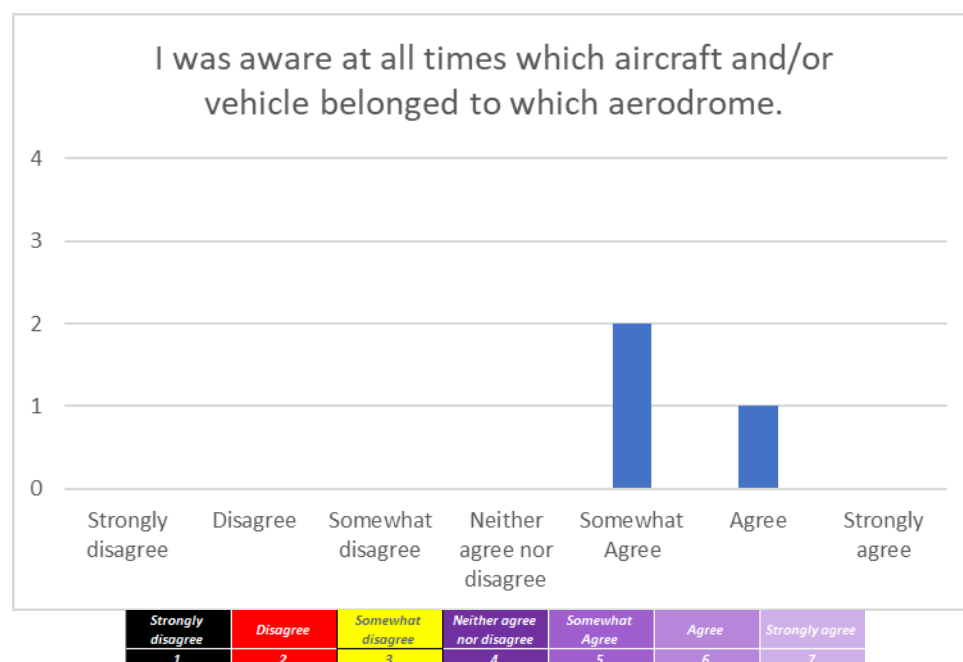


Figure: ATCO – Aircraft & Vehicles– Post EXE Questionnaire

Indeed, ATCOs did not raise any issue in relation with the ability to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | The perceived level of safety was acceptable for most of the ATCOs and in all the solution scenarios. Also, no issues were raised about the increase of conflicting situations in the solution scenarios and thus the criteria is considered as successfully met | OK |

D.3.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | Not addressed | |

D.3.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

OBJ-PJ05-W2-35-V3-VALP-S06

Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations of aircraft emergency | The criteria was met through a dedicated solution scenario which is solution scenario 4. Level of situation awareness for solution 4 dedicated scenario was considered as good | OK |

The criteria was met through a dedicated solution scenario which is solution scenario 4. As it can be observed in the following post run questions' answer the level of situation awareness for solution 4 was considered as good (China lake 10 points scale)

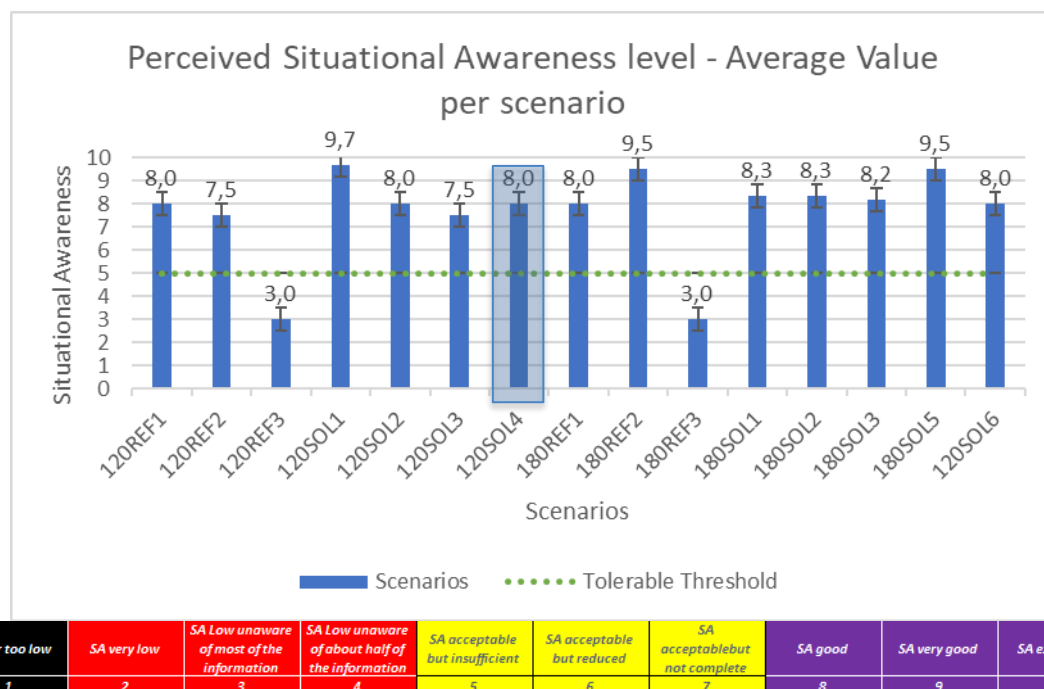


Figure: ATCO – Situational Awareness– Post run Questionnaire

The results have also been mediated for the references and solutions scenarios experimented. They are reported in the following graph:

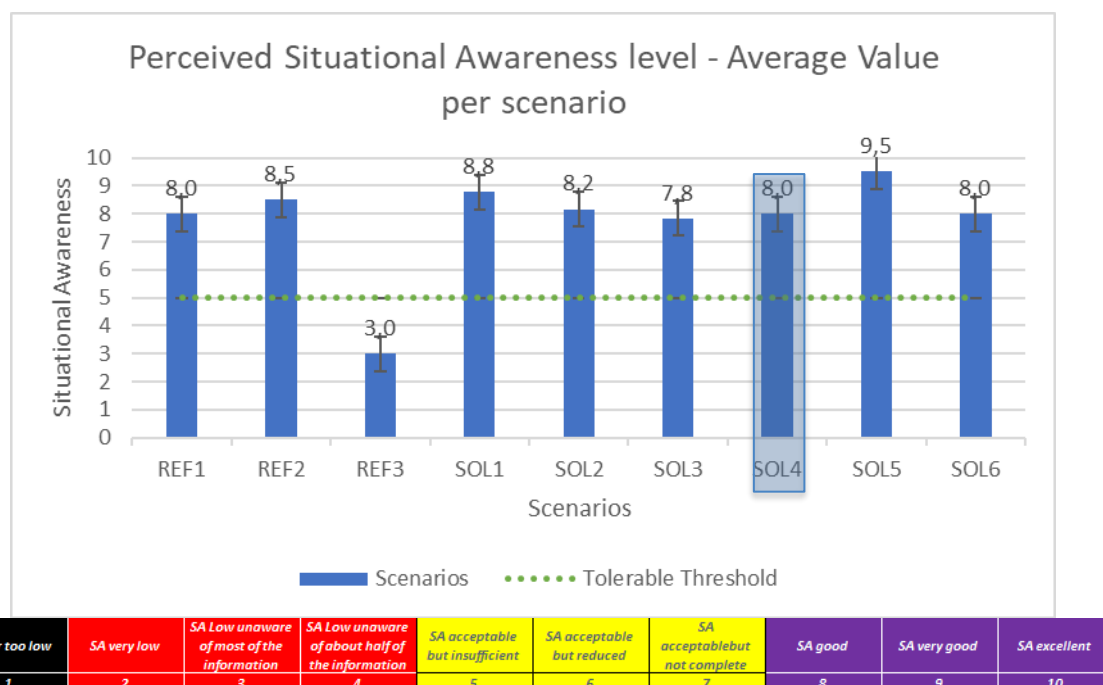


Figure: ATCO – Situational Awareness– Post run Questionnaire

The criteria is considered as successfully met considering the situational awareness is well above the tolerable threshold for solution scenario 4. Also, one of the ATCO commented “During emergencies it's better to work a single airport” and indeed most of the controllers agreed that it is necessary to isolate the airport hosting the emergency to leave the ATCO concentration on the management of the emergency.

D.3.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results

OBJ-PJ05-W2-35-V3-VALP-S07

Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g): <ul style="list-style-type: none"> • Communication • Visualisation system Other airport systems / infrastructure | Not addressed | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | ATCO is able to detect and recover from a technical failure in the MRTM affecting Communication or Visualisation system | The criteria was met through a dedicated solution scenario which are solution scenario 5 and 6. Level of situation awareness for solution 5 and 6 dedicated scenarios was considered as good | OK |

The criteria was met through 2 dedicated solution scenario which were solution scenario 5 and 6. As it can be observed in the following post run questions' answer the level of situation awareness for both the solutions scenario was considered as good (China lake 10 points scale)

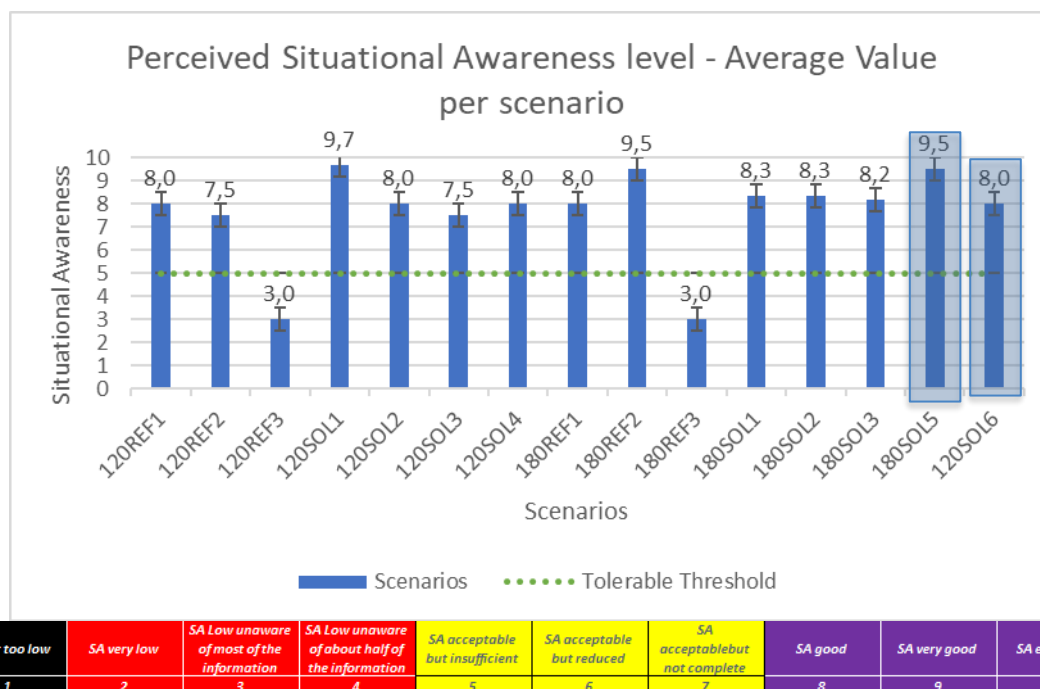


Figure: ATCO – Situational Awareness– Post run Questionnaire

The results have also been mediated for the references and solutions scenarios experimented. They are reported in the following graph:

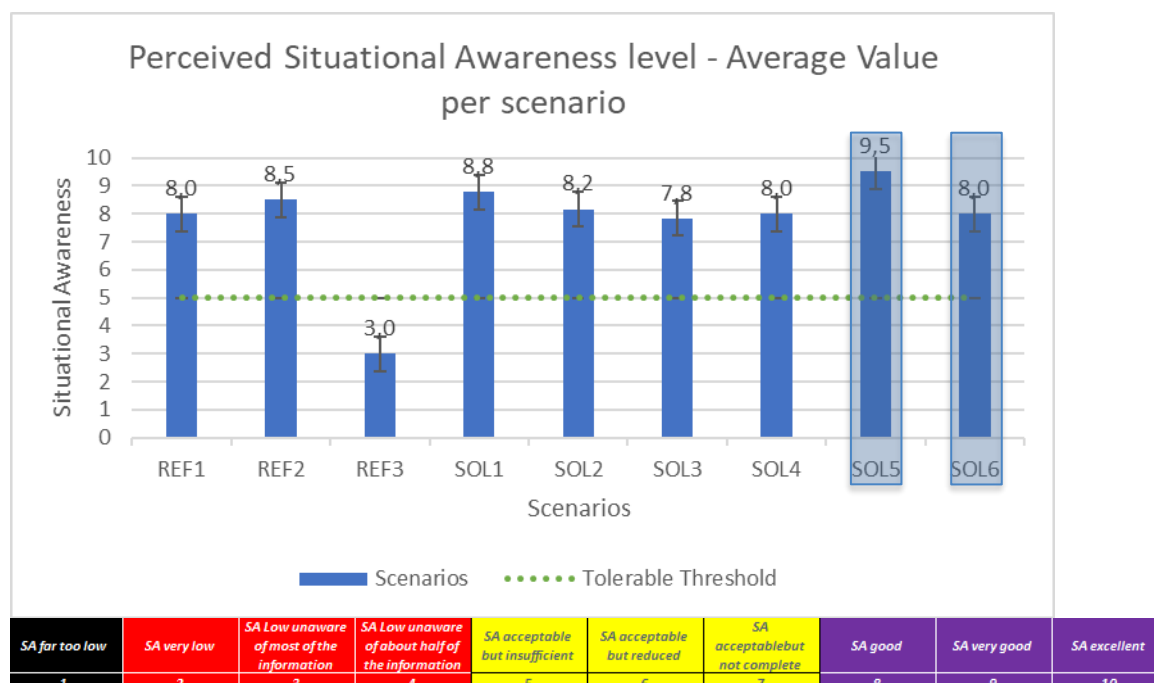


Figure: ATCO – Situational Awareness– Post run Questionnaire

The criteria is considered as successfully met considering the situational awareness is well above the tolerable threshold for solution scenario 5 and 6. Also, one of the ATCO commented “At the moment of contingency I was able to take control of Brindisi Airport without problems”.

D.3.2.8 CAPACITY

D.3.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|-------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | Not addressed | |

D.3.2.9 COST EFFICIENCY

D.3.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time in an RTC of 3 aerodromes | The ATCOs were questioned about the ability to provide ATS to 3 aerodromes at a time to assess the criteria. Not a conclusive result can be achieved from the provided responses, but based on the H02 and H04 objectives assessment the criteria is considered as successfully met considering the workload and the situation awareness were always maintained at acceptable level in the solution scenarios | OK |

The ATCOs were questioned about the ability to provide ATS to 3 aerodromes at a time to assess the criteria. Not a conclusive result can be achieved from the provided responses, but based on the H02 and H04 objectives assessment the criteria is considered as successfully met considering the workload and the situation awareness were always maintained at acceptable level in the solution scenarios.

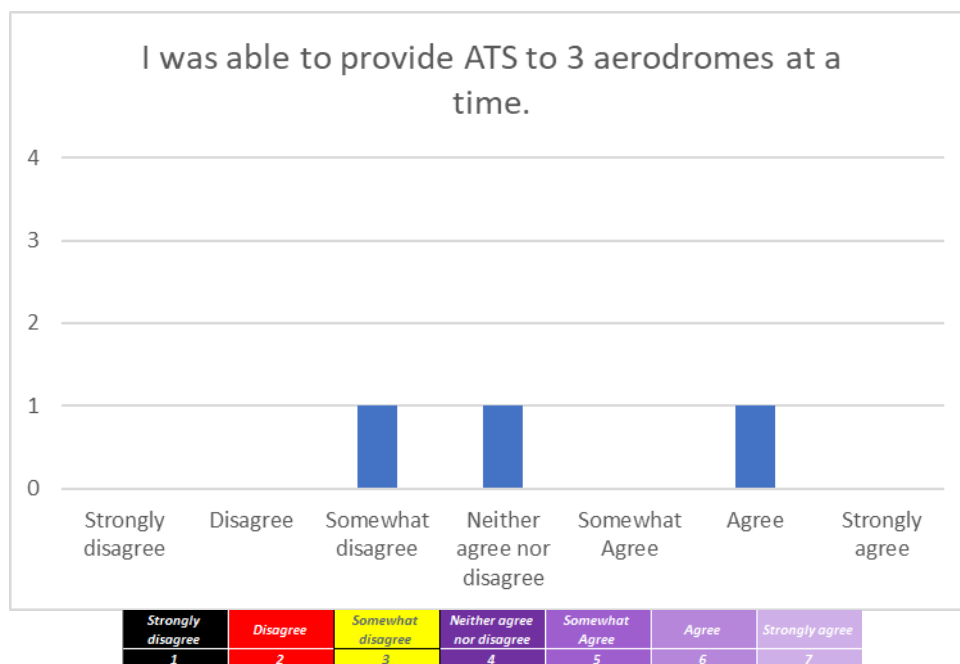


Figure: ATCO – Number of airports– Post EXE Questionnaire

D.3.3 Supervisor - Summary of Validation Exercise Results

| Validation Exercise 2.4 Validation Objective ID | Validation Exercise 2.4 Validation Objective Title | Validation Exercise 2.4 Success Criterion ID | Validation Exercise 2.4 Success Criterion | Sub-operating environment | Exercise #01 Validation Results | Validation Exercise 2.4 Validation Objective Status |
|---|--|--|---|---------------------------|---|---|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H01 | Assess SUP situation awareness when working in an RTC | CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | Majority of SUPs rated the situational awareness at an acceptable value. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | Small airports | The SUPs were generally able to prioritise tasks. Both the SUPs agreed or somewhat agreed with that they could prioritise tasks | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient | Small airports | The user interface was considered adequate to maintain the individual situation awareness at acceptable levels, nevertheless the supervisor | OK |

level of individual
situation awareness

commented that there might be the need of further technical enhancement to have a final evaluation. This statement has to be read in consideration of the missing connection of the supervisor planning tool with the real time simulation platforms. This is a technical limitation of the platform ad-hoc installed for this exercise. Despite the lack of a physical connection between the two platforms, the traffic sample and its evolution over time were always aligned to allow for accurate analysis by the supervisor.

HUMAN PERFORMANCE – WORKLOAD

| | | | | | | |
|----------------------------|--|--------------------------------|---|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-H05 | Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | Different components of workload were assessed: the overall perceived cognitive workload was assessed but it was considered necessary also to assess the planning load, the monitoring load, the R/T load and the coordination load to verify if there was any dimension of the workload that was more | OK |
|----------------------------|--|--------------------------------|---|----------------|--|----|

demanding and required specific mitigations.

All the components of the workload were within the tolerable values

HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

| | | | | | | |
|----------------------------|--|--------------------------------|--|----------------|---|----|
| OBJ-PJ05-W2-35-V3-VALP-H09 | Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal operating conditions, in case of aircraft emergency and in case of failure of the system when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | Operating methods were applied in an accurate, efficient and timely manner in normal operating conditions, in case of aircraft emergency and in case of failure of the system when working in an RTC with a flexible allocation of aerodromes between MRTMs. Anyway, it was discussed and recommended that operational procedures and check lists, as above mentioned, for nominal conditions as well as for abnormal and degraded mode shall be revised, definitely consolidated and put in place to support the RTC with flexible allocation. | OK |
|----------------------------|--|--------------------------------|--|----------------|---|----|



| | | | | | | |
|----------------------------|--|--------------------------------|---|----------------|---|----|
| OBJ-PJ05-W2-35-V3-VALP-H10 | Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable. | Small airports | Considering the positive responses on the research questions on the clarity and acceptability of the roles and responsibilities as well as on the supervision of the assigned number of airports (most of the responses are above the tolerable threshold), the criteria is considered met. Anyway supervisors test subjects raised and agreed on the possibility of undertaking some of the coordination tasks currently assigned to the ATCOs as mentioned in the previous objective. A further comment was also raised about the possibility for the supervisor to support more the handover phase, but while both the supervisor agreed on this option, they did not fully agree on which extend this support was to be provided and on the modality. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned | Small airports | Supervisor confirmed the feasibility and acceptability of | OK |

| | | | number of clusters of aerodromes | supervising a cluster of aerodromes with 3 airports | | |
|---|---|--------------------------------|--|---|--|------|
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H12 | Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | Not conclusive response can be considered from the collected answers (1 somewhat agree and 1 agree answer) | P-OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | Small airports | The main input device in use for the supervisor was the handover system. The usability of the handover system was considered acceptable and thus the criteria is considered as met | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Small airports | Not conclusive response can be considered from the collected answers (1 somewhat agree and 1 agree answer) | P-OK |
| | | CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts for the SUP planning tool | Small airports | Supervisor was informed about emergency situation through the handover system addressed in criteria CRT-PJ05-W2-35-V3-VALP-H12.020. This system was | OK |

| | | | | | | |
|--|---|--------------------------------|--|----------------|---|------|
| | | | and emergency situation | | judged as adequate and usable so the criteria is considered as successfully met. See CRT-PJ05-W2-35-V3-VALP-H12.020 results. | |
| | | CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | Small airports | Potential of increase in human error caused by the HMI was not considered as increasing | OK |
| HUMAN PERFORMANCE – TRUST | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H14 | Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | Small airports | The criteria is considered as not ok in relation to the supervisor planning tool considering the comments about the workload forecast function and OK for the handover system. The overall status is considered P-OK | P-OK |
| HUMAN PERFORMANCE – TRANSITION FACTORS | | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Small airports | No final conclusions on skill and recruitment requirements from the collected responses, as not all the answers are aligned on the positive or negative responses for the supervisors. The overall trend in the discussion was that no real new | P-OK |

requirement or skill is needed, but adaptation to the new way of working would be required.

| | | | | | | |
|--|--|--------------------------------|--|----------------|--|----|
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Small airports | Both the supervisors agreed that the ATCOs and supervisor should be extensively trained to undertake the new role for the supervisor and the new responsibilities for the ATCOs as it can be understood looking at the figure below. | Ok |
|--|--|--------------------------------|--|----------------|--|----|

SAFETY

| | | | | | | |
|----------------------------|---|--------------------------------|---|----------------|--|----|
| OBJ-PJ05-W2-35-V3-VALP-S08 | Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations of emergency flight | Small airports | The criteria was met through a dedicated solution scenario which is solution scenario 4. Level of situation awareness for solution 4 dedicated scenario was considered as good | OK |
| OBJ-PJ05-W2-35-V3-VALP-S09 | Assess Supervisor capability to cope with degraded situations and recover from it | CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC | Small airports | The criteria was met through a dedicated solution scenario which are solution scenario 5 and 6. Level of situation awareness for | OK |



when working in an
RTC with a flexible
allocation of
aerodromes
between MRTMs

related to
Communication or
Visualisation system

solution 5 and 6 dedicated
scenarios was considered as good

| | | | | | | |
|----------------------------|--|--------------------------------|--|----------------|--|------|
| OBJ-PJ05-W2-35-V3-VALP-S10 | Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | Small airports | While for the ability to supervise the assigned number of airports there is consensus on the positive answer, meaning that the supervisor was able to plan the airports' allocation between the available modules (picture above), there is not a clear conclusion for the workload forecast of the supervisor planning tool | P-OK |
|----------------------------|--|--------------------------------|--|----------------|--|------|

Table 34: Supervisor - Validation Results for Exercise 2.4

D.3.4 Supervisor - Analysis of Exercise Results per Validation objective

D.3.4.1 HUMAN PERFORMANCE – SITUATION AWARENESS

D.3.4.1.1 OBJ-PJ05-W2-35-V3-VALP-H01 Results

OBJ-PJ05-W2-35-V3-VALP-H01

Assess SUP situation awareness when working in an RTC

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.010 | Majority of SUPs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Majority of SUPs rated the situational awareness at an acceptable value. | OK |

Supervisor Situational Awareness was measured through China Lake 10 points scale in the post-run questionnaire of supervisor and through a customised question on 7-points scale in the post experiment supervisor questionnaire. The results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations. The following picture gives the measured average value of each solution scenario and the combined average value of the solution scenarios:

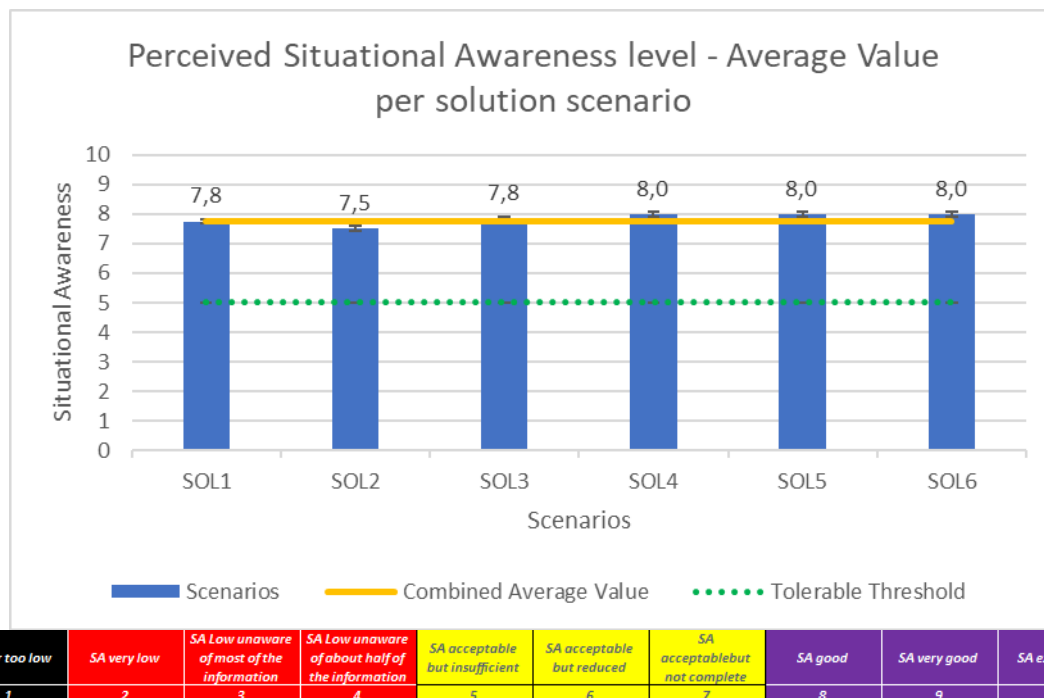


Figure: SUP - Situational Awareness – Post Run Questionnaire

As it can be seen, the average values are well above the tolerable threshold for all the solution scenarios as well as the combined average value that is 7.7 points with a standard deviation of data of ± 0.7 .

The trend is confirmed considering the post simulation questionnaire as it can be observed by the following plot:

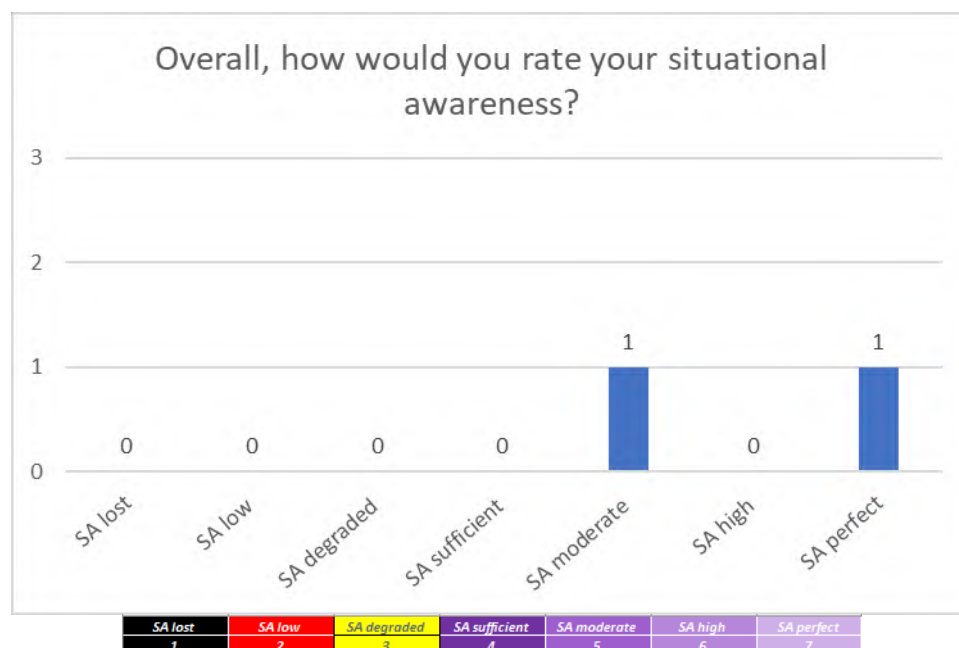


Figure: SUP - Situational Awareness – Post Simulation Questionnaire

The criteria is judged as successfully met considering the above answers and the distribution of post run questionnaire answers' in the picture below as most of the answers rated as good the situation awareness:

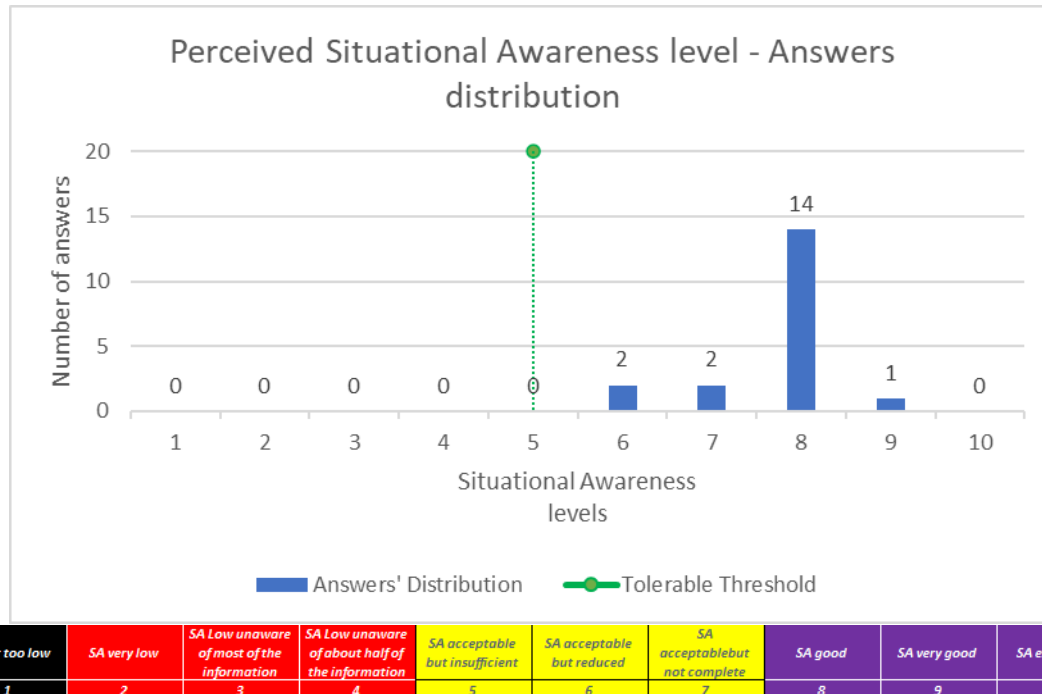


Figure: SUP - Situational Awareness – answers' distribution – Post Run Questionnaire

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.020 | Majority of SUPs state that they can prioritise tasks | The SUPs were generally able to prioritise tasks. Both the SUPs agreed or somewhat agreed with that they could prioritise tasks | Ok |

Task prioritization was investigated in post run questionnaire through ad-hoc 7 points scale question plotted below as average value among scenarios and overall average value:

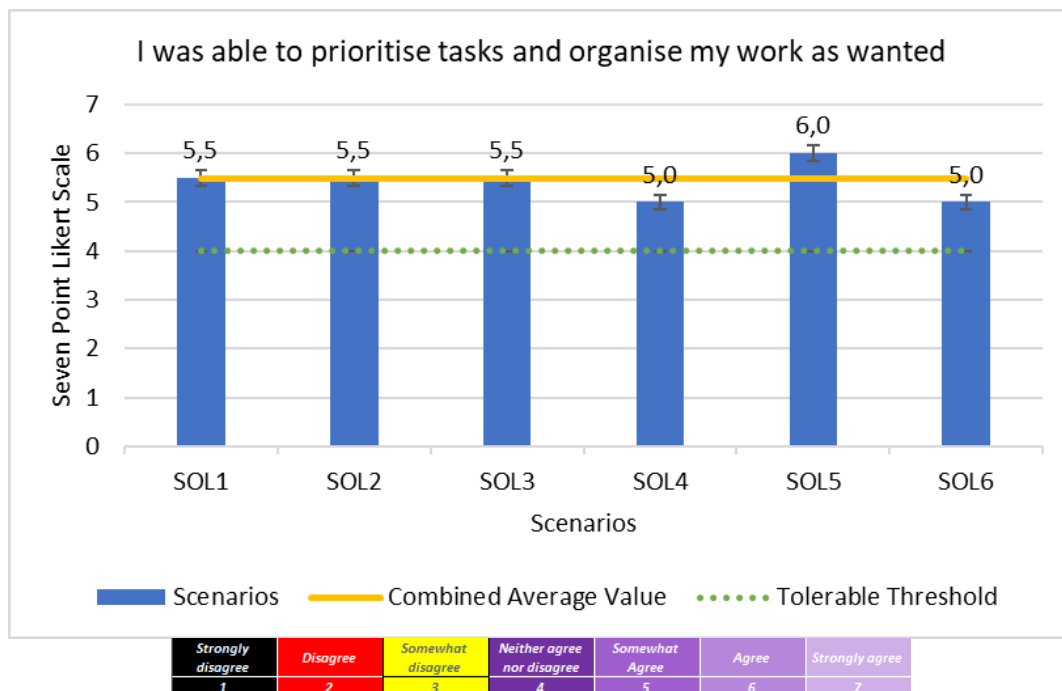


Figure: SUP – Task Prioritisation – Post Run Questionnaire

The measured combined mean value is 5.5 with a standard deviation of ± 0.5 that is above the tolerable threshold of 4 points. Same positive trend can be observed in the post simulation questionnaire plotted below, where both the SUPs agreed or somewhat agreed with the statement on the capability of prioritise tasks.

