Effects of unwanted tracking boxes in a Remote Tower control environment

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What is Remote Tower and what are Tracking Boxes?

	Object of interest	Object not of interest
Object tracked	Wanted → overtrust? → learnt carelessness	Unwanted → negative influence on acceptance, workload or Situation awareness?
Object not tracked	Missed → Safety critical?	Correct Rejection

EUROCAE WG100 ED-240A in accordance to Signal Detetcion Theory (Wickens, 2002)

Research question

What is the minimum acceptable operational performance of a tracking function in a Remote Tower Control context to provide positive effects on?

- Workload
- Situation Awareness
- Acceptance

Set up

Human-in-the-Loop Simulation at DLR Remote Tower Lab

Panorama

Communication Display

PTZ

Spacemouse

TFDPS

Questionnaire
IDVS

Sichtflugkarte
Visual Operation Chart

ELEV 295

BRAUNSCHWEIG-WOLFSBURG
EDVE

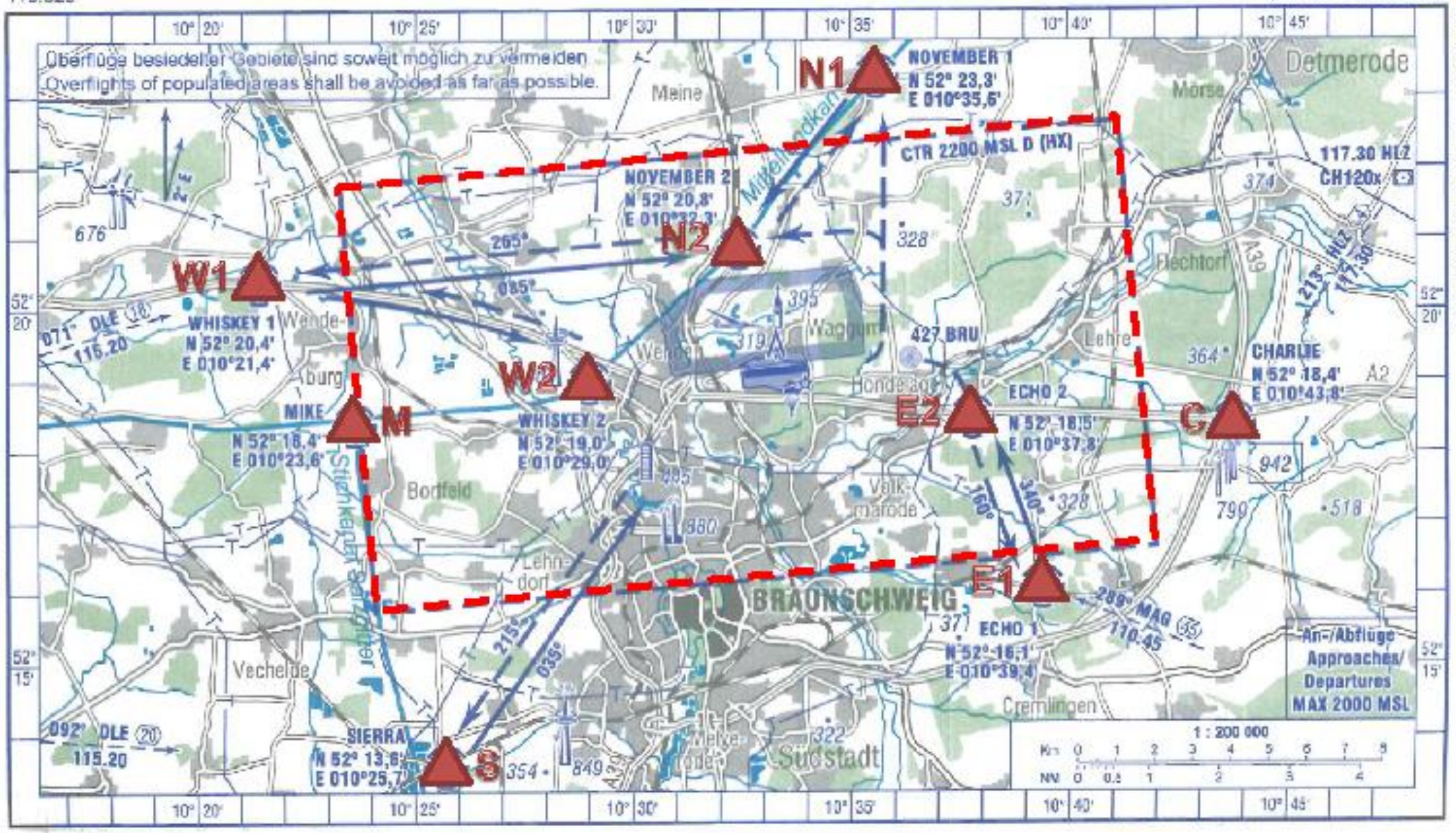
FIS
BREMEN INFORMATION
119.825

VDF 120.050
ILS 26 108.50

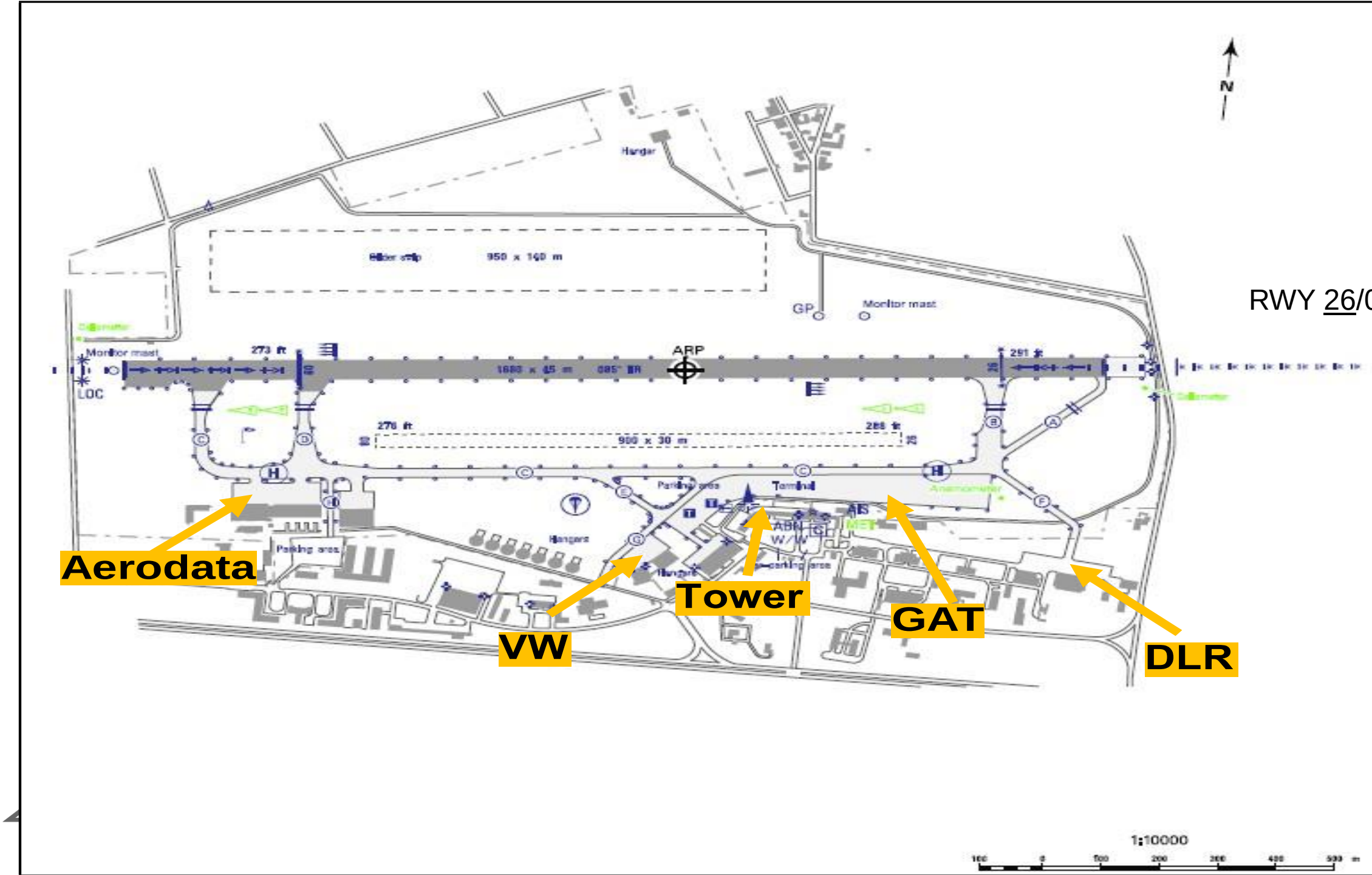
BRAUNSCHWEIG TOWER/TURM
120.050 En/Ge* 369.025 En*

andernfalls/otherwise
BRAUNSCHWEIG INFO 120.050 En/Ge*
*(25 NM 4000 ft GND)

14 JUL 2011



Berichtigung: Hindernis, Messwesung, Topografie.
Correction: Obstacle, variation, topo


N
Hangar
950 x 140 m
GP
Monitor mast
Monitor mast
LOC
273 ft
ARP
1800 x 45 m
085° MR
291 ft
276 ft
900 x 30 m
288 ft
