Demonstration Report RTO

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Abstract

This document is the Demonstration Report for the demonstrations of DFS, LFV and LVNL Remote Tower Operations. The demonstrations EXE-0205-001, EXE-0205-002, EXE-0205-003 and EXE-0205-004 showed how Air Traffic Control Officers (ATCOs) / Aerodrome Flight Information Officers (AFISOs) observe traffic from Single as well as Multiple Remote Tower Working Positions (CWP-remote). Passive and Active Shadow Mode trials for very small to medium sized airports were conducted to cover operational, safety and regulatory aspects of the demonstrations. ATCOs / AFISOs and Airspace Users answered questions addressing operational relevant decisions and ATCOs' / AFISOs' perception.

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Executive summary

The following exercises were run as part of the demonstration activity

- EXE-0205-01 Single Remote Tower AFIS for very small airport (LFV)
- EXE-0205-02 Single Remote Tower ATS for medium size airport (DFS)
- EXE-0205-03 Single Remote Tower ATS for medium size airport (LVNL / NLR)
- EXE-0205-04 Multiple Remote Tower for small and medium size airport (LVNL / NLR)

Based on the validation results of solution #71 (Remote tower for single airport), EXE-0205-01 demonstrated a cost efficient solution for very small airports. The CWP in this downscaled format provided a working environment fully acceptable for the controllers in which to perform their work as AFISO's. The controllers also confirmed a belief that a similar downscaled CWP would work for provision of ATC with an upgrade of the camera tower and the Controller Working Position. Questionnaires and debriefs confirmed results and suggestions from WG 100 regarding standardisation.

The two exercises addressing Single Remote Tower ATS for medium size airports (EXE-0205-02 and EXE-0205-03) were designed to demonstrate solution #12 "Aerodrome Control Service for medium size airport provided from a remote location".

The exercises demonstrated in active as well as in passive shadow mode that ATS can be provided from a remote location to an aerodrome with medium traffic density with a sufficient level of safety. The ATCOs controlled simultaneous movements (frequently occurring) and did not delay any flight due to working from the RTM. Airspace Users provided feedback that the service provided from the RTM was the same as from the local tower.

Based on the validation results of solution #52 (Remote Tower for two low density aerodromes), EXE-0205-04 demonstrated the Multiple Remote Tower application for a small and medium traffic volume airport. The controllers indicated that the Multiple Remote Tower concept that was demonstrated was very mature, yet there were areas that needed further investigation during an implementation. An area that was highlighted was the area of simultaneous operations. Questionnaires and debriefs confirm this finding.

All different single remote tower solutions from very small to medium size aerodromes were successfully demonstrated with no major shortcomings. ATS can safely be provided from a remote location and capacity can be maintained. Initial CBAs have shown positive results but for each aerodrome a specific CBA considering the local factors is required being the baseline for a deployment decision.

The different solutions were all set up on the operational and technical requirements that were provided from SESAR 1 (OFA 06.03.01). These requirements were already considered in rulemaking and standardisation by EUROCAE WG 100 and EASA RMT.0624. Only minor adjustments are proposed as a result of the demonstration.
While regulation and standardisation are covered for Europe by EASA and EUROCAE, equivalent guidelines should be provided by ICAO to facilitate worldwide implementation.

To ensure that all relevant areas such as runways, taxiways, aprons and airspace (e.g. VFR patterns, relevant waypoint, entry and exit points) are visible for the controller, the position of the camera mast is crucial. Local circumstances such as runway layout and geographical orientation of the camera mast can differ for every site.

Capacity levels can remain the same working remotely. During the demonstration activities no reduction in capacity was observed.

For air traffic controllers, air traffic control assistants and flight information officers there is no change in the way they handle traffic.

During the demonstrations there was no need for additional rules and regulations. Current rules and regulations that apply for working from a conventional control tower were sufficient for working from a remote tower facility.

All safety levels were sufficient and all targeted airports could be operated as usual.

Results show that the single remote tower concept is ready for implementation for very small to medium size airports.

Further research is needed on the multiple remote tower concept for airports with more traffic. The number of airports that can be controlled simultaneously, the amount and constellation of traffic, interaction between multiple airports and the impact on controller workload, safety and human factors are topics that need to be explored further.

1 Introduction

1.1 Purpose of the document

This document provides the Demonstration report for remote tower operations related to OFA 06.03.01. It describes the results of demonstration exercises defined in the Demonstration Plan RTO (Edition 00.02.01, dated 29th April 2016) [1] and how they have been conducted.

The following exercises were run and reported by the respective partner in chapter 6:

- 6.1 Single Remote Tower AFIS for very small airport (LFV)
- 6.2 Single Remote Tower ATS for medium size airport (DFS)
- 6.3 Single Remote Tower ATS for medium size airport (LVNL / NLR)
- 6.4 Multiple Remote Tower for small and medium size airport (LVNL / NLR)

All partners contributed to the Demonstration Report.

1.2 Intended readership

The intended audience for this document are all project members. Within SESAR the other demonstration projects related to remote tower operations might be interested in this demonstration report.

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

- Appropriate National Safety Authorities (NSA);
- Affected employee unions;
- Air Navigation Service Providers (ANSP);
- Airport owners;
- Airspace users.
- Rulemaking organisations (e.g. EASA / EUROCAE)

1.3 Structure of the document

The structure of the document is as follows:

- Section 1: (this section) describes the purpose and scope of the document, the intended readership, and gives an explanation of the abbreviations and acronyms used throughout the document.
- Section 2: describes the scope of the demonstrations and a summary of the demonstration exercise.
- Section 3: provides an overview on the programme management.
- Section 4: provides an overview of preparation and execution of all demonstrations.
- Section 5: provides an overview of the demonstration results of all demonstrations.
- Section 6 describes the detailed results from the different demonstration exercises separately. It includes a detailed analysis of the results including a description of the confidence in results.
- Section 7: describes the summary of the communication activities.

1.4 Glossary of terms

Term	Definition
Active Shadow Mode	In an **Active Shadow Mode** configuration the RTM will be operated parallel to the current system and will play an active role in handling air traffic.
AFIS	**AFIS** is the Aerodrome Flight Information Service provided by an **AFISO** (Aerodrome Flight Information Service Officer).
APP	**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).
ATS	**ATS** (Air Traffic Service) is a generic term for the three services Flight Information Service (FIS), Alerting Service (ALRS) and Air Traffic Control Service (ATC). (ATC is then subdivided into the three services of TWR, APP and ACC (Area Control Service).) In this document, when the term ATS is used, it is usually referring to TWR or AFIS in the context of Single & Multiple applications, however referring to TWR only in the context of Contingency applications.
CWP	**CWP** (Controller Working Position) is the operator (ATCO/AFISO) work station including necessary ATS systems.
D1-4	Daily debriefing forms, day 1 to day 4
DF	Debriefing form final
ETQ	End of trial questionnaire
Live Trials	Live trials are run in an operational environment with the live traffic and systems connected to live operational data. Live trials can either be run in passive as well as in active shadow mode.
OTW	In a RTC the **Out The Window** (OTW) view is video-sensor based.
Passive shadow mode	In a **Passive Shadow Mode** configuration the RTM will not interfere and will not play an active part in handling air traffic.
Remote Tower	**Remote Tower** is where ATS are remotely provided through the use of direct visual capture and visual reproduction e.g. through the use of cameras.
Remote Tower Centre	A **Remote Tower Centre** (RTC) is a building where ATS are performed to more than one aerodrome. It usually includes several RTMs (or only one, if that single RTM enables ATS to more than one aerodrome).
Remote Tower Module	**Remote Tower Module** (RTM) is the term for the complete module including both the CWP(s) and the Visual Reproduction display screens.
SASHA	Situational awareness for SHAPE questionnaire
SATI	SHAPE automation trust index
TFQ	Traffic scenario log

Term	Definition
TWR	Aerodrome Control Service (**TWR**) is the air traffic control (ATC) service provided by the Air Traffic Control Officer (**ATCO**) for an aerodrome.
Visual Reproduction	**Visual Reproduction** is the term for the collected aerodrome sensor data (from cameras and/or other sensors) and presented to the ATCO/AFISO in order to provide situational awareness.

1.5 Acronyms and Terminology

Term	Definition
AFISO	**Aerodrome Flight Information Service Officer**
AMAN	**Arrival Manager**
ANSP	**Air Navigation Service Provider**
ASD	**Air Situation Display**
ASM	**Active Shadow Mode**
ATC	**Air Traffic Control**
ATCA	**Air Traffic Control Assistant**
ATCO	**Air Traffic Controller**
ATM	**Air Traffic Management**
ATS	**Air Traffic Services**
ATSEP	**Air Traffic Safety Engineering Personal**
AU	**Airspace Users**
CNS	**Communication Navigation and Surveillance**
CTR	**Control Zone**
CWP	**Controller Working Position**
DFS	**Deutsche Flugsicherung GmbH**
DMAN	**Departure Manager**
DOD	**Detailed Operational Description**
EASA	**European Aviation Safety Agency**
EUROCAE	**European Organisation for Civil Aviation Equipment**

Term	Definition
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
FDPS	Flight Data Processing System
IFR	Instrument Flight Rules
KLS	KLM Flight Academy
KPA	Key Performance Area
LFV	Luftfartsverket
LFT	Lufthansa Flight Training
LVNL	Air Traffic Control the Netherlands
NLR	Netherlands Aerospace Centre
NSA	National Supervisory Authority
OFA	Operational Focus Area
OTW-View	Out The Window View (Visual Reproduction)
PSM	Passive Shadow Mode
PTZ-Camera	Pan-Tilt-Zoom Camera
RTC	Remote Tower Centre
RTS	Real-Time Simulation
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SHAPE	Solutions for Human Automation Partnership in European ATM
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency
STO	Simulator Training Officer
Term	Definition
TIZ	Traffic Information Zone
TWR	Tower

Term	Definition
UDP	**Uniform Daylight Period**
VFR	**Visual Flight Rules**
WTP	**Weather and Traffic Permitting**
WP	**Work Package**

2 Context of the Demonstrations

2.1 Scope of the demonstration and complementarity with the SESAR Programme

Demonstration Exercise ID and Title	EXE-0205-01: Single Remote Tower - AFIS very small Airport
Leading organization	LFV
Demonstration exercise objectives	OBJ-0205-100 Demonstrate that remote AFIS can be provided to a very small size airport in an operational environment with a basic set up of equipment at the airport. OBJ-0205-500 Demonstrate the possibility to develop a basic camera tower for very low density airports. OBJ-0205-600 Provide feedback from different remote tower applications regarding standardization and regulation OBJ-0205-700 Provide feedback from different remote tower applications regarding safety
OFA addressed	OFA 06.03.01 Remote Tower.
Applicable Operational Context	AFIS provided at the aerodrome and its surrounding (TIZ).
Demonstration Technique	Passive Shadow Mode
Number of trials	As the demonstration was a shadow mode trial the number of flights emerged in the course of the demonstration depending on the regular traffic those days summing up to 103 flights during the 16 runs of the demonstration.

Table 1: Exercises overview – EXE-0205-01

Demonstration Exercise ID and Title	EXE-0205-02: Single Remote Tower - ATS for medium Airport
Leading organization	DFS
Demonstration exercise objectives	OBJ-0205-200 Demonstrate that remote ATS can be provided to a medium size airport in an operational and technical environment. OBJ-0205-600

	Provide feedback from different remote tower applications regarding standardization and regulation OBJ-0205-700 Provide feedback from different remote tower applications regarding safety
OFA addressed	OFA 06.03.01 Remote Tower.
Applicable Operational Context	Air Traffic Service provided at the aerodrome and its surrounding (CTR)
Demonstration Technique	Active and Passive Shadow Mode
Number of trials	As the demonstration was a shadow mode trial the number of flights emerged in the course of the demonstration depending on the regular traffic those days summing up to 419 movements during the 9 days of the demonstration. In addition to the regular traffic (scheduled and non-scheduled), Lufthansa Flight Training conducted an agreed flight programme summing up to 239 movements.

Table 2: Exercises overview – EXE-0205-02

Demonstration Exercise ID and Title	**EXE-0205-003: Single Remote Tower - ATS for medium Airport**
Leading organization	LVNL
Demonstration exercise objectives	OBJ-0205-300 Demonstrate that remote ATS can be provided to a medium size airport in an operational and technical environment. OBJ-0205-600 Provide feedback from different remote tower applications regarding standardization and regulation OBJ-0205-700 Provide feedback from different remote tower applications regarding safety
OFA addressed	OFA 06.03.01 Remote Tower.
Applicable Operational Context	Air Traffic Service provided at the aerodrome and its surrounding (CTR)
Demonstration Technique	Active and Passive Shadow Mode
Number of trials	As the demonstration was a shadow mode trial the number of flights emerged in the course of the demonstration depending on the regular traffic those days. The total number of flights summed up to 38 flights during the two runs carried out during the live trial.

Table 3: Exercises overview – EXE-0205-03

Demonstration Exercise ID and Title	EXE-0205-004: Multiple Remote Tower - ATS to small and medium Airport
Leading organization	LVNL
Demonstration exercise objectives	OBJ-0205-400 Demonstrate that remote ATS can be provided to a medium size airport in an operational and technical environment and a small size airport simultaneously in a simulated environment OBJ-0205-600 Provide feedback from different remote tower applications regarding standardization and regulationOBJ-0205-700 Provide feedback from different remote tower applications regarding safety
OFA addressed	OFA 06.03.01 Remote Tower.
Applicable Operational Context	Air Traffic Service provided at the aerodrome and its surrounding (CTR) at two airports simultaneously.
Demonstration Technique	Active and Passive Shadow Mode
Number of trials	As the demonstration was a shadow mode trial the number of flights emerged in the course of the demonstration, depending on the regular traffic those days. The total number of flights summed up to 38 flights during the live trial. The number of (simulated) flights on the second (small-size) airport amounted to three flights.

Table 4: Exercises overview – EXE-0205-04

3 Programme management

3.1 Organisation

The consortium consists of three ANSP's, two airspace users and one non-profit technological research institute. The consortium made use of two subcontractors. See Figure 1 below.

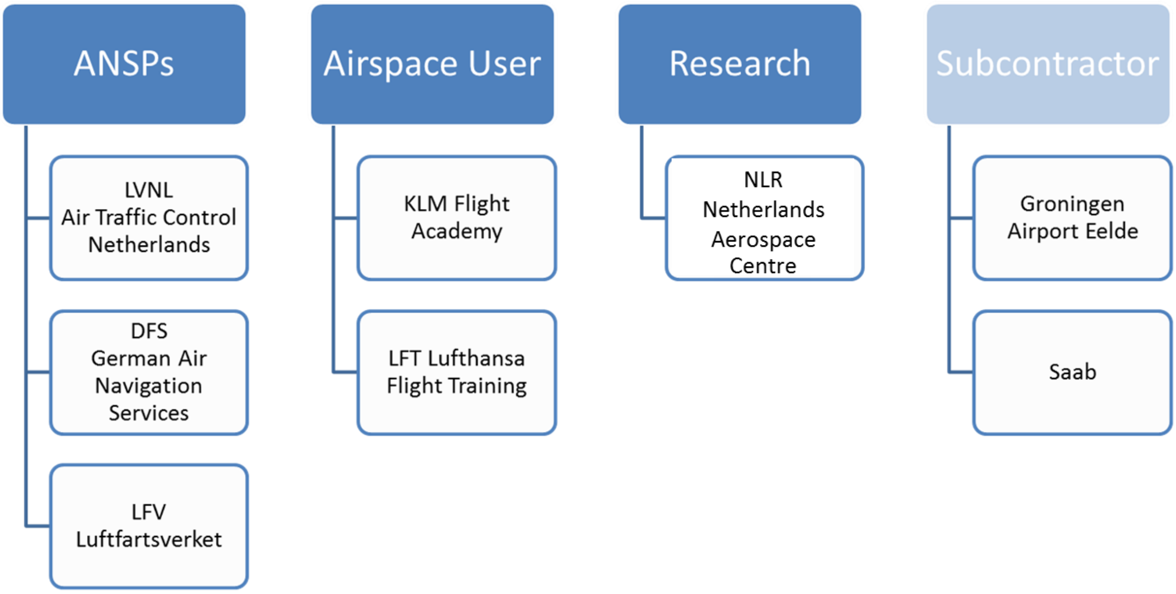


Figure 1: Consortium members and subcontractors

LVNL as the consortium leader provided an overall project coordinator (Global Project Manager), whose task is to ensure – together with the project leaders of the individual organisations – the planning, execution, reporting and communication of the project. The coordinator acted as the direct interface to / the point of contact for SJU. The coordinator was supported by an administrative and contractual coordinator and a quality manager.