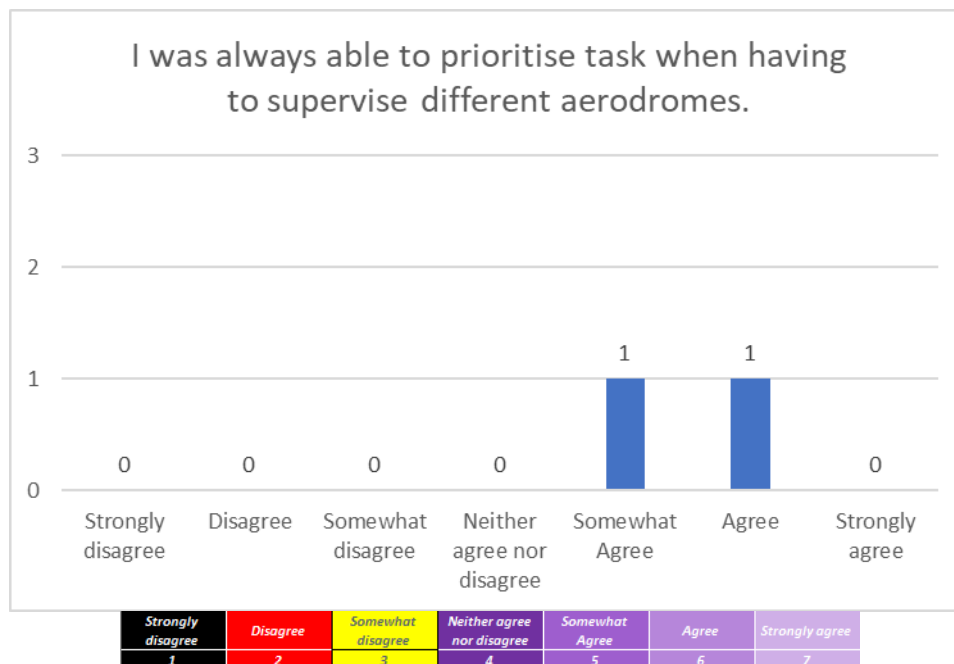


Figure : SUP – Task prioritisation – Post Simulation Questionnaire

The criteria is judged as successfully met, as all the SUPs' responses are distributed between 5 and 6 levels on the 7 points scale.

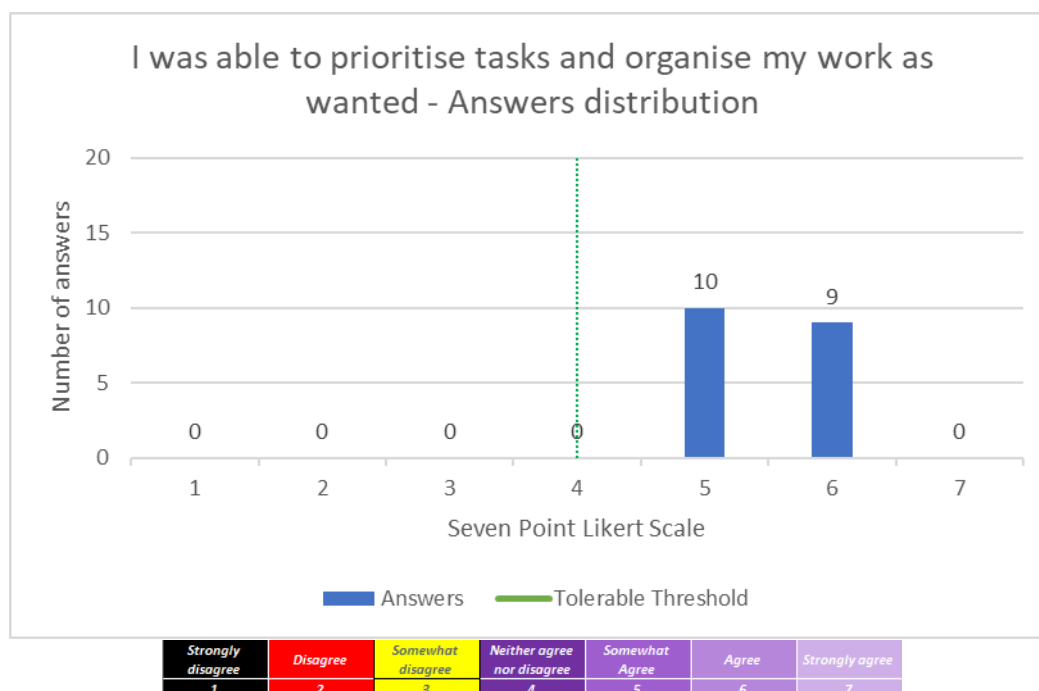


Figure: SUP – Task Prioritisation – answers' distribution – Post Run Questionnaire

- CRT-PJ05-W2-35-V3-VALP-H01.030 Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness

The user interface design was investigated through customised 7 points scale in the post run questionnaire reported below

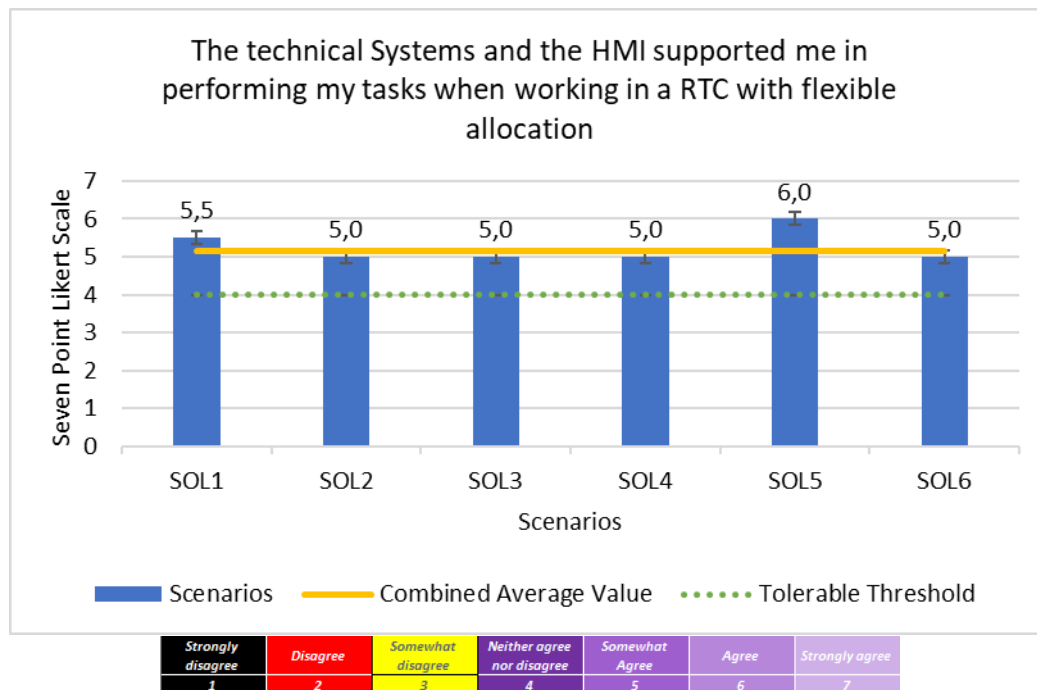


Figure: The technical Systems and the HMI supported me in performing my tasks when working in an RTC with flexible allocation - SUP Post Run Questionnaire

5.2 is the measured combined average value that is above the 4 points tolerable threshold. Standard deviation is ± 0.7 .

The criteria is judged as met, considering the distribution of answers are mostly above the tolerable threshold as indicated in the following plot:

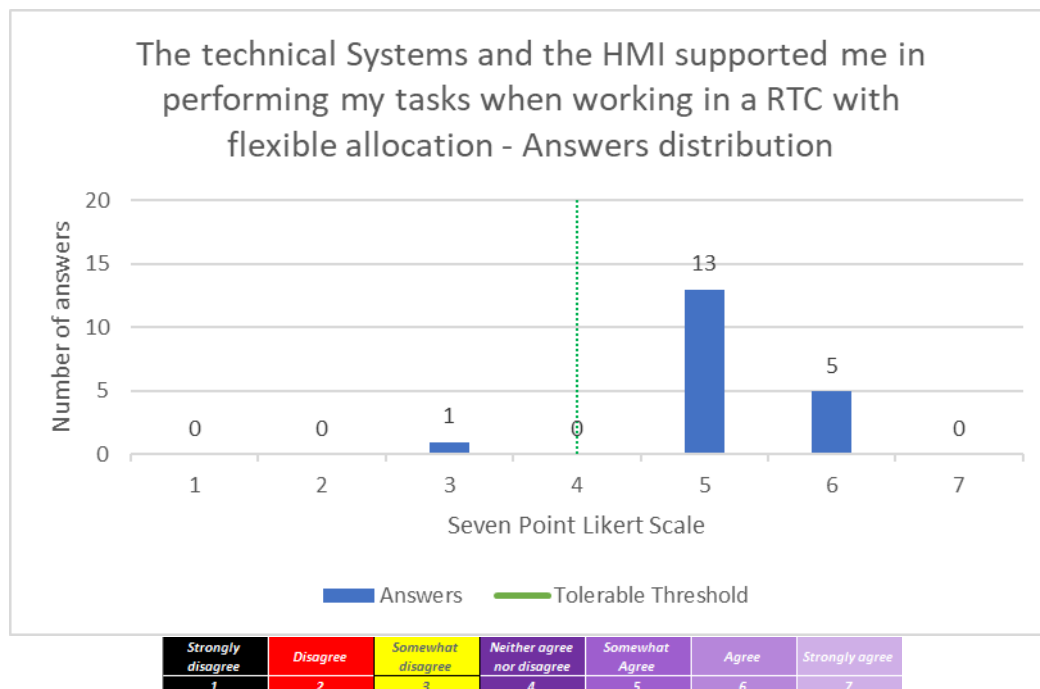


Figure: The technical Systems and the HMI supported me in performing my tasks when working in an RTC with flexible allocation – Answers' distribution- SUP Post Run Questionnaire

Only 1 answer is on the level 3 (Somewhat disagree) and the supervisor commented that there might be the need of further technical enhancement to have a final evaluation. This statement has to be read in consideration of the missing connection of the supervisor planning tool with the real time simulation platforms. This is a technical limitation of the platform ad-hoc installed for this exercise. Despite the lack of a physical connection between the two platforms, the traffic sample and its evolution over time were always aligned to allow for accurate analysis by the supervisor.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.030 | Majority of SUPs confirm that the user interface design supports a sufficient level of individual situation awareness | The user interface was considered adequate to maintain the individual situation awareness at acceptable levels, nevertheless the supervisor commented that there might be the need of further technical enhancement to have a final evaluation. This statement has to be read in consideration of the missing connection of the supervisor planning tool with the real time simulation platforms. This is a technical limitation of the platform ad-hoc installed for this exercise. Despite the lack of a physical connection between the two platforms, the traffic sample and its evolution over time were always aligned to allow for accurate analysis by the supervisor. | Ok |

The user interface design was investigated through customised 7 points scale in the post run questionnaire reported below

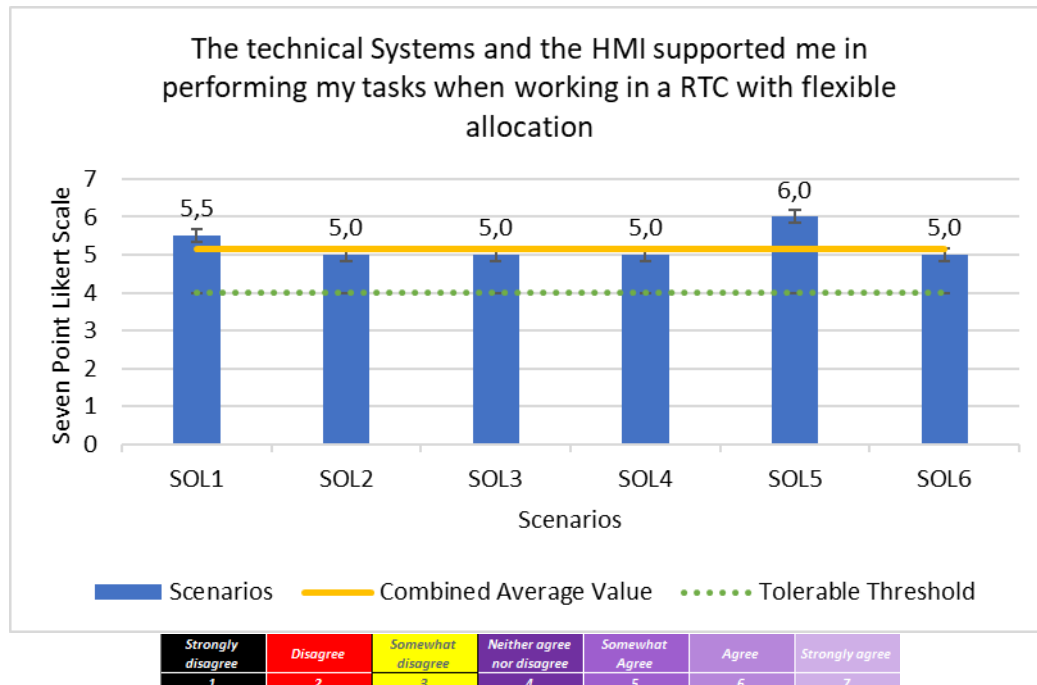


Figure: The technical Systems and the HMI supported me in performing my tasks when working in an RTC with flexible allocation - SUP Post Run Questionnaire

5.2 is the measured combined average value that is above the 4 points tolerable threshold. Standard deviation is ± 0.7 .

The criteria is judged as met, considering the distribution of answers are mostly above the tolerable threshold as indicated in the following plot:

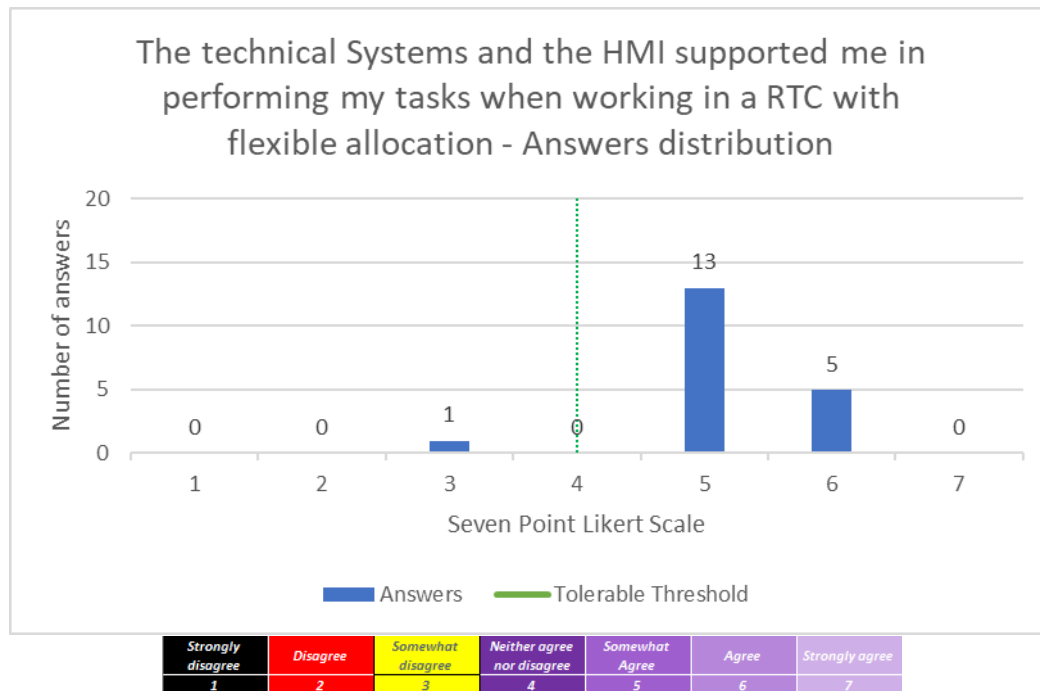


Figure: The technical Systems and the HMI supported me in performing my tasks when working in an RTC with flexible allocation – Answers’ distribution- SUP Post Run Questionnaire

Only 1 answer is on the level 3 (Somewhat disagree) and the supervisor commented that there might be the need of further technical enhancement to have a final evaluation. This statement has to be read in consideration of the missing connection of the supervisor planning tool with the real time simulation platforms. This is a technical limitation of the platform ad-hoc installed for this exercise. Despite the lack of a physical connection between the two platforms, the traffic sample and its evolution over time were always aligned to allow for accurate analysis by the supervisor.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|-------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H01.040 | Majority of SUP confirm that they maintain an adequate level of SA, despite having to divide their attention to different clusters of aerodromes | Not addressed by the exercise | |

D.3.4.2 HUMAN PERFORMANCE – WORKLOAD

D.3.4.2.1 OBJ-PJ05-W2-35-V3-VALP-H05 Results

| OBJ05-W2-35-V3-VALP-H05 Assess Supervisor workload when supporting the provision of ATS to multiple aerodromes | | | |
|---|---|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H05.010 | Majority of SUPs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Different components of workload were assessed: the overall perceived cognitive workload was assessed but it was considered necessary also to assess the planning load, the monitoring load, the R/T load and the coordination load to verify if there was any dimension of the workload that was more demanding and required specific mitigations.</p> <p>All the components of the workload were within the tolerable values</p> | Ok |

The criteria was assessed through post run 10 points Bedford scale and post simulation 7 points scale ad-hoc questionnaires. The results have been complemented by the collected notes of the debriefings and interviews as well as by the conducted observations.

Different components of workload were assessed: the overall perceived cognitive workload was assessed but it was considered necessary also to assess the planning load, the monitoring load, the R/T load and the coordination load to verify if there was any dimension of the workload that was more demanding and required specific mitigations.

The supervisor experienced workload was always acceptable being rated mainly on the level 3 with an average value of 2.7 and a standard deviation of ± 0.7

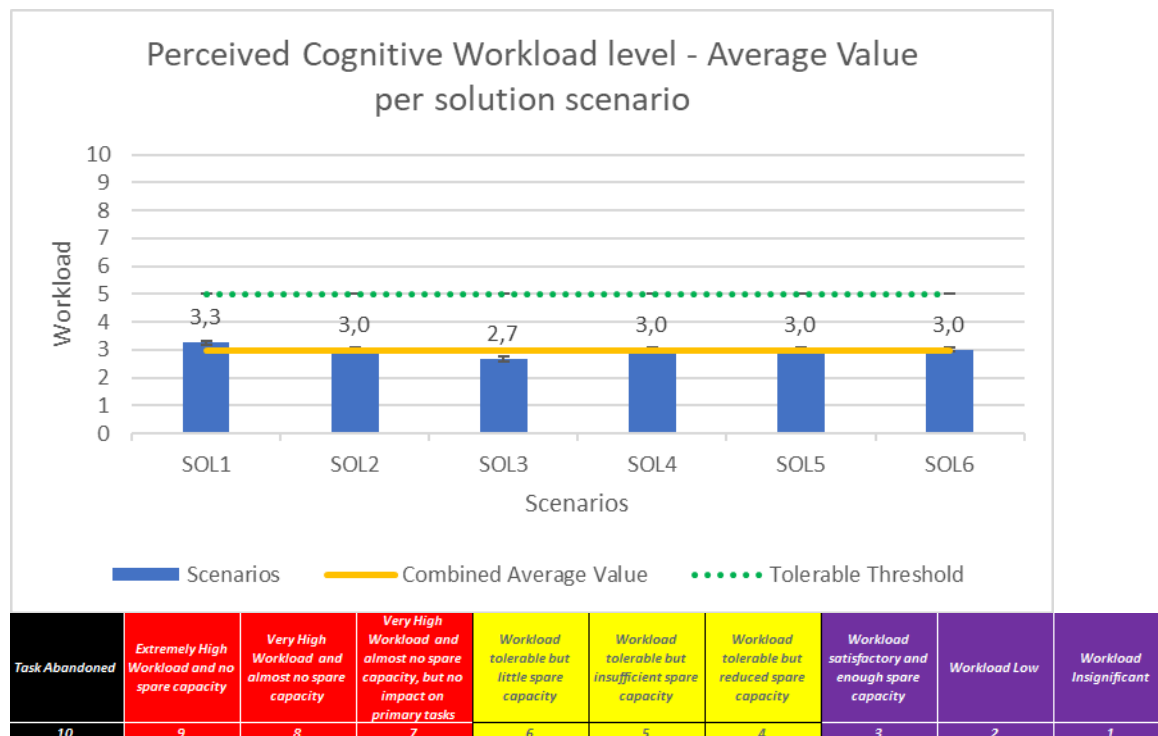


Figure: SUP - Workload – Post Run Questionnaire

Both the supervisors never complained about the workload and the criteria is considered as successfully met being most of the answers on the level 3 well below the tolerable threshold.

Similar results were also observed in the post simulation question reported below:

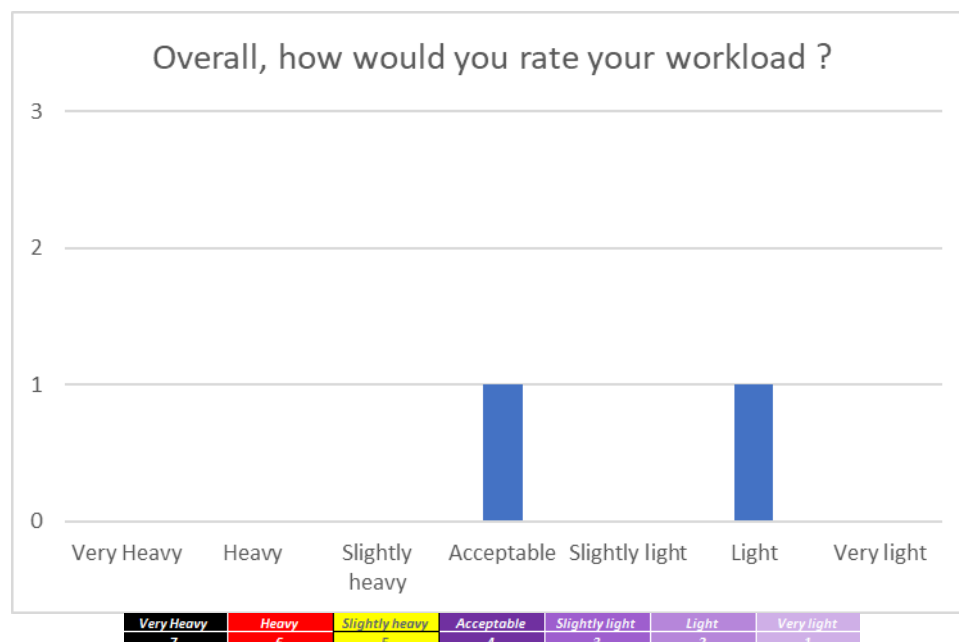


Figure: SUP - Workload – Post EXE Questionnaire

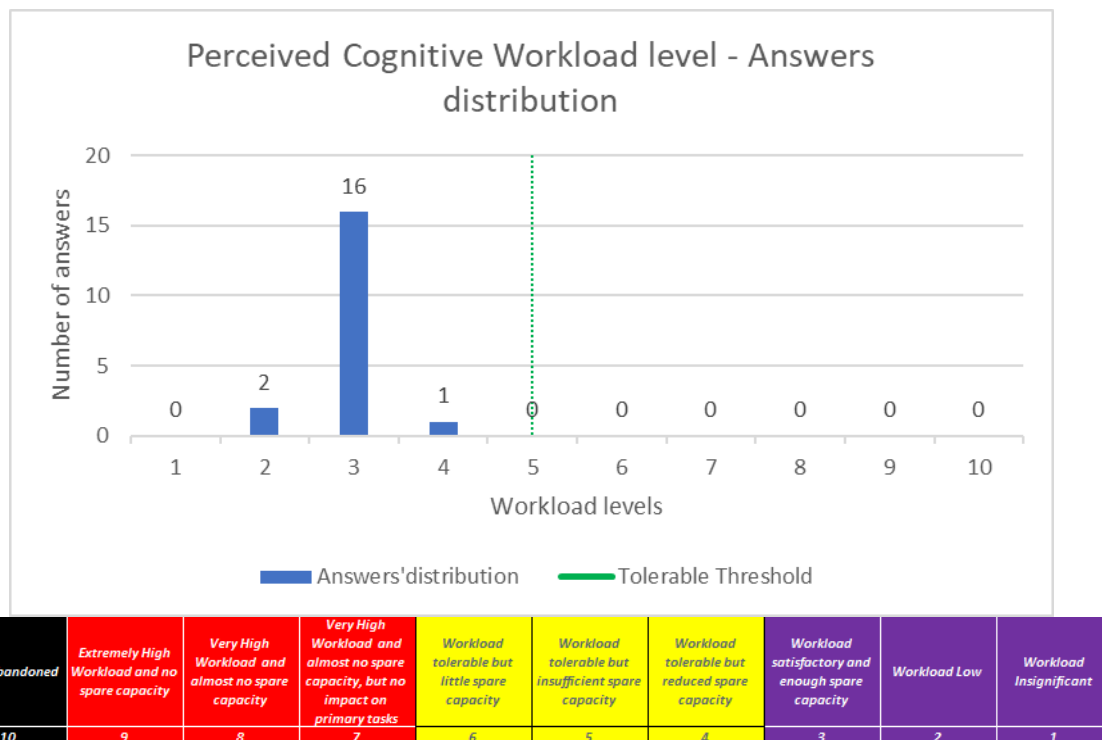


Figure: SUP - Workload – Post Run Questionnaire

Nevertheless, this result was in relation to the simulation experienced workload, but it was discussed that there might be issues in relation to the supervisor workload with the increase of the size of the remote tower centre. Indeed, it was discussed that there might be a dedicated assessment to understand the number of modules that can be assigned to a supervisor.

Coordination load, planning, R/T load and monitoring load were also assessed in the post run questionnaires and both.