Parking area
Terminal
Anemometer
Hangars
Parking area
Hangars
W/V
Aerodata
VW
Tower
GAT
DLR
1:10000

RWY 26/08

Procedure and Environment Description

Airspace classification	D – regional airport
Voice Com and responsibilty	• English • all communication via one R/T channel • No apron and approach control coordination • In- and outbound traffic calls directly from entering CTR until final parking and vice versa
VMC condition	CAVOK, Wind 260° 5 knots
Operational runway	RWY26 (North aerodrome traffic (right traffic pattern) circuit is the preferred one)
traffic	• Mixed traffic (17 mov/45min)
equipage	• Optical sensors only (no radar) • PTZ • TFDPS

Experimental Design 1/2

Treatment: „Number of Unwanted Boxes“ on 4 Levels:

- Baseline (BL) = no visual tracking
- A1 = Low
- A2 = Medium
- A3 = High

Constant Hit Rate:

- = 88% (Wanted/Missed)

	Object of interest	Object not of interest
Object tracked	Wanted → overtrust? → learnt carelessness	Unwanted → negative influence on acceptance, workload or Situation awareness?
Object not tracked	Missed → Safety critical?	Correct Rejection

Experimental Design 2/2

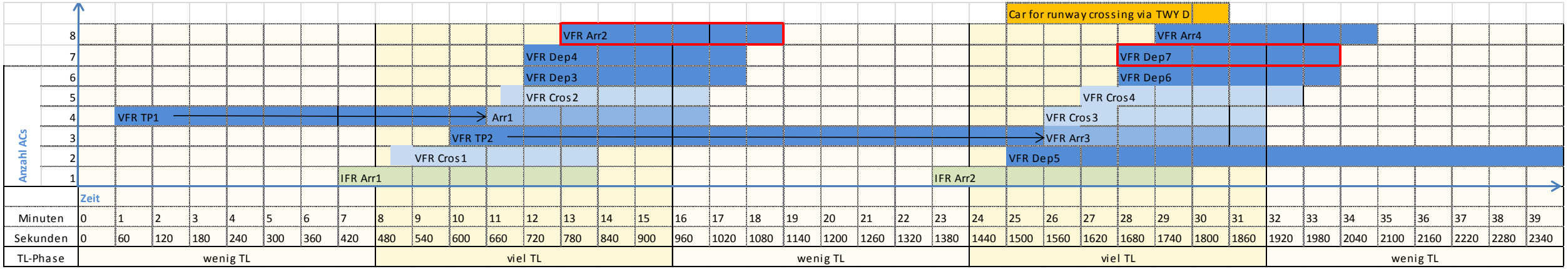
Location →	Runway				Taxiway				Final Approach				Traffic Pattern			
Dwell time ↓	BL	A1	A2	A3	BL	A1	A2	A3	BL	A1	A2	A3	BL	A1	A2	A3
30 sec	0	0	0	7	0	0	7	14	0	0	0	7	0	0	0	7
5 sec	0	0	7	14	0	7	14	28	0	7	7	14	0	7	7	14
2 sec	0	14	28	42	0	14	28	42	0	14	28	42	0	70	140	210