Each of the consortium members was represented by a local project manager with responsibility for the contribution of his/her organisation/unit and the internal organisation, coordination, communication and reporting of the project.

The project was divided into several Work Packages (see chapter 3.2), each consisting of a coherent set of tasks and activities. Each WP was managed by a WP-leader, who was responsible for technical part of the work in that WP. As such, the tasks of each WP-leader comprised:

- Management of activities within the WP;
- Planning of the work within the WP;
- Coordination of the work in the WP;
- Coordination and safeguarding consistency with the other WPs.

The work done by the project itself was mainly be performed by experts committed by the line organisations from project partners.

3.2 Work Breakdown Structure

The figure below gives a schematic overview of the Work Breakdown Structure for the demonstration project.

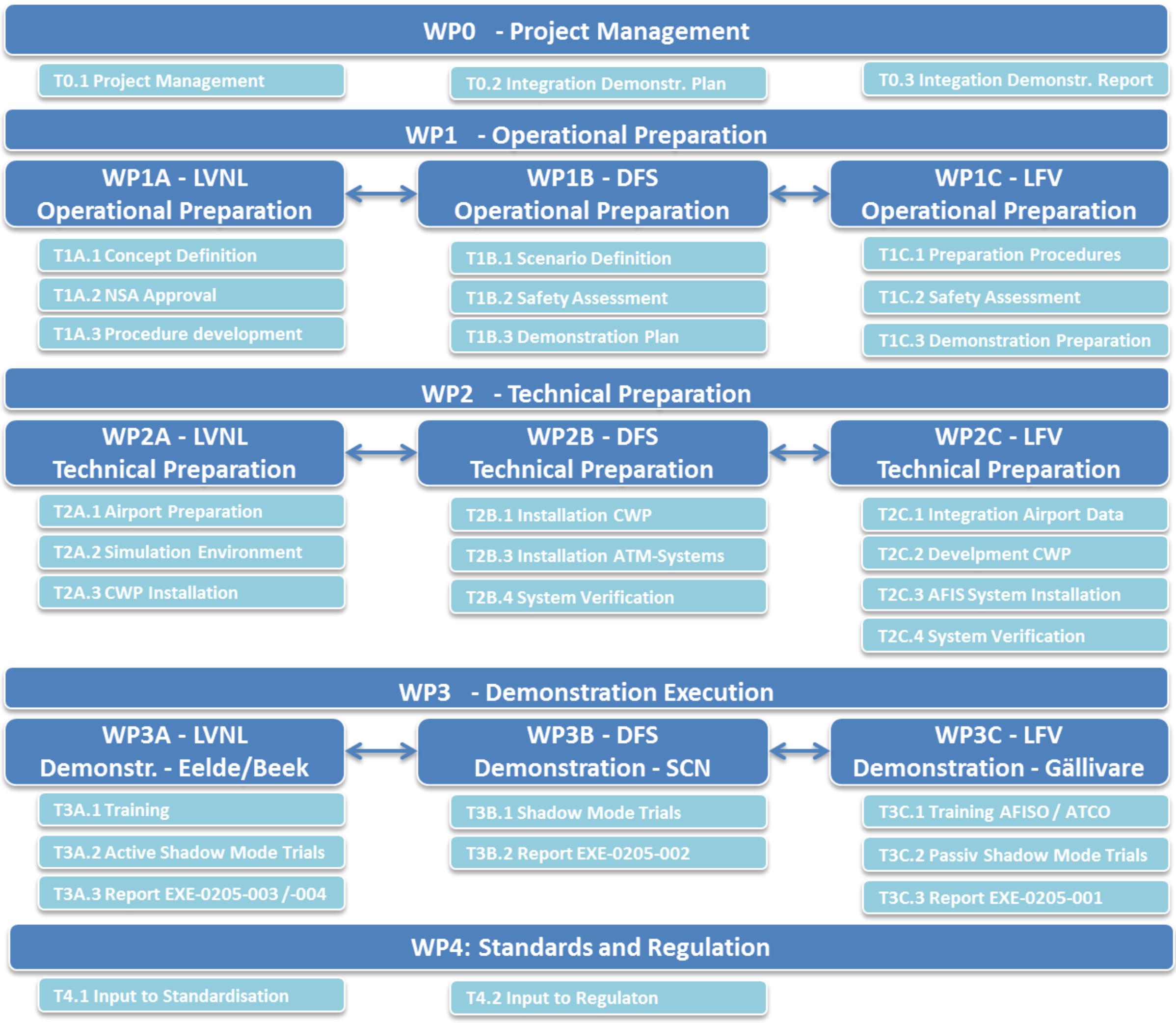


Figure 2: Work Breakdown Structure

The figure above clearly shows the parallel approach to this demonstration project: in Work Packages 1 through 3 each party was responsible for the preparation and execution of its own demonstration project. However, there was a close coordination between the Sub-Work Packages of WP1, WP2 and WP3. The Work Packages 0 and 4 were combined work packages jointly performed by all parties involved.

3.3 Deliverables

The project provides the following two major deliverables:

- Demonstration Plan RTO (Edition 00.02.01, dated 29th April 2016) [1]
- Demonstration Report RTO (this document).

3.4 Risk Management

Although the main goal of the RTO project was to gain valuable experiences, the timely delivery of the project report to SJU was crucial, because of the closure of the SESAR-1 programme and the associated funding.

At the project start the following two major risks were identified:

- Availability of NSA acceptance/approval;
- Availability of ATCO for the demonstration.

All the risks were at the project start were identified and mitigating actions defined. The risks were managed using the SESAR extranet.

4 Execution of Demonstration Exercises

4.1 Exercises Preparation

The demonstrations are aimed at proving that ATS can be provided from a remote location to small and medium sized airfields, both single and simultaneously handled airfields.

For this Demonstration Project four main Exercises were defined, divided between Sweden, Germany and the Netherlands, who have two exercises. Multiple demonstration sites with different airspace users and varying local procedures made it possible to conduct more exercises with different scenarios.

The preparation of each demonstration exercise was as detailed in the corresponding Demonstration Plan.

In preparation of the demonstration activities the RTMs were set up at the demonstration sites. At all sites the ATS-Systems were installed and complemented with the visual reproduction. The visual reproduction was provided by SAAB for the LFV and LVNL demonstrations and by Frequentis for the DFS demonstration.

System verification was done at the demonstration site in order to ensure proper system functionalities with a focus on the visual reproduction and the associated network being the new elements in the Controller working position.

The required safety assessments were developed. While the focus was on the safety assessment for the camera mast for the LFV demonstration, safety assessment from LVNL and DFS focussed on the needs for the application for NSA acceptance for the demonstration.

The flight programmes as well as the ATCO and pilot questionnaires were prepared considering the need for the required indicators (e.g. safety, human performance, acceptance, usability and utility). The measurements of the capacity during the demonstrations were ensured.

The requirements on ATCOs for the demonstrations were defined (ATCOs working in the local tower with permission to coach a trainee and ATCOs with the required licences for the selected airports) and the training scheduled.

4.2 Exercises Execution

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-0205-001	Single Remote Tower - AFIS very small Airport	2015-10-05	2015-10-22	2015-11-04	2016-10-07
EXE-0205-002	Single Remote Tower - ATS for medium Airport	2016-08-16	2016-08-26	2016-08-22	2016-10-07
EXE-0205-003	Single Remote Tower - ATS for medium Airport	2016-09-08	2016-10-04	2016-09-09	2016-10-07
EXE-0205-004	Multiple Remote Tower - ATS to small and medium Airport	2016-09-08	2016-10-04	2016-09-09	2016-10-07

Table 5: Exercises execution/analysis dates

The demonstration approach is described in the following sections.

EXE-0205-001 - **Single Remote Tower Operations - Sweden (AFIS to very Small Airport)**

LFV provided a demonstration in the established RTC at Sundsvall Midlanda Airport where the airport of Örnsköldsvik is set up as remotely controlled single airport. Sundsvall is the second airport to be implemented. The centre had a possibility to establish and demonstrate the CWP aimed for this demonstration

The demonstration showed the possibility to establish and provide a low cost remote solution for AFIS as goal with the same service provided as normal operations for airports in remote regions with a very low density of traffic. The development showed a possibility for these airports to gain features and development that is normally too expensive for investment with that amount of traffic.

Due to the daily traffic at Gällivare the trials took place in morning hours or in the afternoons to gain information from the turnaround flights. This also made it possible to look into different types of operations regarding daylight.

The staff working, during the trials, consisted of ATCOs with a varied experience of ATS in LFV, e.g. experience from AFIS, RTC, ACC, smaller and larger towers. This set-up provided a wide base for feedback to the system and platform developed for this trial

EXE-0205-002 **Single Remote Tower Operations - Germany (ATS to Medium Airport)**

The demonstration took place at the Remote Tower Module in Saarbrücken from where the airport of Saarbrücken was remotely controlled. The Demonstration showed a remotely operated tower in active and passive shadow mode.

In order to be able to demonstrate all required procedures a flight programme was agreed on with Lufthansa Flight Training covering a comprehensive number of scenarios. The scenarios involved IFR as well as VFR flights using different procedures (also including touch and go as well as go-around). The demonstrations covered day operations. Simultaneous movements frequently occurred during the demonstration.

The technical system covered systems used in the local environment today. This reached from radar display and electronic flight strips and communications systems for ground-ground and air-ground communications. Furthermore ATIS was provided.

The operational experts involved in the exercises (pilots from Lufthansa Flight Training as well as ATCOs) provided their feedback on the demonstrations.

EXE-0205-003 and EXE-0205-004 **Multiple Remote Tower Operations - (ATS to Small and Medium Airport)**

The LVNL demonstrations were executed in three main steps. The first step was divided into three sequential phases where both Groningen Airport Eelde and Beek Airport were simulated. This was to get the ATCOs and ATCAs familiarized with the remote tower concept and to build up confidence with the new CWP, to test if the procedure design was complete and as part of the safety case towards the NSA. The final two steps proved that ATS can be provided to one airport in an active shadow mode configuration (EXE-0205-003) and after that to two airports simultaneously in an active shadow mode configuration/ simulation configuration (EXE-0205-004).

The demonstrations took place in the Remote Tower Centre at LVNL headquarters at Schiphol.

The medium sized airport was Groningen Airport Eelde (‘Eelde Airport’) which is located in the northern part of the Netherlands.

During the live demonstrations Tower Controllers at Eelde Airport were present only for backup purposes. From the Remote Tower Facility all flight related information were remotely provided, e.g. ground-ground and air-ground communications, strip handling, the use of a radar display and intercom with the approach unit at Groningen Airport Eelde.

The live trial flights at Eelde consisted of a wide variety of flights, including helicopters, commercial scheduled flights, visiting flight schools and flights carried out by KLM Flight Academy. During the demonstrations all aspects of flight (e.g. various traffic patterns, instrument approaches, touch and go's, mix of VFR and IFR traffic) were covered.

The small size airport was Maastricht Aachen Airport ('Beek Airport') which is located in the southern part of The Netherlands.

Beek was simulated with NLR's NARSIM Tower facility which fed the required information into the RTM. Although Beek is considered a medium size airport, for the purpose of the demonstration the amount of (simulated) traffic at this airport was reduced in order to include Beek in the trials as a small size airport.

The operational experts involved in the exercises (pilots, ATCOs and ATCAs) provided their feedback on the demonstrations.

4.3 Deviations from the planned activities

4.3.1 Deviation from planned activity LFV – EXE-0205-001

With reference to demonstration scenario in the Demonstration Plan RTO

Identifier	SCN-0205-002
Title	Ground movements
Scenario	Ground movements of cooperative and non-co-operative objects on all relevant surface movement areas will be considered.

Monitoring of ground movements was partly affected. This in itself didn't provide any hazards since passive shadow mode was executed. However it did deviate from the intentions of the demonstration.

Further details are described in chapter 6.

4.3.2 Deviation from planned activity DFS – EXE-0205-002

The demonstration was run as planned in the updated demonstration plan with no deviations.

4.3.3 Deviation from planned activity LVNL – EXE-0205-003

Prior to the live trials, passive shadow-mode trials were added as extra compared to the Demonstration Plan. They were carried out for familiarisation of controllers and to assess visibility of aircraft flying in various VFR patterns in the outside view.

4.3.4 Deviation from planned activity LVNL – EXE-0205-004

The demonstration was run as planned in the updated Demonstration Plan with no deviations.

5 Exercises Results

5.1 Summary of Exercises Results

In this chapter the results of the different Demonstration Exercises are summarised. The table below shows the summary of results compared to the success criteria identified within the Demonstration Plan per demonstration objective.

This chapter is the synthesis of the demonstration results, whereas chapter 6 provides the detailed results per exercise.

Exercise ID	Demonstration Objective Title	Objective ID	Success Criterion	Exercise Results	Objective Status
0205-001	Demonstrate that remote AFIS can be provided to a very small size airport in a full operational environment with a basic set up of equipment at the airport.	0205-100	The AFISO or ATCO agrees that a sufficient level of service is provided from the CWP during the trial	The low three level objectives were evaluated: - OBJ-0205-111 o CRT-0205-1111 - OK o CRT-0205-1112 – OK o CRT-0205-1113 – OK - OBJ-0205-112 o CRT-0205-1121 – OK o CRT-0205-1122 – OK	OK
	Demonstrate the possibility to develop a basic camera tower for very low density airports.	0205-500	The camera tower provides a proper view for the AFISO or the ATCO to provide the requested level of service at the airport	The low three level objectives were evaluated: - OBJ-0205-511 o CRT-0205-5111 - OK o CRT-0205-5112 – OK o CRT-0205-5113 – OK - OBJ-0205-512 o CRT-0205-5121 – OK o CRT-0205-5122 – OK	OK
	Provide feedback from different remote tower applications regarding standardization and regulation	0205-600	Different technical solutions for Remote Tower Operations are compared and the necessary	EASA guidelines are available and sufficient.	OK

Exercise ID	Demonstration Objective Title	Objective ID	Success Criterion	Exercise Results	Objective Status
			common parts to be considered in standardisation are identified.		
	Provide feedback from different remote tower applications regarding safety	0205-700	Safety Assessment will be conducted according to local methodology.	The safety assessment has to comply to the local safety management system.	OK

0205-002	Demonstrate that remote ATS can be provided to a medium sized airport in an operational and technical environment.	0205-200	The ATCO operates from the RTM with a sufficient level of capacity.	The low three level objectives were evaluated:
				- OBJ-0205-221
				  o CRT-0205-2211 - OK
				  o CRT-0205-2212 - OK
				- OBJ-0205-222
				  o CRT-0205-2221 - OK
				- OBJ-0205-223
				  o CRT-0205-2231 - OK
				  o CRT-0205-2232 – OK
					OK

	Provide feedback from different remote tower applications regarding standardization and regulation	0205-600	Different technical solutions for Remote Tower Operations are compared and the necessary common parts to be considered in standardisation are identified.	EASA guidelines are available and only minor updates for medium size aerodromes are proposed.	OK
	Provide feedback from different remote tower applications regarding safety	0205-700	Safety Assessment will be conducted according to local methodology.	The safety assessment was conducted according to local methodology for the active shadow mode demonstration.	OK

0205-003	Demonstrate that remote ATS can be provided to a medium sized airport in an operational and technical environment.	0205-300	The ATCO operates from the RTM with a sufficient level of capacity.	The two low-level objectives were evaluated:
				- OBJ-0205-333
				  o CRT-0205-3331 - OK
				  o CRT-0205-3332 - OK
				- OBJ-0205-334
					OK

Exercise ID	Demonstration Objective Title	Objective ID	Success Criterion	Exercise Results	Objective Status
				○ CRT-0205-3341 – OK ○ CRT-0205-3342 - OK	
	Provide feedback from different remote tower applications regarding standardization and regulation	0205-600	Different technical solutions for Remote Tower Operations are compared and the necessary common parts to be considered in standardisation are identified.	EASA guidelines are available and sufficient.	OK
	Provide feedback from different remote tower applications regarding safety	0205-700	Safety Assessment will be conducted according to local methodology.	The safety assessment has to comply to the local safety management system.	OK
0205-004	Demonstrate that remote ATS can be provided to a medium sized airport in a full operational and technical environment and a small size airport simultaneously in a simulated environment.	0205-400	The ATCO agrees that service can be provided to both airports at the same time with sufficient level of capacity.	The low-level objectives were evaluated: - OBJ-0205-431 ○ CRT-0205-4311 - OK ○ CRT-0205-4312 – OK ○ CRT-0205-4313 - OK	OK
	Provide feedback from different remote tower applications regarding standardization and regulation	0205-600	Different technical solutions for Remote Tower Operations are compared and the necessary common parts to be considered in standardisation are identified.	EASA guidelines are available and sufficient.	OK
	Provide feedback from different remote tower applications regarding safety	0205-700	Safety Assessment will be conducted according to local methodology.	The safety assessment has to comply with the local safety management system.	OK

Table 6: Summary of Demonstration Exercises Results

5.2 Choice of metrics and indicators

In Table 7 the demonstration objectives with the associated KPAs that were addressed in the demonstrations are listed.