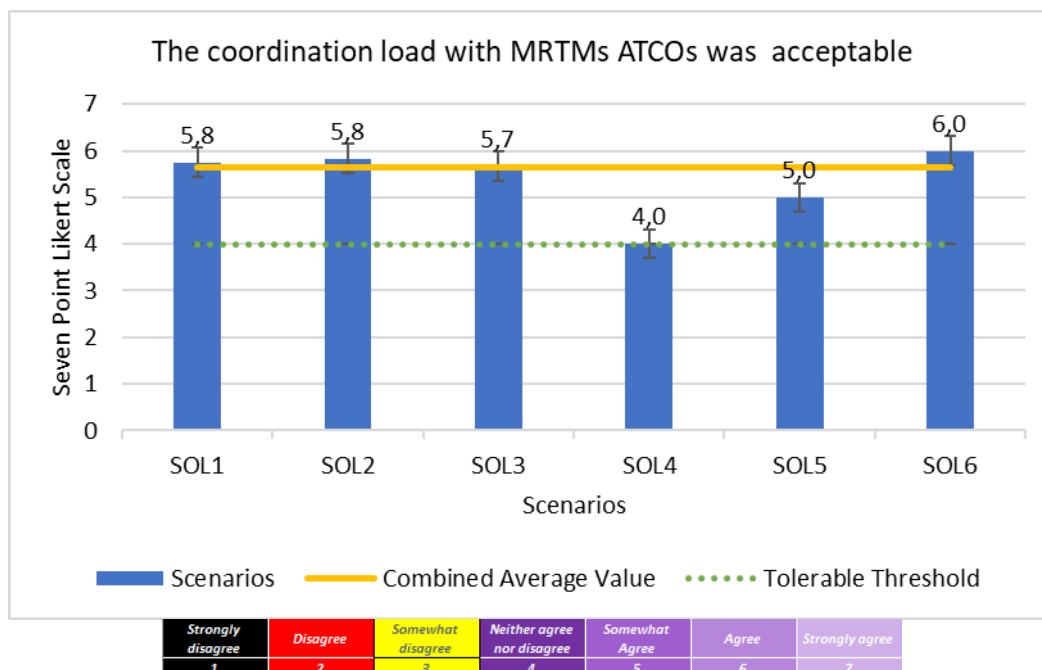


Figure: SUP - Workload – Coordination load Post Run Questionnaire

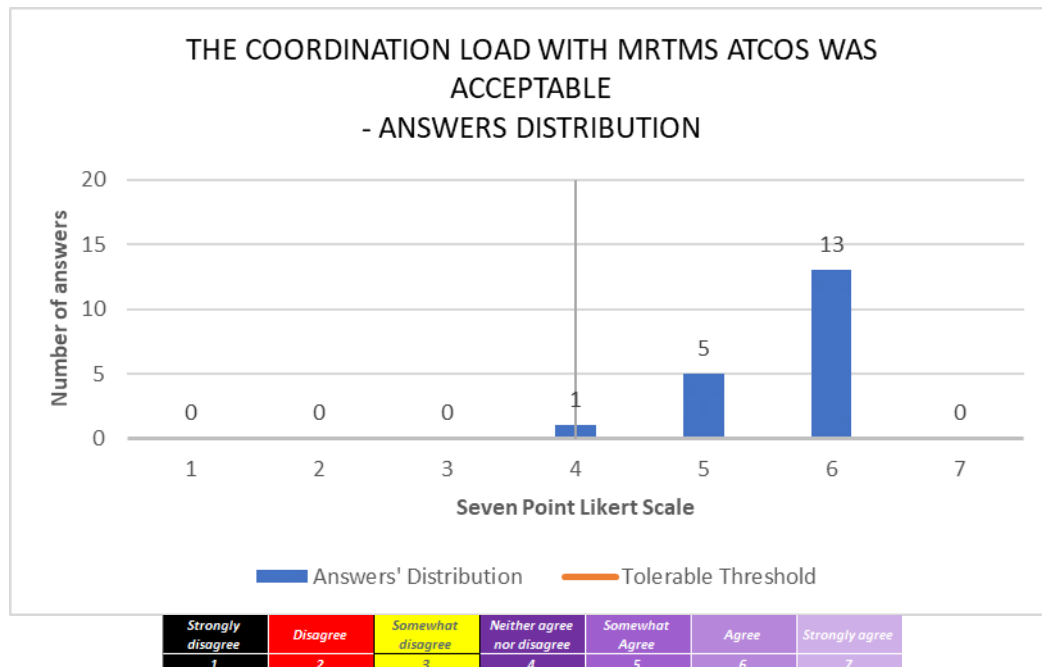


Figure: SUP - Workload – Coordination load Post Run Questionnaire

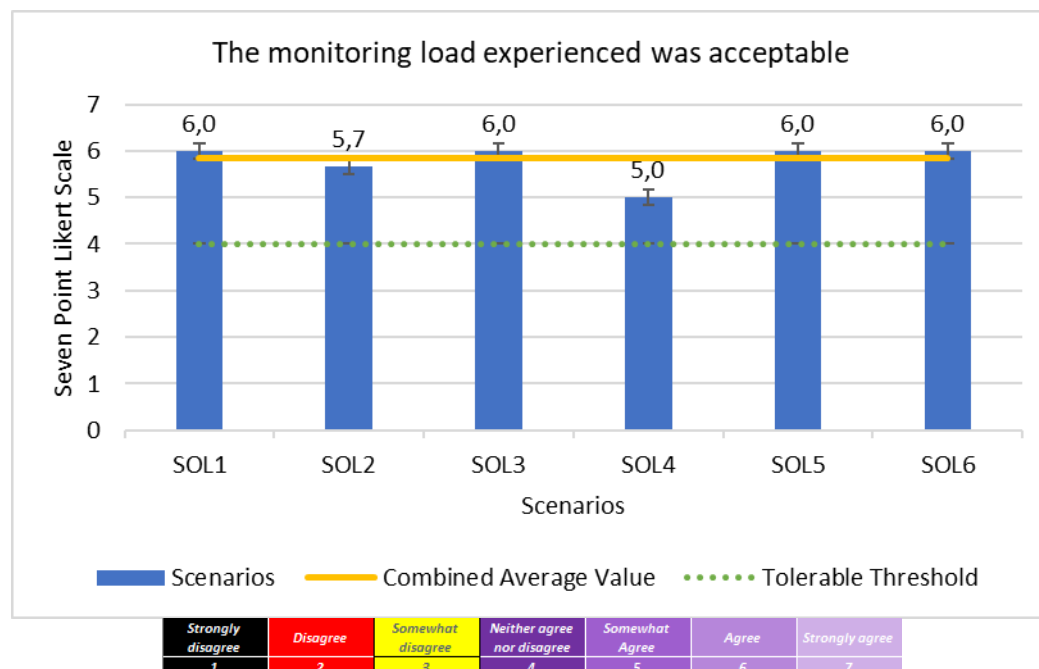


Figure: SUP - Workload – Monitoring load Post Run Questionnaire

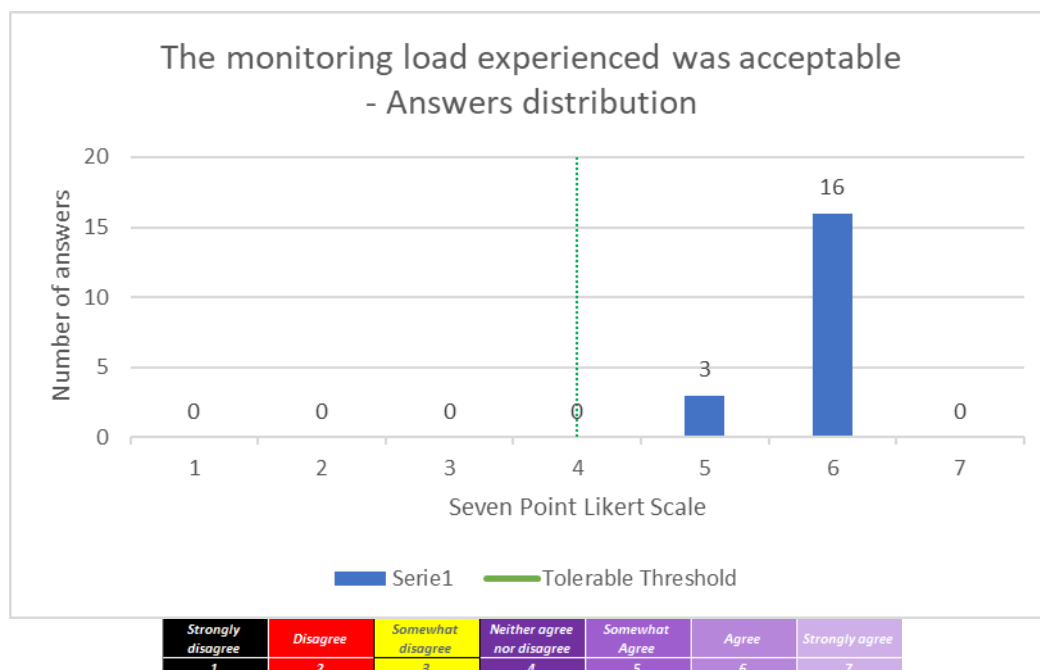


Figure: SUP - Workload – Monitoring load Post Run Questionnaire

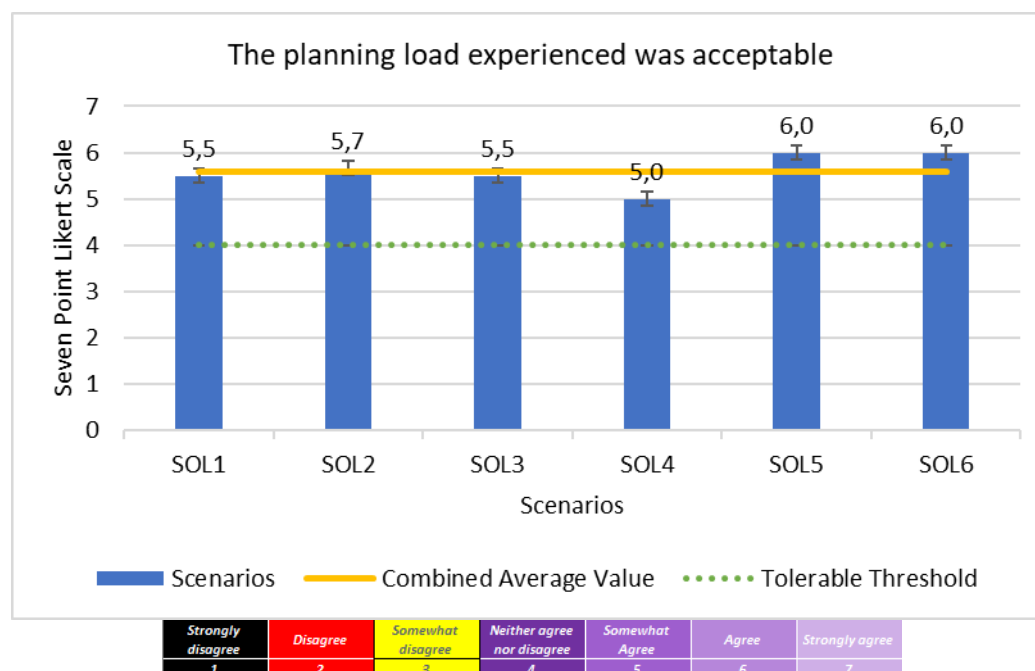


Figure: SUP - Workload – Planning load Post Run Questionnaire

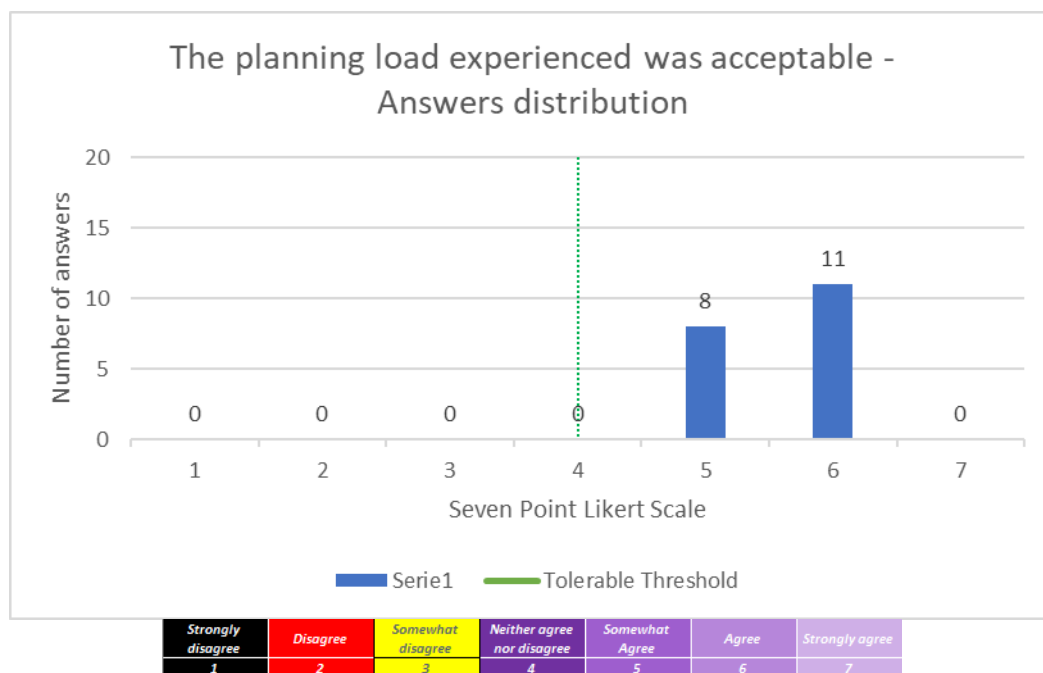


Figure: SUP - Workload – Planning load Post Run Questionnaire

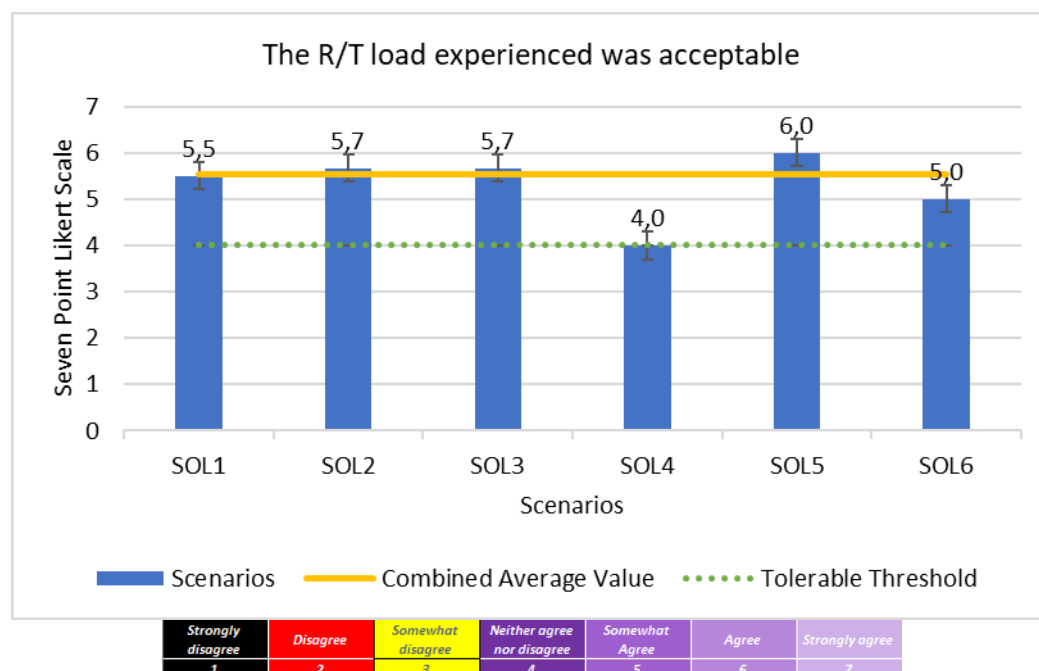


Figure: SUP - Workload – R/T load Post Run Questionnaire

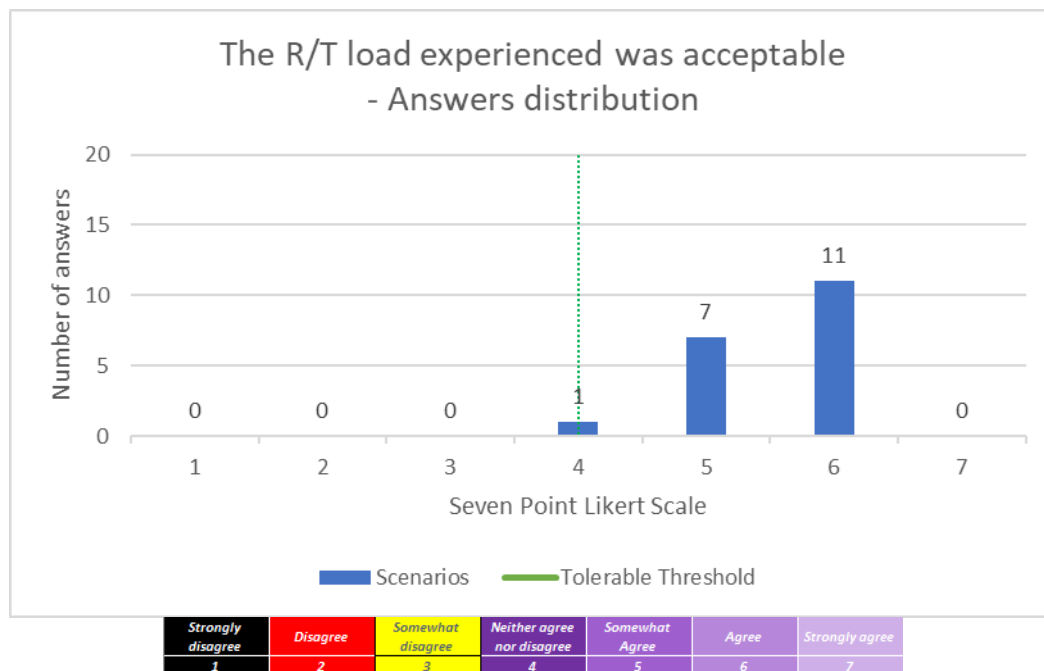


Figure: SUP - Workload – R/T load Post Run Questionnaire

All the above reported components of workload were perceived as acceptable from the participating supervisors being all above the tolerable thresholds as it can be observed in the graphs above except for the R/T load in a specific scenario, the solution scenario 4 which experimented an aircraft in emergency on Treviso airport. This is a specific abnormal case which justifies the increase of the R/T load to communicate with the module hosting the emergency.

D.3.4.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

D.3.4.3.1 OBJ-PJ05-W2-35-V3-VALP-H09 Results

| OBJ-PJ05-W2-35-V3-VALP-H09 Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H09.010 | Majority of SUPs assess that operating methods can be applied in an accurate, efficient and timely manner in normal operating conditions, in case of aircraft emergency and in case of failure of the system when working in an RTC with a flexible allocation of aerodromes between MRTMs | Operating methods were applied in an accurate, efficient and timely manner in normal operating conditions, in case of aircraft emergency and in case of failure of the system when working in an RTC with a flexible allocation of aerodromes between MRTMs. Anyway, it was discussed and recommended that operational procedures and check lists, as above mentioned, for nominal conditions as well as for abnormal and degraded mode shall be revised, definitely | Ok |

OBJ-PJ05-W2-35-V3-VALP-H09

Assess Supervisors acceptance of operating methods when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|--|--------|
| | | consolidated and put in place to support the RTC with flexible allocation. | |

The criteria was successfully met considering the results of the post simulation questionnaires positive answers plotted below (complemented by the collected notes of the debriefings and interviews as well as by the conducted observations):

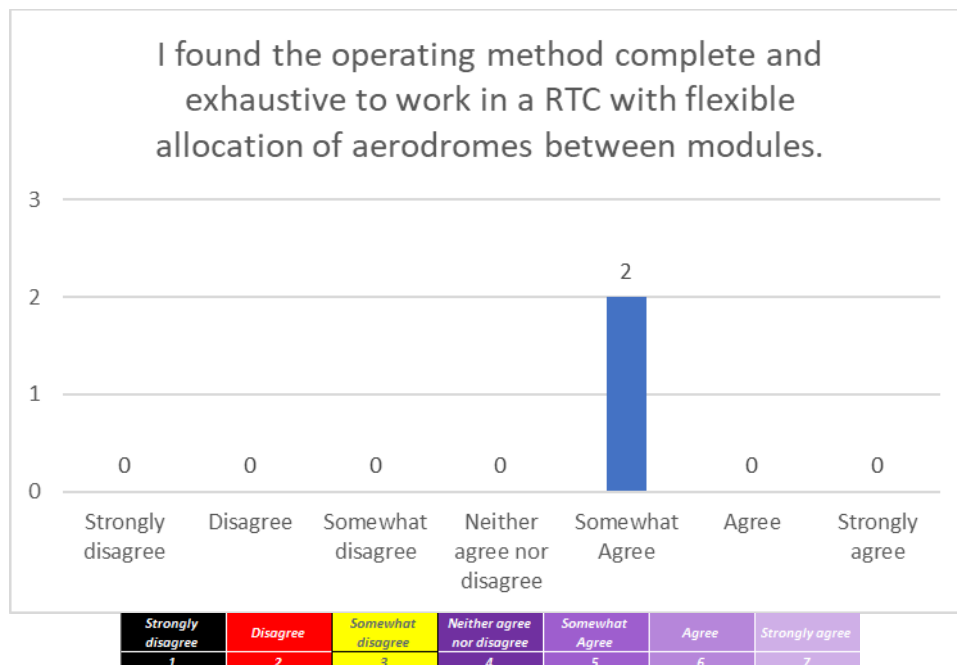


Figure: SUP Operating methods – Post EXE Questionnaire

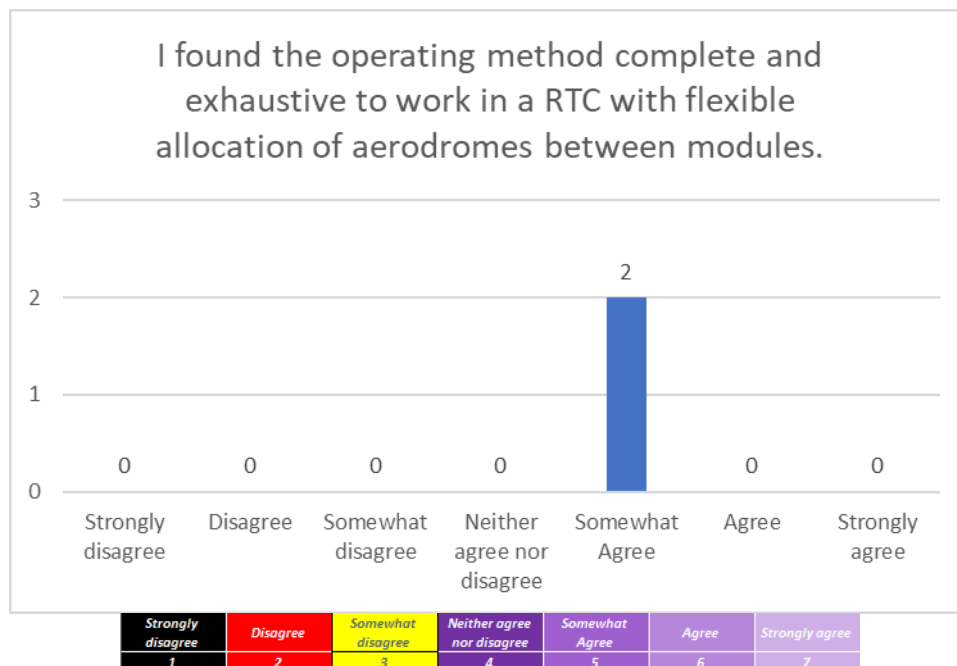


Figure: SUP Operating methods – Post EXE Questionnaire

Anyway, it was discussed and recommended that operational procedures and check lists, as above mentioned, for nominal conditions as well as for abnormal and degraded mode shall be revised, definitely consolidated and put in place to support the RTC with flexible allocation.

D.3.4.4 HUMAN PERFORMANCE – USABILITY and UTILITY

D.3.4.4.1 OBJ-PJ05-W2-35-V3-VALP-H10 Results

OBJ-PJ05-W2-35-V3-VALP-H10

Assess Supervisor acceptance of roles and responsibilities when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H10.010 | Majority of Supervisors assess that changes to their roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable | Considering the positive responses on the research questions on the clarity and acceptability of the roles and responsibilities as well as on the supervision of the assigned number of airports (most of the responses are above the tolerable threshold), the criteria is considered met. Anyway supervisors test subjects raised and agreed on the possibility of undertaking some of the coordination | Ok |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| | | <p>tasks currently assigned to the ATCOs as mentioned in the previous objective. A further comment was also raised about the possibility for the supervisor to support more the handover phase, but while both the supervisor agreed on this option, they did not fully agree on which extend this support was to be provided and on the modality.</p> <p>Level of acceptance was also within tolerable limits.</p> | |
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H10.030 | Majority of Supervisors confirm the feasibility and acceptability of supervise the assigned number of clusters of aerodromes | Supervisor confirmed the feasibility and acceptability of supervising a cluster of aerodromes with 3 airports | Ok |

Both the criteria have been assessed through dedicated 7 points scale questions in the post run and post simulation questionnaires reported below (complemented by the collected notes of the debriefings and interviews as well as by the conducted observations).

While both the criteria are considered to be successfully met considering the positive responses on the research questions on the clarity and acceptability of the roles and responsibilities as well as on the supervision of the assigned number of airports (most of the responses are above the tolerable threshold), supervisors test subjects raised and agreed on the possibility of undertaking some of the coordination tasks currently assigned to the ATCOs as mentioned in the previous objective.

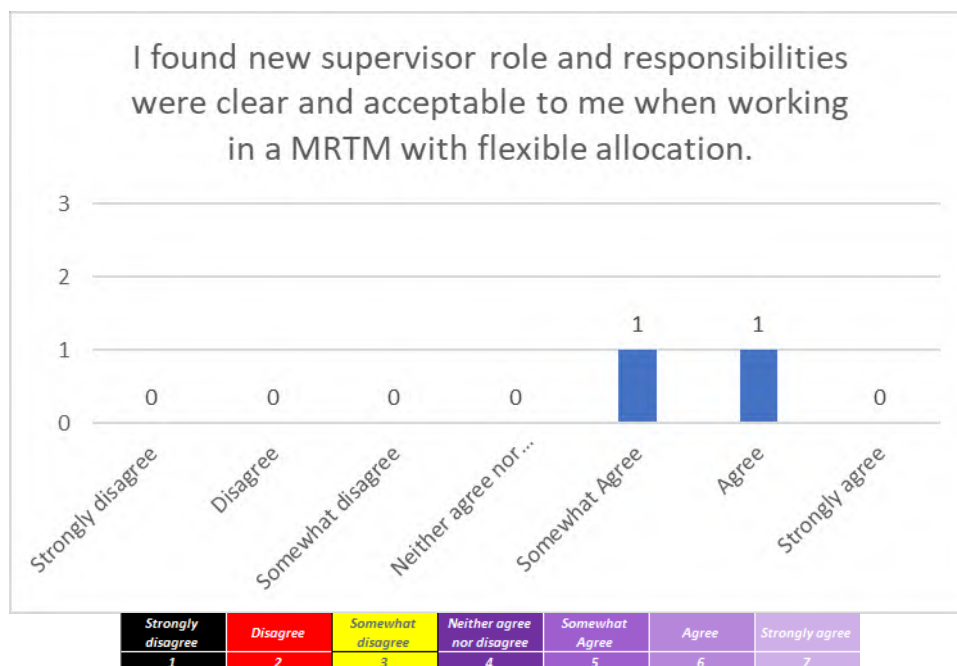


Figure: SUP – Roles and responsibilities Post EXE Questionnaire

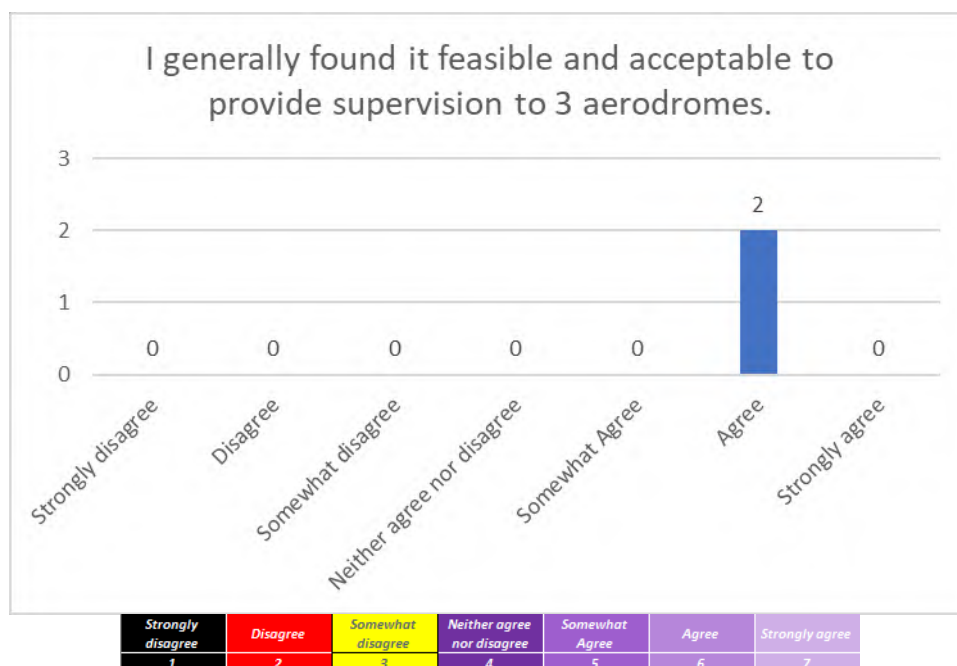


Figure: SUP – Number of aerodromes Post EXE Questionnaire

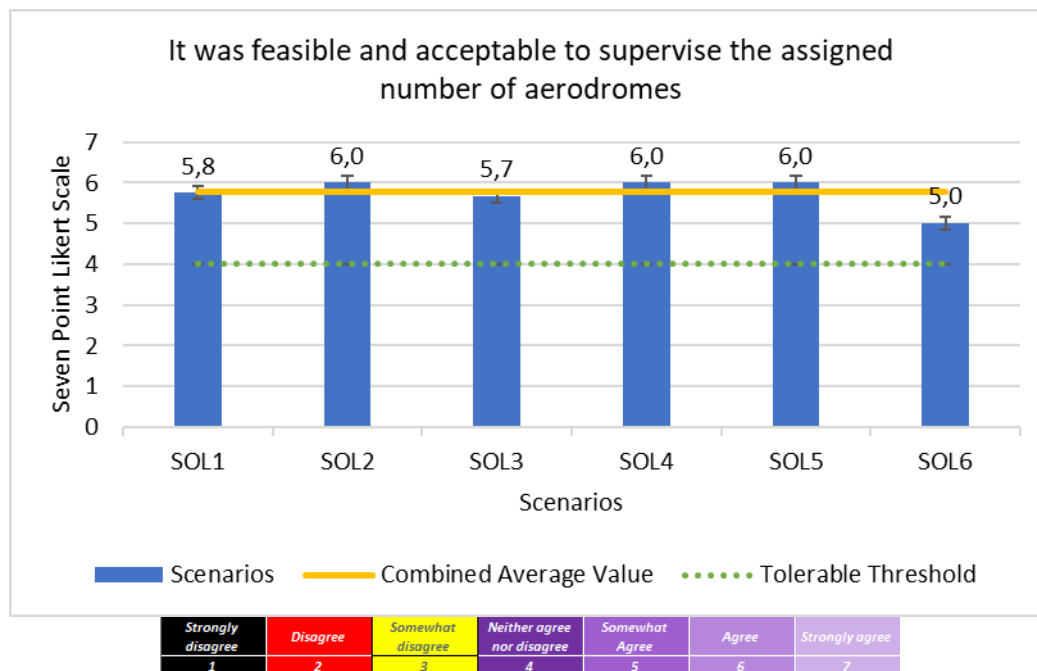


Figure: SUP – Number of aerodromes Post run Questionnaire

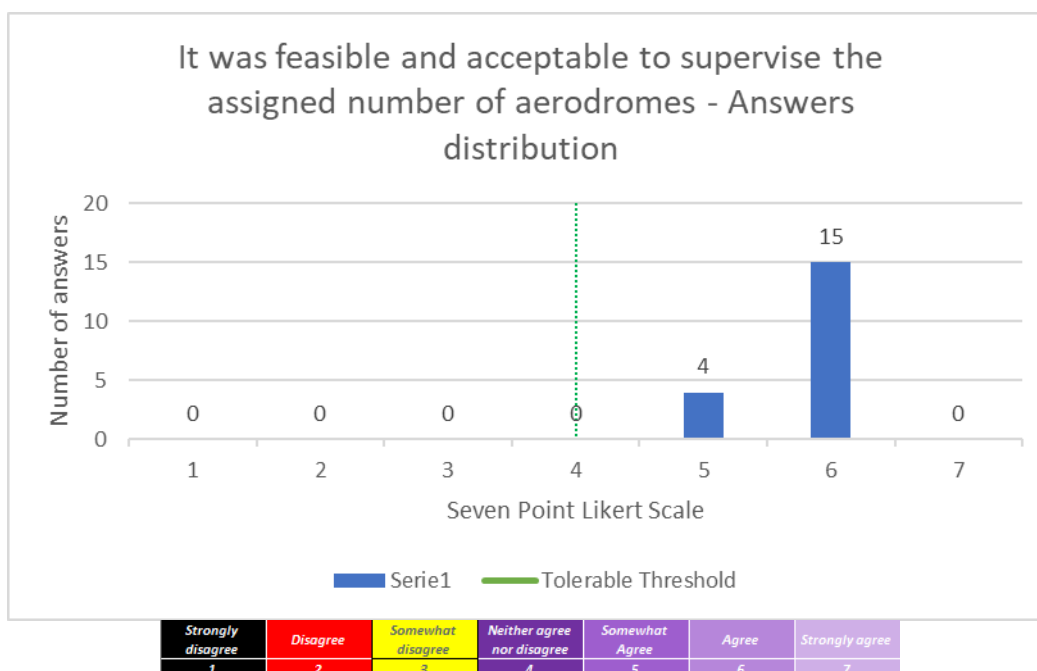


Figure: SUP – Number of aerodromes Post run Questionnaire

A further comment was also raised about the possibility for the supervisor to support more the handover phase, but while both the supervisor agreed on this option, they did not fully agree on which extend this support was to be provided and on the modality.