…looks like this

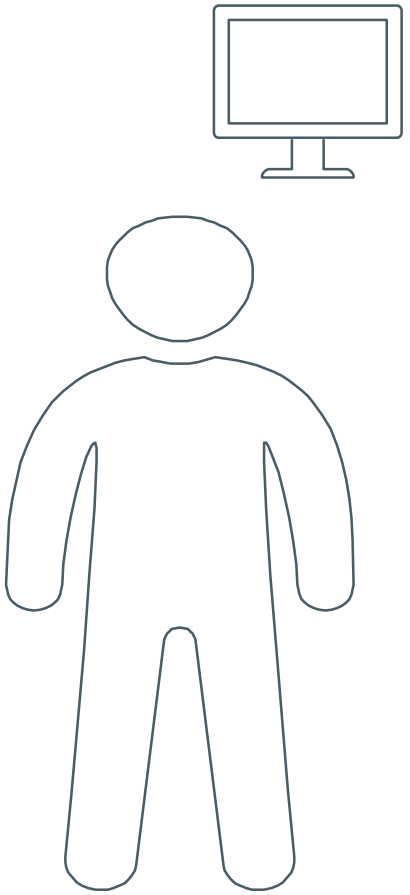
Traffic Scenario

- 17 air movements over ca. 45min
  - 15 VFR / 2 IFR
    - 2 Traffic Pattern, 4 Arrivals, 7 Departures, 4 Crossers

- Unnormal Situations
  - 1 Maintenance car, crossing the runway without clearance
  - 1 Intruder, crosses the CTR from north to south without initial call nor clearance



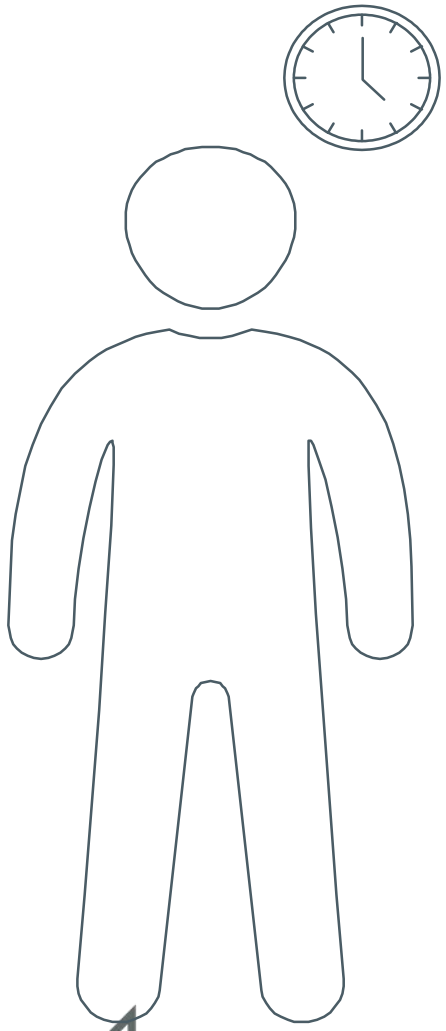
Randomisation and blind experiment



Training

Baseline 1	Szenario 2 LOW	Szenario 3 MIDDLE	Szenario 4 HIGH
1	2	3	4
2	3	4	1
3	4	1	2
4	3	2	1
3	2	4	1
2	1	3	4
4	2	1	3

schedule



- 09:00 Briefing
- 09:30 Training
- 10:15 Test Run 1
- 11:00 Debriefing
- 11:30 Break
- 12:30 Test Run 2
- 13:15 Debriefing
- 13:45 Test Run 3
- 14:30 Debriefing
- 15:00 Test Run 4
- 15:45 Debriefing
- 18:00 End

participants

7 male volunteer ATCOs between 31-62 years

average 19 years experience (SD = 19)

All know Remote tower and believe it is a sustainable concept

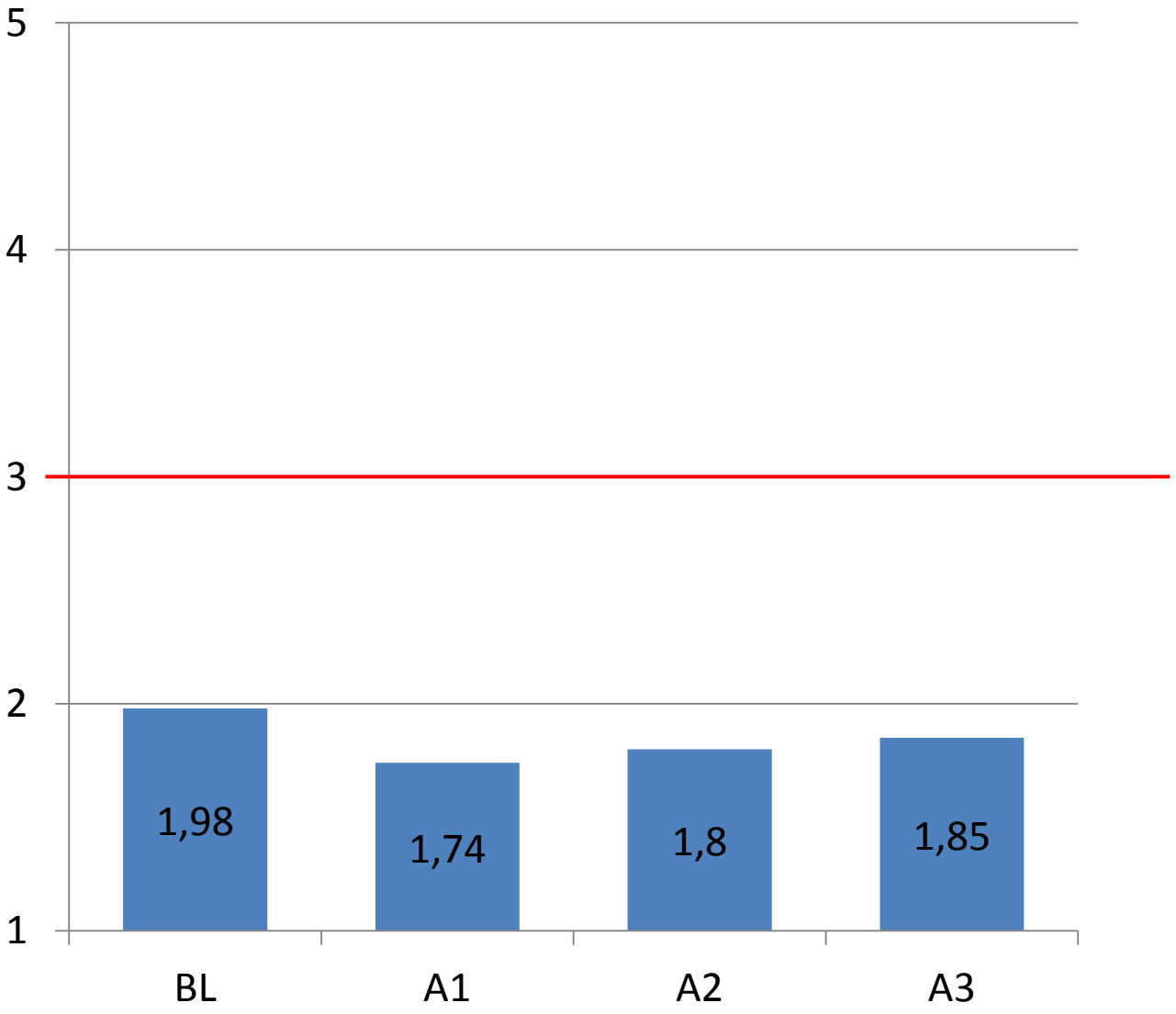
4 of them had experience with visual tracking