The focus of the exercises is on demonstrating that the required capacity can be provided (one demonstration objective was defined per exercise). Capacity was measured in terms of aircraft movements. Along with the aircraft movements the demonstrations provided feedback of ATCOs on Safety under the given scenarios.

In addition to the Capacity, the exercises provided feedback on safety (one common objective was defined for all demonstrations). While the measure for this was mainly provided by the safety assessments that were provided in preparation of the demonstrations, some exercises also looked into safety during the demonstrations using ATCO feedback (see chapter 6 on detailed exercise results for EXE-0205-003 and EXE-2005-004).

Objective ID	KPA	Success Criterion / Expected Benefit	Result of the demonstration
OBJ-0205-700	Safety	Safety remains at sufficient level	Results says that safety is maintained for very small to medium size aerodromes
OBJ-0205-100	Capacity	There shall be no impact on airport capacity when remotely providing ATS to one aerodrome	Movements were measured and there was no impact on traffic levels for very low density aerodromes
OBJ-0205-200	Capacity	There shall be no impact on airport capacity when remotely providing ATS to one aerodrome	Movements were measured and there was no impact on traffic levels for medium size aerodromes
OBJ-0205-300	Capacity	There shall be no impact on airport capacity when remotely providing ATS to one aerodrome	Movements were measured and there was no impact on traffic levels for medium size aerodromes
OBJ-0205-400	Capacity	There shall be no impact on airport capacity when remotely providing ATS to two aerodromes	Movements were measured and there was no impact on traffic levels for a small and medium size aerodrome

Table 7: Summary of metrics and indicators

5.3 Summary of Assumptions

No assumptions have been identified in the demonstration plan and also during the exercises no assumptions have been identified. Therefore this chapter is N/A.

5.3.1 Results per KPA

An overview of the results per KPA (Capacity, Safety, Cost-Efficiency) are given in the subchapters below.

5.3.1.1 Safety

Exercise	Object Identifier	Success Criterion	Result of the demonstration
EXE-205-001 EXE-205-002 EXE-205-003 EXE-205-004	OBJ-0205-700	Safety remains at sufficient level	Results says that safety is maintained

5.3.1.2 Capacity

Exercise	Object Identifier	Success Criterion	Result of the demonstration
EXE-205-001	OBJ-0205-100	There shall be no impact on airport capacity when remotely providing ATS to one aerodrome	Movements were measured and there was no impact on traffic levels for very low density aerodromes
EXE-205-002	OBJ-0205-200	There shall be no impact on airport capacity when remotely providing ATS to one aerodrome	Movements were measured and there was no impact on traffic levels for medium size aerodromes
EXE-205-003	OBJ-0205-300	There shall be no impact on airport capacity when remotely providing ATS to one aerodrome	Movements were measured and there was no impact on traffic levels for medium size aerodromes
EXE-205-004	OBJ-0205-400	There shall be no impact on airport capacity when remotely providing ATS to two aerodromes	Movements were measured and there was no impact on traffic levels for a small and medium size aerodrome

5.3.1.3 Cost-Efficiency

While the main driver for the remote tower concept is an expected increase in cost-efficiency, it cannot be measured in a demonstration as it is an effect of scaling (mostly improved rostering of staff). In order to provide an order of magnitude, an internal assessment was made by the ANSPs involved in the project which is given below.

As implementation cost may significantly vary for different aerodromes having different baselines and specific requirements, a range for implementation cost was estimated by LVNL, LFV and DFS. The cost considers all cost that is necessary for adding a new airport in a Remote Tower Centre and includes the cost share for setting up the Remote Tower Centre as well as the cost for the Remote Tower Module (including the CWP). The cost does not consider the development cost for the initial implementation (which is much higher). It does not include the cost for running the Remote Tower (e.g. cost for maintenance or data transmission), which in earlier CBAs has shown to reduce cost.

The increase in cost efficiency is estimated by the reduction in ATCO staff. The range also depends on the specific local implementation and the baseline conditions as well as multiple ratings.

Investments cost for remote tower positions:

4 – 11 M€ for a centre with one remote tower position. This includes airport infrastructure and installation. Following remote tower modules will cost less.

The CBA calculations on a basic solution for AFIS show that costs can be reduced to 2 M€ per remote tower position installed in an existing remote tower centre.

Note: The figures estimated for implementation cost and reduction in staff cost are not necessarily correlating, i.e. it is not true that higher implementing cost will lead to higher reduction in staff cost.

Reduction of number of ATCO (Single Remote) by more efficient rostering can be between 10% - 25% if remote ATS is provided from a Remote Tower Center. It is expected to foresee further costs savings with a multiple remote tower system. Depending on the local implementation, having just a few aerodromes in the RTC (less than 6) might make savings more insecure due to needed back-up capacity or unexpected events. Remote Tower Facilities/Centres will significantly reduce the requirement to operate and maintain actual control tower buildings and infrastructure, leading to further cost savings (not considered here).

A possibility to standardise implementation and approval processes would have a positive impact on the cost break down period, as the implementation and approval process are in the CBA calculation. The entire industry is new and future development suggests that even more cost efficient solutions will be feasible in the future.

Note:

Figures in CBA calculations are struggling with uncertainty due to a number of variables such as deployment sites, NSA approval and lack of data of running cost for local towers.

NSA approval processes can be costly and time consuming. This can impact investment costs and the payback period for a new cheaper solution, such as the one in EXE.02.05-001.

5.3.2 Impact on Safety, Capacity and Human Factors

The impact on safety, capacity is given in the chapter above (5.3.1). Human Factor is part of the Safety assessment.

5.3.3 Description of assessment methodology

Subjective measurements from the participating controllers in the form of pre-experiment, post-experiment and debriefing questionnaires were obtained.

The pre-experiment questionnaires focused on personal data, as well as controller experience, and roles and tasks during their time of duty. Questions also concerned earlier simulation or trial experience and the general opinion on the objectives of this demonstration activity.

5.3.4 Results impacting regulation and standardisation initiatives

All demonstrations:

The system used in the demonstration was based on the operational and technical requirements that were produced within OFA 04.01.01. These requirements were already considered by EUROCAE WG 100 for standardisation and EASA RMT.0624 for regulation.

With respect to EASA Decision 2015/14 and the respective EASA Explanatory note to Decision 2015/014/R the following comments can be provided:

- **Approach to Regulatory Level**
  In line with EASA Decision, no need is seen for AMC or Implementing Rule for Remote Tower as existing rules are sufficient. The provision of EASA Guidance Material is welcomed as it supports implementation of remote tower but at the same time avoids overregulating.
  A unit endorsement for remote tower operations offers the required flexibility to ANSPs and ATCOs and is in line with the 'European Manual of Personnel Licensing for Air Traffic Controllers' which states: 'Unit endorsements may also indicate the specific types of surveillance equipment used by the Unit in the provision of air traffic control services on specific sectors, groups of sectors or operational positions.'

- **Basic Equipage and Enhanced Equipage**
  During the demonstrations object bounding and automated PTZ-Tracking where used which are considered enhanced equipage. These functionalities were well received by the ATCOs.

- **Level of Safety in comparison to conventional operations**
  An adequate Safety level of remote tower operations must be proven with the applicable local safety assessment methodology.

- **Impact on airspace users**
  Feedback from pilots indicated that there is no impact on airspace users when ATS is remotely provided.

Regarding ratings, endorsements and licensing, no new results have been identified compared to what is already described in the OSED:

"*A potential suggestion for the way forward regarding the licensing of remote tower ATCOs is that they shall hold an ADI rating with appropriate endorsements (i.e. radar, etc.) and additionally hold an RTC unit endorsement, complemented with specific local endorsements for the appropriate aerodromes that the skills will be applied to. It is however suggested, as part of safety assessments performed, that endorsement training shall be complemented by (or put extra emphasis on) local airport knowledge and conditions (such as local geography, local weather conditions, typical traffic type and mix etc.) in order to compensate for being placed remote. Note: the different aerodromes in an RTC should be treated similarly to the sectors in an ACC, from a licensing point of view.*

Cross licensing enables ATCOs to provide ATS to various aerodromes. Hence flexible staffing may be achieved and thus costs may be reduced as ATCOs are not bound to one aerodrome."

Single Remote - very small aerodromes:

Results from EXE-0205-001 show no changes from Demonstration Report RTO, D94 from P.06.08.04 and P.06.09.03.

These inputs have been used as baseline for EXE-0205-001 and are consistent with suggested standardisations in WG 100.

Single Remote - medium size aerodromes:

Based on the demonstration results the following operational requirement has to be formulated as 'should' requirements for medium size aerodromes compared to a 'may' requirements for small size aerodromes:

Identifier	REQ-06.09.03-OSED-VA03.1401
Requirement	The visual presentation ***may*** (***should*** for medium size aerodromes) incorporate overlaid information associated with a specific element or target in the visual field, aiding or facilitating detection, recognition, identification and ranging of objects relevant for the service provision - in order to increase ATCO/AFISO heads up time.

All demonstrations support the change of the requirements made in the last update of the OSED. The requirements should be considered in standardisation and regulation.

Identifier	REQ-06.09.03-OSED-VQ03.1201
Requirement	During CAVOK conditions, the ATCO/AFISO ***shall*** be able to visually **detect** an aircraft of type A320, ATR72 or similar size on 2NM final, by using the visual presentation (excluding the binocular functionality).

Identifier	REQ-06.09.03-OSED-VQ03.1220
Requirement	During CAVOK conditions, the ATCO/AFISO ***should*** be able to visually **detect** an aircraft of type A320, ATR72 or similar size on 4NM final, by using the visual presentation (excluding the binocular functionality).

The overlaid information has been highly rated during several trials and could just as well be considered for a conventional tower to enhance operator's possibility to detect objects or increase possibility for time spent looking out. All advanced features are dependent on the image quality.

Results show that ATCO's are able to limit traffic according to available tools and features in combination with image reproduced on the OTW view.

5.4 Analysis of Exercises Results

In the context of the demonstration execution no dedicated reference and solution scenarios were run. The demonstrations were based on live traffic. As the capacity was one major KPA in the demonstrations, the table below provides the average movements per hour that was measured during the demonstrations. The performance indicators which are related to safety/human performance were addressed in the questionnaires but were not measured in the demonstration as objective values. The respective results are described in the text in following sections but are therefore not listed in the table.

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPI ID	Measure Value
EXE-205-001	OBJ-0205-100	SCN-0205-003	Flights approaching to or departing	Annual Movements for targeted airports	Number of movements not affected
EXE-205-002	OBJ-0205-200	SCN-0205-003	Flights approaching to or departing	Annual Movements for targeted airports	Number of movements not affected
EXE-205-003	OBJ-0205-300	SCN-0205-003	Flights approaching to or departing	Annual Movements for targeted airports	Number of movements not affected
EXE-205-004	OBJ-0205-400	SCN-0205-003	Flights approaching to or departing	Annual Movements for targeted airports	Number of movements not affected

Table 8: Performance Indicators

5.4.1 Unexpected Behaviours/Results

There were no unexpected behaviours or results.

5.5 Confidence in Results of Demonstration Exercises

5.5.1 Quality of Demonstration Exercises Results

The quality of the demonstration results is considered as very high due to the following aspects:

- The exercise results are based on measured traffic volumes;
- A high number of ATCOs provided feedback that was collected by means of questionnaires and debriefs;
- Some of the ATCOs had experience from previous single remote tower trials
- The ATCOs were chosen holding an active licence for the demonstration aerodromes as well as others that could provide feedback on the potential transfer to other aerodromes that are also targeted The ATCOs participating in the demonstrations have experience from AFIS, RTC, ACC, smaller and larger towers;
- Airspace users provided a flight programme allowing the ATCOs to evaluate a wide spectrum of procedures;
- Normal, abnormal and degraded modes were considered.
- Eurocontrol's standardised indicators SASHA and SATI were used during the trials.

5.5.2 Significance of Demonstration Exercises Results

The operational significance of the demonstration results can be considered as very high since the demonstration took place in an operational environment (either in active or passive shadow mode). This implied the following items:

- Traffic volumes were representative for the targeted very small to medium sized aerodromes comprising of VFR and IFR traffic;
- ATCOs actively provided ATS from the remote working position (which was based on a mix of operational and pre-operational systems);
- The demonstration was run over a couple of weeks at different locations, Sweden, Netherlands and Germany.
- The demonstrations consisted of more than just the trials as there were simulations, training and passive shadow mode trials prior to the execution. EXE.02.05-001 also made a comparison with the already implemented system in Sundsvall.

5.5.3 Conclusions and recommendations

5.5.3.1 Single remote - very small aerodromes

EXE-02.05-01 successfully demonstrated a feasible and cost efficient solution for very small airports with AFIS as Air Navigation Service in focus, addressing solution #71 (Remote Tower for single airport). The solution was built on the already existing implemented single remote tower system in Sweden, in this case with a simplified camera tower and CWP. Still with the same clear picture and high resolution as well as frame rate update. Results based on operators feedback and debriefs clearly state and confirm that a cost efficient solution would be sufficient from which to execute AFIS.

It has been proven within EXE.02.05.-001 that Remote Tower Services can be provided over a distance of 700 km between the airport and the RTC which enables efficient RTC geographical planning.

The tested low cost AFIS solution needs to be compared with usage of a more advanced system suitable for both ATC and AFIS. It can cost more but be operationally flexible as one of the challenges is to receive NSA approval for any new system.

Note: To meet future requests from airports, airspace users and ANSPs concerning needs for ATC as service the recommendation is to use a system that is possible to scale and update. Main difference between AFIS and ATC are the rules for separation.

5.5.3.2 Single remote – medium size aerodromes

The two exercises addressing Single Remote Tower ATS for medium size airports (EXE-0205-02 and EXE-0205-03) were designed to demonstrate solution #12 "Aerodrome Control Service for medium size airport provided from a remote location".

Remote tower operations to medium size aerodromes were demonstrated by DFS at Saarbrücken Airport and by LVNL for Eelde Airport in active as well as in passive shadow mode based on the same procedures as they are used in the conventional tower. ATS can safely be provided from a remote location and capacity can be maintained. Initial CBAs have shown positive results but for each aerodrome a specific CBA considering the local factors is required being the baseline for a deployment decision.

In total 11 ATCOs from DFS and 2 ATCOs and 2 ATCAs from LVNL were involved in the demonstration. During the demonstrations 419 flights were evaluated at Saarbrücken airport and 38 flights at Eelde Airport.

With the visual reproduction used in the demonstrations, the size of the aircraft appears smaller than in the OTW view and along with this the visual range for detecting aircraft is also lower than in the OTW view. While this is still sufficient to provide ATS aerodromes it might limit capacity at medium size aerodromes. For medium size aerodromes, depending on the specific local needs, this should be compensated by means like:

- Use of PTZ
  As the PTZ is used more frequently than a binocular on the local tower, the workload allocated to positioning of the PTZ should be minimised. This can be done by different means like an easy to use interface for manual control, automatic PTZ-Tracking, pre-defined hotspot buttons or selection of positions on a map to directly focus PTZ in a certain direction.
- Object Bounding
  Object bounding increase the probability of detecting an aircraft and positively affects the certainty of the ATCO to re-establish visual contact after looking away.
- Use of other surveillance information
  Other surveillance information like the display of radar data in the OTW view can be used in addition to the visual presentation.

It should be noted that in all the demonstrations for medium size aerodromes radar displays (air surveillance) were part of the RTM.