Level of acceptance was also rated in the post run questionnaire on the 10 points CARS rate. The results in terms of average are plotted below for the different scenarios:

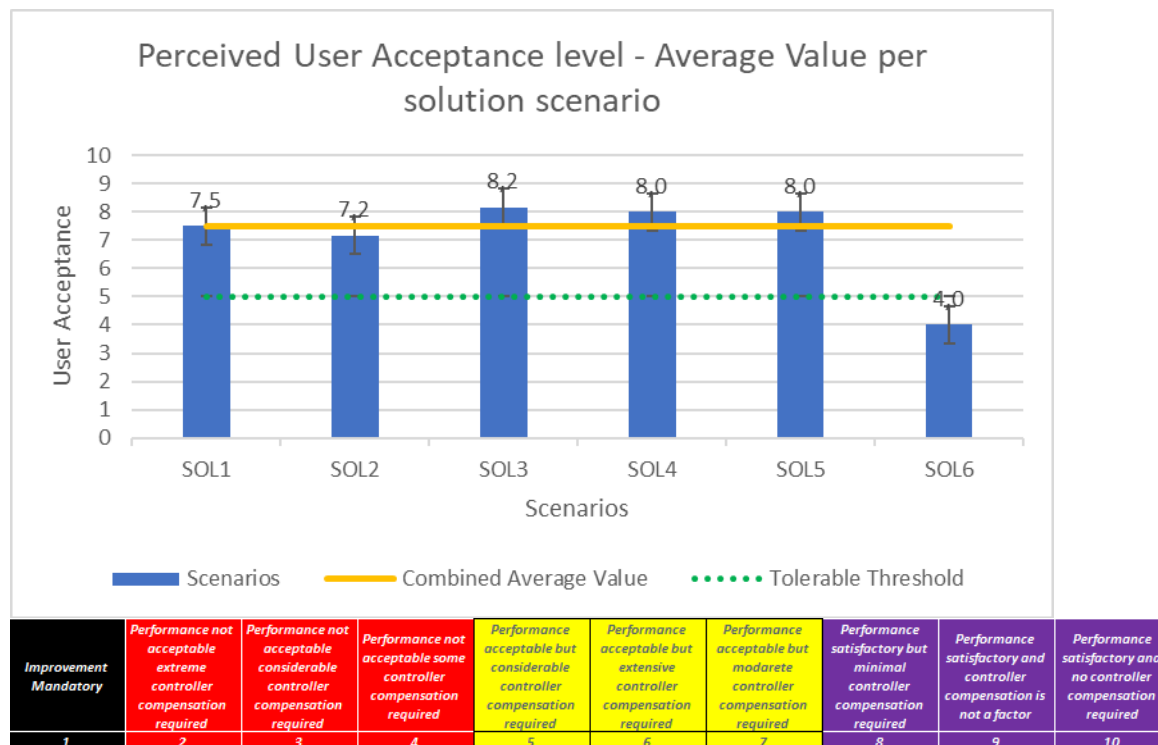


Figure: SUP – User acceptance - Post run Questionnaire

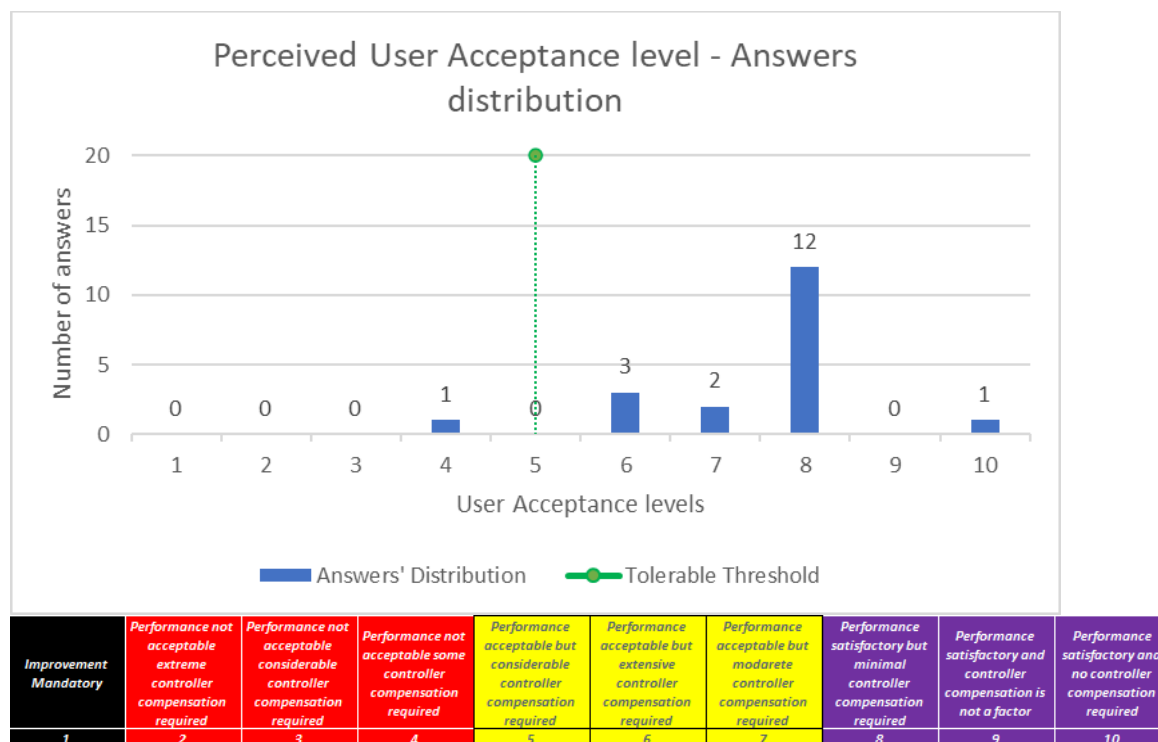


Figure: SUP – User acceptance - Post run Questionnaire

The most of the above provided results demonstrate that the user acceptance was generally rated at acceptable levels, with the exception of solution 6 that was a safety related scenario with failure simulated.

D.3.4.4.2 OBJ-PJ05-W2-35-V3-VALP-H12 Results

OBJ-PJ05-W2-35-V3-VALP-H12

Assess usability and utility of Supervisor human machine interface when supporting provision of ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.010 | Majority of Supervisors assess that they have all required information available when working in an RTC with a flexible allocation of aerodromes between MRTMs | Not conclusive response can be considered from the collected answers (1 somewhat agree and 1 agree answer) | P-OK |

The criteria is considered as partially ok as there is not a conclusive response that can be based on the questions on the 7 point scale in the supervisor post simulation questionnaire plotted below.

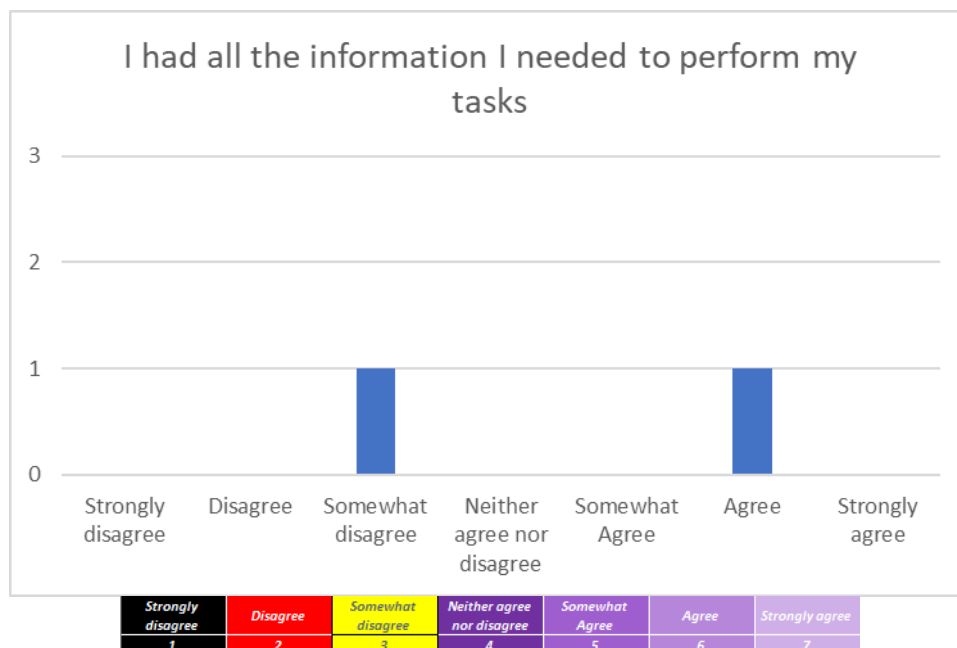


Figure: SUP – Information - Post EXE Questionnaire

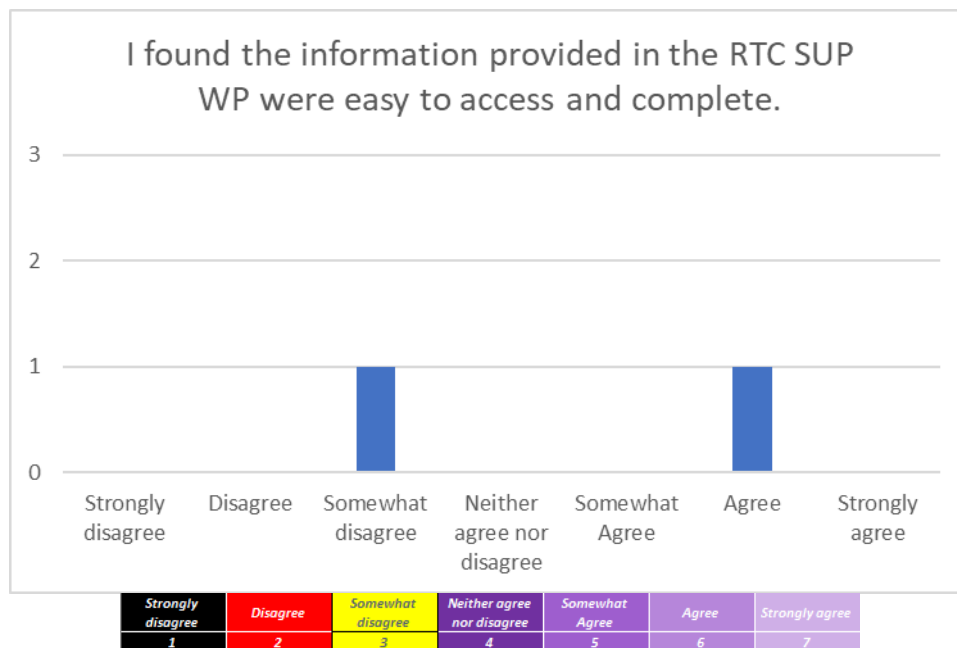


Figure: SUP – Information - Post EXE Questionnaire

Indeed, for both the questions “I had all the information I needed to perform my tasks” and “I found the information provided in the SUP Working Position” one answer is somewhat disagree and the other one is agree. The reason for not achieving a conclusive result is behind the technical limitation of the supervisor planning tool that due to time and resources constraint was not linked to the simulation platform and thus all the calculation were based on a planned traffic sample rather than the live traffic managed in the simulation experiment. For one of the ATCO this was a big issue that was affecting the level of information provided to him, while the other supervisor easily adequate his working method to deal with the limitation of the supervisor tool.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.020 | Majority of Supervisors confirm adequate usability of input devices | The main input device in use for the supervisor was the handover system. The usability of the handover system was considered acceptable and thus the criteria is considered as met | Ok |

The main input device in use for the supervisor was the handover system. The usability of the handover system was considered acceptable and thus the criteria is considered as met on the basis of the responses collected in the post run and post simulation questionnaire on a 7-point scale provided below.

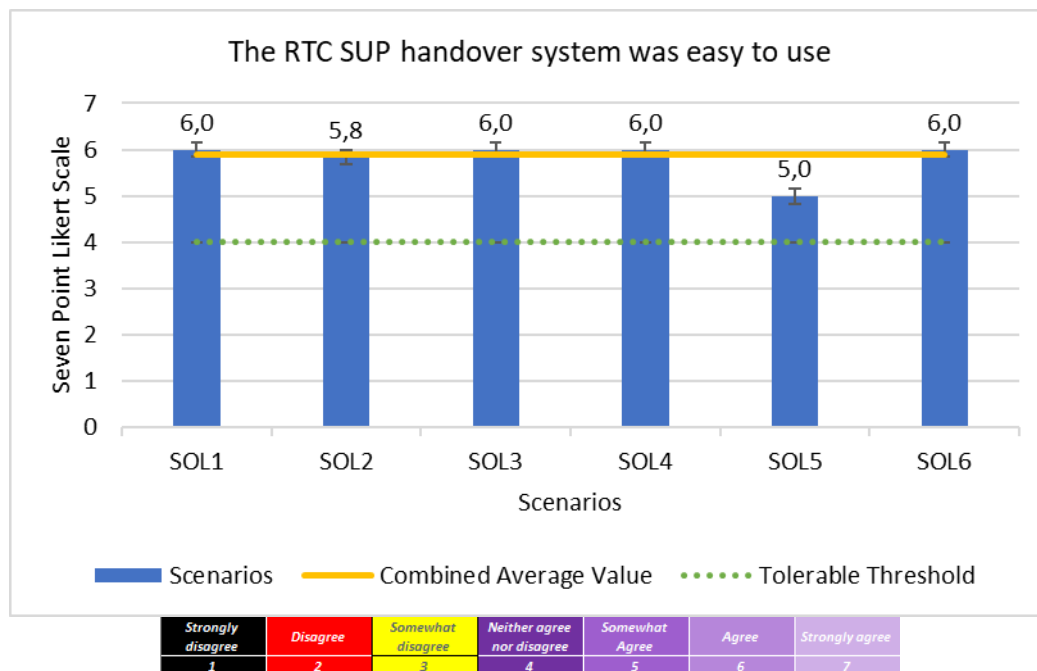


Figure: SUP – Usability - Post run Questionnaire

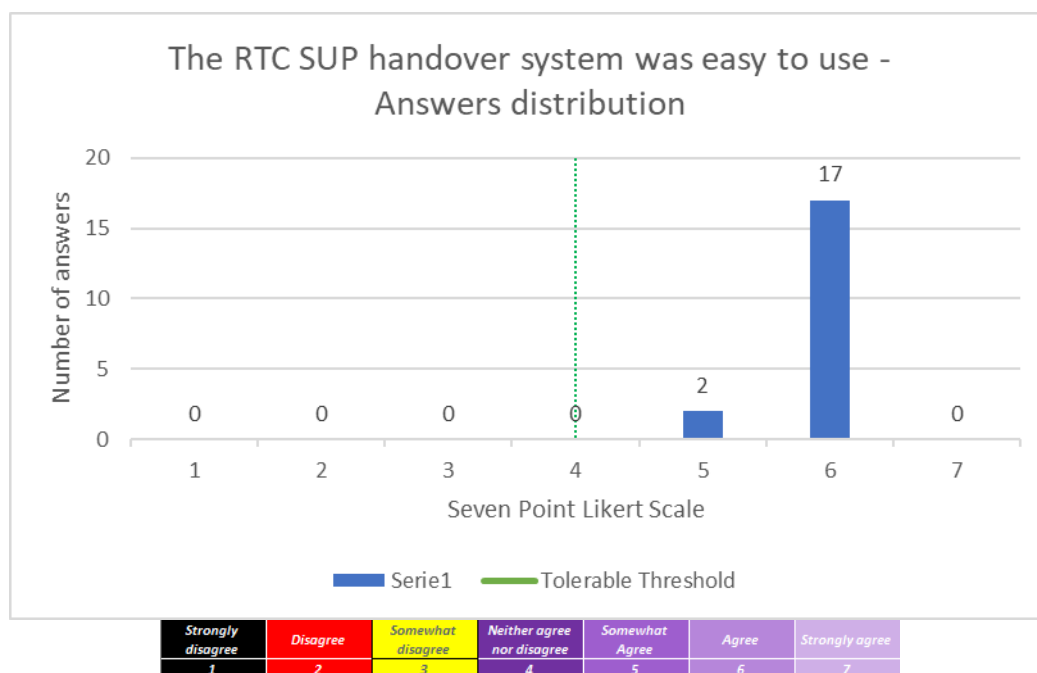


Figure: SUP – Usability - Post run Questionnaire

The handover system was really easy to use and was based on a clear HMI as discussed during the debriefing and as understandable from the provided distribution of answers all in the positive area of the plot. Coherent result was collected in the post simulation questionnaire reported in the next figure:

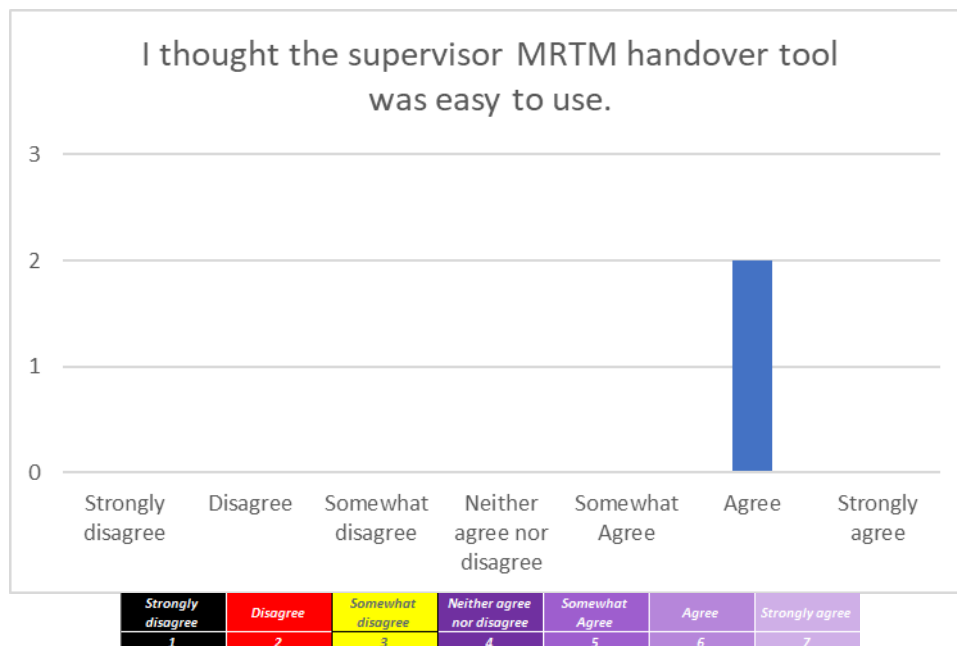


Figure: SUP – Usability - Post EXE Questionnaire

The post simulation questionnaire also questioned about the possibility of confusion about the displayed airports on the transferring system and looking at the graphs providing the answers this never happened for the handover system:

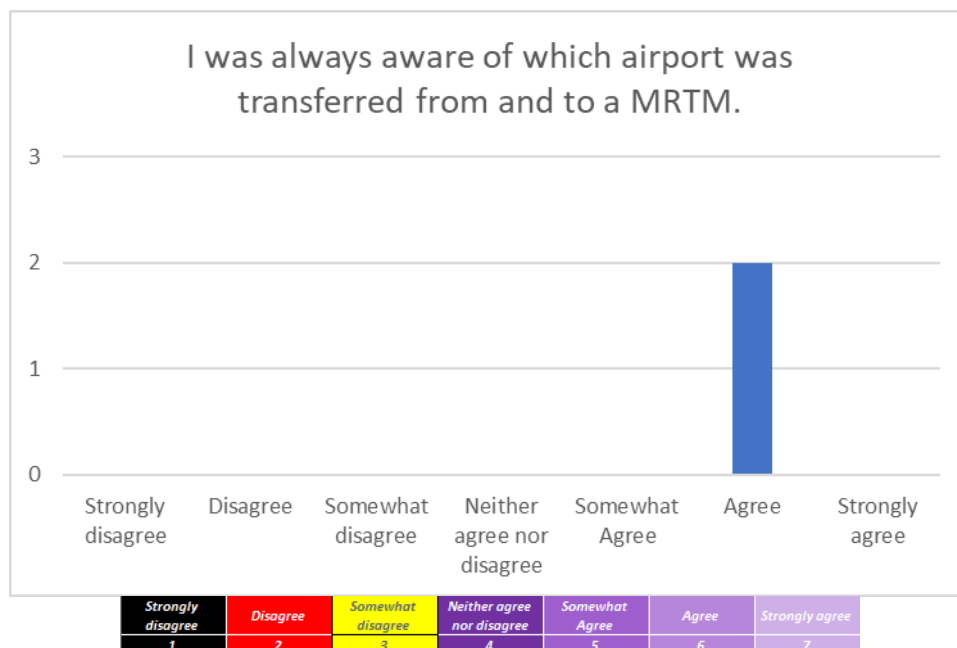


Figure: SUP – Handover - Post EXE Questionnaire

Not so positive answers on the other hand were collected for the integration of the various functions.

The handover system was also judged as adequate in terms of timely execution of the transfer considering the relevant question in the post simulation questionnaire indicated in the next figure:

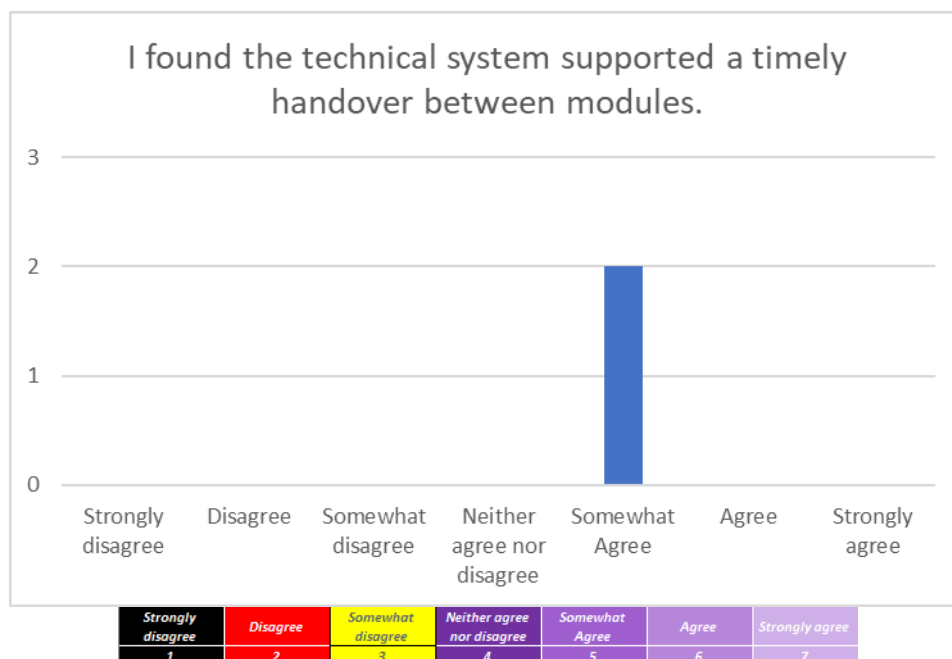


Figure: SUP – Handover - Post EXE Questionnaire

As already mentioned above and clear from the picture below, one of the supervisors complained about the lack of integration of the supervisor planning tool in the simulation live data flow.

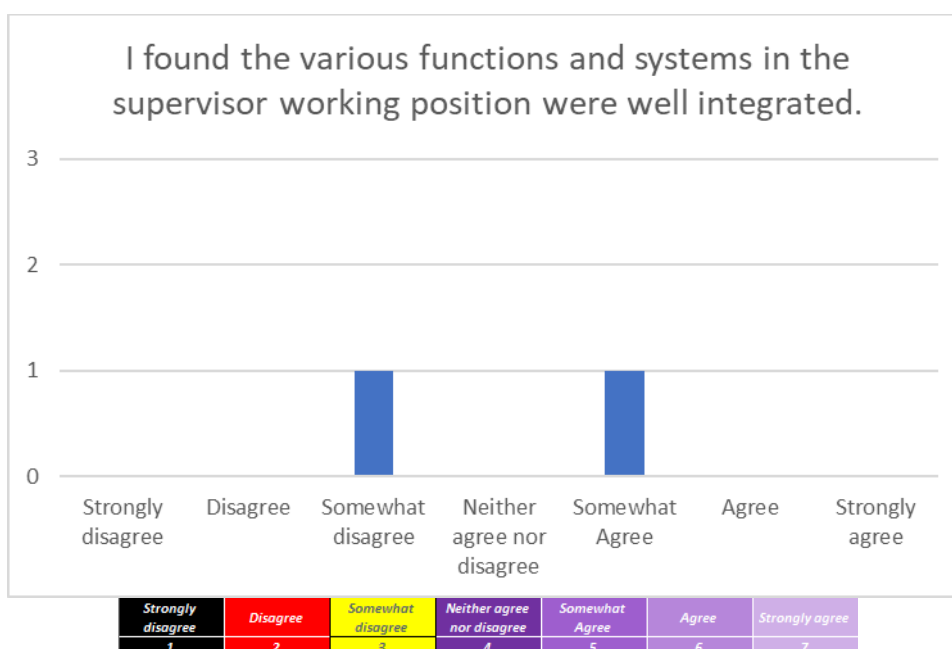


Figure: SUP – Integration - Post EXE Questionnaire

To conclude the criteria is considered as successfully met considering also the integration aspect is more relevant for the supervisor planning tool.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.030 | Majority of Supervisors confirm adequate usability and utility of supervisor planning tool | Not conclusive response can be considered from the collected answers (1 somewhat agree and 1 agree answer) | P-OK |

Usability of supervisor planning tool was assessed through a customised set of questions based on SUS using a 7 points scale. The average response for the different experimental conditions is reported in the figures below:

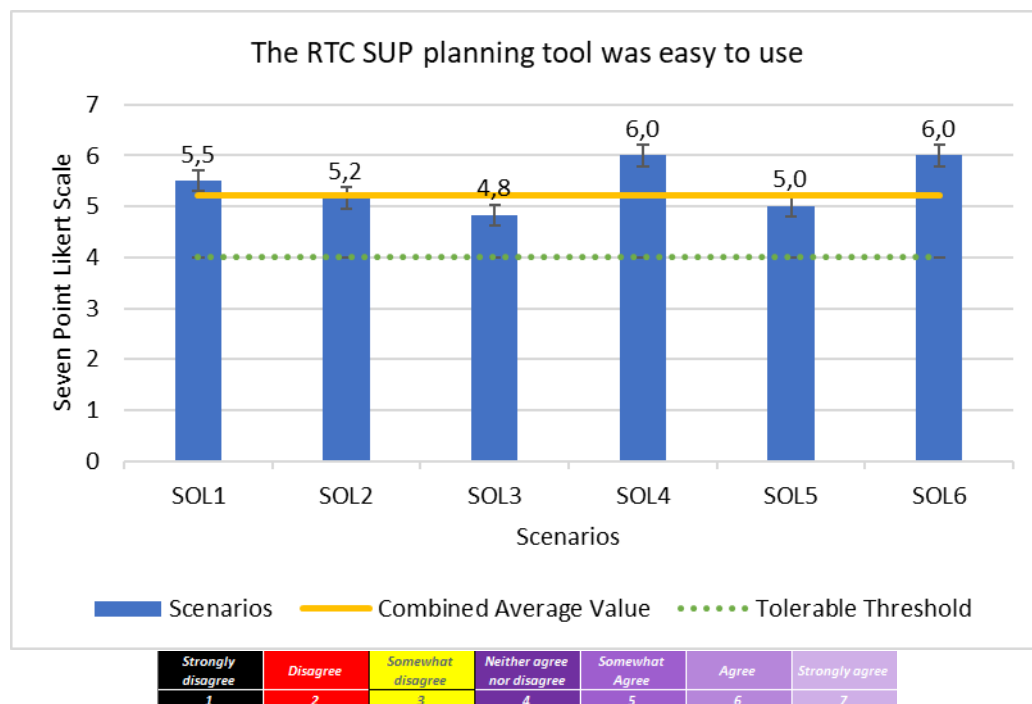


Figure: SUP Planning tool - Post run Questionnaire

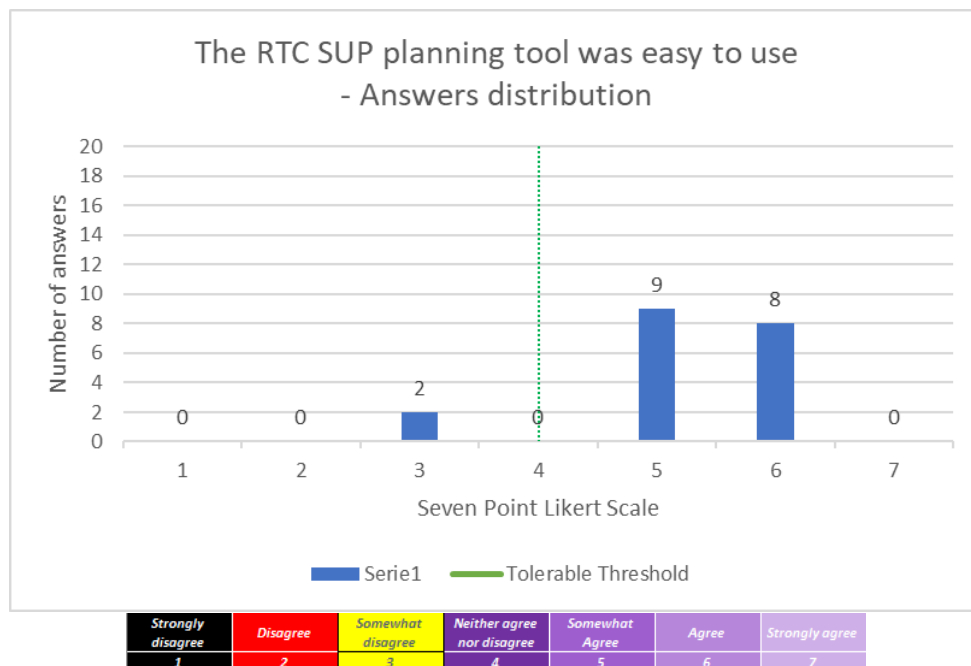


Figure: SUP Planning tool - Post run Questionnaire

From the above answers the supervisor planning tool resulted easy to use considering that most of the responses are positive. Nevertheless, several improvements were recommended for the supervisor planning tool in order to achieve a better HMI and an improved interaction and a satisfactory user experience. This is also understandable looking at the contradictory answers of the post simulation result.