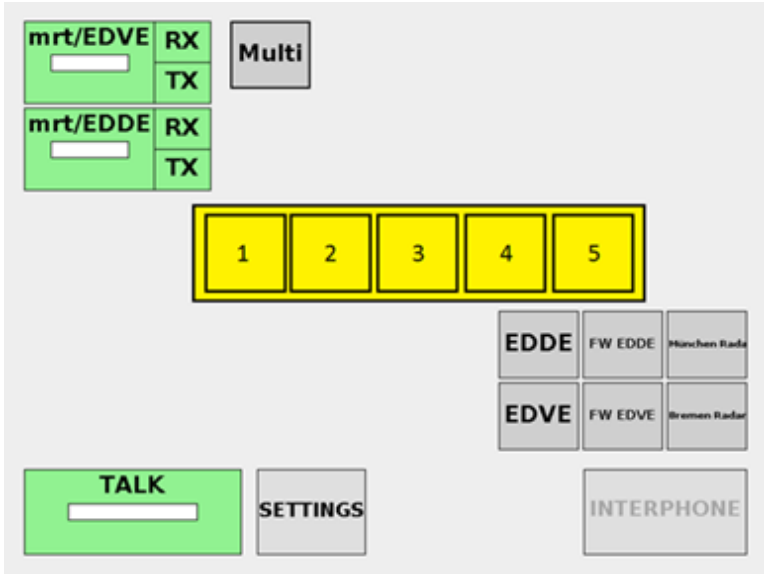
Measurements

Workload	• SARA-T (mid-run) • I.S.A. (mid-run) • AIM (post-run)
Situation Awareness	• SARA-T (mid-run) • SASHA (post-run) • Debriefing
Acceptance	• 3point Likert Scale (mid-run) • SATI (post-run) • Debriefing