To ensure that all relevant areas such as runways, taxiways, aprons and airspace (e.g. VFR patterns, relevant waypoint, entry and exit points) are visible for the controller, the position of the camera mast is crucial. Local circumstances such as runway layout and geographical orientation of the camera mast can differ for every site.
Selecting a position for the camera mast might be easier than for a tower building and thus the viewing is potentially even improved compared to the conventional tower. Also, additional camera positions can be used for areas for which the visibility is poor, such as locations further away from the camera mast or the manoeuvring area.

Different implementations of the visual presentation were demonstrated. While the cameras covered 360 degree at all demonstrations, the image was either completely displayed continuously or just a selected field of view (225 degree) were shown to the ATCO continuously with the feature to pan the viewing direction.

The vertical viewing angle must ensure that all relevant areas are covered by the visual presentation. This must be considered especially if the cameras are placed in landscape orientation (additional cameras might be used to cover manoeuvring area or other areas of interest).

The demonstrations showed that ATCO training is required before providing ATS from an RTM. The ATCOs need to get used to the sources they can retrieve the best available information from and get used to handling of PTZ and Visual Presentation. That kind of familiarisation would happen in the same way as in a newly built conventional tower.

Capacity levels can remain the same working remotely. During the demonstration activities no reduction in capacity was observed. During the demonstrations traffic numbers about 32 movements including ground movements per hour were observed.

Safety Assessments were conducted according to local methodology for all demonstrations.

5.5.3.3 Multiple remote – small and medium size aerodromes

Based on the validation results of solution #52 (Remote Tower for two low density aerodromes), EXE-0205-04 demonstrated the Multiple Remote Tower application for a small and medium traffic volume airport was feasible and acceptable during the experimental trials.

The recommendation is to further investigate the concept for multiple remote towers in SESAR2020. During that investigation it may be relevant to study different ways of managing task load for the ATCOs and assistants, and to maximise safety. In particular, solutions have to be explored on how to handle tasks that need attention at different airports at the same time. Further, it must be ensured that the likelihood that ATCOs will confuse the two airports will be minimal. A number of mostly hardware-related suggestions to reduce that likelihood were made.

5.5.3.4 Common conclusion

All different single remote tower solutions from very small to medium size aerodromes were demonstrated with no significant shortcomings. ATS can safely be provided from a remote location and capacity can be maintained. Initial CBAs have shown positive results but for each aerodrome a specific CBA considering the local factors is required being the baseline for a deployment decision.

The different solutions were all set up on the operational and technical requirements that were provided from SESAR 1 (OFA 06.03.01). These requirements were already considered in rulemaking and standardisation by EUROCAE WG 100 and EASA RMT.0624. Only minor adjustments are proposed as a result of the demonstration. The same requirements are valid for all investigated solutions ranging from very small to medium size aerodromes.

To ensure that all relevant areas such as runways, taxiways, aprons and airspace (e.g. VFR patterns, relevant waypoint, entry and exit points) are visible for the controller, the position of the camera mast is crucial. Local circumstances such as runway layout and geographical orientation of the camera mast can differ for every site.

All working positions within a future remote tower centre might be universal or at least have the same functionalities so the controller working position are suitable for any type of air traffic service; air traffic control and flight information service. This will have a positive effect on the possibility to improve any request of service. This also could have a positive effect on the habituation by the controllers as well have a positive effect on capital expenditure and operational costs.

For air traffic controllers, air traffic control assistants and flight information officers there is no change in the way they handle traffic.

During the demonstrations there was no need for additional rules and regulations. Current rules and regulations that apply for working from a conventional control tower were sufficient for working from a remote tower facility.

All safety levels were sufficient and all targeted airports could be operated as usual.

Results show that the single remote tower concept is ready for implementation for very small to medium size airports.

Further research is needed on the multiple remote tower concept for airports with more traffic. The number of airports that can be controlled simultaneously, the amount and constellation of traffic, interaction between multiple airports and the impact on controller workload, safety and human factors are topics that need to be explored further.

6 Demonstration Exercises reports

6.1 EXE-0205-001 (Single – AFIS very small Airport)

6.1.1 Exercise Scope

LFV executed a Passive Shadow Mode (PSM) demonstration of operations in Gällivare from the established RTC at Sundsvall Midlanda Airport, The demonstration was carried out in line with the Demonstration Plan for LSD.02.05 [1] addressing OFA 06.03.01.

The aim of the demonstration was to show that it is possible to establish and provide a low cost remote solution for AFIS, provided in TIZ, with the same service provided as normal operations for airports in rural regions with a very low density of traffic. The aim was also to demonstrate a possibility for these airports to gain features and development that are normally too expensive for investment with that amount of traffic. Objectives addressed are described in detail in chapter 2.1.

Gällivare is a very small airport in the northern regions of Sweden, having a total of 3152 movements during 2015. The distance between Gällivare airport and RTC Sundsvall is 537 km as the crow flies (738 km by land transport), see Figure 3 below.

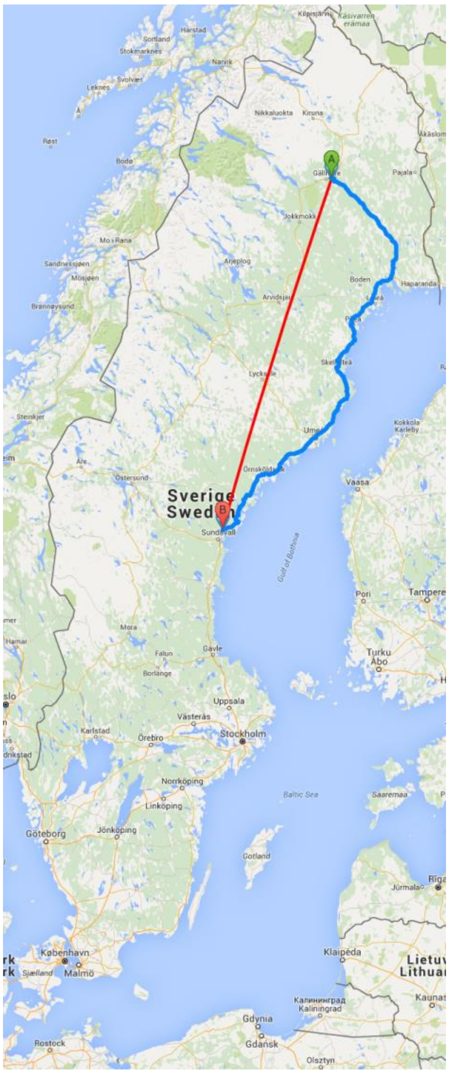


Figure 3: Map showing the location of Gällivare Airport (A) and RTC Sundsvall (B), in Sweden

6.1.2 Conduct of Demonstration Exercise

6.1.2.1 Exercise Preparation

The demonstration platform used in this exercise was delivered by SAAB. Requirements were built upon results from earlier SESAR work and the implementation program, however here scaled down in order to obtain a basic low cost remote tower solution for very small airports, taking the development a step further.

The platform configuration is detailed in the following subsections.

The preparation activities undertaken for the demonstration are detailed in Table 9 below.

Activities	Finalised by
Preparation of platform, CWP and connected camera tower	July 10th 2015
Installation of basic CWP in Sundsvall RTC	August 25th 2015
Installation and integration of airport data to Sundsvall and the CWP	September 3th 2015
Demonstration preparation, preparation of schedule, questionnaires and briefing forms	September 17th 2015
System verification and platform tests	September 24th 2015
Safety assessment on the installations	July 2015
Training of ATCO	Sept-Oct 2015

Table 9: Preparation activities for EXE-0205-001

6.1.2.1.1 Camera tower positioning

For the demonstration the position of the camera tower was chosen in collaboration with the operational personnel in Gällivare tower in order not to cause any interference with the operational work. The industrial partner SAAB proposed a few possible places that would provide a true picture of the airfield and its surroundings. All inputs considered the camera tower was erected just east of the ordinary tower. The view presented from the camera tower involved visual contact with apron A which the operators normally don't see but on the other hand involved partial lack of visual contact with apron B which they normally see fully.

A screen displaying the pictures from the camera tower was placed in the ordinary tower for the operators to look at. One picture/camera at the time was selectable. This way they could compare the picture produced by the camera tower with what they saw in real life. Figure 4 below presents the 360 degree visual view as achieved from the camera tower placement. (The ordinary tower can be seen slightly right of centre in the picture).

Figure 4: Footage from the site survey showing the 360 degree view of the chosen camera tower placement

6.1.2.1.2 Visual Reproduction Configuration

Camera Tower

The camera tower installation consisted of 9 cameras in landscape orientation, providing a 360 degree view (each camera presenting 40 degrees (360/9)). They were divided into 6 "frontal" cameras with high definition resolution, providing a front view of 240 degrees centred on the runway - and 3 "rear" cameras with a lower resolution for a back view of the remaining 120 degrees. In addition there was a PTZ (Pan Tilt Zoom) camera replacing the binoculars of a traditional tower.

Visual Reproduction (OTW)

The Remote Tower Module (RTM) was installed in a normal office room (with windows to the outer world) within the RTC Sundsvall premises. The aerodrome view, or "out the window" (OTW) view, was presented on six 42" LCD screens in landscape mode, one camera represented by one screen. Hence the visual reproduction provided a view of 240 degrees (6*40) at a time. It also included a toggle functionality allowing the operator to toggle between three pre-defined views, in order to obtain full 360 degree view coverage. The toggling between different views was instant (without any delay). The three pre-defined views were:

- Straight (primary view)
  - Using the 6 frontal HD cameras for a 240 degree view centred on the runway. This view included the full runway as well as the approach and departure sectors of both runway ends.
- Left/behind
  - Using the 3 left of the frontal HD cameras and the three rear cameras. This provided a view starting from the centre of the runway and 240 degree to the left, "behind the back".
- Right/behind
  - Using the 3 right of the frontal HD cameras and the three rear cameras. This provided a view starting from the centre of the runway and 240 degree to the right, "behind the back".

6.1.2.1.3 Technical configuration

The following systems and functionalities were present in the CWP (Controller Working Position):

- OTW (aerodrome view), including:
  - 3 selectable views (front / left / right – as described above)
  - PTZ – presentation and manoeuvring
    - Free hand steering (via computer mouse directly in the OTW)
    - Auto tracking functionality (lock on moving targets)
    - 2 pre-defined camera (including zoom and focus levels) positions (at each runway end)
    - 2 pre-defined camera (including zoom and focus levels) sweeping patterns (sweeping the full runway from each runway end to the other, both directions)
    - SLG dummy functionality - to show a possible way of handling the signal light gun
  - Overlays (digitally overlaid information within the OTW)
    - Fixed presentation area including:
      - Wind presentation for each runway end (digital presentation, selectable between instant/2min/10min)
      - QNH
      - Airport designator (ICAO code)
      - Clock (hours, minutes and seconds in UTC)
    - Met-report (expandable from the presentation area described above)
    - RVR (runway visual range) for RWY 30 (permanently presented beside the runway end)
    - Cardinal/compass direction presentation (S, W, N, E) in the top of the visual view, selectable
    - Runway and taxiway markings/frames & designators, selectable
    - Visual/video tracking, selectable on/off (highlighting moving objects)
- Air Situational Display (RDP radar presentation)

- WACOM pen/tablet screen, including the following functionalities and presentations;
  - e-strip
  - AWOS (weather presentation system) & FDP (flight plan system)
  - Accident and distress alarm activation buttons (for demonstration purposes only, no airport connection)
  - NAV and RWY light manoeuvring and presentation (for demonstration purposes only, no airport connection)
  - Re-play of pre-recorded scenarios (OTW view only, no sound replay)
- Airport ambient sound
- Radio and interphone/telephone, (only listening, no transmitting)
- Strip printer (dummy to show a possible backup solution for e-strip)
- Binder, including printed AIP maps and other various information relevant for the demonstration

A picture of the RTM/CWP as it looked during the demonstration is presented in Figure 5 below.

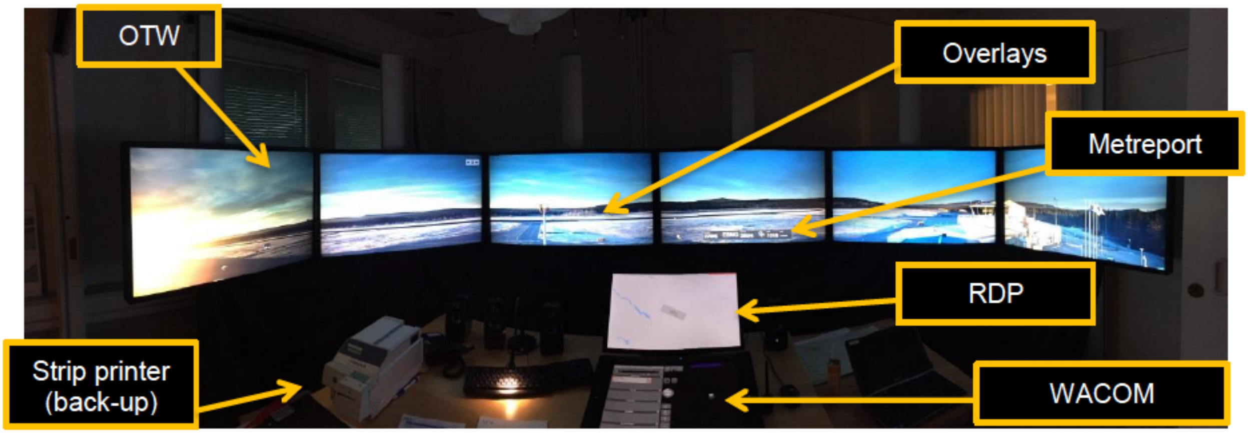


Figure 5: The demonstration platform / CWP

6.1.2.1.4 Training of operators (ATCOs)

Each operator was provided time for training and familiarization with the platform prior to their first demonstration session. An operator handbook in Swedish was distributed to the operators a few weeks prior to the demonstration. A visit to Gällivare tower before exercising the demonstration was offered to all operators in order for them to have an "on site" experience as reference in the demonstration. Intention was to have AFISOs as operators but none was available and therefore replaced by ATCOs.

6.1.2.1.5 Questionnaires and debriefing forms

During the demonstration a various sample of questionnaires, a traffic log and debriefing forms where used. Most where constructed by a LFV Human Performance expert in cooperation with the project team. Standardized SASHA/SATI from Eurocontrol was also used. Intention was to be able to retrieve results with focus on Objectives for this demonstration. The traffic log was used to follow up on actual traffic, weather conditions, flight rules etc. and there was a column for comments on events; technical as well as operational.

6.1.2.2 Exercise execution

The demonstration was based on live traffic and scenarios based on daily work so there are neither reference nor solution scenarios available. In addition some recorded scenarios where used to facilitate the demonstration.

As the demonstration was executed as a PSM (passive shadow mode trial) the operators at the demonstration platform did listen to the frequency and communication without any possibility to interfere with the day to day work. The operators did follow the traffic and made all the system inputs and other actions they would have done in an active mode trial. The AFISO in Gällivare tower did maintain their work and routines during the trial and where not interfered with any safety issues due to the demonstration.

The demonstration took place Monday to Thursday during 3 weeks with Friday as spare day. In total there were 16 runs split on 4 ATCOs some with AFISO experience and some with RTC experience.

Scheduled traffic at Gällivare takes place in the early morning hours into the early evening and the trials followed ordinary shift hours for Gällivare. This made it possible to look into different types of operations regarding daylight and also feedback on human performance issues working from a remote facility. All operators followed the same set up as seen in schedule below which makes their experience comparable.

All runs had an appointed demonstration leader who ran briefing, debriefing and logged the follow up on actual air- and ground activities, comments on events and technical issues as well as weather conditions. There were 4 persons appointed and scheduled for this task.

Schedule:

Oct 5-8	Monday	Tuesday	Wednesday	Thursday	Friday
Operator 1	Evening	Morning	Evening	Morning	Spare

Oct 12- 15	Monday	Tuesday	Wednesday	Thursday	Friday
Operator 3	Evening	Morning	Evening	Morning	Spare
Operator 2		Evening	Morning		

Oct 19-22	Monday	Tuesday	Wednesday	Thursday	Friday
Operator 4	Evening	Morning	Evening	Morning	Spare
Operator 2		Evening	Morning		

6.1.2.3 Deviation from the planned activities

Ground movement was partly affected.

Identifier	SCN-0205-002
Title	Ground movements
Scenario	Ground movements of cooperative and non-co-operative objects on all relevant surface movement areas will be considered.