The post simulation questionnaire also questioned about the possibility of confusion about the displayed airports on the supervisor planning tool which is reported in the next figure:

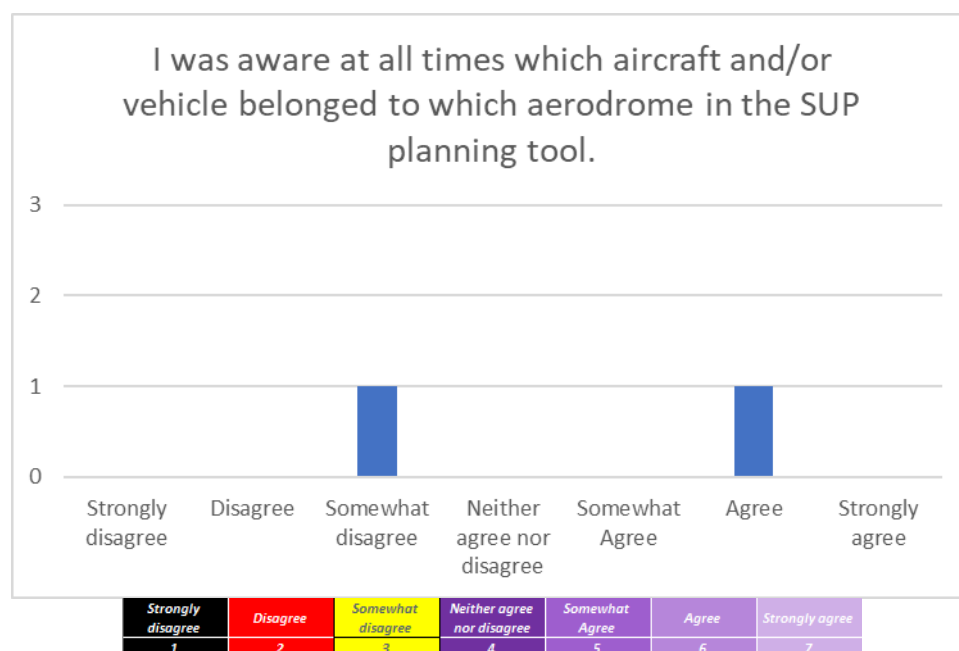


Figure: SUP Planning tool - Post EXE Questionnaire

But not a conclusive result can be appointed to the supervisor planning tool considering those results.

Indeed, the supervisors during the debriefing complained about the HMI of the supervisor planning tool that could be enhanced displaying multiple windows, which currently was not the case, and using a more friendly and intuitive code for understanding the airports displayed in the traffic sample plots.

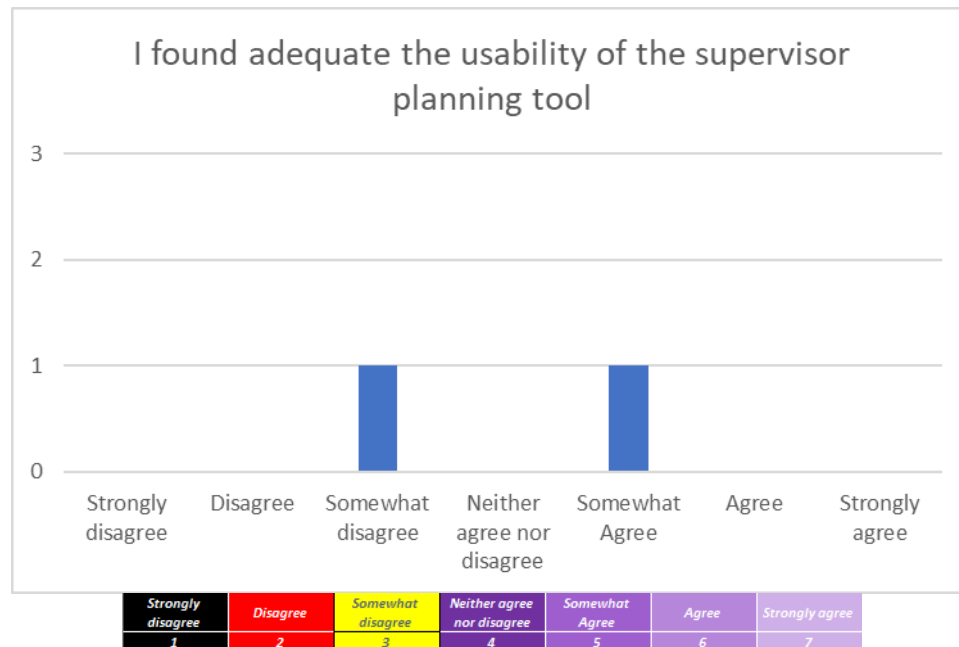


Figure: SUP Planning tool Usability- Post EXE Questionnaire

The criteria is considered as partially met considering the provided results are not all aligned in the positive area.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.040 | Majority of Supervisors confirm adequate usability and utility of alarms and alerts for the SUP planning tool and emergency situation | Supervisor was informed about emergency situation through the handover system addressed in criteria CRT-PJ05-W2-35-V3-VALP-H12.020. This system was judged as adequate and usable so the criteria is considered as successfully met. See CRT-PJ05-W2-35-V3-VALP-H12.020 results. | Ok |

Supervisor was informed about emergency situation through the handover system addressed in criteria CRT-PJ05-W2-35-V3-VALP-H12.020. This system was judged as adequate and usable so the criteria is considered as successfully met. See CRT-PJ05-W2-35-V3-VALP-H12.020 results.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H12.050 | The SUP human machine interface does not increase the potential for human error | Potential of increase in human error caused by the HMI was not considered as increasing | Ok |

Potential of increase in human error caused by the HMI was addressed in the following graphed questions in relation to the supervisor planning tool HMI, handover system HMI and in general for both the tool.

The answers all fit in the somewhat level of the responses based on the 7 points scale and thus positively addressed as it can be seen in the next pictures:

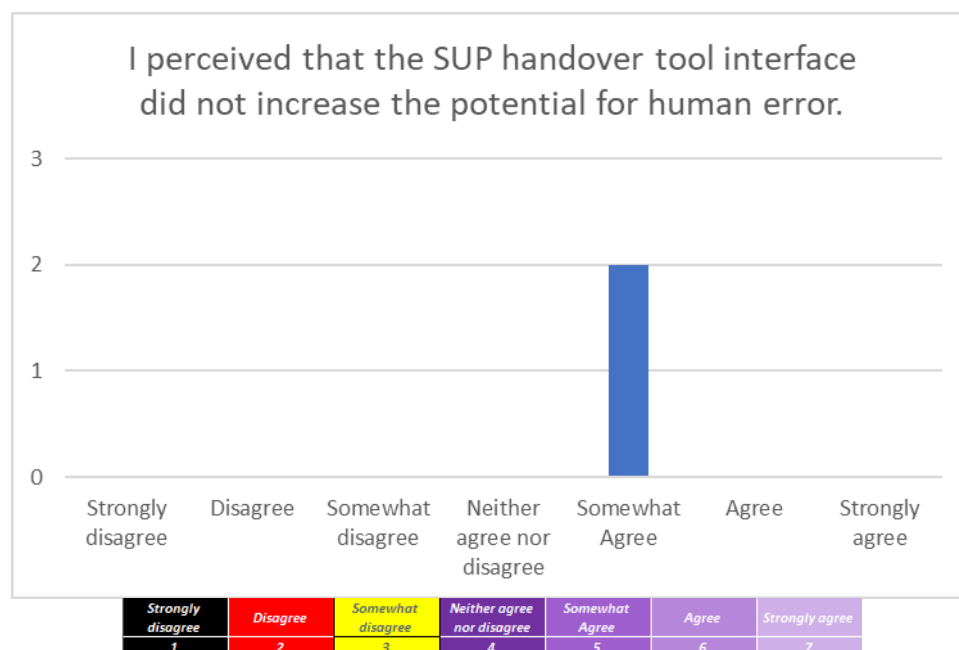


Figure: SUP – Human Error - Post EXE Questionnaire

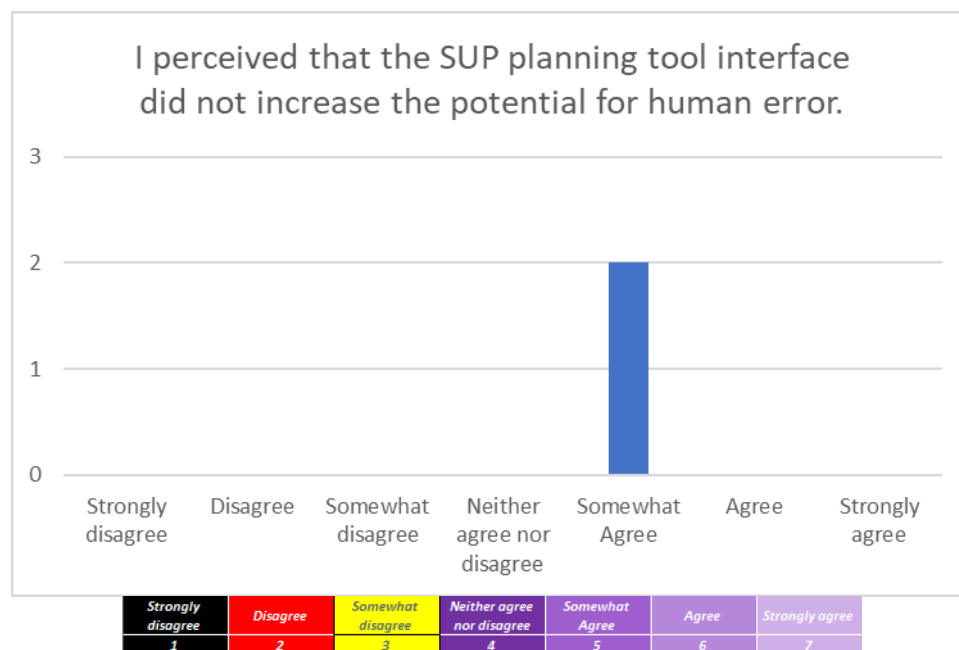


Figure: SUP – Human Error - Post EXE Questionnaire

The criteria is considered as successfully met.

D.3.4.5 HUMAN PERFORMANCE – TRUST

D.3.4.5.1 OBJ-PJ05-W2-35-V3-VALP-H14 Results

| OBJ-PJ05-W2-35-V3-VALP-H14 Assess Supervisor trust in support systems when supporting provision of ATS to multiple aerodromes | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H14.010 | Supervisor trust the functionalities of the supervisor planning tool when working in an RTC with a flexible allocation of aerodromes between MRTMs | The criteria is considered as not ok in relation to the supervisor planning tool considering the comments about the workload forecast function and OK for the handover system. The overall status is considered P-OK | P-OK |

The trust level was addressed during the debriefing and no issue were raised in relation to the trust in the supervisor system except for what already mentioned in the previous sections about the lack of integration of the supervisor planning tool with the other systems. This is also evident considering the responses provided in relation with the level of confidence, the perceived reliability of the supervisor planning tool and the workload forecast that it provided assessed in the post simulation questionnaire:

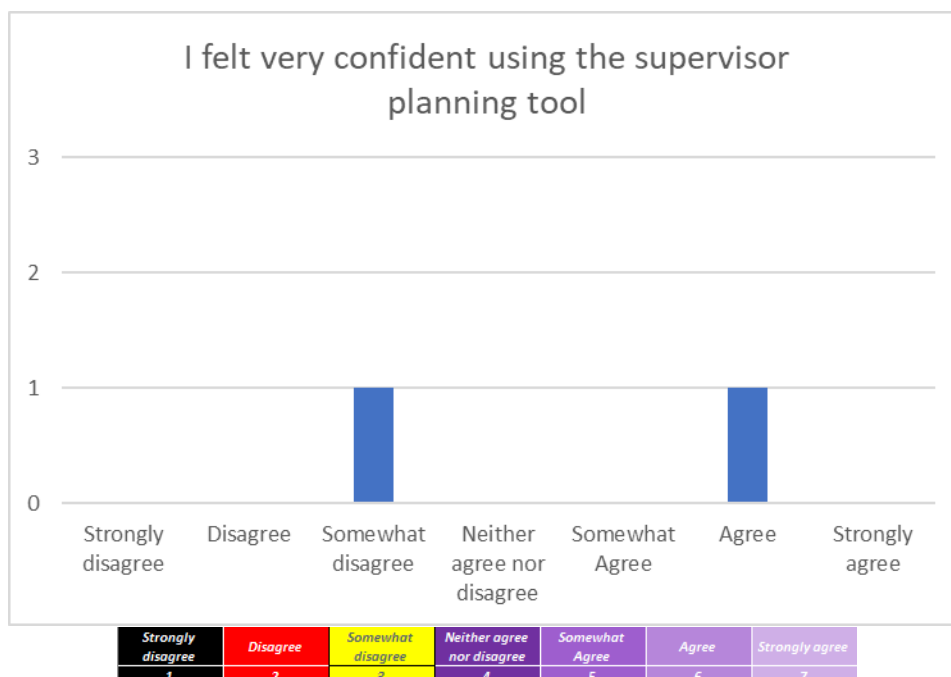


Figure: SUP – Trust - Post EXE Questionnaire

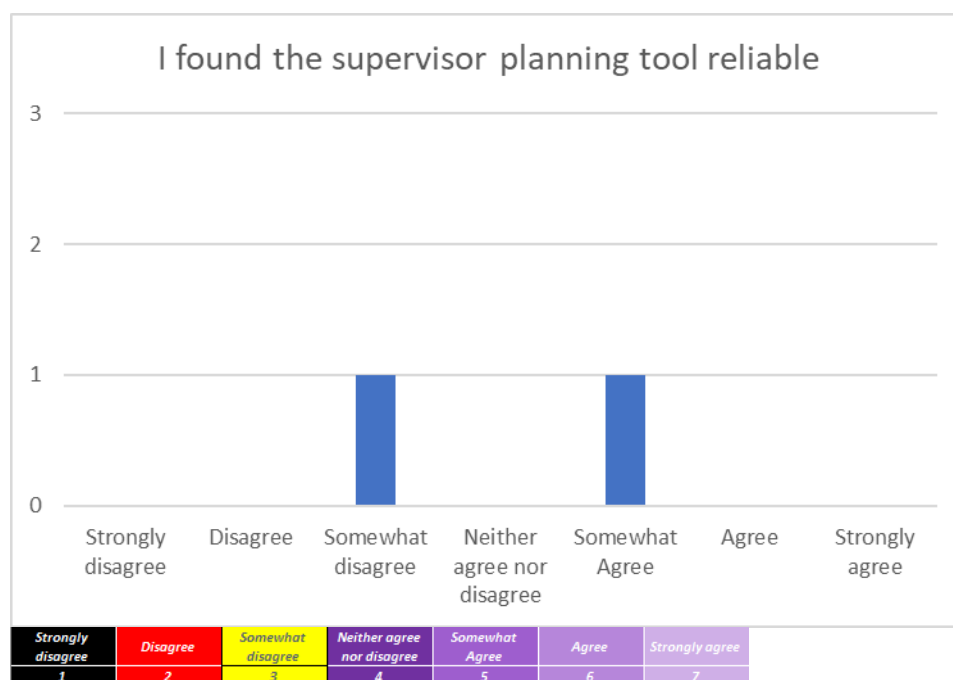


Figure: SUP – Trust - Post EXE Questionnaire

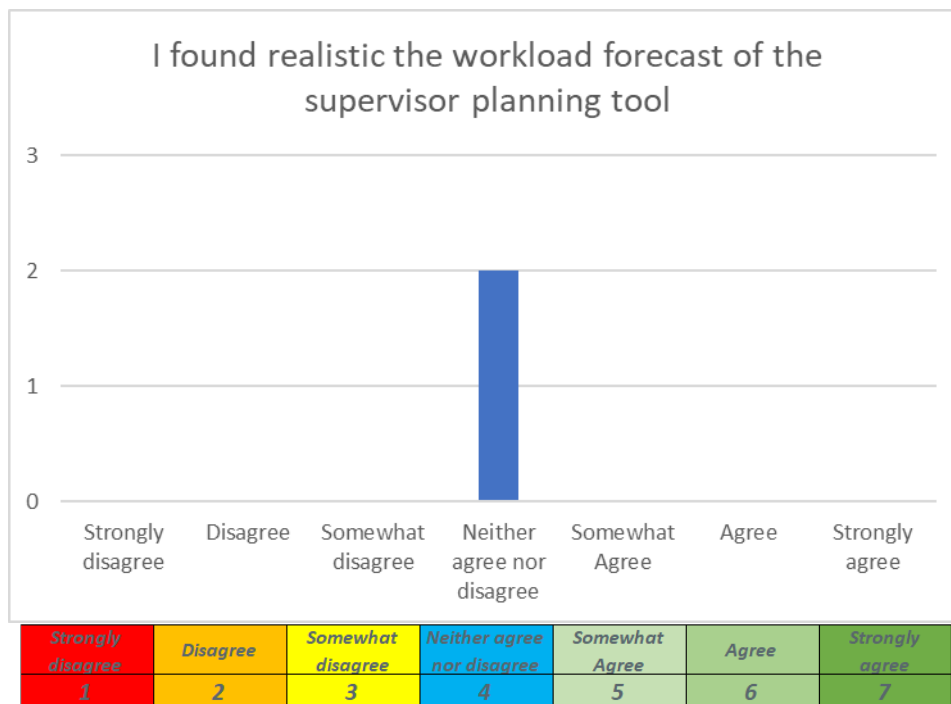


Figure: SUP – Trust - Post EXE Questionnaire

The criteria is considered as not ok in relation to the supervisor planning tool considering the above responses.

On the other hand, the level of reliability and confidence of the handover system was considered as adequate, see following post simulation questions results.

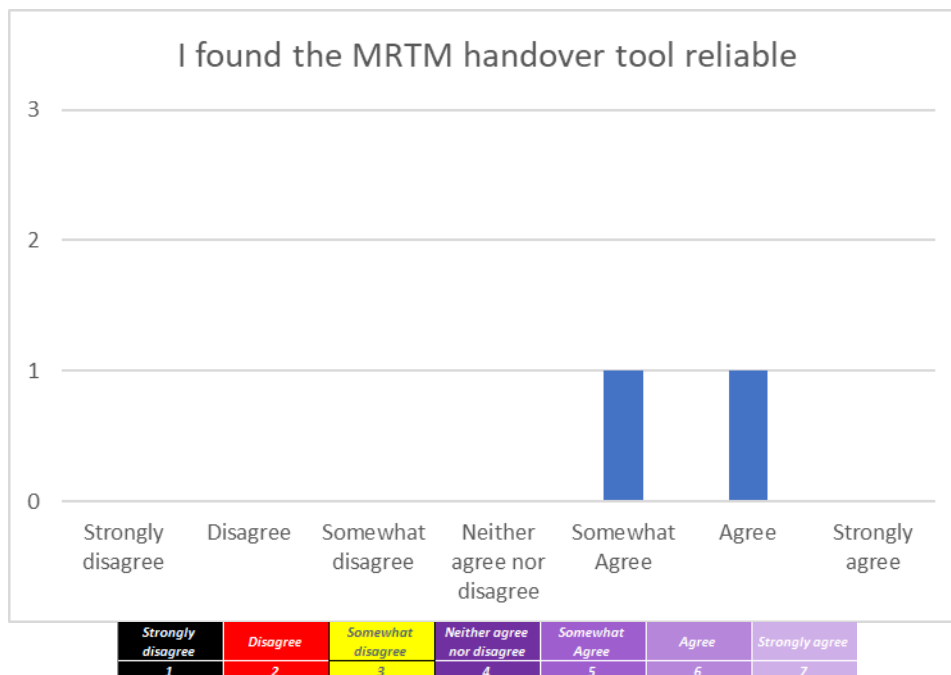


Figure: SUP – Trust - Post EXE Questionnaire

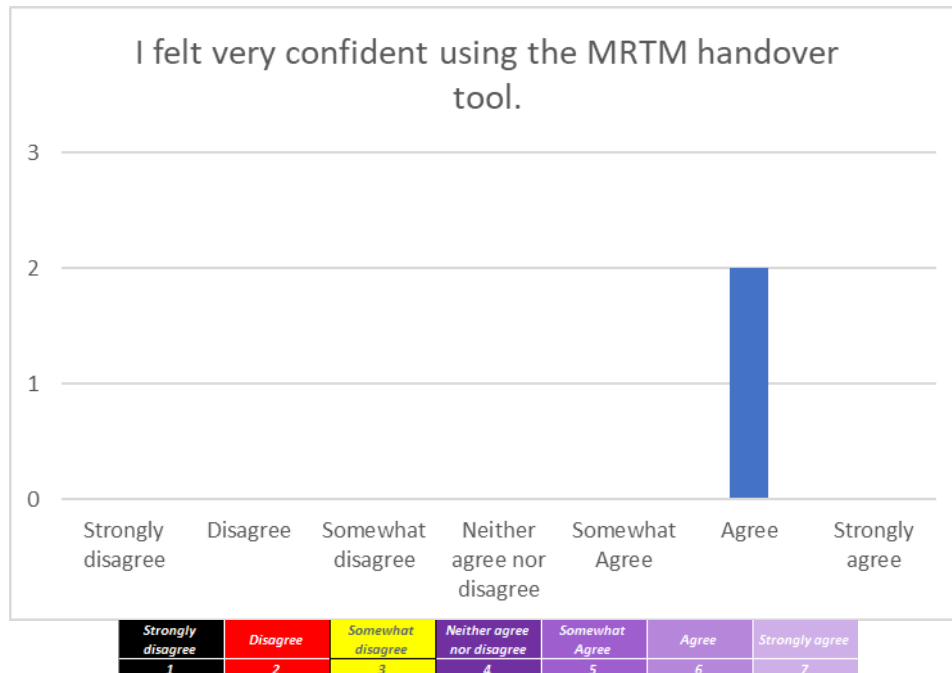


Figure: SUP – Trust - Post EXE Questionnaire

The criteria is considered as ok for the handover system and thus partially ok overall.

D.3.4.5.2 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | No final conclusions on skill and recruitment requirements from the collected responses, as not all the answers are aligned on the positive or negative responses for the supervisors. The overall trend in the discussion was that no real new requirement or skill is needed, but adaptation to the new way of working would be required. | P-OK |

No final conclusions on skill and recruitment requirements from the collected responses, as not all the answers are aligned on the positive or negative responses for the supervisors. (figure below)

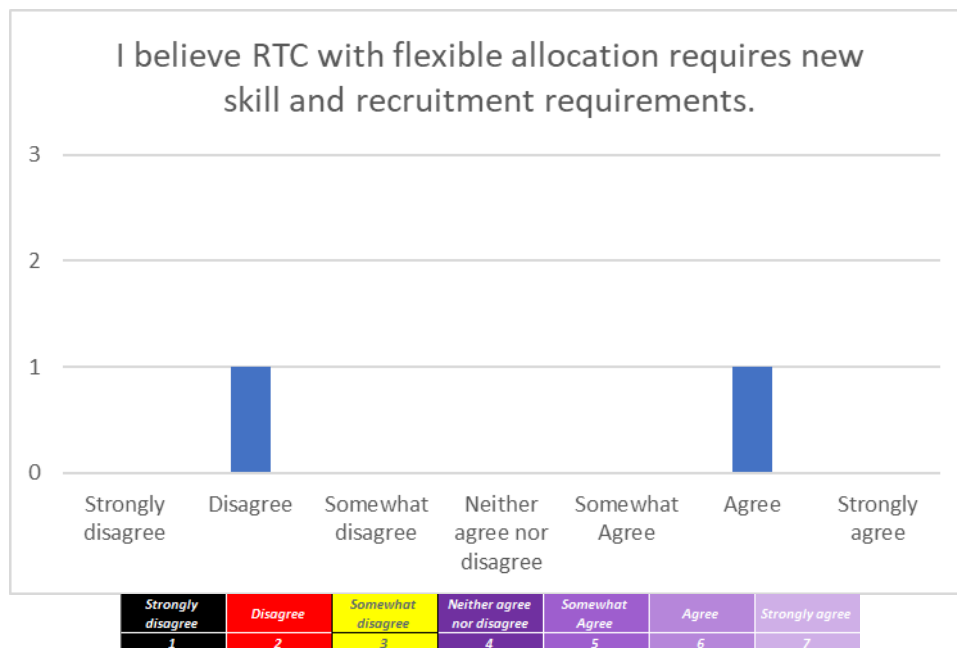


Figure: SUP – Skill and recruitment - Post EXE Questionnaire

The overall trend in the discussion was that no real new requirement or skill is needed, but adaptation to the new way of working would be required.

The criteria is considered as partially ok

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Both the supervisors agreed that the ATCOs and supervisor should be extensively trained to undertake the new role for the supervisor and the new responsibilities for the ATCOs as it can be understood looking at the figure below. | Ok |

Both the supervisors (first figure below) agreed that the ATCOs and supervisor should be extensively trained to undertake the new role for the supervisor and the new responsibilities for the ATCOs as it can be understood looking at the figure below.

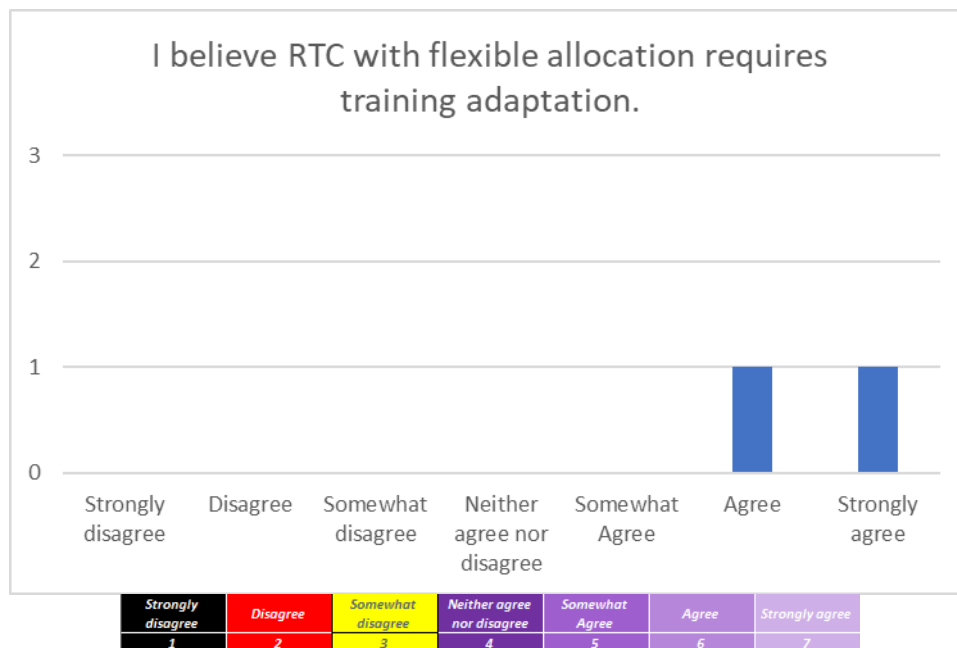


Figure: SUP – Training - Post EXE Questionnaire

The criteria is considered as successfully met.