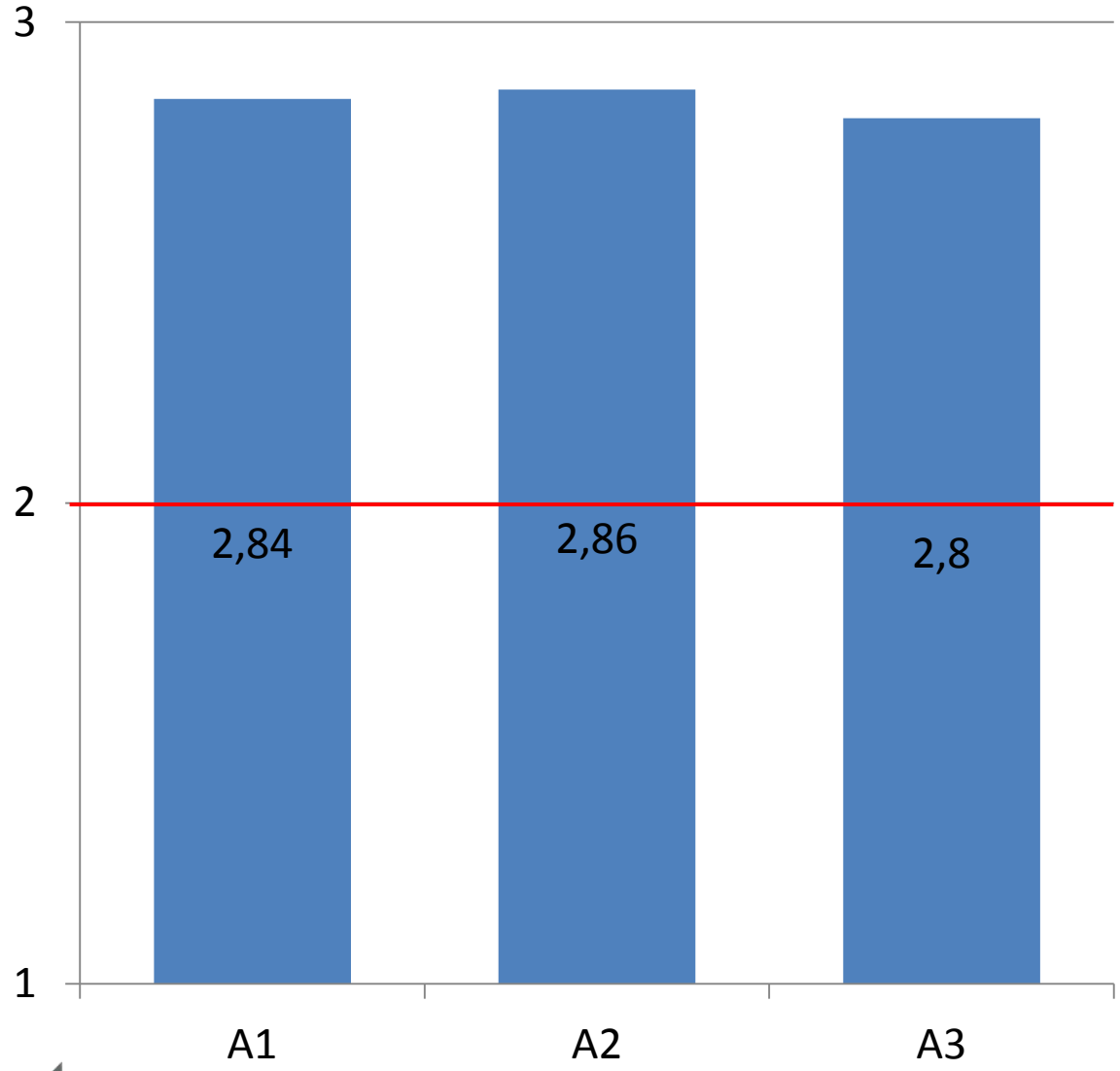
Results

Workload


5
4
3
2
1
1,98
1,74
1,8
1,85
BL
A1
A2
A3
I.S.A. Workload scale


mrt/EDVE
RX
TX
Multi
mrt/EDDE
RX
TX
1
2
3
4
5
EDDE
FW EDDE
EDVE
FW EDVE
TALK
SETTINGS
INTERPHONE

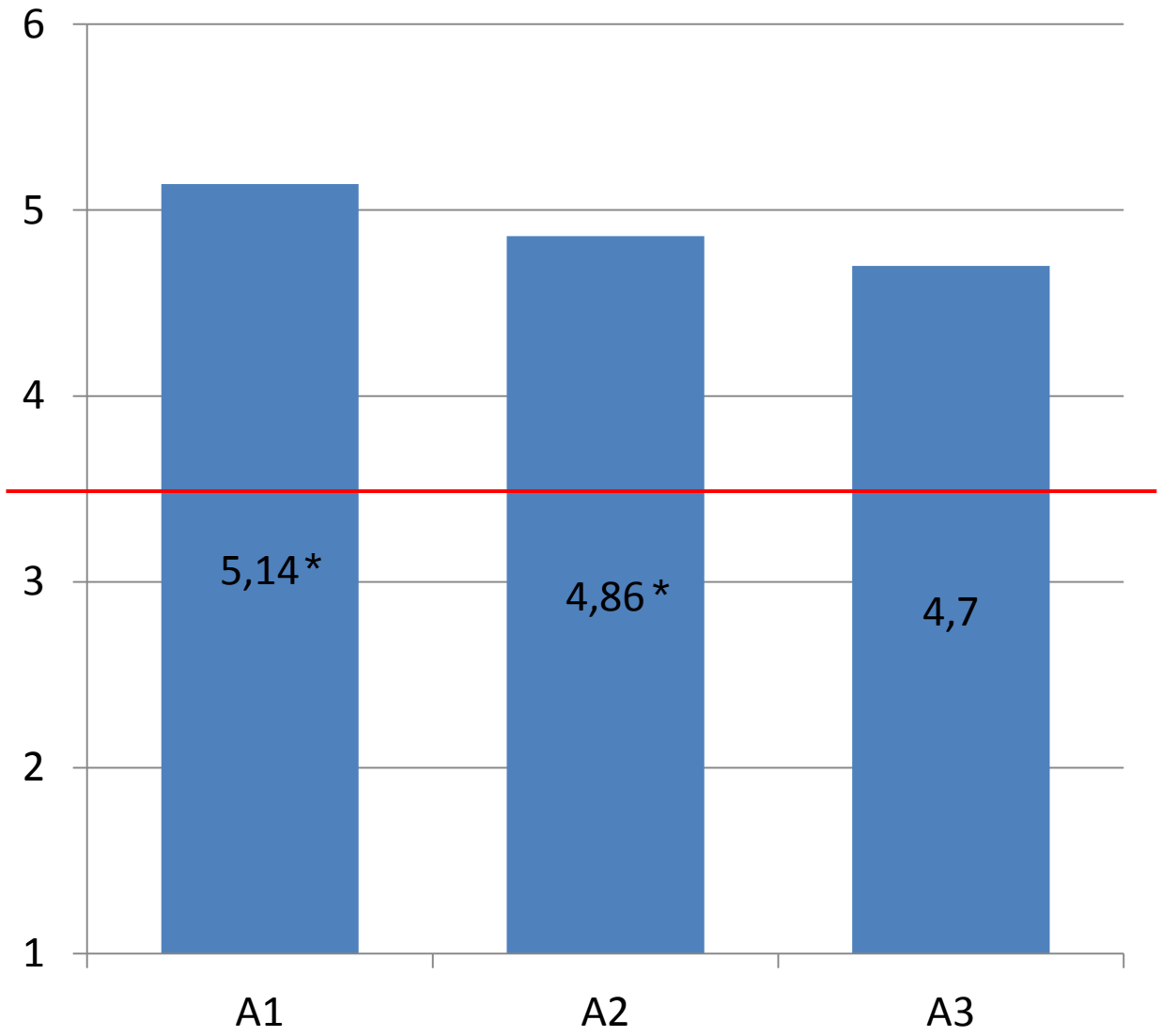
Acceptance 3point Likert Scale (mid-run)



During the past 5 minutes I found the „Visual Tracking“:

3	2	1
Helpful	Not of interest	Disturbing

Acceptance (post-run) (wanted/missed/unwanted)