On the technical side there was a deviation from planned activity regarding the transferring of sound to the RTM in Sundsvall over the surface vehicle UHF frequency. The communication between the vehicles and the tower was left out. This led to situations where the operators in the remote facility noticed vehicle ground movements only by looking at the screens. This in itself didn't provide any hazards since passive shadow mode was executed. However it did deviate from the intentions of the demonstration. The ambition of the demonstration was to log all movements during the active demonstration period however a few of the ground movements might have been missed.

A feature in the demonstration platform is a visual tracking function. This function helped the operators to spot vehicles and people early when on the airfield even without having heard the radio communication between e.g. a vehicle driver and the tower.

-"I noticed a vehicle on its way to apron B but I don't know where it came from since we can't monitor the surface vehicle frequency at this point"

6.1.3 Exercise Results

6.1.3.1 Summary of Exercise Results

Table 10 below describes a summary of exercise results.

Low level objective	Low level objective	Success criteria identifier	Success criteria	Indicator	OK / NOK	Comments
OBJ-0205-111	To demonstrate that the basic RTM is reliably functioning and deployable at the RTC in Sundsvall	CRT-0205-1111	The RTM is properly implemented from a technical point of view with tools and features that are a must for a basic product.	ETQ	OK	The operators confirm that tools and features are sufficient for a basic product however there where some technical disturbances caused by the short preparation time for the demonstration. Mitigations are described in 6.1.3.1.15.
		CRT-0205-1112	AFISOs acknowledge that all mandatory aspects regarding working environment are covered.	DEBRIEF, SATI	OK	The operators agree or strongly agree by expressing trust in the system
		CRT-0205-1113	All necessary training has been executed in order for the AFISOs/ATCOs to operate the RTM at Sundsvall RTC (e.g. introduction to the RTM and familiarization with the remotely operated location)	TFQ	OK	All operators confirmed by agree or strongly agree that training, preparation, familiarization and introduction prior to operating the RTM was sufficient and satisfactory.
OBJ-0205-112	To demonstrate that availability and capacity remains while operating the basic RTM under various visibility conditions.	CRT-0205-1121	Under comparable weather conditions the AFISOs are able to handle traffic from the RTM with sufficient efficiency.	DEBRIEF, TRAFFIC LOG, SASHA	OK	In the weather conditions that ruled during the demonstration the operators confirmed that they could handle the traffic sufficiently
		CRT-0205-1122	Under comparable day/night conditions the ATCOs are able to handle traffic from the RTM with sufficient efficiency.	DEBRIEF, TRAFFIC LOG, SASHA	OK	The operators could handle the traffic efficiently during both day and night condition
OBJ-0205-511	Assess if the visual production is fit for purpose for the AFIS	CRT-0205-5111	The visual reproduction allows the AFISO to provide AFIS with the basic camera tower.	ETQ, DEBRIEF	OK	The operators agree

	operations during this demonstration.	CRT-0205-5112	AFISOs acknowledge that all mandatory aspects regarding working environment are covered (e.g. camera view, usefulness and visual specifications).	ETQ, DEBRIEF	OK	All operators agree or strongly agree
		CRT-0205-5113	AFISO acknowledge that the basic camera tower provides sufficient visual coverage of the airfield.	ETQ, DEBRIEF	OK	All operators agree or strongly agree
OBJ-0205-512	Gain an initial insight into the safety of the basic camera tower concept	CRT-0205-5121	Feedback suggests that safety levels can be maintained.	ETQ	OK	All operators strongly agree
		CRT-0205-5122	Feedback gives an initial insight into the potential safety contribution of each component.	ETQ	OK	All operators agree or strongly agree that enhanced functionalities in the working position will contribute to safety. However several of the functionalities are to be considered a “nice to have rather than a need to have” to perform AFIS. Instructions and regulations have to be adapted to chosen level of equipment and chosen view, e.g. 240-360 degrees for the operator.
OBJ-0205-600	Provide feedback from different remote tower applications regarding standardization and regulation	CRT-0205-6001	Different technical solutions for Remote Tower Operations are compared and the necessary common parts to be considered in standardization are identified.	All questionnaires	OK	All operators agree that existing regulations are applicable for remote tower services. Same standard as in 06.09.03 was used and confirmed feasible.
OBJ-0205-700	Provide feedback from different remote tower applications regarding safety	CRT-0205-7001	Internal safety assessments according to LFV/LVNL/DFS own internal guidelines show only tolerable risks	SMS	OK	LFV safety assessment procedures were followed when installing the CWP, the camera tower and the data link. No excessive assessment was needed.

Table 10: Summary of Exercise Results EXE-0205-001

6.1.3.1.1 CRT-0205-1111 Technical implementation

Questions regarding the technical implementation and the usability of the system was asked in the End of Trial Questionnaire, responses given where overall very positive, see graph in Figure 8 below. However, minor but annoying deficiencies were expressed by a majority of the operators when it came to user acceptance rating. Mildly unpleasant deficiencies- system is acceptable and minimal compensation is needed to meet desired performance was expressed by the rest of the operators. Comments about technical drawbacks mainly concern behaviour of the PTZ in particular during darkness, lagging in the presentation in the OTW, the lack of sun filter on the cameras and the lack of hearing vehicles during the demonstration.

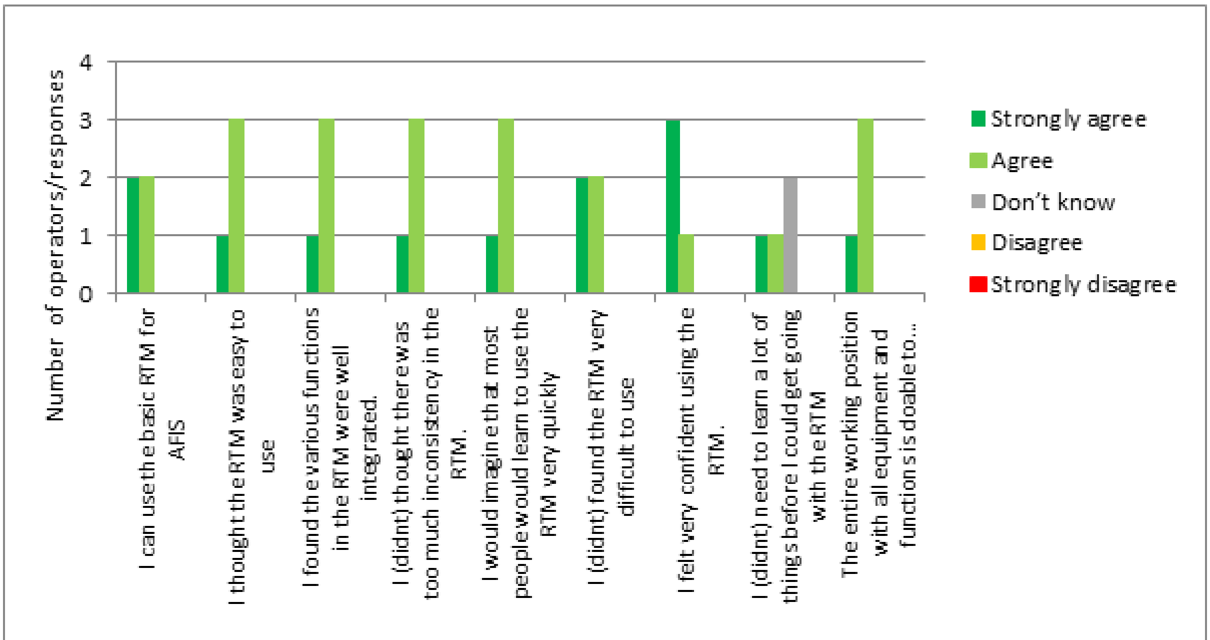


Figure 6: Questions and answers regarding CRT-0205-1111

6.1.3.1.2 CRT-0205-1112 Working environment

Goal for working environment was to figure out a CWP suitable for an office environment. Due to the short period of time and the demonstrations nature as a test all parts weren't able to sort out such as the room, distance to screens, and angle between the outer screens. Due to this several comments concerning working environment were given by the operators, which was to be expected. Some of the feedback given is presented below:

- *"Working position overall: A bit of experimental, it works for a demonstration but needs to be improved for an operational implementation, with a better table, placing of equipment on the table, etc."*
- *"Lights and placing of them is important in such an environment."*
- *"Working in an environment with windows is nice, they also gives a possibility to get some fresh air."*

When working with a new system, it is important to be able to trust the system and find it useful, reliable and understandable. Additionally, the system must work accurately and be robust in difficult situations in a consistent manner which will lead to operator confidence in the system.

The operators were asked to fill in the SATI trust rating questionnaire after each run; this questionnaire measures the levels of trust the operators have in components of the system. The questionnaire was filled by each operator after each run, giving a total of 16 data collection points for each question (4 operators * 4 runs). Figure 7 below presents the collected SATI result for the entire demonstration and

Table 11 gives the question/statement for each category. As can be seen in the graph, responses were overall very positive.

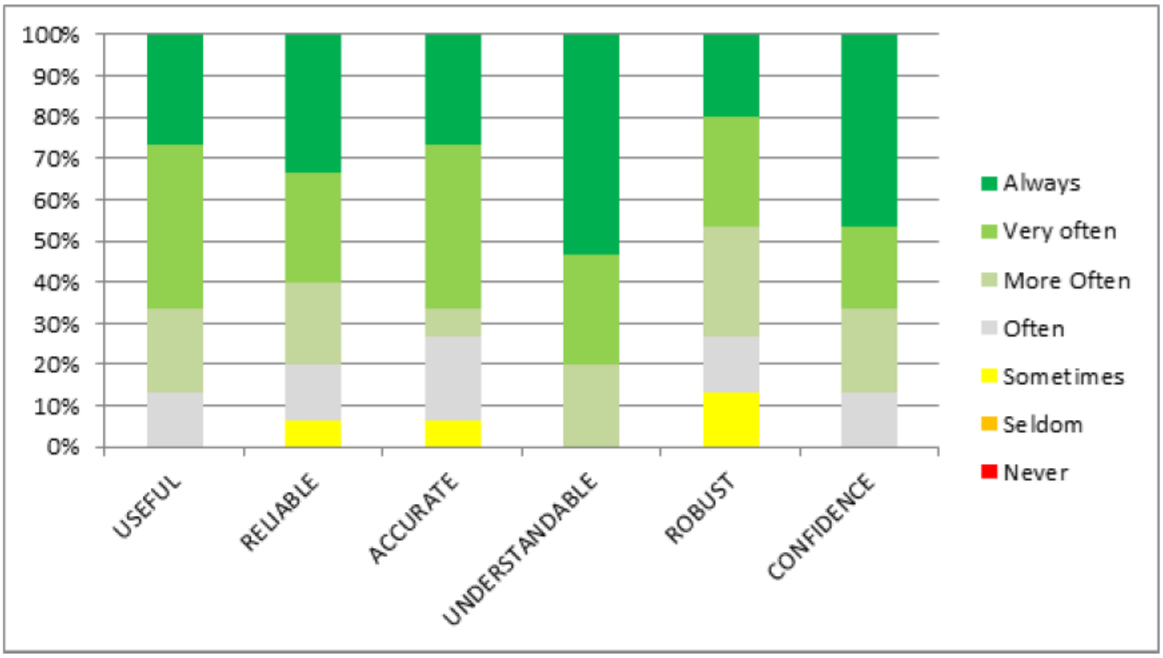


Figure 7: Summary of SATI

Key	***SATI Question***
Useful	The system was useful.
Reliable	The system was reliable.
Accurate	The system worked accurately.
Understandable	The system was understandable.
Robust	The system worked robustly (in difficult situations, with invalid inputs etc.).
Confident	I was confident when working with the system.

Table 11: SATI Questions

Hence, despite the nature of the trial, the demonstration showed that this working environment is usable with suggested improvements in a future implementation.

6.1.3.1.3 CRT-0205-1113 Training

All operators agree or strongly agree that training was sufficient.

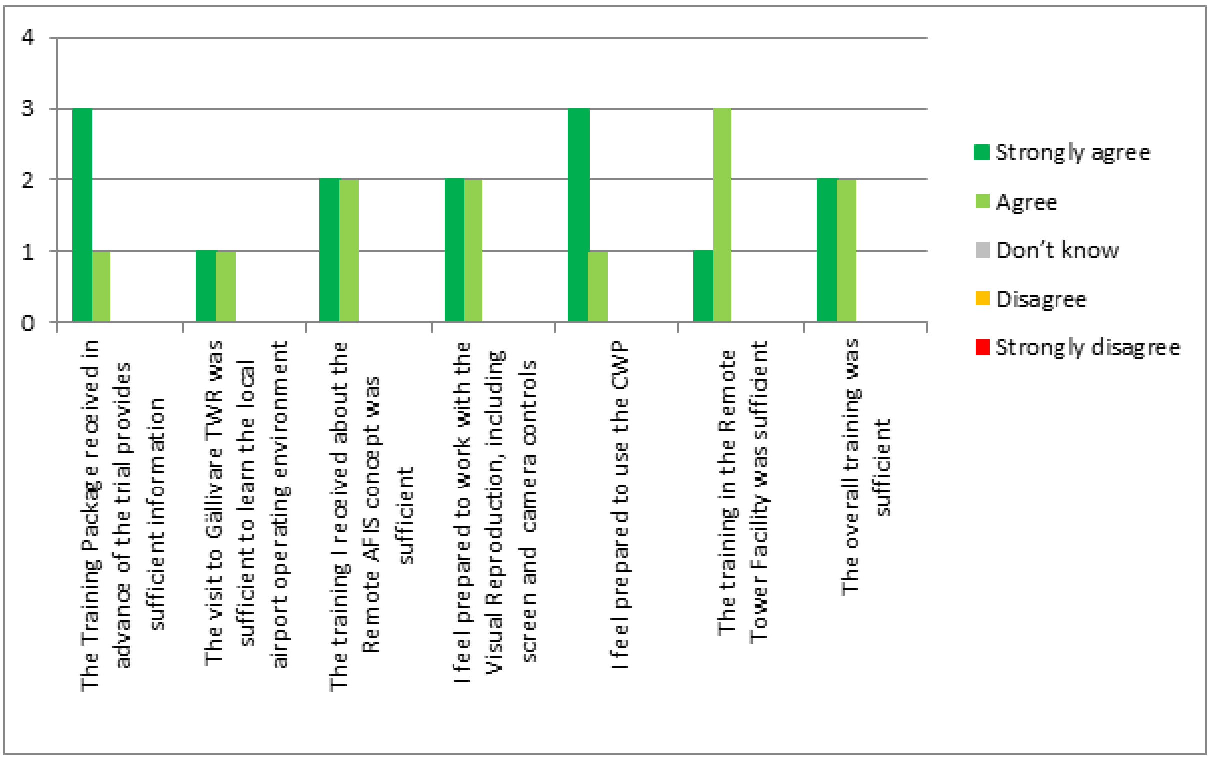


Figure 8: Summary of training questionnaire

6.1.3.1.4 CRT-0205-1121 Utility to provide ATS in different weather conditions

We didn't experience any adverse weather conditions during the demonstration. VMC conditions occurred for 93% of all movements; see Figure 9 below. The operators in Gällivare tower could however, outside the demonstration, experience poor weather conditions. They made comments that the presentation on the screen in the ordinary tower was good/fully acceptable also in poor weather conditions.

"We noticed precipitation on the screens, shortly afterwards it was presented in the AWOS system. We also confirmed the weather condition with Gällivare tower." Oral feedback given from AFISO in Gällivare tower.

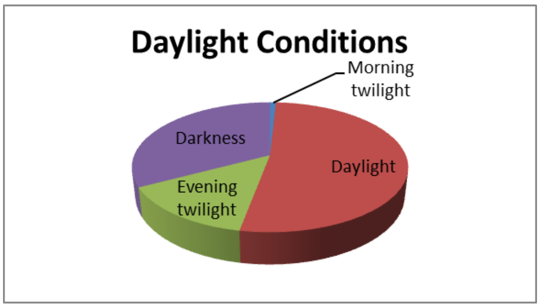
6.1.3.1.5 CRT-0205-1122 Utility to provide ATS in different daylight conditions

The experienced resolution on the screens was that it became somewhat poorer in darkness than in daylight during the demonstration. No cleaning of the cameras was done during the demonstration.