D.3.4.6 SAFETY

D.3.4.6.1 OBJ-PJ05-W2-35-V3-VALP-S08 Results

| OBJ-PJ05-W2-35-V3-VALP-S08 Assess Supervisor capability to support the ATCO in abnormal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S08.010 | Supervisor is able to support an ATCO in abnormal situations of emergency flight | The criteria was met through a dedicated solution scenario which is solution scenario 4. Level of situation awareness for solution 4 dedicated scenario was considered as good | OK |

The criteria was met through a dedicated solution scenario which is solution scenario 4. As it can be observed in the following post run questions' answer the level of situation awareness for solution 4 was considered as good (China lake 10 points scale)

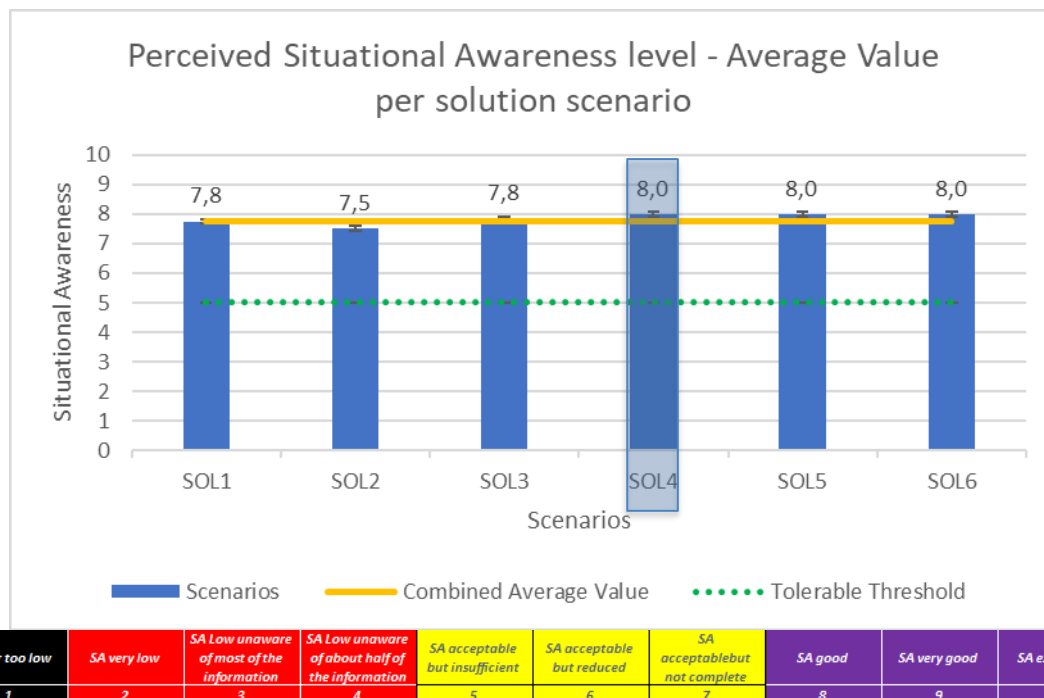


Figure: SUP - Situational Awareness – Post Run Questionnaire

The assessment was complemented through a dedicated post simulation question reported in the following figure.

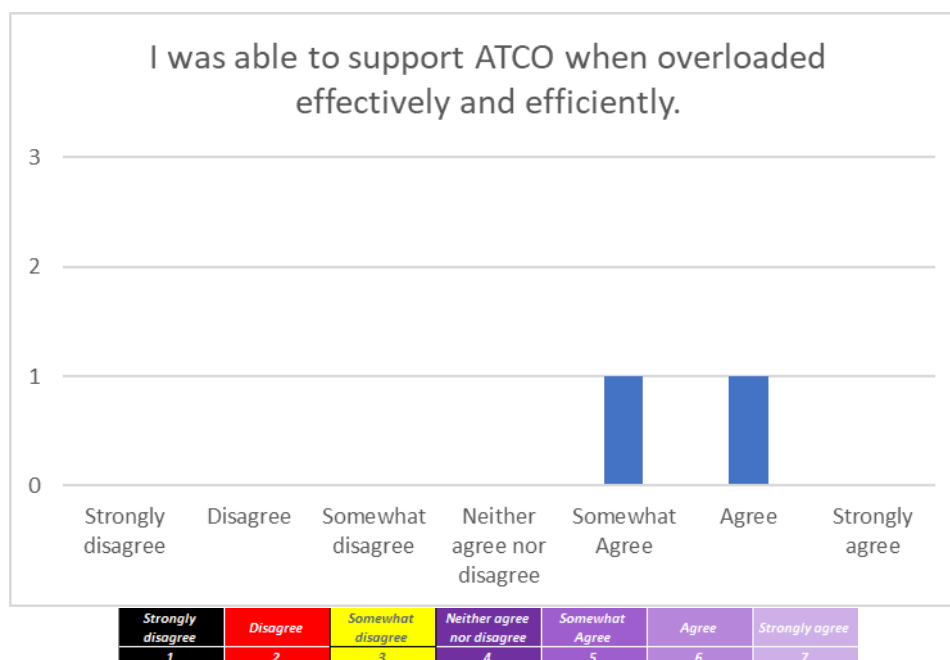


Figure: SUP – Support to ATCO – Post EXE Questionnaire

The supervisor was generally able to support ATCO when overloaded effectively and efficiently as in the case of emergency situations and both the supervisors provided positive response to the question.

D.3.4.6.2 OBJ-PJ05-W2-35-V3-VALP-S09 Results

| OBJ-PJ05-W2-35-V3-VALP-S09 Assess Supervisor capability to cope with degraded situations and recover from it when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|---|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S09.010 | Supervisor is able to detect and manage technical failures occurring in one module of the RTC related to Communication or Visualisation system | The criteria was met through a dedicated solution scenario which are solution scenario 5 and 6. Level of situation awareness for solution 5 and 6 dedicated scenarios was considered as good | OK |

The criteria was met through 2 dedicated solution scenario which were solution scenario 5 and 6. As it can be observed in the following post run questions' answer the level of situation awareness for both the solutions scenario was considered as good (China lake 10 points scale)

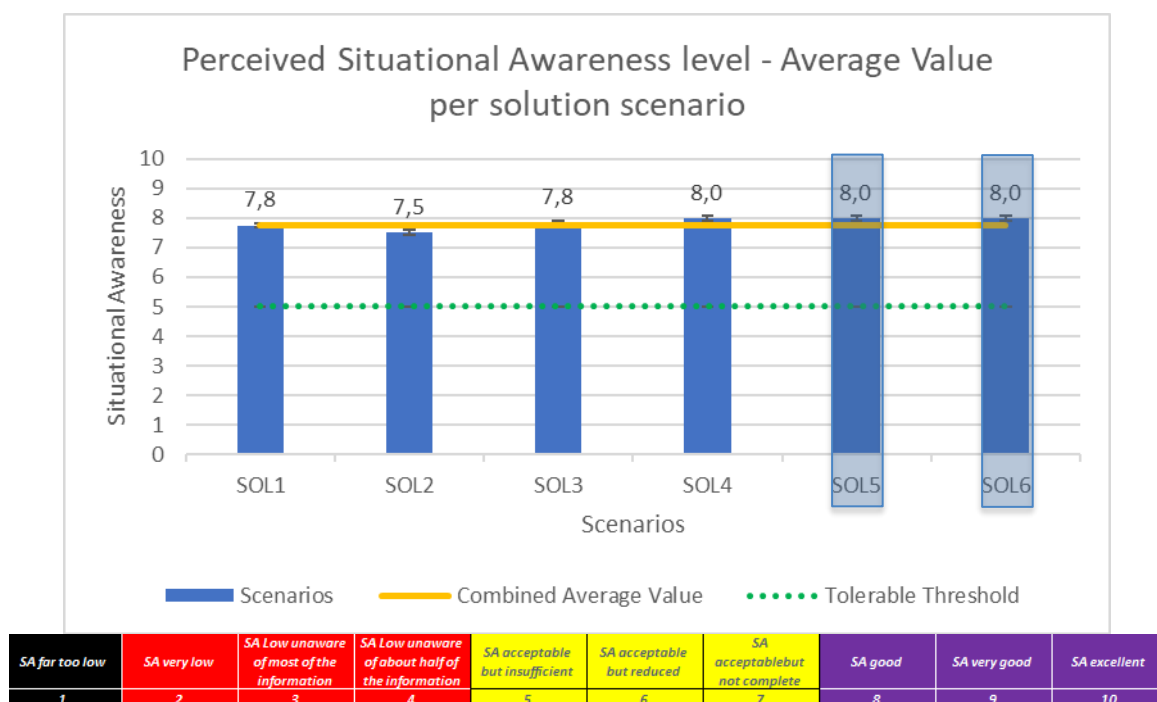


Figure: SUP - Situational Awareness – Post Run Questionnaire

The assessment was complemented through a dedicated post simulation question reported in the following figure.

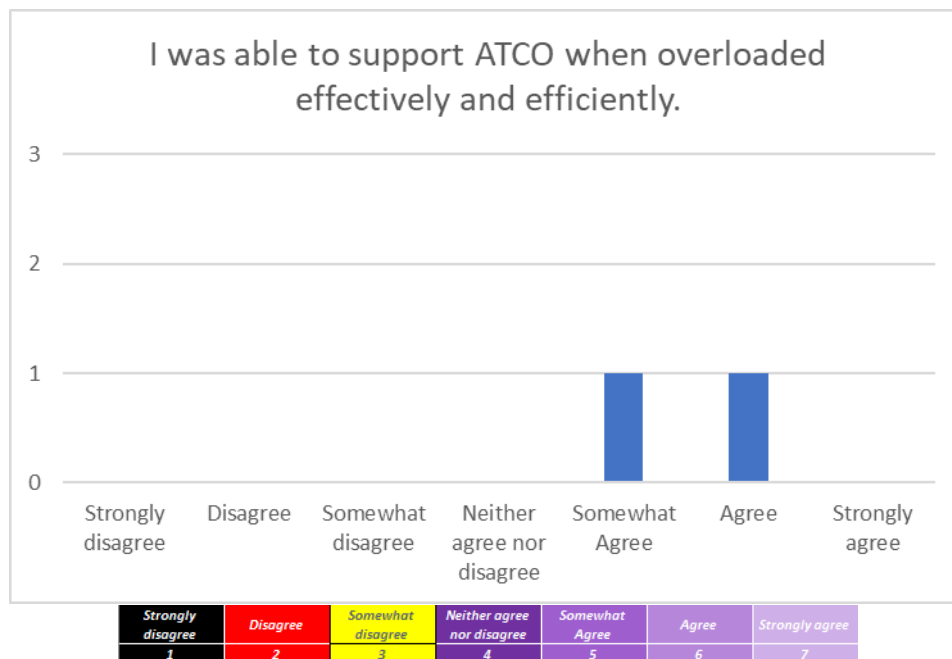


Figure: SUP – Support to ATCO – Post EXE Questionnaire

The supervisor was generally able to support ATCO when overloaded effectively and efficiently as in the case of emergency situations and both the supervisors provided positive response to the question.

D.3.4.6.3 OBJ-PJ05-W2-35-V3-VALP-S10 Results

| OBJ-PJ05-W2-35-V3-VALP-S10 Assess Supervisor capability to support the ATCO under all normal conditions when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
|--|--|--|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S10.010 | SUP is able to foresee traffic with supervisor planning tool to safely manage RTC operations | While for the ability to supervise the assigned number of airports there is consensus on the positive answer, meaning that the supervisor was able to plan the airports' allocation between the available modules (picture above), there is not a clear conclusion for the workload forecast of the supervisor planning tool | P-OK |

The criteria has been assessed through 2 questions in the post simulation questionnaires on a 7 points scale:

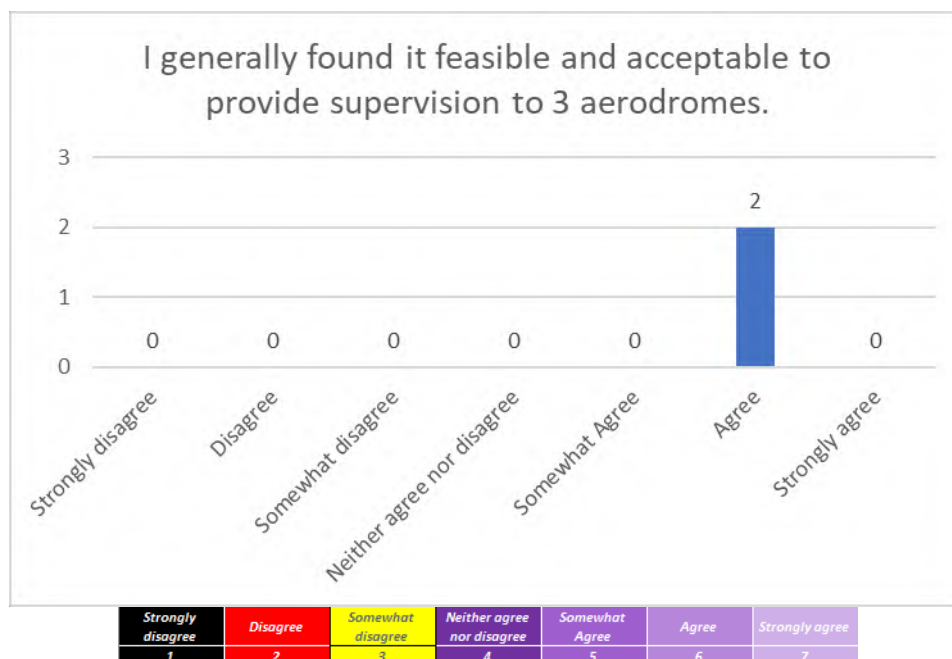


Figure: SUP – Aerodromes – Post EXE Questionnaire

While for the ability to supervise the assigned number of airports there is consensus on the positive answer, meaning that the supervisor was able to plan the airports' allocation between the available modules (picture above), there is not a clear conclusion for the workload forecast of the supervisor planning tool as indicated in the next figure:

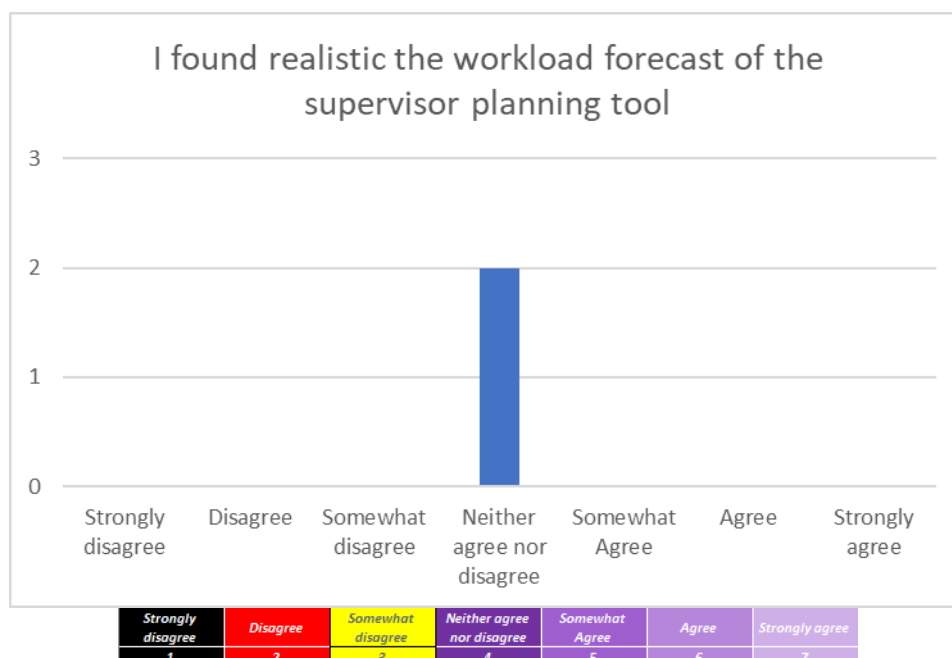


Figure: SUP – Workload forecast – Post EXE Questionnaire

Indeed, the main issue was that the supervisor planning tool was not using real time traffic, but planned traffic for the assessment of the workload as explained in the human performance objectives.

The criteria is considered as partially ok considering the provided results.

D.3.4.7 Final Debriefing

During the final debriefing a WANT-HAVE analysis was conducted in order to let ATCOs envisioning next needed development of the concepts to drive the deployment phases. ATCOs were questioned about what they liked about the system, what they did not like, what they would like to be added to the current concept and what they want to avoid (even if not experimented) for the technology. The picture below shows the results of the analysis:

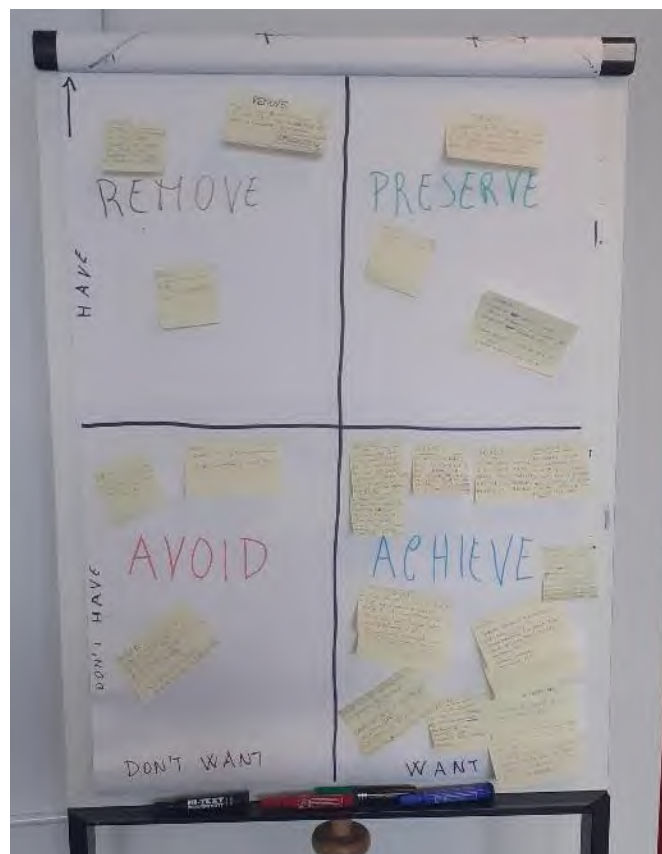


Figure: WANT-HAVE analysis Matrix

The following tables report the WANT-HAVE analysis recorded input:

| REMOVE (have but don't want) | PRESERVE (have and want) |
|--|---|
| <ul style="list-style-type: none"> ○ Too much strip bay flight status ○ Unconformable ground radio equipment ○ PTZ function usage is too complex, it could be more comfortable to have a Picture in the Picture function in the out of the window view to zoom on aircraft ○ Everything increasing ATCO's workload to coordinate with SUP e.g. Acceptance of airport transfer between modules; coordination that might be performed by SUP instead of the ATCO | <ul style="list-style-type: none"> ○ RWY Deconflicting tool (Conflicting clearances tool alert) ○ Less intrusive interaction means between SUP and ATCOs' module ○ Means to act with adequate situational awareness ○ SUP support during contingency situations |

| AVOID (don't have and don't want) | ACHIEVE (don't have but want) |
|---|--|
| <ul style="list-style-type: none"> ○ SUP Tool: <ul style="list-style-type: none"> • too many windows and exclusive (cannot be shown at the same time) • multiple screen e.g. handover and management of workload on different screen ○ Multiple TWR busy airports ○ Handle Critical Situations in multiple TWR condition (Switch modules) | <ul style="list-style-type: none"> ○ SUP Tool: <ul style="list-style-type: none"> • More interactive system with multiple windows • Integration of handover and management system with acknowledge of completed handover • Improved HMI for SUP tool • Clear and Fix Module traffic load • Editable workload and traffic plot by drag and drop with changes automatically transferred to the modules without need of voice coordination • Strip Bay easier to understand for the SUP position ○ SUP position <ul style="list-style-type: none"> • Operational procedure for emergency and workload management to be revised and finally consolidated • Further technology providing actual Module's information replication on SUP position to enhance situational awareness • Avoid multiple screens not connected each other; efficient and automatic alerts • Contingency check-list to be revised and finalised • SUP-ATCO module systems integration • Training and procedures for ATCOs module and SUP • Back-up systems ○ ATCO Module Position: <ul style="list-style-type: none"> • Back-up module for contingency and emergency • situation awareness (e.g. phones, CWP etc.) • Marked separation (not in the frame) in the out of the window view between airports • More visible clock |

| | |
|--|---|
| | <ul style="list-style-type: none"> • Aircraft emergency toolbar easier to use, possibly integrated in the strip board and touch screen • Picture in the Picture PTZ function instead of a dedicated monitor • FDP + RDP ground target in picture • RDP ground target • RWY Automation scan tool • Flexible strip compilation • More user-friendly emergency and module transfer button • Strip Bay RWY window identification • Transfer button between modules integrated in the strip bay board to facilitate the usage • Do not change airport visualization order (i.e. never add the airport in the middle if a third airport is transferred, but add it at the bottom) • Improve contingency management procedures • Maximum workload allowed (IFR, VFR, RTC maintenance) • Handover procedure between ATCOs improvements • Improvements of vehicles management • To underline RWY in use on the strip bay • RTC design to reflect license and contingency needs |
|--|---|

Table 35 WANT-HAVE analysis Matrix

As it can be seen from the above matrix, during the final debriefing it was possible to collect a set of suggested improvements to feed the deployment phase. Some of the recommended improvements were mainly related to the validation platform even if the simulation environment was judged as realistic and reliable: the ATCOs suggested to reduce the number of strip bay phases they tested during the simulation and to design the strip bay dedicated to the specific airport to be remoted, also they suggested to have more flexibility to fill-in the strips, especially for VFR.

The Remote Tower Module ATCOs didn't like a dedicated monitor for the PTZ function and would have preferred to have a picture in the picture function with command integrated in the strip bay to facilitate the interactions with the OTW and the zoom functions. Also, Remote Tower Module ATCOs suggested improvements to the OTW: to mark the line between the airports in the OTW to make more visible the borders between airports and to provide the aircraft labels on the OTW only for active flights.

Also, they suggested to change the fix position of airports in the OTW and in the head-down controller working position: while in the design choice it was judged more appropriate to have fix position of airports (e.g. Treviso airport always displayed as first airport, Lamezia Terme airport as second one and

Brindisi as last one) they suggested the transferred airport is always displayed as last one: in the bottom for the OTW and on the right in the head down CWP strip bay.

Remote Tower Modules ATCOs recommended to further develop operational procedures for normal, abnormal and failure modes (e.g. always isolate airport expecting aircraft in emergency etc.).

Margin of improvements were also observed for the supervisor tool. Although it was considered a powerful means to assess the workload for the ATCOs module, the tool was not integrated in the simulation platform and thus providing the forecast and computation of workload on the planned traffic rather than the real time traffic (technical limitation explained in the dedicated section 3.4.1 of this appendix). Also, both the supervisors suggested the tool includes multiple windows rather than exclusive windows to look at the same time at the forecasted workload, the details of the traffic and the load on the different airports so that they could perform the changes in any of the available windows, also dragging and dropping the elements they wanted to change and to directly see the effect of the implemented changes. This HMI improvements were also recommended to be complemented by an automation improvement to directly transmit the changes (e.g. vehicles or VFR departures times etc.) to the remote tower module CWP. Also, while in the simulation environment the supervisor position was based on different screens and systems (e.g. supervisor tool, handover management system, FDP), they would prefer to have all the systems in one screen or in a reduced number of screens with the transfer system integrated in the Supervisor tools.

The available plots (workload and traffic view) were also recommended to be improved in order to have data visible on rolling minute and editable on demand.

To also enhance the supervisor situation awareness of the remote tower modules, they suggested further technology providing actual Module's information replication to be locally assessed before the deployment.

Both the supervisors also recommended to review and finally consolidate operational procedures and checklists for the handover, in case of contingency and in case of emergency trying to delegate to the supervisors all the tasks that can be reduced for the remote tower module ATCO, like coordination tasks with external authorities in case of emergency etc. so that the ATCO workload can be reduced. Further recommendations from the supervisor were to provide more automation in the communication ATCOs-SUP and vice versa to minimise the coordination workload and to enhance the shared situational awareness.

All ATCOs and Supervisors agreed about the need of back-up modules in case of failure of operational RT modules.

Emergency button and acceptance HMI should be improved for both the positions.

Another point that was discussed was that being it a simulation environment a significant load of coordination was not simulated (e.g. workload of no flight plans aircraft, scheduled VFR in the simulation which is not always the case in the reality). These elements should be taken into account when defining a new RTC with flexible allocation of airports.

A possible technology improvement discussed was a RWY Automated scan tool that supports Atco in checking the runway is clear before providing a clearance.

Finally, all the participating test subjects agreed on the possible job satisfaction improvements of Remote tower centre especially for small airports where the technology is usually limited and the airports are located in regional area often without attractions.

D.3.5 Unexpected Behaviours/Results

No unexpected Behaviours/Results observed.

D.3.6 Confidence in Results of Validation Exercise 1

D.3.6.1 Level of significance/limitations of Validation Exercise Results

Some limitations on the validation exercise may impact the level of significance of the results:

- The use of a visual simulator to execute the validation exercise instead of real time image provided by real cameras generates some limitations related to the requirements referred to the Out of The Window part.
- The MRTM CWP is a touch monitor and its maximum size is limited by usability. In these conditions, as the number of airports allocated to the MRTM increases, the HMIs of the tools cannot be viewed to their full potential.
- Only a limited number of ATCOs participated. It cannot be assumed that all results will hold true for all controllers.
- The use of limited number of pseudo pilots means that there is not a realistic diversity of voices and accents. Additionally, pseudo pilots tend to be less proactive than real pilots and tend to respond to requests in a more uniform manner.
- The SUP tool workload forecast is based on the planned traffic and not updated live with the simulation evolution: it was not possible due to time and technical constraints to integrate the SUP tool in the simulation platforms' system.

Nevertheless, exercise has involved a wide range of test subjects (5ATCOs) for a total numbers of 10 simulation days (training + execution). Five test subjects were involved in the exercise with different roles, experience and background in order to expose the concept to a wide range of ATCOs' representatives:

- 2 ATCOs, who in their operational life fulfil the role of TMA/ACC supervisors , were employed as RTC supervisors in the simulation;
- 3 ATCOs, who in their operational life fulfil the role of responsible of airport rostering and training, were employed as MRTM ATCO in the simulation. They currently work on different airport environments encompassing big size airport with multiple runways and regional airports so that different points of view could be collected.

The ATCOs' age is between 36 and 57 with a working experience between 11 and 38 years.

The simulation environment represented the operational environment with a high level of fidelity. Considering the simulation conditions, the results for the RTC with Flexible Allocation are judged to be characterised by a high level of significance.

D.3.6.2 Quality of Validation Exercises Results

Questionnaires have been used to collect ratings from the test subjects on the different HP and SAF areas as presented in the previous section: both the accuracy and the confidence on the collected results and measured indicators are judged at a high quality to support the maturity assessment of V3 phase.

D.3.6.3 Significance of Validation Exercises Results

The simulation exercise has been conducted on an experimental platform representing the operational environment with a high degree of fidelity providing an operational significance adequate to support the V3 maturity assessment, of course with the limitations already mentioned in above sections 1.

3 Training days have been executed to properly prepare the ATCOs to the execution of the validation exercise. A significant number of total runs have been conducted among 7 simulation days (26 total number of runs) as well as a significant number of test subjects (5 ATCOs) have been involved to conclude that results are significant to support the V3 maturity assessment, but it cannot be considered that the results have statistical significance. Considering the validation technique (real time simulation) and the executed numbers of runs it is judged the results have a high level of significance.

D.3.7 Conclusions

D.3.7.1 Conclusions on concept clarification

Collected results are not affecting concept description.

D.3.7.2 Conclusions on technical feasibility

No objectives relevant for technical feasibility appointed to the exercise. The simulation environment was reproducing the operational environment in a high-fidelity way and the test subjects were exposed to the new concept well prepared through three intensive training days.

D.3.7.3 Conclusions on performance assessments

The validation exercise addressed Human Performance, Safety and Cost Efficiency performance areas.

For human performance and safety areas, situational awareness was assessed and in the solution scenarios it was always maintained at acceptable level for both the positions (RTC SUP and ATCO Module).

Measured workload also was acceptable for both the positions RTC SUP and ATCO Module in the solution scenarios.

User acceptance of roles and responsibilities as well as operating methods were adequate for both the RTC SUP and ATCO Module positions.

Nevertheless for both workload and operating methods and roles and responsibilities areas, the participating ATCOs and SUPs also commented that there was the need to review and finally consolidate operational procedures and checklists for the handover, in case of contingency and in case of emergency trying to delegate to the supervisors all the tasks that can be reduced for the remote

tower module ATCO, like coordination tasks with external authorities in case of emergency etc. so that the ATCO workload can be reduced. Further recommendations from the supervisor were to provide more automation in the communication ATCOs-SUP and vice versa to minimise the coordination workload and to enhance the shared situational awareness.

Phraseology was considered adequate.

About the HMI and the usability areas, important feedback were collected to feed the deployment phase. Some of the comments were mainly related to the validation platform even if the simulation environment was judged as realistic and reliable: the ATCOs suggested to reduce the number of strip bay phases they tested during the simulation.

The Remote Tower Module ATCOs didn't like a dedicated monitor for PTZ function and would have preferred to have a picture in the picture function with command integrated in the strip bay to facilitate the interactions with the OTW and the zoom functions. Also, Remote Tower Module ATCOs suggested improvements to the OTW: to mark the line between the airports in the OTW to make more visible the borders between airports and to provide the aircraft labels on the OTW only for active flights.

In addition, they suggested to change the fix position of airports in the OTW and in the head-down controller working position: while in the design choice it was judged more appropriate to have fix position of airports (e.g. Treviso airport always displayed as first airport, Lamezia Terme airport as second one and Brindisi as last one) they suggested the transferred airport is always displayed as last one: in the bottom for the OTW and on the right in the head down CWP strip bay.

Margin of improvements were also observed for the supervisor tool. Although it was considered a powerful mean to assess the workload for the ATCOs module, the tool was not integrated in the simulation platform and thus providing the forecast and computation of workload on the planned traffic rather than the real time traffic (technical limitation explained in the dedicated section 3.4.1 of this appendix). Also both the supervisors suggested the tool includes multiple windows rather than exclusive windows to look at the same time at the forecasted workload, the details of the traffic and the load on the different airports so that they could perform the changes in any of the available windows, also dragging and dropping the elements they wanted to change and to directly see the effect of the implemented changes. This HMI improvements were also recommended to be complemented by an automation improvement to directly transmit the changes (e.g. vehicles or VFR departures times etc.) to the remote tower module CWPs. Also, while in the simulation environment the supervisor position was based on different screens and systems (e.g. supervisor tool, handover management system, FDP), they would prefer to have all the systems in one screen or in a reduced number of screens with the transfer system integrated in the Supervisor tools.