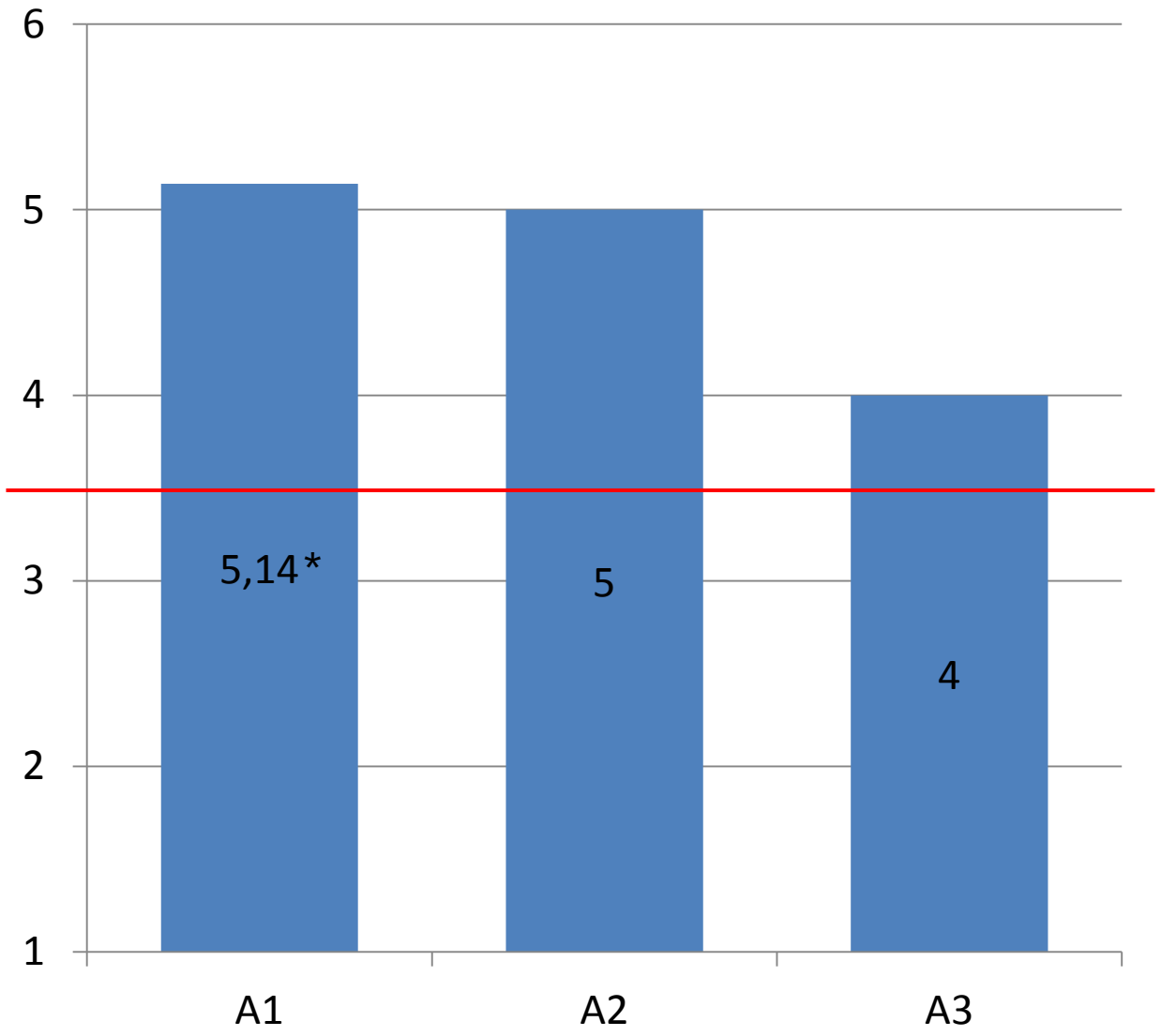


The experienced wanted, missed and unwanted Boxes had an acceptable rate to help me increasing my situational awareness.

Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree

■ Acceptance Post-run likert 1-6

Acceptance (post-run) (unwanted)



I experienced unwanted Boxes (nuisance boxes) but they popped up in an acceptable amount that did not prevent me from working in a safe and efficient manner

Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree

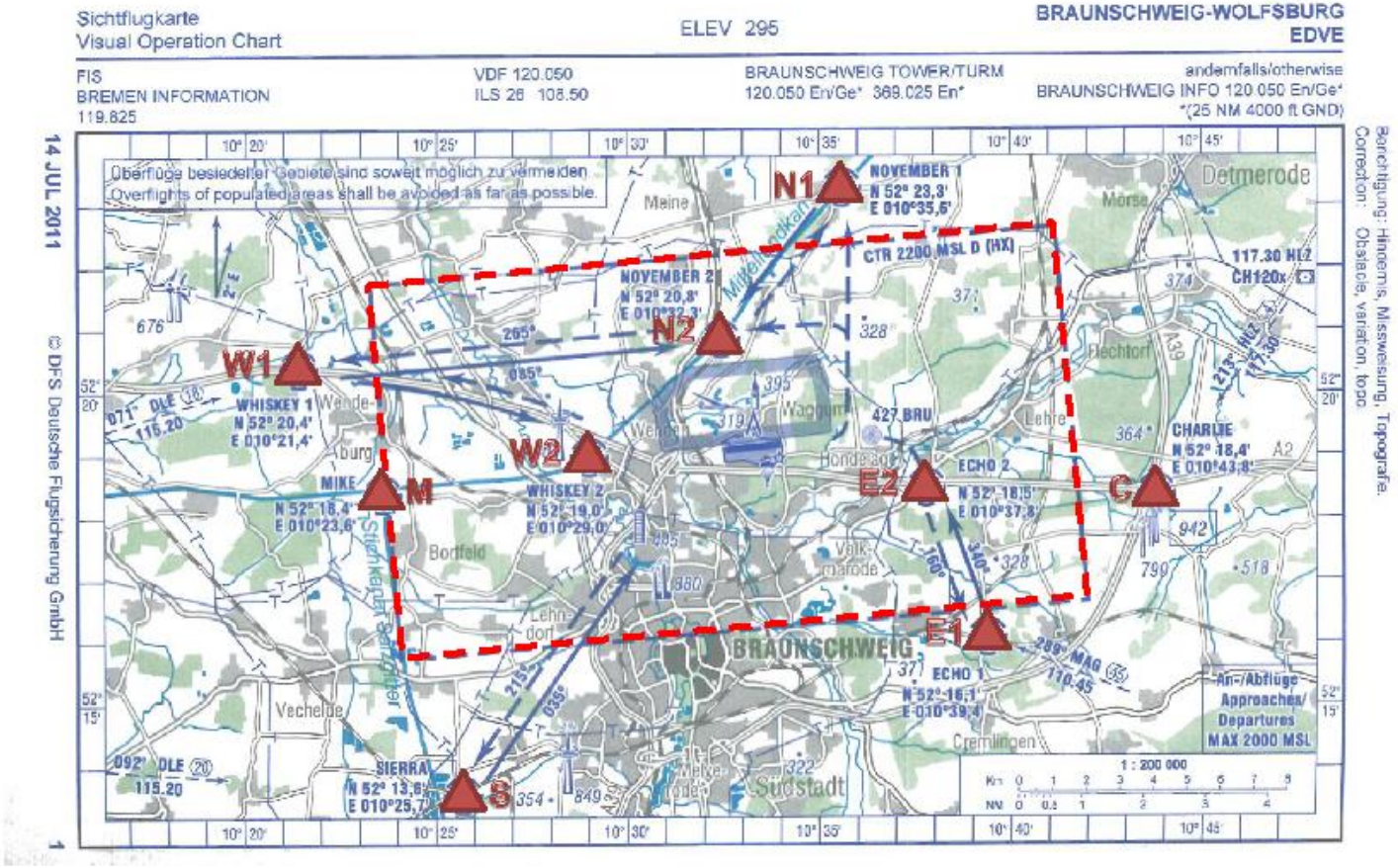
■ Acceptance Post-run likert 1-6

Crosser detection

- Overflight without radio contact and clearance

- In baseline not detected at all
- With tracking 4/7

- Friedman-Test: χ^2 (3) = 12.000, p = .007



Maintanance Car detection

- Was cleared to taxi and hold on holding point RWY26
- During a take-off it crossed without clearance