The automatic PTZ zoom during darkness, in particular, needs trimming. In this situation a manual zoom would have been preferred.

The visual tracking sometimes helped the operators to see traffic slightly earlier than just by looking out *"Some difficulties seeing the aircraft on taxiway B during darkness. Visual tracking on the aircraft lights helped to spot it. Once on the runway the aircraft was easier to spot again."* See also CRT-0205-5121. See Figure 9 below.

- *"No decrease in safety and efficiency. Business as usual."*
- *"The service will be the same. Pilots will not notice any change."*
- *"Capacity will be the same or better. It is plausible for a need to standardize operational procedures for VFR traffic, in particular SVFR, e.g. holding patterns."*



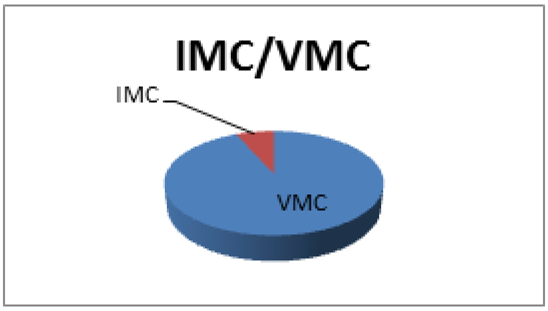


Figure 9: View of weather and daylight conditions monitored for all movements

6.1.3.1.6 CRT-0205-5111 Visual Reproduction

The quality of the resolution is enough to provide a safe and secure Air Traffic Service for this type of aerodrome (very low density) was confirmed by the operators. Note, see Figure 10 and Figure 11.

6.1.3.1.7 CRT-0205-5112 Controller Working position

The entire working position with all equipment and functions is doable to conduct Air Traffic Service from. Note: see Figure 10 and Figure 11.

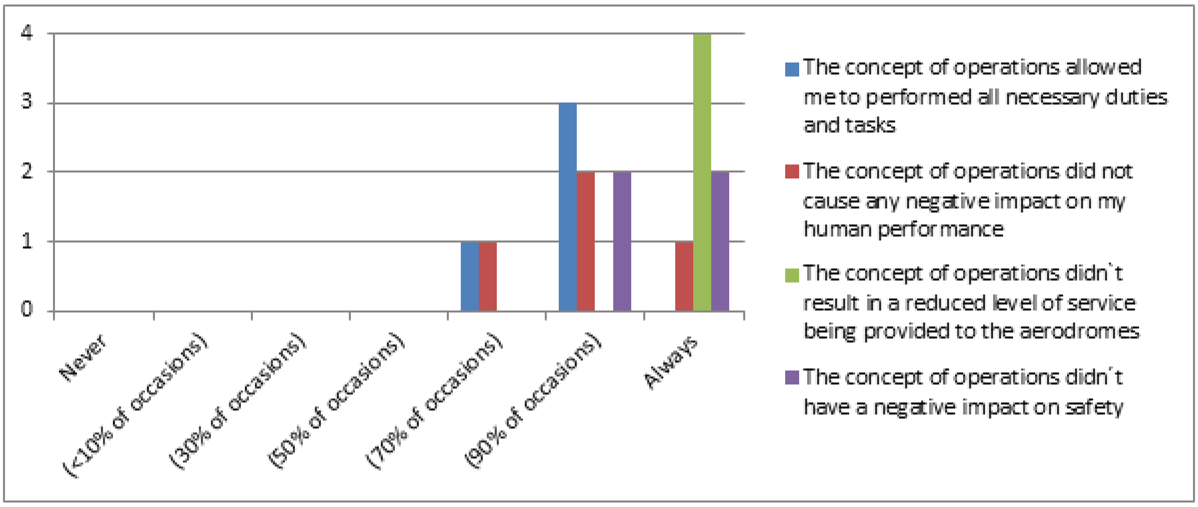


Figure 10: View of acceptance of the concept.

6.1.3.1.8 CRT-0205-5113 Acceptance of provided view

All operators agree to that the 240 degrees view provides a possibility to conduct a safe and secure Air Traffic Service. All operators agree or strongly agree to that the set up with 6 HD cameras combined with 3 cameras for the rear view (the remaining 120 degrees) is enough to conduct Air Traffic Service even with a less resolution on the rear cameras. Note, see Figure 10.

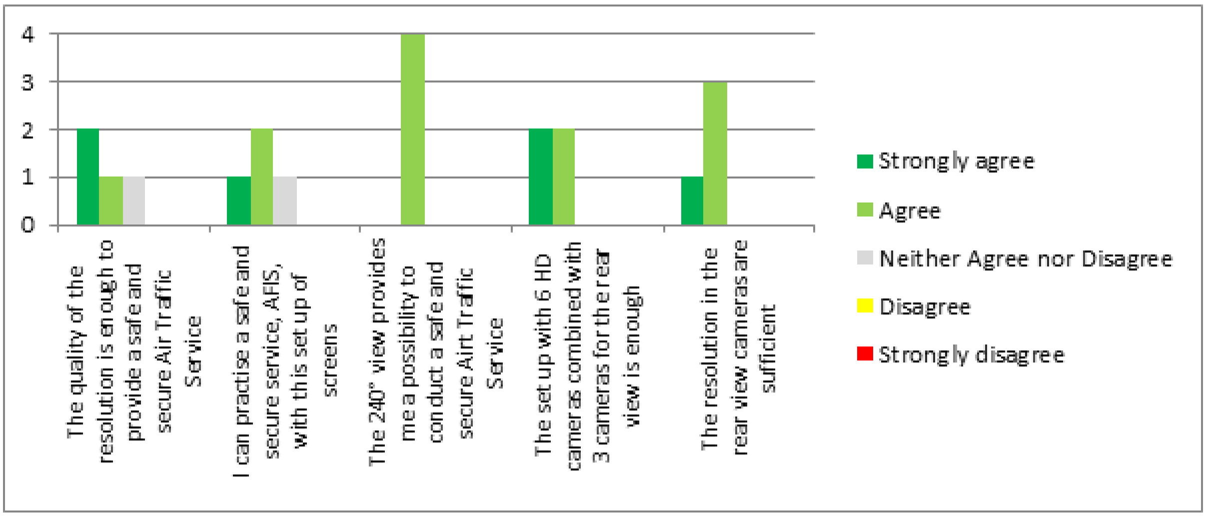


Figure 11: View of acceptance of the concept.

6.1.3.1.9 CRT-0205-5121 Safety level

Safety levels are as seen in Figure 10 either maintained or increased to an ordinary tower. The most important conclusion is that this basic solution with a limited view and lower resolution do NOT increase safety risks.

- *"It is a safe concept. Some working methods might need to be altered slightly but overall no big issues."*
- *"I felt very confident using the RTM."*
- *"No decrease in safety and efficiency. Business as usual."*

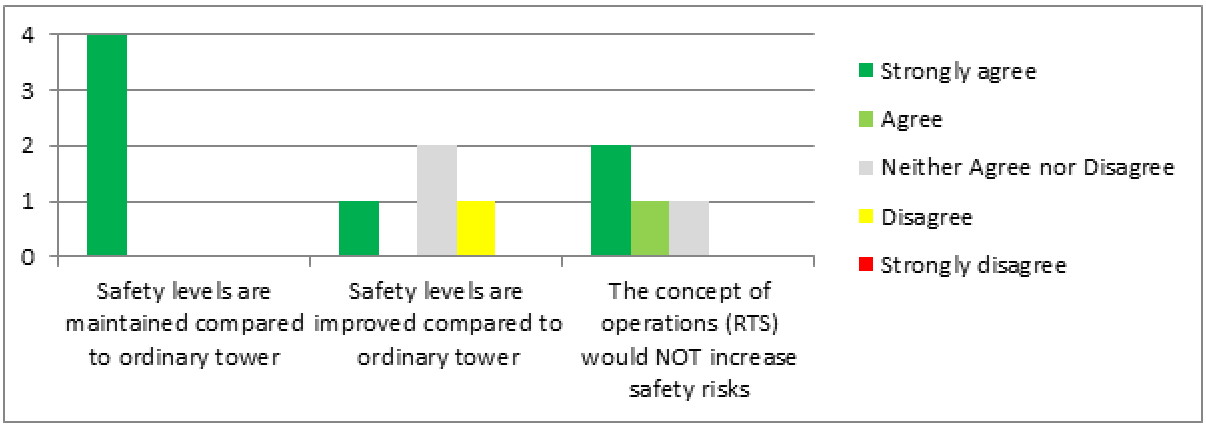


Figure 12: View of safety measurement

6.1.3.1.10 CRT-0205-5122 Safety contributing tools and features

The operators were asked to answer which of the various technical features and functions that contributed the most to the increasing or maintaining of safety for the concept. Responses were given as follows:

<u>Operator 1</u>: *#1 Visual tracking, #2 Overlays, #3 E-strip (the RWY blocked function).*

<u>Operator 2:</u> *#1 Visual tracking, #2 Overlays, #3 PTZ (would require a well-functioning PTZ).*

<u>Operator 3:</u> *#1 Visual Tracking is a useful tool, especially for detecting arriving traffic early.*

<u>Operator 4:</u> *#1 Visual tracking, #2 Overlays (especially during darkness). #3 The addition of a radar in AFIS environment.*

Based on the feedback given above, the conclusion is that the two tools that contribute to a maintained or increased safety the most are; Visual Tracking and Overlays. In addition to that PTZ, E-strip and inclusion of radar, was also mentioned as having a positive impact of safety.

Comments from operators during the demonstration:

- Visual tracking for finding birds, help prevent RWY incursion, help to find traffic earlier on the OTW and a general feeling of increased situational awareness.
- Radar presentation in tower will increase safety and capacity in many areas, e.g. when it comes to:
  - increased situational awareness and check pilot reported position
  - provide more accurate traffic information
  - search and rescue, mark last known position for an aircraft
  - planning traffic in accordance with clearing the runway from snow

6.1.3.1.11 CRT-0205-6001 Standardization and Regulation

The requirements for EXE.02.05-001 regarding technical implementation were based on OFA 06.03.01 and LFVs single remote tower implementation. These requirements are in line with EUROCAE WG 100.

Chapter 6.1.3.1.10 show the impact different components have on safety and should therefore be considered for implementation. Chapter 6.1.3.1.14 show results on usage of radar as standard equipment for AFIS.

6.1.3.1.12 CRT-0205-7001 Safety assessment

It was possible to follow the already existing safety assessment methodology for LFV at all installations, CWP, camera tower and data link, for EXE.02.05-001. This shows that there is no need for any excessive methodology when it comes to remote towers.

6.1.3.1.13 Results per KPA

The amount of traffic measured during the demonstration shows that the concept is feasible for even higher traffic levels than expected, as there were more irregular traffic than usual day to day operations. Traffic levels during the demonstration were comparable to annual level of approximately 4.000 movements (Ordinary traffic levels are about 3.000).

- The demonstration shows that safety and capacity can be met according to Figure 12 and Figure 13 supported by quotes from ATCOs e.g. *"It is a safe concept. Some working methods might need to be altered slightly but overall no big issues" "No decrease in safety and efficiency. Business as usual"*.

Activity	Logged occurrences	
Arrival	40	34%
Departure	49	41%
Ground movements	16	13%
Crossing	6	**5%**
Dep TIZ	4	3%
Arr TIZ	4	3%
Total:	**119**	**100%**

Flight Rule	Logged occurrences	
IFR	68	66%
VFR	35	34%
SVFR	0	0%
Total:	**103**	**100%**
Ground M.	*16*	
Checksum	*119*	

Figure 13: Capacity

6.1.3.1.14 Results impacting regulation and standardisation initiatives

Radar or equal presentation for AFIS should be considered as standard to enhance safety. All operators agree or strongly agree that introduction of radar improve their capability to perform AFIS and that situational awareness is improved.

Quotes:

- With appropriate training for AFISO I see little to no risk in implementing radar
- Radar can be used for information and positioning of aircrafts without active control
- Information can be improved, both to pilots and in search and rescue situations.
- Increased efficiency on the frequency, especially at situations with accurate positioning due to snow sweeping or similar. (*project comment: would improve multiple capability*)
- When informing about other traffic and not have radar license there is a risk of misinterpret radar information and then provide incorrect traffic info to other pilots. This could be mitigated with some kind of radar training. If AFIS would be allowed to have/use radar, some kind of training should be implemented.

6.1.3.1.15 Unexpected Behaviours/Results

Network issues with picture lagging on moving objects. The problem is solvable and is a must for a future implementation. The lagging didn't affect the results for the demonstration but wouldn´t be approved for an operational system. Lessons learned are to make a specific communication test to mitigate the risk for lost information packages/lagging and to test all parts in the communication chain.

PTZ was only equipped with an automatic zoom without a possibility to focus manually. The automatic zoom was at this stage not fully functional in darkness and in need for either manual steering or a more advanced automatic function.

Time frame from idea to execution of the demonstration was nine months which was shown too short for a possibility to solve all issues.

6.1.3.1.16 Quality of Demonstration Results

The quality of all demonstration results has been delivered to the highest level possible. Some points might have impacted the results: The chosen method of performing this trial was based on previous results with mitigations on risks foreseen.

- A shadow mode trial based on live traffic doesn´t enable repetitive traffic patterns and weather, compared to a simulation. The operators (ATCO or AFISO) are not able to actively control the traffic. However operators in this demonstration where able to perform inputs and interactions to most systems in the CWP, feeding data in to a test system, wherefore ATCOs got a proper view of the system and it´s functionality. All demonstration leaders had predefined focus areas for each and every run to ensure a comparable measurement between the operators.
- Questionnaires where based on knowledge from previous trials, this time focusing on new features or set-ups. Standardised SASHA and SATI forms from EUROCONTROL where used.
- The CWP and camera tower where based on previous results from the P.6.9.3 program. A temporary installation was used for this demonstration and hence there was an impact on the results.
- All participating operators where ATCOs from other towers than Gällivare which might have had an impact on the comparison of the day to day work. However two of the ATCOs had AFISO experience, one from Gällivare.

6.1.3.1.17 Significance of Demonstration Results

Traffic logs with input on weather, light conditions, time, type of movement, etc. where used to build a statistical significance during the entire demonstration. All operators performed the trial during the same shift hours to minimize the independent variables during the demonstration. SASHA and SATI was used during all 4 days to provide reasons for a variety through the week of demonstration. There was an increase in trust from day 1 to day 4.

The traffic was very realistic as they were shadowing ordinary traffic and had to act on a real life environment.

6.1.4 Conclusions and recommendations

6.1.4.1 Conclusions

The demonstration has shown that it is possible to provide AFIS as service, with maintained traffic levels, on a platform with reduced and/or simplified technology. It was possible to follow the already existing safety assessment methodology for LFV at all installations. This shows that there is no need for any excessive assessment methodology when it comes to remote towers.

6.1.4.2 Recommendations

The recommendation from this part of the demonstration is that deployment of a low cost solution is possible for aerodromes with a limited number of traffic focusing on AFIS as service provided. It is also recommended to use a scalable system to ensure a possibility to update the system if there is a request for provision of ATC. The main differences are rules for separation and the operator’s possibility to use the visual reproduction for separation.

6.2 EXE-0205-002 (Single – ATS for medium Airport)

6.2.1 Exercise Scope

DFS executed a combined Active and Passive Shadow Mode (PSM) demonstration of remote tower operations in Saarbrücken. The demonstration was carried out in line with the Demonstration Plan for LSD.02.05 [1] with the RTM being located in Saarbrücken.

The aim of the demonstration was to show that it is possible to establish and provide a single remote tower solution for medium size aerodromes with the same service provided as normal operations and sufficient level of safety being provided. The focus of the demonstration was on medium traffic density (a mix of IFR and VFR traffic) with frequent simultaneous movements which is a major additional requirement compared to providing ATS to small size aerodromes (that are characterised by mainly one movement at a time).

Airspace Users (Lufthansa Flight Training, LFT) contributed to the demonstration with a flight programme that allowed ATCOs to evaluate different procedures. This was especially important as one of the most challenging traffic is given by flight schools executing various different procedures (e.g. radar vectored precision and non-precision approaches, go-around/missed approach, visual circuit / visual approach, circling approach, departure according to flight plan and clearance)

The demonstration focused on normal operating conditions during daytime.

The annual movements at Saarbrücken airport are around 11.000 IFR and 6.000 VFR flights. During the demonstration additional traffic was provided by LFT. The figure below shows the airport layout of Saarbrücken airport with one runway.