The available plots (workload and traffic view) were also recommended to be improved in order to have data visible on rolling minute and editable on demand.

To also enhance the supervisor situation awareness of the remote tower modules, they suggested further technology providing actual Module's information replication to be locally assessed before the deployment.

Level of trust was considered adequate, of course the above-mentioned feedback need to be taken into account for further enhancing the trust levels.

Perceived level of safety was considered always acceptable even in failure and abnormal modes, but the above-mentioned comment about further developing and consolidating checklists and operational procedures also applies to safety area.

All ATCOs and Supervisors agreed about the need of back-up modules in case of failure of operational RT modules.

Emergency button and transfer acceptance HMI should be improved for both the positions.

ATCOs and supervisors commented about rosters and working hours that should be also tailored to the new concepts for both the RTM ATCO and RTC Supervisor roles.

Another point that was discussed was that being it a simulation environment a significant load of coordination was not simulated (e.g. workload of no flight plans aircraft, scheduled VFR in the simulation which is not always the case in the reality). These elements should be taken into account when defining a new RTC with flexible allocation of airports.

A possible technology improvement discussed was a RWY Automated scan tool that supports Atco in checking the runway is clear before providing a clearance.

Finally, all the participating test subjects agreed on the possible job satisfaction improvements of Remote tower centre especially for small airports where the technology is usually limited and the airports are located in regional area often without attractions.

About cost effectiveness, ATCOs were able to provide ATS to 3 aerodromes at a time in an RTC of 3 aerodromes supported by the supervisor that balanced the workload.

D.3.8 Recommendations

Clear and stable checklist and operational procedures for nominal, abnormal and failure mode shall be consolidated finally to support the deployment of the RTC with flexible allocation of airports between modules.

Out of the window view requirements shall be refined finally to support the deployment of the RTC with flexible allocation of airports between modules.

Position of displayed airports in the out of the window view and in the CWP head down displays shall be flexible, i.e. transferred airport always displayed as last one: in the bottom for the OTW and on the right in the head down CWP/Strip bay.

Assessment of ATCOs coordination tasks that can be delegated to SUP shall be locally (specific for the operational environment) conducted to support the deployment of the RTC with flexible allocation of airports between modules.

A RWY Automated scan tool should be assessed and developed to support ATCO in checking the runway is clear before providing a clearance.

Supervisor planning tool shall use up-to-date and real time data to proper support the forecast workload.

Supervisor planning tool HMI shall be reviewed for the deployment of the RTC with flexible allocation of airports between modules.

Coordination load shall be locally assessed to properly measure ATCOs workload and establish airports allocation for the deployment of the RTC with flexible allocation of airports between modules.

It is confirmed that spare modules in case of failure of operational RTMs shall be available at the RTC.

Supervisor facilitation of handover and best practices shall be locally assessed and put in place for the deployment of the RTC with flexible allocation of airports between modules.

Appendix E Validation Exercise EXE-2.5-DFS Report

E.1 Summary of the Validation Exercise EXE-2.5-DFS Plan

E.1.1 Validation Exercise description, scope

The operational scope of this validation exercise includes simultaneous ATS provided to three small size aerodromes from a MRTM by one ATCO. All airports have a single runway and a simple layout of the manoeuvring area.

The objective is to assess in a real-time simulation the ATCO's capability to provide ATS to three aerodromes simultaneously with a flexible allocation of aerodromes to different positions within the MRTM while the ATCO being supported by automation tools.

The evaluation focussed on situation awareness and human performance associated with different characteristics like amount of traffic handled over time, number of simultaneous movements and complexity of traffic distribution over the aerodromes.

The ATCOs feedback will be taken to optimise HMI design and automation support needs for up to three aerodromes being allocated to one MRTM at a time.

The ATCO covers the roles of Clearance Delivery, Ground Controller and Tower Runway Controller for up to three aerodromes simultaneously.

The exercise will be run as a real-time simulation.

The validation platform to be used will be DFS Tower simulator platform (TOSIM) extended by the prototypes provided by Frequentis (visual systems and voice communication) and DFS (flightplan and surveillance display).

The operational scope of the shadow mode validation part comprises of the generations of alarms and alerts as well as indication of clearances that need to be provided based on the basic ground surveillance. The shadow mode validates the functionality for one aerodrome only, based on real data (while the full functionality is validated in RTS based on simulated data).

The shadow mode gave an indication of the achievable performance of the basic ground surveillance used for a MRTM. The validation platform comprised of Thales basic ground surveillance in combination with DFS automation support tools.

Basic ground surveillance was evaluated by technical experts on selected days in week 24 and 34 where traffic was chartered to generate additional movements. In addition to this basic ground surveillance was evaluated by two ATCOs based on recorded real data.

Results are described in CRT-PJ05-W2-35-V3-VALP-H13.020 and CRT-PJ05-W2-35-V3-VALP-H13.040.

E.1.2 Summary of Validation Exercise EXE-2.5-DFS Validation Objectives and success criteria

The following table provides an overview on the validation objectives and success criteria applied in EXE-2.5-DFS.

| SESAR Solution Validation Objective | SESAR Solution Success criteria | Coverage and comments on the coverage of SESAR Solution Validation Objective in Exercise V3-2.5 | Exercise Validation Objective | Exercise Success criteria |
|--|---------------------------------|---|-------------------------------|---------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H02 | CRT-PJ05-W2-35-V3-VALP-H02.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – WORKLOAD | | | | |
| CRT-PJ05-W2-35-V3-VALP-H04 | CRT-PJ05-W2-35-V3-VALP-H04.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | CRT-PJ05-W2-35-V3-VALP-H06.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H07 | CRT-PJ05-W2-35-V3-VALP-H07.030 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H08 | CRT-PJ05-W2-35-V3-VALP-H08.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.040 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.050 | Fully covered Questionnaire, debrief | as solution | as solution |

| | | | | |
|----------------------------|--------------------------------|---|-------------|-------------|
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.060 | partially covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H11 | CRT-PJ05-W2-35-V3-VALP-H11.070 | Fully covered Questionnaire, debrief | as solution | as solution |
| HUMAN PERFORMANCE – TRUST | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3VALP-H13.010 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3VALP-H13.020 | Fully covered Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-H13 | CRT-PJ05-W2-35-V3VALP-H13.040 | Fully covered Questionnaire, debrief | as solution | as solution |
| SAFETY | | | | |
| OBJ-PJ05-W2-35-V3VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04.010 | Partially covered (just examples) Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S04 | CRT-PJ05-W2-35-V3-VALP-S04.20 | Partially covered (just examples) Questionnaire, debrief | as solution | as solution |
| OBJ-PJ05-W2-35-V3-VALP-S06 | CRT-PJ05-W2-35-V3-VALP-S06.010 | Partially covered (just examples) Questionnaire, debrief | as solution | as solution |
| CAPACITY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | CRT-PJ05-W2-35-V3-VALP-CA1.010 | Fully covered Questionnaire | as solution | as solution |
| COST EFFICIENCY | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | CRT-PJ05-W2-35-V3-VALP-CE1.010 | Fully covered Questionnaire | as solution | as solution |

Table 36: Validation Objectives addressed in EXE-05.03-V3-2.5 DFS

E.1.3 Summary of Validation Exercise EXE-2.5-DFS Validation scenarios

There were 24 movements per hour in each of the scenarios. All Scenarios will be run with VMC daytime condition with no significant wind. Flexible allocation of aerodromes within MRTM was

changed between different simulation runs (and not within one simulation run). This will cover an application of the concept when flexible allocation is just changed within fixed blocks (e.g. shifts or days).

All of the scenarios contained abnormal situations like runway incursions, arrival static on the runway. Between six of the simulation runs the allocation of the aerodromes within the MRTM was changed. Each scenario was designed to last for one hour. The following characteristics of the table shown above were varied:

- **Traffic distribution**
the distribution of the traffic volume over the three aerodromes is varied in the following ways
 - equal: all aerodromes have the same amount of movements (8/8/8)
 - max: one aerodrome has two third of all movements while (16/4/4)
 - mix: aerodromes have different number of movements (4 / 8 / 12)
- **Traffic complexity**
traffic complexity was varied in terms of different amounts of VFR movements
 - Medium: VFR traffic amounts between 30 – 50%
 - High: VFR traffic amounts between 50 – 60%
- **Runway direction**
the runway direction was varied in the following ways:
 - Same: similar operating direction at all aerodromes SCN27 / DRS 22 / ERF 28
 - Opposite: operating direction at ERF changed, i.e. SCN27 / DRS 22 / ERF 10

| Scenario | Traffic Distribution | Traffic complexity | Runway Direction |
|---------------------|----------------------|--------------------|------------------|
| S01 - Baseline | equal | Medium | Same |
| S02 - Uneven | max | High | Same |
| S03 - VFR | equal | High | Same |
| S04 - Rwy Direction | equal | Medium | Opposite |
| S05 - Mix | Max | Medium | Same |

E.1.4 Summary of Validation Exercise EXE-2.5-DFS Validation Assumptions

The same assumptions applied as mentioned in chapter 3.2.3 (Validation Assumptions).

In addition to the common validation assumptions, DFS exercise assumed availability of ground surveillance in the real-time validation.

E.2 Deviation from the planned activities

Due to staffing limitations no ATCOs who have experience with Remote Tower could participate at the exercise.

The basic ground surveillance was addresses with cooperative sensors (ADS-B and MLAT) but was not support as initially planned by the video extract for primary targets.

E.3 Validation Exercise EXE-2.5-DFS Results

E.3.1 ATCO - Summary of Validation Exercise 2.5-DFS Results

The following table summarises the results of the Validation Exercise compared to the success criteria identified within the Validation Plan per validation objective.

Results obtained are assessed against the success criteria and considering the characteristics of the simulation in order to decide if the Validation Objective Analysis Status is OK, partially OK, NOK or Not Applicable (N/A).

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| HUMAN PERFORMANCE – SITUATION AWARENESS | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H02 | Assess ATCO situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Situation awareness was at a satisfactory to acceptable level when providing ATS to 3 aerodromes at a time and using flexible allocation of aerodromes.</p> <p>Nevertheless, ATCOs stated they needed a generally higher level of attention to keep their SA for all three aerodromes compared to controlling just one aerodrome.</p> <p>Flexible allocation of aerodromes had about no effect on situation awareness.</p> <p>Especially reminder events (such as landing reminders) and safety alerts helped to maintain SA.</p> | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|------------------------------|---|--------------------------------|--|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs can prioritize tasks when providing ATS to three aerodromes at a time | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | The user interface supported ATCO SA in a satisfactory way. The results indicate acceptable levels of SA for all scenarios. 'Column-wise' arrangement of information belonging to one aerodrome supported them to differentiate between the different aerodromes. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | Not addressed in DFS validation | N/A |
| OBJ-PJ05-W2-35-V3-VALP-H03 | Assess team situation awareness when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | Not addressed in DFS validation | N/A |
| HUMAN PERFORMANCE – WORKLOAD | | | | | |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|---|--|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-H04 | Assess ATCO workload when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Overall workload remained at a satisfactory or tolerable level. It took the ATCOs mainly ‘little’ to ‘very little’ effort to perform their tasks. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The amount of R/T communication load was rated as acceptable. | OK |
| HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H06 | Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>While most challenging situations could be solved either without impairment or by applying measures reducing capacity, there were some situations where workload was too high and should be reduced.</p> <p>It was discussed during the debriefings that ATCOs need to be trained to work using conservative separations and not to try to speed up traffic as much as possible (as they are used to in today operations. (see procedural solutions in 3.2.1.1)</p> | Partially ok |
| OBJ-PJ05-W2-35-V3-VALP-H07 | Assess ATCO acceptance of roles and responsibilities when | CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are | Not addressed in DFS validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|---|---|--------------------------------|--|--|-----------------------------|
| | providing ATS to multiple aerodromes | | clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | | |
| | | CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | <p>Providing ATS service is in general feasible and acceptable.</p> <p>Attention must be paid to the number of simultaneous movements which was rated critical. Especially traffic that cannot be delayed (like rescue or police helicopters) and thus might increase the number of simultaneous movements must be considered.</p> | Partially OK |
| OBJ-PJ05-W2-35-V3-VALP-H08 | Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | The ATCOs highlighted that the pilots starting a call using the respective tower in the phraseology helped to maintain situation awareness. | OK |
| HUMAN PERFORMANCE – USABILITY and UTILITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H18 | Assess that human-machine interface supports the team in carrying out their tasks | CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | Not addressed in DFS validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|--|-----------------------------|
| | | CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | Not addressed in DFS validation | N/A |
| OBJ-PJ05-W2-35-V3-VALP-H11 | Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs rated that the required information was easy to access and presented in an effective way. Flexible allocation of aerodromes was no problem, and ATCOs could easily get used to. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | ATCOs agreed that inputs to the system was easy to do. | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | ATCOs rated the usability and utility of the events as being quite helpful | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The ATCO did not see that the human machine interface will increase the potential for human error | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short | The ATCOs confirmed the usability and utility of the task prioritisation provided by the events | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| | | | term planning tool/traffic forecast and/or prioritisation tool. | | |
| | | CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | ATCOs were in general aware about which airport was displayed on which display | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | Not addressed in DFS validation | N/A |
| HUMAN PERFORMANCE – TRUST | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-H13 | Assess ATCO trust in support systems when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | The ATCOs confirmed that they could trust the task prioritisation provided by the events | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | ATCOs trusted in the reliability of the conformance monitoring provided by the events | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | ATCOs trusted in the reliability of the alarms and alerts provided by the events | OK |
| | | CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer | Not addressed in DFS validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|--|-----------------------------|
| | | | of aerodromes between modules up to the completion of the transfer | | |
| OBJ-PJ05-W2-35-V3-VALP-H15 | Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Not addressed in DFS validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Not addressed in DFS validation | N/A |
| SAFETY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-S04 | Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions | CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none">In the vicinity of the aerodromeIn the runway areaOn the manoeuvring area | ATCOs were able to solve conflicts in a timely manner | OK |
| | | CRT-PJ05-W2-35-V3-VALP-S04.020 | ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.): <ul style="list-style-type: none">Unstable approachesBird strikes | The ATCOs were able to solve potentially hazardous situations in a timely manner | OK |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|--|---------------------------------|-----------------------------|
| | | | <ul style="list-style-type: none"> Aircraft not vacating RWY as expected | | |
| | | CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | Not addressed in DFS validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | Not addressed in DFS validation | N/A |
| OBJ-PJ05-W2-35-V3-VALP-S05 | Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | Not addressed in DFS validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|--|--------------------------------|--|---|-----------------------------|
| OBJ-PJ05-W2-35-V3-VALP-S06 | Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S06.010 | <p>ATCO is able to identify and manage abnormal situations (e.g.):</p> <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport • Unplanned closure of an airport | The ATCOs were able to identify and manage abnormal situations. | OK |
| OBJ-PJ05-W2-35-V3-VALP-S07 | Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system • Other airport systems / infrastructure | Not addressed in DFS validation | N/A |
| | | CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system | Not addressed in DFS validation | N/A |

| Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Validation Result | Validation Objective Status |
|----------------------------|---|--------------------------------|---|--|-----------------------------|
| CAPACITY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CA1 | Assess capacity constraints when providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | <p>Providing ATS service is in general feasible and acceptable.</p> <p>Attention must be paid to the number of simultaneous movements which was rated critical. Especially traffic that cannot be delayed (like rescue or police helicopters) and thus might increase the number of simultaneous movements must be considered.</p> | Partially OK |
| COST EFFICIENCY | | | | | |
| OBJ-PJ05-W2-35-V3-VALP-CE1 | Assess the staff required for providing ATS to multiple aerodromes | CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | <p>ATCO stated that flexible allocation of aerodromes does not impose a much higher workload or reduction in situation awareness.</p> <p>Furthermore ATCOs stated that they can provide ATS in a safe manner.</p> | OK |

Table 37: ATCO - Validation Results for Exercise 2.5-DFS

E.3.2 ATCO - Analysis of Exercise 2.5-DFS Results per Validation objective

E.3.2.1 HUMAN PERFORMANCE – SITUATION AWARENESS

In this section, results for each validation objective are presented in detail. The criteria were assessed with two questionnaires and semi-structured debriefing interviews. One questionnaire was administered after each run (**post-run, PR**) and the second at the end of the second day (**post-exercise, PE**).

ATCOs completed two or three training scenarios (depending on their previous experience with MRTM) before starting the evaluation runs. For these, four different scenarios were used in a randomized order. Depending on the schedule, the ATCOs completed between four and five runs. Therefore, an incomplete design with five conditions (runs) was achieved. In total, 16 evaluation runs were conducted. Allocation of aerodromes within the MRTM was changed in 6 runs.

The measures used were validated questionnaires and tailored questions. The tailored questions were mostly answered on a 0-6 agreement scale (0 - “strongly disagree”; 6 - “strongly agree”). If applicable, comments from the debriefing interviews are presented for the respective objective.

The post run questionnaire was completed for a total of 16 simulation runs. The post exercise questionnaire was completed by all 4 ATCOs participating in the exercise. The questionnaires were complemented by a debriefing after each run and after the exercise.

E.3.2.1.1 OBJ-PJ05-W2-35-V3-VALP-H02 Results

OBJ-PJ05-W2-35-V3-VALP-H02

Assess team situation awareness when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.010 | Majority of ATCOs state that situation awareness is at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>Situation awareness was at a satisfactory to acceptable level when providing ATS to 3 aerodromes at a time and using flexible allocation of aerodromes.</p> <p>Nevertheless, ATCOs stated they needed a generally higher level of attention to keep their SA for all three aerodromes compared to controlling just one aerodrome.</p> | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------|-------------------|---|--------|
| | | <p>Flexible allocation of aerodromes had about no effect on situation awareness.</p> <p>Especially reminder events (such as landing reminders) and safety alerts helped to maintain SA.</p> | |

The **China-Lake scale** assesses SA on a 1-10 scale (1 = SA far too low; 10 = SA excellent). In the PE-Questionnaire the following assessment was given:

Two ATCOs rated the situation awareness being 'at a satisfactory level':

- 1 ATCO: Rating 9
My SA with respect to the task was **very good**. I was able to perform the task well **all** of the time
- 1 ATCO: Rating 8
My SA with respect to the task was **good**. I was able to perform the task well **most of** the time

One ATCO rated the situation awareness being 'at an acceptable level':

- 1 ATCO: Rating 7
My SA with respect to the task was **not complete**. I was able to perform the task, but not satisfactorily

Only one ATCO rated the situation awareness being 'not possible to perform the task'

- 1 ATCO: Rating 4
My SA with respect to the task was **low**. I was unaware of about half of the information required to perform the task effectively.

The PR-Questionnaire showed comparable results. It should be noted that the lower assessment was given by one ATCO and were not related to a specific scenario.

ATCOs stated that three simultaneous landings should be avoided in order to have spare capacity if other unpredicted traffic like a rescue helicopter occurs. One of the common ATCO statements was the need of minimizing complexity and workload by using pre-defined procedures especially between TWR and Approach to avoid the above-mentioned situations without the need of oral or written coordination in the situation itself. A smaller number of tasks to be prioritized by the ATCO could be a result as well.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.020 | Majority of ATCOs assess that they can prioritise tasks | ATCOs can prioritize tasks when providing ATS to three aerodromes at a time | OK |

PR-Questionnaire as well as PE-Questionnaire shows that ATCOs were able to prioritise tasks and requests

5. H02.020 - During the previous run I was able to ...

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4. H02.020 - During the whole exercise I was able to ...

[Weitere Details](#)



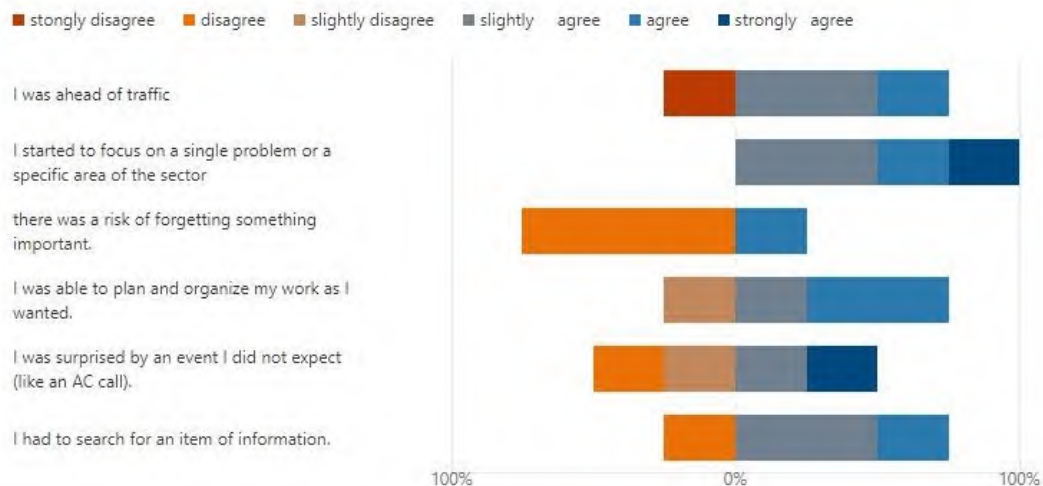
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.030 | ATCOs confirm that the user interface design supports a sufficient level of situation awareness | <p>The user interface supported ATCO SA in a satisfactory way. The results indicate acceptable levels of SA for all scenarios.</p> <p>'Column-wise' arrangement of information belonging to one aerodrome supported them to differentiate between the different aerodromes.</p> | OK |

The PE-Questionnaire showed that the user interface design in general supported the ATCOs. Although the ATCOs stated that they 'started to focus on a single problem' and sometimes 'were surprised by an AC call, they confirmed in the debriefings, that the events helped them to maintain the overall overview.

In the debriefings the ATCOs stated that the 'column-wise' arrangement of the monitors and aerodromes (e.g. all information for one aerodrome can be found on the left monitor and the left column of the FDPS) supported maintaining situation awareness.

3. H02.030 - Please rate how the user interface design supported you during the whole exercise (based on SASHA).

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The PR-Questionnaire showed comparable results with a somewhat more negative evaluation of the last question. There was no significant difference in the evaluation of the different scenarios given by the PR-Questionnaire.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H02.040 | ATCO maintain an adequate level of SA, despite having to divide their attention to several airports with different procedures and characteristics (geographical area, urban infrastructure, weather conditions etc.) | Not addressed in DFS validation | N/A |

E.3.2.1.2 OBJ-PJ05-W2-35-V3-VALP-H03 Results

| OBJ-PJ05-W2-35-V3-VALP-H03 Assess team situation awareness when providing ATS to multiple aerodromes | | | |
|---|--|---------------------------------|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H03.010 | HMI supports an acceptable level of team (ATCOs and SUP) situation awareness when working in an RTC with a flexible allocation of aerodromes between MRTMs | Not addressed in DFS validation | N/A |

E.3.2.2 HUMAN PERFORMANCE – WORKLOAD

E.3.2.2.1 OBJ-PJ05-W2-35-V3-VALP-H04 Results

| OBJ-PJ05-W2-35-V3-VALP-H04 Assess ATCO workload when providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-H04.010 | Majority of ATCOs assess workload at an acceptable level when working in an RTC with a flexible allocation of aerodromes between MRTMs | Overall workload remained at a satisfactory or tolerable level. It took the ATCOs mainly 'little' to 'very little' effort to perform their tasks. | OK |

Workload was assessed with the **Bedford scale** which promotes self-assessment of the experienced workload on a 1-10 scale (1 = WL insignificant; 10 = unable to perform task). In the PE-Questionnaire the following assessment was given:

Two ATCOs rated the situation awareness being 'at a satisfactory level':

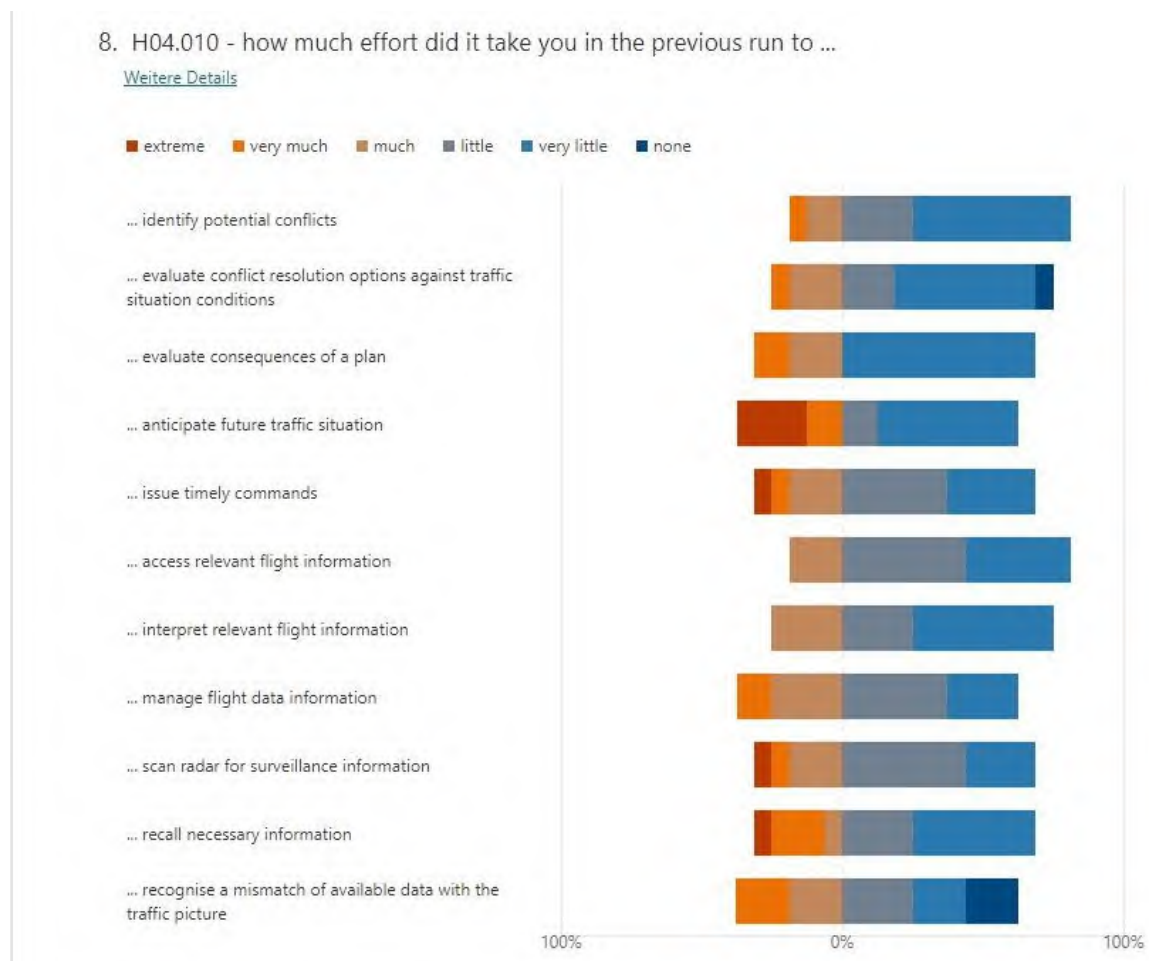
- 2 ATCO: Rating 3
Enough spare capacity for all desirable additional tasks.

Two ATCOs rated the situation awareness being 'at a tolerable level':

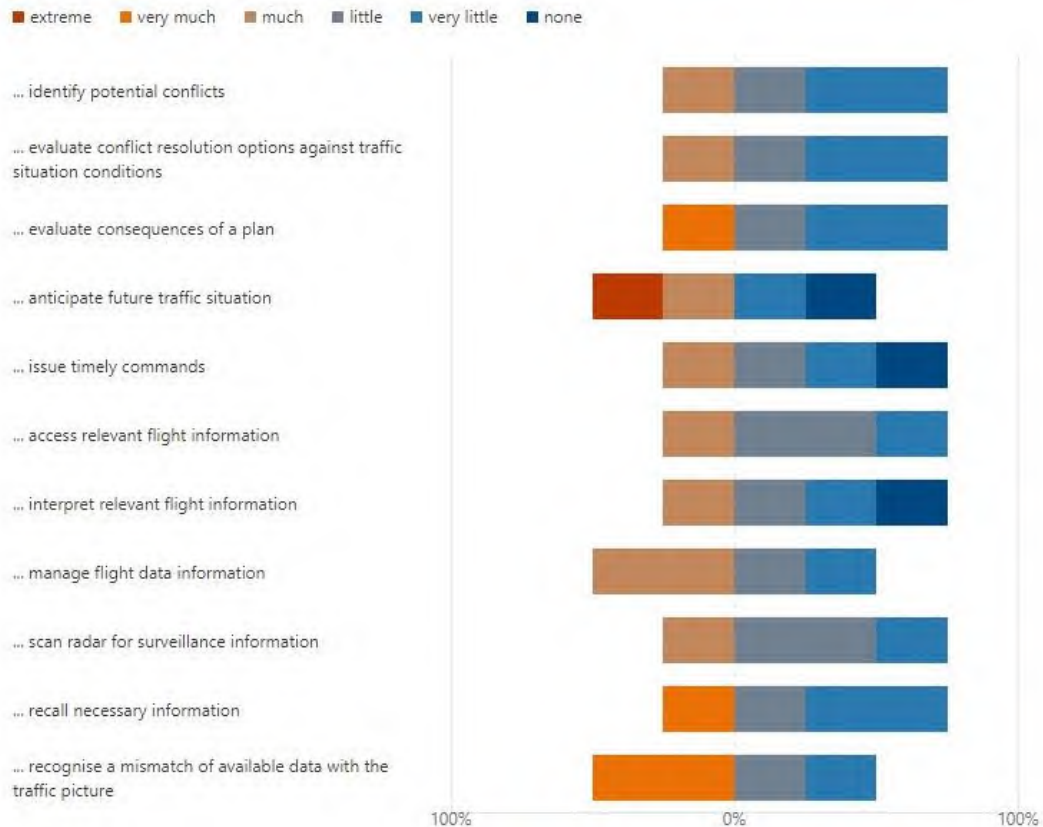
- 1 ATCO: Rating 5
Reduced spare capacity. Additional or other tasks cannot be given the desired amount of attention
- 1 ATCO: Rating 6
Little spare Capacity. Level of effort allows little attention to additional or other tasks.