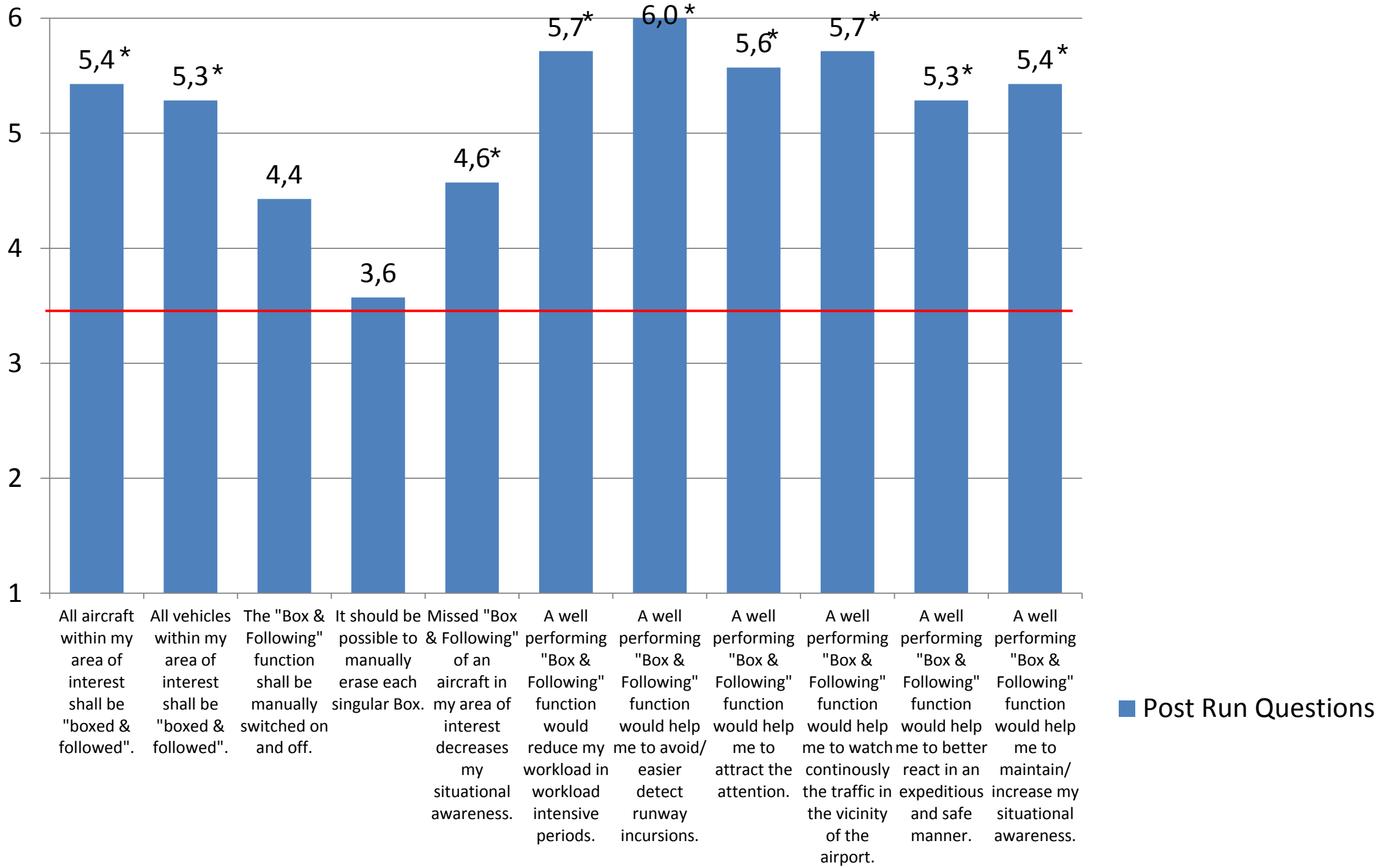
- Seen by all when boxed but only 4 of 7 in baseline

Pust Trial Questions

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
All aircraft within my area of interest shall be "boxed & followed".	7	4,00	6,00	5,4286	,78680
All vehicles within my area of interest shall be "boxed & followed".	7	4,00	6,00	5,2857	,75593
The "Box & Following" function shall be manually switched on and off.	7	1,00	6,00	4,4286	2,07020
It should be possible to manually erase each singular Box.	7	1,00	6,00	3,5714	2,22539
Missed "Box & Following" of an aircraft in my area of interest decreases my situational awareness.	7	4,00	6,00	4,5714	,78680
A well performing "Box & Following" function would reduce my workload in workload intensive periods.	7	4,00	6,00	5,7143	,75593
A well performing "Box & Following" function would help me to avoid/ easier detect runway incursions.	7	6,00	6,00	6,0000	0,00000
A well performing "Box & Following" function would help me to attract the attention.	7	5,00	6,00	5,5714	,53452
A well performing "Box & Following" function would help me to watch continously the traffic in the vicinity of the airport.	7	5,00	6,00	5,7143	,48795
A well performing "Box & Following" function would help me to better react in an expeditious and safe manner.	7	4,00	6,00	5,2857	,75593
A well performing "Box & Following" function would help me to maintain/ increase my situational awareness.	7	5,00	6,00	5,4286	,53452
Valid N (listwise)	7				

Pust Trial Questions

Binomial Test					
	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
All aircraft within my area of interest shall be "boxed & followed".	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
All vehicles within my area of interest shall be "boxed & followed".	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
		7	1,00		
The "Box & Following" function shall be manually switched on and off.	<= 3	2	,29	,50	,453
	> 3	5	,71		
It should be possible to manually erase each singular Box.	<= 3	3	,43	,50	1,000
	> 3	4	,57		
Missed "Box & Following" of an aircraft in my area of interest decreases my situational awareness.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
A well performing "Box & Following" function would reduce my workload in workload intensive periods.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
A well performing "Box & Following" function would help me to avoid/ easier detect runway incursions.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
A well performing "Box & Following" function would help me to attract the attention.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
A well performing "Box & Following" function would help me to watch continously the traffic in the vicinity of the airport.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
A well performing "Box & Following" function would help me to better react in an expeditious and safe manner.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		
A well performing "Box & Following" function would help me to maintain/ increase my situational awareness.	<= 3	0	0,00	,50	,016
	> 3	7	1,00		