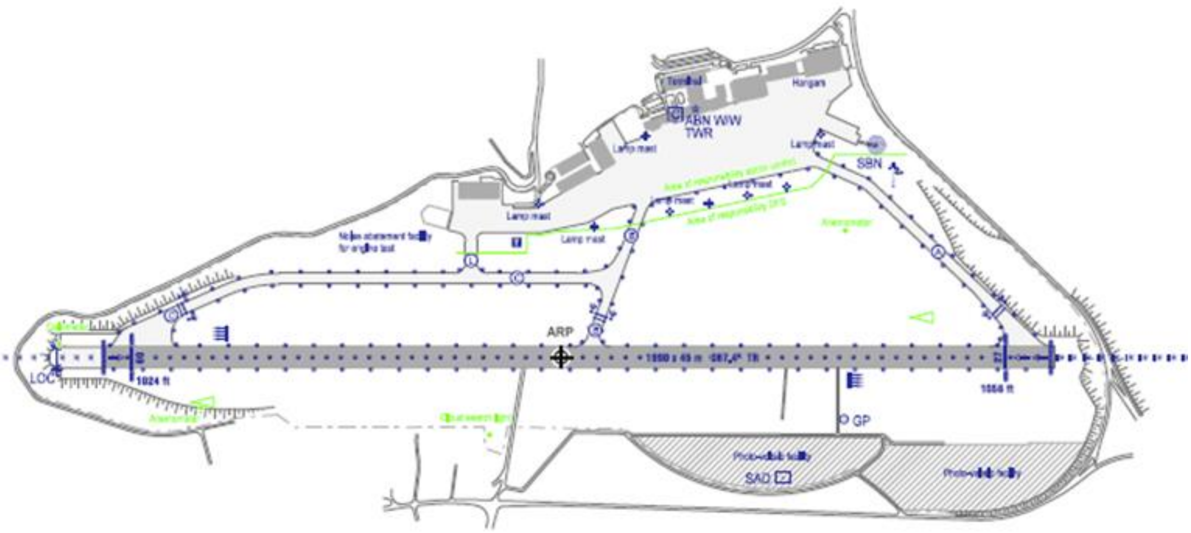


Figure 14: Saarbrücken Aerodrome Chart (AIP Germany)

6.2.2 Conduct of Demonstration Exercise

6.2.2.1 Exercise Preparation

The demonstration platform used in this exercise was delivered by Frequentis (visual system) and DFS (ATS-Systems). Requirements where built upon results from earlier SESAR work for remote tower solution.

The preparation activities undertaken for the demonstration are detailed in Table 12 below.

Activities	Finalised by
Preparation of CWP and visual reproduction	June 2015
Demonstration preparation, preparation of schedule, questionnaires and briefing forms	August 2015
System verification and platform tests	July 2016
Safety assessment on the installations	June 2016
Training of ATCO	August 2016

Table 12: Preparation activities for EXE-0205-002

The platform configuration is detailed in the following subsections.

6.2.2.1.1 Remote Tower Module

The Remote Tower Module (RTM) was installed in an office room within the Saarbrücken premises of DFS. The RTM comprised of the visual reproduction/PTZ-cameras and the ATS-Systems. A detailed description of the RTM is given below.

Visual Reproduction

The camera tower installation consisted of 10 cameras in landscape orientation, providing colour image covering 360 degrees. In addition to this an infrared sensor also provided an image covering 360 degrees.

The ATCO could switch between infrared and colour image. The visual reproduction was displayed to the ATCO on 5 monitors that were oriented in landscape and covered a 220° field of view. The ATCO could pan that field of view using a jog-shuttle and thus access the full 360 degree range.

The visual reproduction was overlaid with additional information which could be toggled on and off. This overlay included object bounding (a frame around a moving object), a static outline of the runway and taxiways, an indication of the glide path as well as the naming of certain areas of the airport (e.g. holding points, taxiways etc.).

Apron Image

In addition to this there were two fixed cameras installed to cover the apron view in colour image which were displayed on an additional monitor below the visual view described above.

Pan Tilt Zoom Cameras

In addition to the visual reproduction there were two PTZ (Pan Tilt Zoom) cameras replacing the binoculars of the traditional tower. The second PTZ was introduced for redundancy reasons. At the same time it can complement the main PTZ aiming at a second point of interest.

The PTZ cameras could be steered manually moving the finger in the PTZ image. In addition to that the PTZ cameras could be focused on an aircraft or pre-defined point using the PTZ-map which provided surveillance information or by using pre-defined hotspot buttons.

The PTZ cameras could also be operated in auto tracking mode (lock on moving targets). In addition to this the PTZ cameras could follow a pre-defined path (e.g. runway check).

ATS-Systems

The usual systems also used in the normal DFS tower were used in the CWP, i.e. Air Situation Display, Electronic Flight Strip System, Weather Information Display.

The ATCO actively used the radio frequency during active shadow mode while ATCOs were only listening during the passive shadow mode. Telephone connection to local tower and adjacent units was available.

A picture of the RTM/CWP as it was used during the demonstration is presented in the figure below.

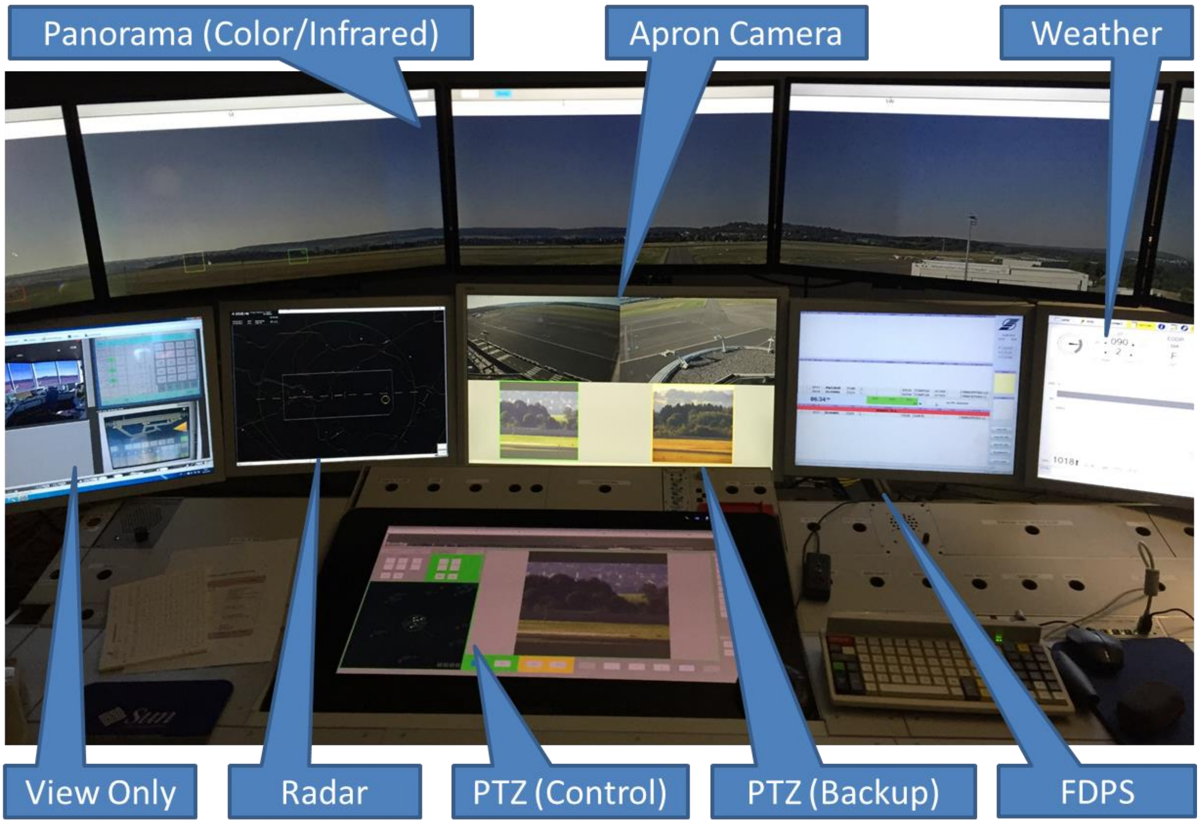


Figure 15: DFS Demonstration Platform

6.2.2.1.2 Training of operators (ATCO)

All the ATCOs involved in the active demonstration have had previous experience with the remote tower from earlier validations and were familiar with Saarbrücken airport. The ATCOs involved were recruited from Saarbrücken, Leipzig, Erfurt and Dresden. Only the ATCOs from Saarbrücken took part in the active shadow mode, the others evaluated the system based on the passive shadow mode.

Each operator was provided time for training and familiarization with the platform prior to their first demonstration session. The ATCOs from Saarbrücken worked one full day in passive shadow mode before having their active shadow mode session.

6.2.2.1.3 Questionnaires and traffic log

During the demonstration each ATCO filled out a questionnaire and participated to the debriefing which was a structured interview. A traffic log was used in order to count the traffic during the demonstration.

6.2.2.2 Exercise execution

For the demonstration the solution scenario with the ATCO providing ATS from a remote position (not from the local tower) was used. The demonstration was based on live traffic constituting of IFR and VFR traffic. In addition to the traffic normally operating at Saarbrücken, LFT provided a flight programme which allowed to demonstrate all kinds of live scenarios.

One part of the demonstration was run in active shadow mode while the other part was run in passive shadow mode. This is indicated in the table with the demonstration schedule below.

When the demonstration was executed as a PSM (passive shadow mode trial) the operators at the demonstration platform listened to the radio frequency and looked at the information provided within the ATS systems without any possibility to interfere with the day to day work. The operators followed the traffic and only made inputs to the visual reproduction as well as PTZ cameras but had no possibility to interact with the live traffic.

When the demonstration was executed as ASM (active shadow mode trial) the operators at the demonstration platform had full control of traffic and made all the system inputs and actions that were required at the RTM. In addition to this ATCO working at the RTM, staff was provided in the local TWR in order to take over in case critical situations would have appeared (“coach/trainee principle”)

The demonstration took place during two weeks, starting on Tuesday the first week (due to a holiday on Monday). In total there were 9 days of demonstration (running from early morning to early evening with a break between 12:30 and 14:00 local time every day due to noise constraints) with 5 days in ASM and 4 days in PSM.

All operators followed the same set up as seen in schedule below which makes their experience comparable.

All runs had an appointed demonstration leader who ran briefing, debriefing and logged the follow up on actual air- and ground activities, comments on events and technical issues as well as weather conditions.

Schedule:

Week 1		
Date	Shadow Mode	ATCO
16.08.2016	PSM	ATCO-1
		ATCO-2
17.08.2016	ASM	**ATCO-1**
		ATCO-2
18.08.2016	PSM	ATCO-3
		ATCO-4
		ATCO-5
19.08.2016	ASM	**ATCO-3**
		ATCO-4
		ATCO-5

Week 2		
Date	Shadow Mode	ATCO
22.08.2016	PSM	ATCO-6
		ATCO-7
23.08.2016	ASM	**ATCO-6**
		ATCO-7
24.08.2016	PSM	ATCO-8
		ATCO-9
25.08.2016	ASM	**ATCO-8**
		ATCO-10
26.08.2016	ASM	**ATCO-9**
		ATCO-11

During the demonstration in total 11 ATCOs provided feedback on the Remote Tower Module with 6 of them (highlighted in **bold** letters) having actively controlled traffic from the RTM.

6.2.2.3 Deviation from the planned activities

As the focus of the demonstration was on active shadow mode, there was not sufficient time to evaluate degraded modes in depth.

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

Table 13 below describes a summary of exercise results.

Low level objective	Low level objective	Success criteria identifier	Success criteria	Indicator	OK / NOK	Comments
OBJ-0205-221	To demonstrate that the basic RTM is reliably functioning and deployable at the RTC in Saarbrücken	CRT-0205-2211	The RTM is properly implemented from a technical point of view.	SATI	OK	Despite the nature of the trial (the system will be further developed until implementation and ATCOs have a limited working experience with the system), the demonstration showed that ATCOs have a positive trend to trust into this system.
		CRT-0205-2212	All necessary training has been executed in order for the ATCOs to operate the RTM in the demonstration.	DEBRIEF	OK	All ATCOs working in ASM had participated in previous validations related to remote tower for medium size aerodromes. Training on the demonstration platform was part of the trial.
OBJ-0205-222	To demonstrate that no decrease in capacity is experienced while operating the RTM under various visibility conditions	CRT-0205-2221	Under comparable weather conditions the ATCOs are able to handle traffic from the RTM with no significant delay.	ETQ, DEBRIEF	OK	Rating of the utility/usability of the RTM has significantly increased in the demonstration compared to the VP-640 validation and shows mainly positive values
OBJ-0205-223	To demonstrate that no decrease in capacity is experienced regardless of operational procedures while operating the RTM during shadow mode (several scenarios will be executed).	CRT-0205-2231	Working with the RTM the ATCOs evaluate that there will be no significant delay as regards the experienced traffic mix (IFR/VFR).	ETQ, DEBRIEF TRAFFIC LOG	OK	The data log provides the figures which prove that the demonstration was run with a representative mix of IFR and VFR traffic. The number of flights per day during the demonstration was significantly above the average traffic normally operating at Saarbrücken airport.

		CRT-0205-2232	Working with the RTM the ATCOs evaluate that there will be no significant delay as regards the experienced traffic constellation.	ETQ, DEBRIEF	OK	Considering the high amount of traffic and the ATCO rating which has shown no significant delay that was imposed on the flights and the airspace users' feedback did not show any negative impact.
OBJ-0205-600	Provide feedback from different remote tower applications regarding standardization and regulation	CRT-0205-6001	Different technical solutions for Remote Tower Operations are compared and the necessary common parts to be considered in standardization are identified.	DEBRIEF	OK	Differences in requirements for small and medium size aerodromes were identified.
OBJ-0205-700	Provide feedback from different remote tower applications regarding safety	CRT-0205-7001	Safety Assessment will be conducted according to local methodology.	ETQ, DEBRIEF	OK	The safety assessments for the demonstration of single remote tower and the associated training have been conducted according to DFS methodology in parallel to RTM development. ATCO feedback regarding safety in normal and abnormal conditions revealed mainly positive values. ATCO feedback regarding safety in degraded conditions needs to be further addressed during implementation

Table 13: Summary of Exercise Results EXE-0205-002

6.2.3.1.1 Exercise Results Introduction

During the demonstration 11 ATCOs (from Saarbrücken, Leipzig, Erfurt and Dresden) evaluated the remote tower module for medium size aerodrome in passive and active shadow mode. In general each ATCO spent a session of two days at the RTM (starting with a training part and continuing with the actual evaluation). At the end of the session the ATCOs filled out an end of trial questionnaire (ETQ) and participated in a final debriefing (DEBRIEF).

In the ETQ questionnaire the ATCOs were asked to answer to statements with the possible answer ranging from '1' (strongly disagree) to '6' (strongly agree). Alternatively it could be stated that 'no assessment is possible'. In addition to this a free text comment could be given to each of the questions.

The only deviation from this answering scheme is given in the standardised SATI (which is explained in the chapter below).

In addition to the subjective assessment the data-log was used to determine number of movements during the demonstration.

In the chapters below a detailed description of the exercise results is provided.

6.2.3.1.2 CRT-0205-2211 Technical Implementation

For the objective 'To demonstrate that the basic RTM is reliably functioning and deployable at the RTC', the criteria was defined as 'The RTM is properly implemented from a technical point of view'.

The RTM has been developed in an iterative process for more than one year. ATCOs have regularly verified the prototype in passive shadow mode and provided their feedback on the maturity of the various functionalities and provided proposals on how to improve the prototype. In addition to this the prototype was validated in two P6.8.4 exercises (VP639 and VP640) by ATCOs who evaluated operational usability and utility as well as safety and human performance aspects.

As a result of the final verification which has taken place in June 2016 along with the safety assessment, the conclusion was drawn that the system has reached a level of maturity that allows running the demonstration in active shadow mode.

When working with a new system, it is important to be able to trust the system and find it useful, reliable and understandable. Additionally, the system must work accurately and be robust in difficult situations in a consistent manner which will lead to operator confidence in the system. The respective questions are part of the standardised SATI questionnaire:

Key	SATI Question
Useful	The system was useful.
Reliable	The system was reliable.
Accurate	The system worked accurately.
Understandable	The system was understandable.
Robust	The system worked robustly
Confident	I was confident when working with the system.