The PR-Questionnaire showed similar results. Only in 3 runs the workload was assessed as not tolerable (i.e. 'very high workload with almost no spare capacity'). It should be noted that these lower assessments were given by one ATCO and were not related to a specific scenario.

The PR-Questionnaire as well as the PE-Questionnaire show that it took the ATCOs mainly 'little' to 'very little' effort to perform their tasks.



7. H04.010 - how much effort did it take you during the whole exercise to ...

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It must be highlighted that the traffic scenarios were designed in a way to put high workload on the ATCOs in order to evaluate the potential of the support functionalities.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H04.020 | Majority of ATCOs confirm that the amount of communication and time on the frequency are acceptable | The amount of R/T communication load was rated as acceptable. | OK |

8. H04.020 - Please rate the R/T communication load you experienced during the whole exercise

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■ strongly disagree
 ■ disagree
 ■ slightly disagree
 ■ slightly agree
 ■ agree
 ■ strongly agree

the amount of R/T communication was acceptable.

100% 0% 100%

E.3.2.3 HUMAN PERFORMANCE – ACCEPTANCE OF OPERATING METHODS / ROLES

E.3.2.3.1 OBJ-PJ05-W2-35-V3-VALP-H06 Results

OBJ-PJ05-W2-35-V3-VALP-H06

Assess ATCOs acceptance of operating methods when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H06.010 | Majority of ATCOs assess that operating methods can be applied in an accurate, efficient and timely manner in normal and abnormal operating conditions and degraded modes when working in an RTC with a flexible allocation of aerodromes between MRTMs | <p>While most challenging situations could be solved either without impairment or by applying measures reducing capacity, there were some situations where workload was too high and should be reduced.</p> <p>It was discussed during the debriefings that ATCOs need to be trained to work using conservative separations and not to try to speed up traffic as much as possible (as they are used to in today operations. (see procedural solutions in 3.2.1.1)</p> | Partially ok |

The ATCOs were asked to rate their capacity during a challenging situation using a Cooper Harper Scale in the post Run questionnaire.

In the majority of runs the ATCOs could solve the situation without major impairment (7) or solved the situation by measures reducing capacity (5). In 4 situations the ATCOs rated workload is too high and should be reduced.

In the post-exercise questionnaire two ATCOs stated that they could solve the situation without major impairment (2) or solve the situation by measures reducing capacity (1). One ATCO stated that workload is too high and should be reduced.

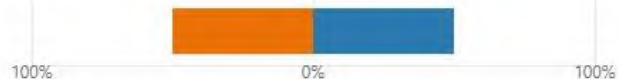
It was discussed with the ATCOs during the debriefings that ATCOs need to be trained to work using conservative separations and not to try to speed up traffic as much as possible (as they are used to in today operations. For example, if there are two simultaneously landings and one departure at one of these airports, the ATCO should not try to bring the departure into the air with a minimum separation in front of the landing as the ATCO would normally do it in a single airport environment. The awareness bent by this constellation does not guarantee the needed capacity in case of an unexpected event at the same time. All procedures and separation minima should be designed in a way to make sure, that the ATCO has a capacity reserve for handling unusual and unexpected situations.

12. H06.010 - For **Non Standard** Situations (like when you received safety alerts), please rate to which extend you disagree or agree with the following statement ...

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strongly disagree disagree slightly disagree slightly agree agree strongly agree

... I was able to maintain an adequate level of situation awareness



The ATCOs noted that situations occurred where it was difficult to maintain situation awareness in terms of staying ahead of traffic during non-standard situations. But at the same time the events ensured that all required tasks were performed.

E.3.2.3.2 OBJ-PJ05-W2-35-V3-VALP-H07 Results

OBJ-PJ05-W2-35-V3-VALP-H07

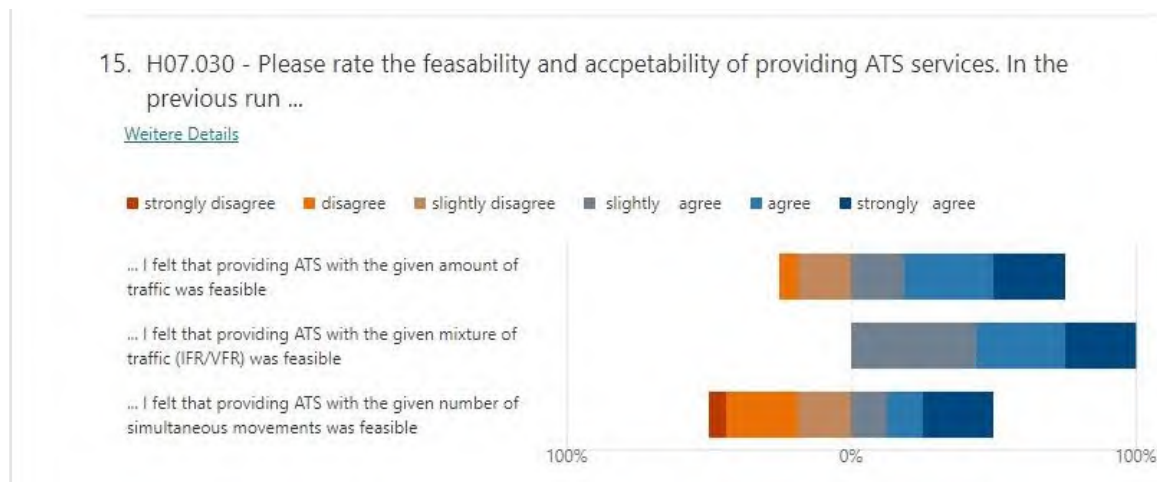
Assess ATCO acceptance of roles and responsibilities when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H07.010 | Majority of ATCOs assess that changes to ATCOs roles and responsibilities introduced by the multiple remote tower concept are clear, consistent, stable and acceptable when working in an RTC with a flexible allocation of aerodromes between MRTMs | Not addressed in DFS validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------------|
| CRT-PJ05-W2-35-V3-VALP-H07.030 | Majority of ATCOs confirm the feasibility and acceptability of providing ATS services to the assigned number of aerodromes | <p>Providing ATS service is in general feasible and acceptable.</p> <p>Attention must be paid to the number of simultaneous movements which was rated critical. Especially traffic that cannot be delayed (like rescue or police helicopters) and thus might increase the number of simultaneous movements must be considered.</p> | Partially OK |

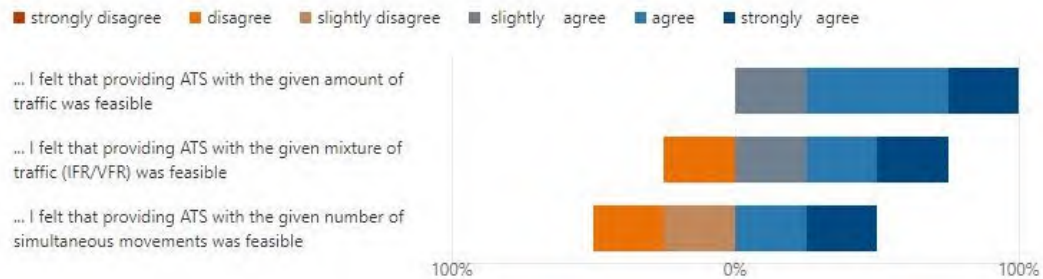
Post-run as well as post-exercise questionnaires showed that providing ATS service with flexible allocation of aerodromes is feasible and acceptable. During the simulation runs 5-6 simultaneous movements occurred. ATCOs stated that especially traffic that cannot be delay (like rescue or police helicopters) and might increase the number of simultaneous movements must be considered.

The ratings of the post-run and post-exercise questionnaire are given below.



16. H07.030 - Please rate the feasibility and acceptability of providing ATS services. In the previous run ...

[Weitere Details](#)



E.3.2.3.3 OBJ-PJ05-W2-35-V3-VALP-H08 Results

OBJ-PJ05-W2-35-V3-VALP-H08

Assess usage of the ATCO phraseology when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H08.010 | The phraseology is acceptable for the ATCO in normal and abnormal operating conditions and degraded modes | The ATCOs highlighted that the pilots starting a call using the respective tower in the phraseology helped to maintain situation awareness. | OK |

In the debriefings ATCOs highlighted that the pilots starting a call using the respective tower in the phraseology helped to maintain situation awareness. The rating of the post-exercise questionnaire is given below.

9. H08.010 - Please rate the R/T communication you experienced during the whole exercise

[Weitere Details](#)



E.3.2.4 HUMAN PERFORMANCE – USABILITY and UTILITY

E.3.2.4.1 OBJ-PJ05-W2-35-V3-VALP-H18 Results

OBJ-PJ05-W2-35-V3-VALP-H18

Assess that human-machine interface supports the team in carrying out their tasks

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.010 | Technical System/HMI support ATCOs and SUP when working in an RTC with a flexible allocation of aerodromes between MRTMs. | Not addressed in DFS validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H18.020 | Number and/or severity of team errors in the solution is within tolerable limits or not increased with respect to the reference scenario. | Not addressed in DFS validation | N/A |

E.3.2.4.2 OBJ-PJ05-W2-35-V3-VALP-H11 Results

OBJ-PJ05-W2-35-V3-VALP-H11

Assess usability and utility of ATCO human machine interface when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.010 | Majority of ATCOs assess that they have all required information easy to access and presented in an effective way. | ATCOs rated that the required information was easy to access and presented in an effective way. Flexible allocation of aerodromes was no problem, and ATCOs could easily get used to. | OK |

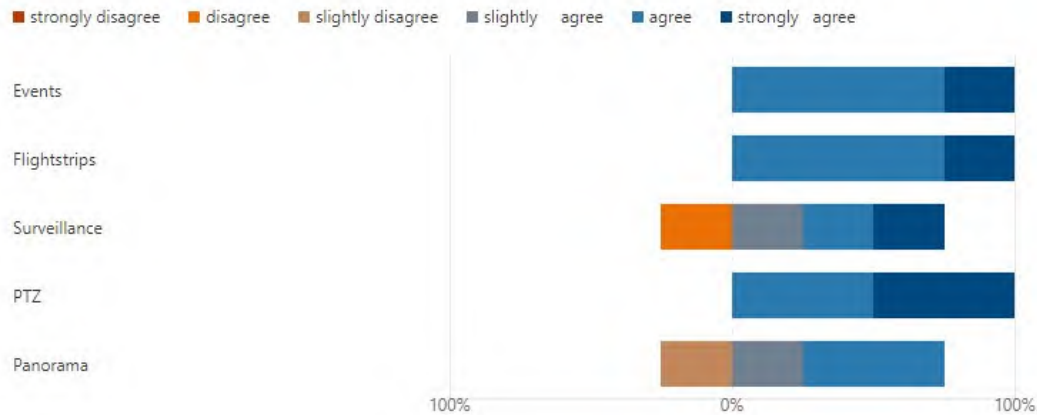
ATCOs stated in the questionnaires that flexible allocation of aerodromes was 'no problem', 'the change of the allocation did not affect my work' and 'For me it was easy to get used to the new position of airports'

ATCOs rated that the required information was easy to access and presented in an effective way. Some problems with the surveillance resulted from label conflicting (no label deconflicting was implemented in the prototype).

ATCOs proposed to place the monitors lower in order to avoid that the ATCOs have to raise their head to view the panorama monitors.

17. H11.010 - Please rate whether the required information was easy to access and presented in an effective way for the following parts

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| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.020 | Majority of ATCOs confirm adequate usability of input devices and HMI controls. | ATCOs agreed that inputs to the system was easy to do. | OK |

In general, ATCOs agreed that inputs to the system were easy to do. ATCOs proposed to add the possibility to input flight strip information also in the surveillance display. The hardware keyboard that was used for setting up VFR flightstrips should be replaced by a digital keyboard in a final system.

19. H11.020 - Please rate the usability of input devices and HMI controls.

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| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.040 | Majority of ATCOs confirm adequate usability and utility of alarms and alerts | ATCOs rated the usability and utility of the events as being quite helpful | OK |

The ATCOs emphasised the utility of the alarms and alerts provided by the different events.

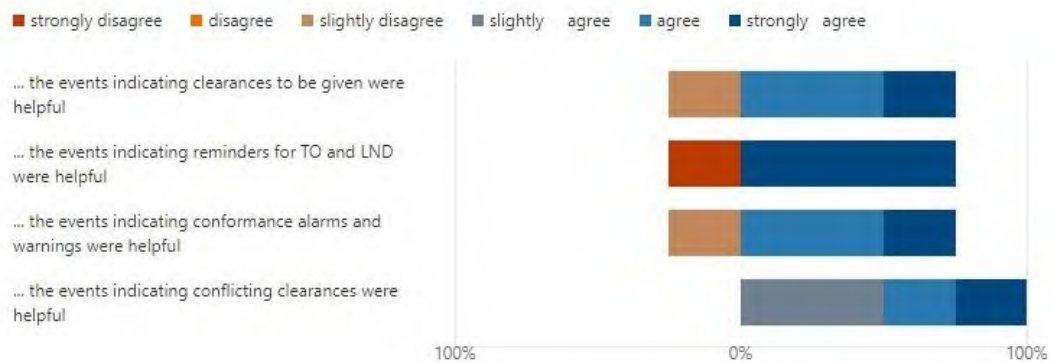
The events indicating clearances were generally rated as being helpful. ATCOs commented that the event for VFR takeoff and VFR traffic leaving the CTR were not required. An other event for VFR traffic entering and exiting the CTR via the same route (same entry / exit fix) should be added.

The events indicating reminders for TO and LND were generally rated as being helpful. ATCOs commented that the takeoff reminder should be issued earlier than implemented in the prototype.

The results of the post-exercise questionnaire are given below (the results of the post-run questionnaire showed similar results).

21. H11.040 - Please rate the **usability** of the events. In the whole exercise ...

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| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.050 | The ATCO human machine interface does not increase the potential for human error | The ATCO did not see that the human machine interface will increase the potential for human error | OK |

The answers from the post-exercise questionnaire are given below. The ATCOs stated in the debriefing, that they partly 'disagreed' as the HMI naturally is more complex than the one for today operations or single remote tower but did not see a any problem in the specific setup for MRTC.

25. H11.050 - Please rate the human machine interface as a whole

[Weitere Details](#)



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.060 | ATCOs confirm the adequacy of the usability and utility of ATCO short term planning tool/traffic forecast and/or prioritisation tool. | The ATCOs confirmed the usability and utility of the task prioritisation provided by the events | OK |

ATCOs reported in the debriefing that they did not use the event overview frequently but used the events displayed in the FDPS. Nevertheless, they stated that the event overview supported in situations where attention was focussed on one aerodrome and an alarm/alert at another aerodrome occurred. ATCOs proposed to simplify the design of the event overview as the number of active events is not of interest – but the priority given by colour coding is essential.

The results from the post-exercise questionnaire are given below (compare also results given in CRT-PJ05-W2-35-V3-VALP-H11.040).

23. H11.060 - Please rate the **usability** of the task prioritisation given by the events. During the whole exercise ...

[Weitere Details](#)



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.070 | Majority of ATCOs confirm there is no confusion about which aerodromes are displayed on which display | ATCOs were in general aware about which airport was displayed on which display | OK |

ATCOs were in general aware about which airport was displayed on which display. In the debriefings the ATCOs mentioned that they had sometimes problems to reliably identify which panorama was displayed on the top monitor row (as this panorama changes with the selected aircraft) and proposed to add further hints indicating the airport being displayed.

The results from the post-run and post exercise questionnaire are given below.

20. H11.070 - Please rate wheter there was any confusion about which aerodrome was displayed on which monitor. During the previous run ...

[Weitere Details](#)



PE:

26. H11.070 - Please rate wheter there was any confusion about which aerodrome was displayed on which monitor. During the whole exercise ...

[Weitere Details](#)



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H11.080 | Majority of ATCOs confirm there is no confusion about which aerodrome will be transferred between the MRTMs. | Not addressed in DFS validation | N/A |

E.3.2.5 HUMAN PERFORMANCE – TRUST

E.3.2.5.1 OBJ-PJ05-W2-35-V3-VALP-H13 Results

OBJ-PJ05-W2-35-V3-VALP-H13

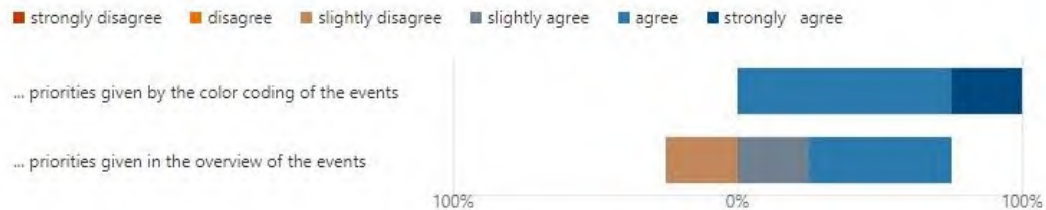
Assess ATCO trust in support systems when providing ATS to multiple aerodromes

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.010 | ATCOs trust the functionality of the automated task prioritisation | The ATCOs confirmed that they could trust the task prioritisation provided by the events | OK |

The result from the post-exercise questionnaire is given below (compare also with CRT-PJ05-W2-35-V3-VALP-H11.060).

24. H13.010 - Please rate the **reliability** of the task prioritisation given by the events. During the whole exercise I could trust in ...

[Weitere Details](#)



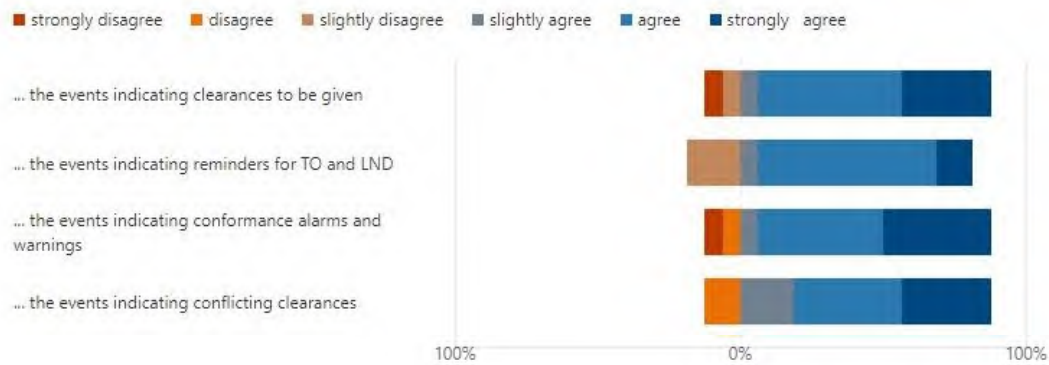
| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.020 | ATCOs trust the functionality of the conformance monitoring | ATCOs trusted in the reliability of the conformance monitoring provided by the events | OK |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.040 | ATCOs trust in reliability of alarms and alerts | ATCOs trusted in the reliability of the alarms and alerts provided by the events | OK |

The results of the post-run questionnaire are given below (For more information compare CRT-PJ05-W2-35-V3-VALP-H11.040).

17. H13.040 - Please rate the **reliability** of the events. In the previous run I could trust in the reliability of ...

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During the shadow mode the reliability of the events were evaluated. During the shadow mode operating direction 28 was active. Although the different events (as referenced in the questionnaire given in the figure above) were generated reliably, some issues were identified but could be solved by an updated configuration. One item remaining was the temporary loss of identification of an aircraft as being on final which needs to be fixed.

For non-ADS-B equipped targets, ground surveillance based on the mini MLAT showed in general a good performance regarding accuracy and probability-of-detection. For ADS-B equipped targets validated by the system, ground surveillance showed an excellent performance.

Nevertheless, certain areas could be identified where the mini MLAT surveillance showed low performance (i.e. low accuracy or low probability of detection). These areas were already forecasted based on the initial surveillance simulations and are due to the positions and the low number of the MLAT antennas. For the antenna positions existing housings/masts were chosen in order to keep cost at a minimum. Antennas on the airport vicinity were all wireless connected to the central processing system of the mini MLAT.

For those areas the tracker was configured to maintain the track based on coasting and extended coasting rules up to 60 seconds. During coasting the track position is predicted based on the estimated kinematics; during extended coasting the last predicted position is frozen. The coasting / extended coasting status was highlighted on the surveillance display.

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H13.080 | Majority of ATCOs trust the HMI functionalities to support transfer of aerodromes between modules up to the completion of the transfer | Not addressed in DFS validation | N/A |

E.3.2.6 HUMAN PERFORMANCE – Transition Factors

E.3.2.6.1 OBJ-PJ05-W2-35-V3-VALP-H15 Results

OBJ-PJ05-W2-35-V3-VALP-H15

Early assessment of transition factors in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.010 | Knowledge, skill and experience requirements are identified/consolidated per actor group | Not addressed in DFS validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-H15.020 | Training needs per actor group are identified (preliminary identification only). | Not addressed in DFS validation | N/A |

E.3.2.7 SAFETY

E.3.2.7.1 OBJ-PJ05-W2-35-V3-VALP-S04 Results

OBJ-PJ05-W2-35-V3-VALP-S04

Assess ATCO capability to provide ATC services in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs under all normal conditions

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.010 | ATCO is able to identify and solve potential conflicts in a timely manner: <ul style="list-style-type: none"> • In the vicinity of the aerodrome • In the runway area • On the manoeuvring area | ATCOs were able to solve conflicts in a timely manner | OK |

ATCOs agreed in the post-run and post-exercise questionnaire that they could provide ATS in a safe manner. The ratings are given below.

23. S04.010 - Please rate the capability to provide ATS in a safe manner. In the previous run ...

[Weitere Details](#)



28. S04.010 - Please rate the capability to provide ATS in a safe manner.

[Weitere Details](#)



| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|--|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.020 | ATCO is able to identify and solve potential hazardous situations in a timely manner (e.g.): <ul style="list-style-type: none"> • Unstable approaches • Bird strikes • Aircraft not vacating RWY as expected | The ATCOs were able to solve potentially hazardous situations in a timely manner | OK |

The result of the post-run and post-exercise questionnaire is given below.

24. S04.020 - Please rate the capability to provide ATS in a safe manner. In the previous run ...

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29. S04.020 - Please rate the capability to provide ATS in a safe manner.

[Weitere Details](#)

■ strongly disagree
 ■ disagree
 ■ slightly disagree
 ■ slightly agree
 ■ agree
 ■ strongly agree

I was able to solve potentially hazardous situations in a timely manner

100% 0% 100%

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.030 | ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with | Not addressed in DFS validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S04.050 | ATCO is not inducing more conflicting situations than in the reference scenario | Not addressed in DFS validation | N/A |

E.3.2.7.2 OBJ-PJ05-W2-35-V3-VALP-S05 Results

OBJ-PJ05-W2-35-V3-VALP-S05

Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S05.010 | ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads | Not addressed in DFS validation | N/A |

E.3.2.7.3 OBJ-PJ05-W2-35-V3-VALP-S06 Results

| OBJ-PJ05-W2-35-V3-VALP-S06 | | | |
|--|---|---|--------|
| Assess ATCO capability to cope with / manage abnormal situation in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-S06.010 | ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> • Aircraft emergency • Crash on an airport or its vicinity • Fire on an airport Unplanned closure of an airport | The ATCOs were able to identify and manage abnormal situations. | OK |

The result of the post-run and post-exercise questionnaire is given below.

26. S06.010 - Please rate the capability to provide ATS in a safe manner. In the previous run I ...

[Weitere Details](#)



31. S06.010 - Please rate the capability to provide ATS in a safe manner.

[Weitere Details](#)



E.3.2.7.4 OBJ-PJ05-W2-35-V3-VALP-S07 Results

| OBJ-PJ05-W2-35-V3-VALP-S07 | | | |
|--|--|--|--|
| Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner when working in an RTC with a flexible allocation of aerodromes between MRTMs | | | |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|--|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.010 | <p>ATCO is able to detect and recover from a technical failure occurring at one of the airports affecting (e.g):</p> <ul style="list-style-type: none"> • Communication • Visualisation system <p>Other airport systems / infrastructure</p> | Not addressed in DFS validation | N/A |

| Criterion ID | Success Criterion | Validation Result | Status |
|--------------------------------|---|---------------------------------|--------|
| CRT-PJ05-W2-35-V3-VALP-S07.030 | <p>ATCO is able to detect and recover from a technical failure in the MRTM affecting the operation at one or more aerodromes (e.g):</p> <ul style="list-style-type: none"> • Communication <p>Visualisation system</p> | Not addressed in DFS validation | N/A |

E.3.2.8 CAPACITY

E.3.2.8.1 OBJ-PJ05-W2-35-V3-VALP-CA1 Results

| OBJ-PJ05-W2-35-V3-VALP-CA1 Assess capacity constraints when providing ATS to multiple aerodromes | | | |
|---|---|--|--------------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CA1.010 | An indication for controller capacity is given (in terms of simultaneous movements, up to 6) when ATS is provided to multiple remote towers | <p>Providing ATS service is in general feasible and acceptable.</p> <p>Attention must be paid to the number of simultaneous movements which was rated critical. Especially traffic that cannot be delayed (like rescue or police helicopters) and thus might increase the number of simultaneous movements must be considered.</p> | Partially OK |

For the detailed results of the questionnaires compare CRT-PJ05-W2-35-V3-VALP-H07.030.

E.3.2.9 COST EFFICIENCY

E.3.2.9.1 OBJ-PJ05-W2-35-V3-VALP-CE1 Results

| OBJ-PJ05-W2-35-V3-VALP-CE1 Assess the staff required for providing ATS to multiple aerodromes | | | |
|--|--|---|--------|
| Criterion ID | Success Criterion | Validation Result | Status |
| CRT-PJ05-W2-35-V3-VALP-CE1.010 | ATCO can provide ATS to 3 aerodromes at a time and due to the limit on endorsements out of a group of 4 aerodromes | <p>ATCO stated that flexible allocation of aerodromes does not impose a much higher workload or reduction in situation awareness.</p> <p>Furthermore ATCOs stated that they can provide ATS in a safe manner.</p> | OK |

E.3.3 Unexpected Behaviours/Results

No showstoppers were encountered in the validations.

E.3.4 Confidence in Results of Validation Exercise 1

E.3.4.1 Level of significance/limitations of Validation Exercise Results

See chapter 4.3.1 for Level of significance/limitations of Validation Exercise Results

The following items were not considered in the DFS validation exercise:

- No coordination tasks were considered
- No ground vehicles were considered in the scenarios

E.3.4.2 Quality of Validation Exercises Results

See chapter 4.3.1.1 for Quality of Validation Exercises Results

E.3.4.3 Significance of Validation Exercises Results

See chapter 4.3.1.2 for Significance of Validation Exercises Results

E.3.5 Conclusions

A.1.1.1. Conclusions on concept clarification

Situation Awareness

Situation awareness was at a satisfactory to acceptable level when providing ATS to three aerodromes at a time and using flexible allocation of aerodromes. Nevertheless, ATCOs stated they needed a generally higher level of attention to keep their SA for all three aerodromes compared to controlling just one aerodrome. Flexible allocation of aerodromes had about no effect on situation awareness and ATCOs stated that they easily could get used to it.

The following aspects supported the ATCOs in maintaining situation awareness:

- Especially reminder events - such as landing reminders and safety alerts - helped to maintain SA.

- 'Column-wise' arrangement of information belonging to one aerodrome supported them to differentiate between the different aerodromes.
- The ATCOs highlighted that the pilots starting a call using the respective tower in the phraseology helped to maintain situation awareness.

Workload and Operating Methods

Overall workload remained at a satisfactory or tolerable level. It took the ATCOs mainly 'little' to 'very little' effort to perform their tasks. While most challenging situations could be solved either without impairment or by applying measures reducing capacity, there were some situations where workload was too high and should be reduced.

Attention must be paid to the following aspects:

- It was discussed during the debriefings that ATCOs need to be trained to work using conservative separations and not to try to speed up traffic as much as possible (as they are used to in today operations).
- Providing ATS service is in general feasible and acceptable. Attention must be paid to the number of simultaneous movements which was rated critical. Especially traffic that cannot be delay (like rescue or police helicopters) and might increase the number of simultaneous movements must be considered. All procedures and separation minima should be designed in a way to make sure, that the ATCO has a capacity reserve for handling unusual and unexpected situations.

Safety

ATCOs were able provide ATS in a safe manner, being able to solve conflicts and potentially hazardous situations in a timely manner as well as being able identify and manage abnormal situations.

A.1.1.1. Conclusions on technical feasibility

The following conclusion on the technical feasibility could be drawn:

- The MRTM setup could be used to provide ATS to 3 aerodromes at a time
- Electronic flight strips and air surveillance are a must in the validated scenarios
- Events supported the ATCO (especially landing and take-off reminder and the safety alerts and warnings were well appreciated)
- Automatic PTZ-Tracking and automatic Zooming was very helpful
- Quality of object bounding in panorama needs to be proven with real data

A.1.1.1. Conclusions on performance assessments

- General
 - The need to focus on a certain situation a 'longer period' on different aerodromes at a time should be minimised by the ATCO. It must be trained that safety is absolutely prior to efficiency.
- Simultaneous landings and/or takeoffs
 - Simultaneous landings and/or take-offs could be handled. Nevertheless, three simultaneous landings should be avoided as the ATCO needs spare capacity if other traffic also needs attention or other unforeseen traffic like a rescue helicopter occurs.
- Operating Direction
 - Aerodromes with camera facing south and north could be handled at the same time without increasing workload or reducing situation awareness.
 - Aerodromes with 'opposite' runway directions could be handled at the same time without increasing workload or reducing situation awareness.
- VFR Traffic
 - ATCO Workload increased with increasing amount of VFR traffic.

E.3.6 Recommendations

The following recommendations were given to further improve the MRTM:

HMI

The monitors should be placed lower in order to avoid the necessity to look up too high (ideally the top edge of the upper monitors should not be much higher than the level of the eyes).

ATCOs proposed to add the possibility to input flight strip information also in the surveillance display.

The hardware keyboard that was used for setting up VFR flight strips should be replaced by a digital keyboard in a final system.

Events

The event for VFR takeoff and VFR traffic leaving the CTR were not required.

An other event for VFR traffic entering and exiting the CTR via the same route (same entry / exit fix) should be added.

ATCOs commented that the takeoff reminder should be issued earlier than implemented in the prototype.