6
5
4
3
2
1
5,4*
5,3*
4,4
3,6
4,6*
5,7*
6,0*
5,6*
5,7*
5,3*
5,4*
All aircraft within my area of interest shall be "boxed & followed".
All vehicles within my area of interest shall be "boxed & followed".
The "Box & Following" function shall be manually switched on and off.
It should be possible to manually erase each singular Box.
Missed "Box & Following" of an aircraft in my area of interest decreases my situational awareness.
A well performing "Box & Following" function would reduce my workload in workload intensive periods.
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A well performing "Box & Following" function would help me to watch continously the traffic in the vicinity of the airport.
A well performing "Box & Following" function would help me to better react in an expeditious and safe manner.
A well performing "Box & Following" function would help me to maintain/ increase my situational awareness.
Post Run Questions

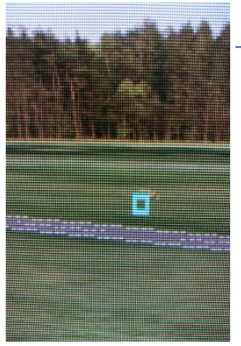
What did you like best about “Visual Tracking”?

- The ability to rather quickly handle traffic in an totally unknown environment-that proves the positive affect it has to the situational awareness
- “Unwanted” boxes simply disregard
- Easier detection and following the objects

What did you like least about “Visual Tracking”

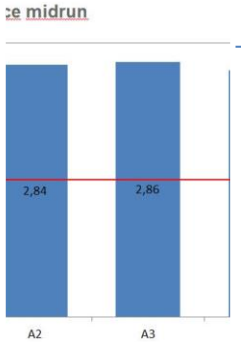
- The boxes around parked aircraft after their arrival
- Missing wanted targets
- “Unwanted” boxes that clutter the screen
- Jerk motion of the boxes

Main Results



"**Wanted**" boxes very appreciated, "**Unwanted**" did not disturb that much

Intruders much better detectable - **Safety** ⬆



Ceiling effects with WL, SA, Acceptance

Interpretation of the Main Results

Traffic scenario too easy &

Measurement tools not sensitive enough

“What the eye does not see, the heart does not grieve over”

Similarity between „Unwanted“ Boxes and „Wanted“ Boxes too small

Conclusions

- “Unwanted” Boxes disturb less than expected
- Minimum performance value for “unwanted” hard to quantify
- Visual Tracking is not a control tool – similar to non-cooperative radar information
- Increase “hit” rate from 88% close to 100% on eventual costs of more “Unwanted” Boxes

What is still to be done?

More realistic unwanted boxes

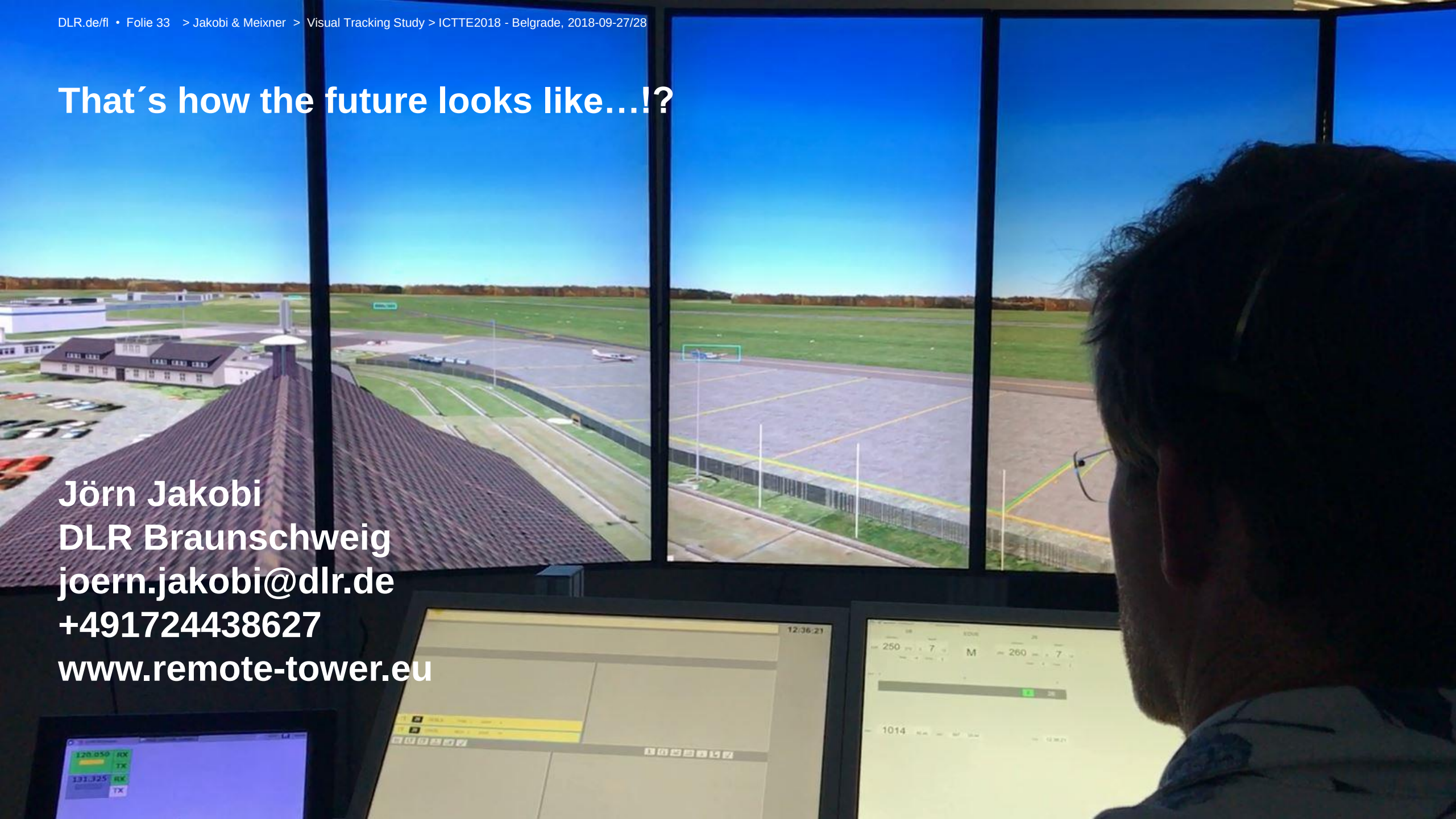
Variation of traffic mix and amount

Variation of Sensibility (Hit Rate)

Greater sample size

Standardisation

That´s how the future looks like…!?



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