Table 14: SATI Questions

All operators were asked to fill in the SATI questionnaire (System automation trust indicator) once at the end of their demonstration session, giving a total of 9-11 data collection points for each question (some ATCOs did not answer all questions). The figure below presents the collected SATI result for the entire demonstration.

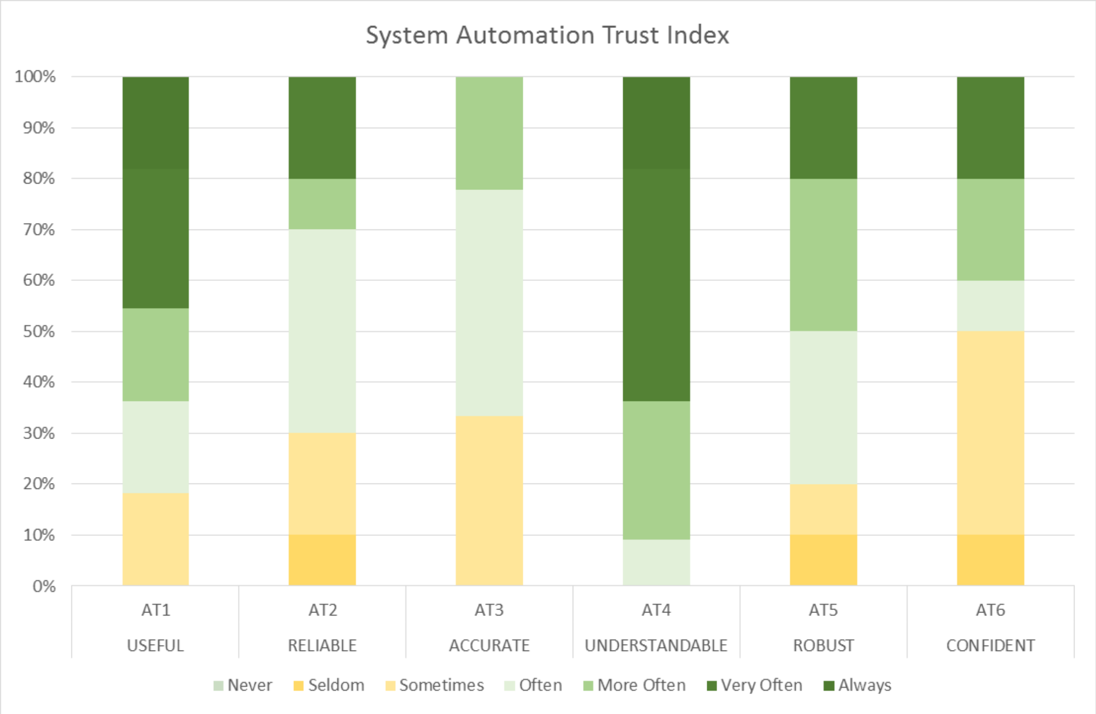


Figure 16: Summary of SATI

Despite the nature of the trial (the system will be further developed until implementation and ATCOs have a limited working experience with the system), the demonstration showed that ATCOs have a positive trend to trust into this system.

The focus of the system development addressed the topics 'useful' and 'understandable' which show mainly positive results. The aspects 'robust', 'accurate' and 'reliable' show some limitations in the ATCO answers but will be further developed till implementation. The aspect 'confidence' was rated lowest from the ATCOs. It is expected that the rating will significantly improve when the system is more reliable and accurate as required for an implementation (this was not a requirement for the demonstration) and the ATCOs have more experience working with the system.

Considering the ATCO rating and the interpretation given in the previous paragraphs this criteria is evaluated 'OK'.

6.2.3.1.3 CRT-0205-2212 Training

The criteria was defined as 'All necessary training has been executed in order for the ATCOs to operate the RTM (e.g. introduction to the RTM and familiarization with the remotely operated location)'.

All ATCOs working in ASM had participated in previous validations related to remote tower for medium size aerodromes. Training on the updated demonstration platform was part of the trial. Each ATCO worked two days at the RTM with the first day being the training session.

The ATCOs involved in the Active Shadow Mode were also introduced into the operating procedures that were applicable for this part of the demonstration (including among others checklists for taking over control responsibility).

Based on the explanation given above this criteria is evaluated 'OK'.

6.2.3.1.4 CRT-0205-2221 Utility of RTM to provide ATS

This criteria was defined in order to prove that 'under comparable weather conditions the ATCOs are able to handle traffic from the RTM with no significant delay'.

The objective was designed to assess utility of the RTM in different visibility conditions. As the demonstration took place at Saarbrücken airport, no night operations could be evaluated due to the night closure at Saarbrücken. Furthermore only very short periods of IMC conditions occurred during the demonstration. The ATCOs therefore evaluated the RTM under daylight conditions and answered the questions regarding low visibility based on their subjective expectation.

The ATCO rating for this criteria was focused on utility of the RTM for safely and orderly providing ATS as the impact on capacity/delay was explicitly evaluated by the ATCOs in CRT-0205-2231 and CRT-0205-2232.

The questionnaire addressed the utility/usability of the remote tower module separately for general utility, utility/usability of PTZ-camera and utility/usability of panorama. The related questions are shown in the tables and the results of the ATCO rating are shown in the figures below.

Ratings – General Utility:

The ATCO ratings show that the RTM is utile in VMC as well as in IMC conditions. It should be noted that there were only very short periods with IMC conditions and no night conditions during the demonstration and the ATCOs were therefore asked to provide their rating on their expectation.

The ATCO ratings furthermore show that all relevant phases of flight can sufficiently be monitored for arrivals as well as for departures. Comparable ratings were given for all phases of flight.

Item key	Item Short
General Assessment 3	Utility in VMC
General Assessment 30	Utility in IMC
General Assessment 12	Monitor aircraft in traffic pattern
General Assessment 14	Monitor approaching aircraft
General Assessment 18	Detect vehicles on RWY
General Assessment 19	Monitor landing aircraft
General Assessment 20	Monitor aircraft / vehicle on manoeuvring area
General Assessment 21	Monitor aircraft / vehicle on apron
General Assessment 22	Monitor departing aircraft
General Assessment 31	Monitor aircraft taking-off

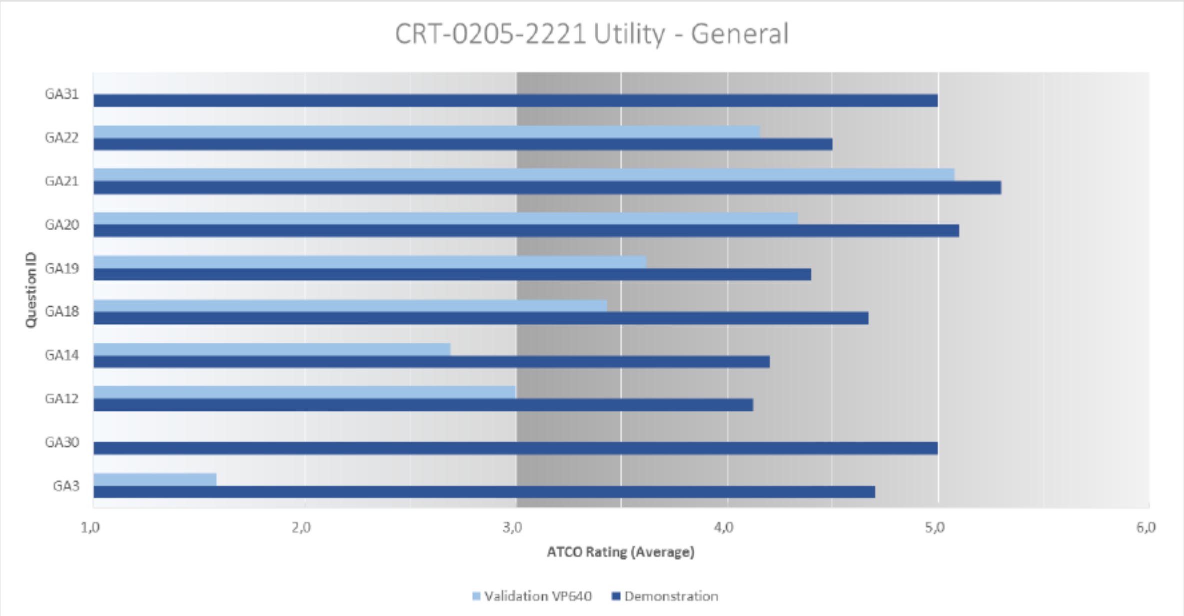


Figure 17: Results – Utility General

Ratings – Utility and Usability of Panorama:

The overall ratings of the ATCOs show mainly positive values for utility and usability of the visual reproduction. ATCOs agree that it is possible to perform ATC tasks with the presented horizontal viewing angle of the airport in the real time panorama view.

A significant improvement in the ATCO rating compared to the validation VP640 can be seen for all ratings. Especially the automatic display adaption in brightness and contrast to the actual conditions as well as the horizontal and vertical viewing angle are now rated as 'OK'.

Item key	Item Short
General Assessment 5	Utility of panorama
General Assessment 6	Usability of panorama
Assessment Panorama 6	Switching Colour and Infrared-Image is easy to use
Assessment Panorama 24	Brightness and contrast in different lighting conditions
Assessment Panorama 27	Horizontal and vertical viewing segment

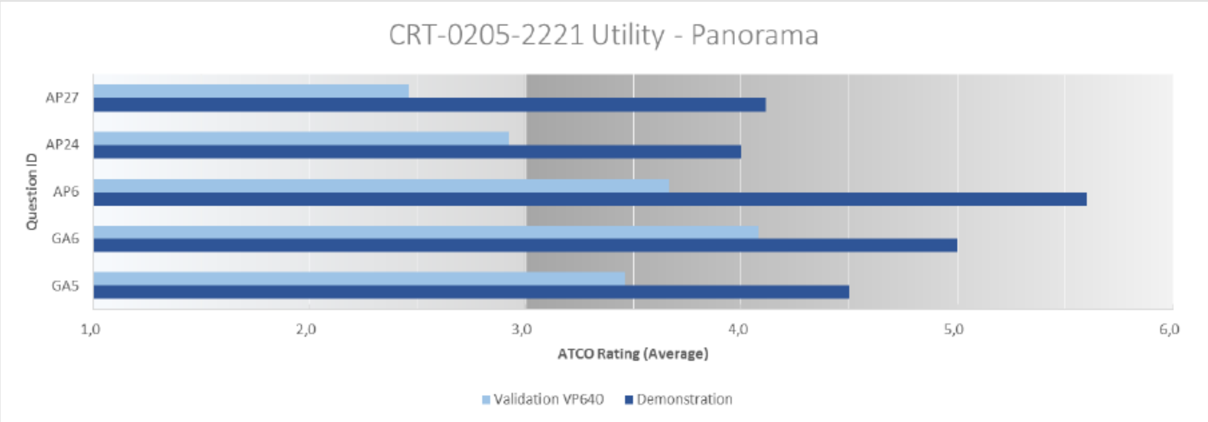


Figure 18: Results – Utility Panorama

Ratings – Utility and Usability of PTZ-Camera:

The overall ratings of the ATCOs show mainly positive values for utility and usability of the PTZ-Camera. ATCOs state with mainly positive values that usability of PTZ in terms of the different options for interaction with the PTZ-camera is given. Highest ratings are given for handling of PTZ-Camera via PTZ-map and selection of Hot Spots.

Item key	Item Short
General Assessment 7	Utility of PTZ
Assessment PTZ Camera 8	Usability of PTZ - manual tracking
Assessment PTZ Camera 10	Usability of PTZ – selection of Hot spots
Assessment PTZ Camera 21	Usability of PTZ - Selection of objects
Assessment PTZ Camera 33	Usability of PTZ Map

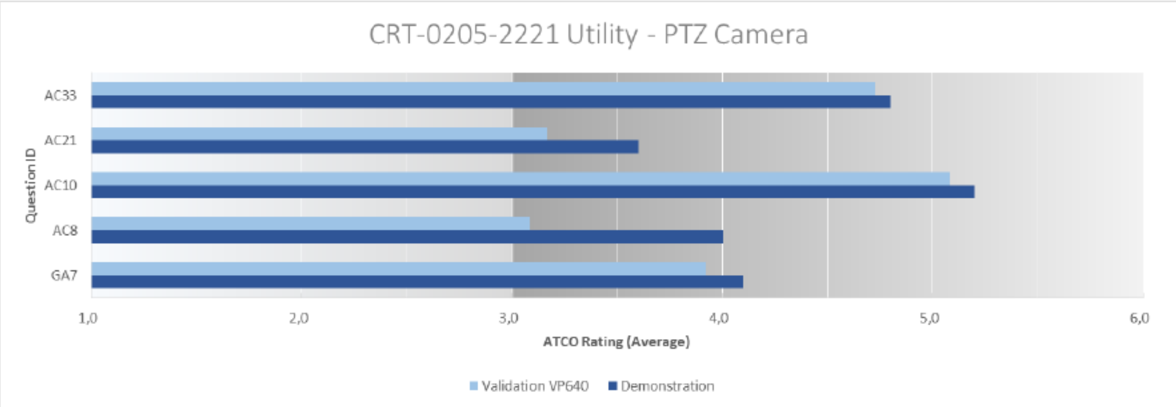


Figure 19: Results – Utility PTZ Camera

Overall result CRT-0205-2221

Rating of the utility/usability of the RTM has significantly increased in the demonstration compared to the VP-640 validation. As all of the ratings are above 4 (except for a single one), the criteria is evaluated as ‘OK’.

6.2.3.1.5 CRT-0205-2231 Capacity – Traffic Mix

One criterion defined for evaluating capacity was: 'Working with the RTM the ATCOs evaluate that there will be no significant delay as regards the experienced traffic mix (IFR/VFR)'.

The table below provides an overview on the traffic that occurred during the whole demonstration – summarising active and passive shadow mode (ARR = Arrivals, DEP = Departures, XNG = Crossing Traffic, TG = Touch and Go, LA = Low Approach).

Date	Duration	ARR	DEP	XNG	TG	LA	Total
16.08.2016	6,5	10	12	4	9	4	39
17.08.2016	7,5	12	14	7	10	5	48
18.08.2016	6,5	8	10	8	17	3	46
19.08.2016	5,0	6	7	6	1	1	21
22.08.2016	5,5	4	6	2	6	2	20
23.08.2016	8,5	12	14	19	24	7	76
24.08.2016	8,0	17	23	21	23	5	89
25.08.2016	6,5	8	11	10	20	7	56
26.08.2016	4,5	7	7	3	6	1	24
Total	58,5	84	104	80	116	35	419

Figure 20: Results – Traffic Volumes

The average traffic per day during the demonstration was 7.2 movements per hour. The traffic was composed of an average of 69% IFR movements and 31% VFR movements.

Out of these traffic figures, Lufthansa Flight Training (LFT) provided an overall of 239 movements (including the majority of touch and go as well as low approaches). The traffic was composed of:

	Number of movements
'normal' Movements	180
LFT Movements	239
Total Movements	419

This shows that the demonstration was run with a considerable amount (more than 100%) of traffic beyond the normal traffic amount of Saarbrücken airport, indicating that remote tower operations can be provided at medium size aerodromes.

The active shadow mode was run for a duration of 21 hours (provided by 6 different ATCOs) with a total of 190 movements which gives an average of 9.0 movements per hour during the active shadow mode!

During the demonstration also quite complex traffic situations with many simultaneous movements could be handled from the remote tower module. As an example the following situation evolved as given below on 23. August at 16:00:

- IFR 8 NM on final
- VFR abeam 3 NM final (which was turned onto final before the IFR mentioned above)
- VFR crossing (doing airwork at the boundary of the CTR)
- Rescue Helicopter (starting outbound) from a nearby hospital within CTR
- IFR Departure (on ground with Startup Clearance)
- Additional IFR ARR for opposite APP, followed by circling approach, immediately after the Landing of preceding ARR

Overall result CRT-0205-2231

The data log provides the figures which prove that the demonstration was run with a representative mix of IFR and VFR traffic. The number of flights per day during the demonstration was significantly above the average traffic normally operating at Saarbrücken airport. LFT provided a flight program which allowed to assess any potential impact on capacity due to various traffic constellations and with frequently occurring simultaneous movements.

6.2.3.1.6 CRT-0205-2232 Capacity - Procedures

In addition to the criteria above, the other criteria defined for evaluating capacity was: 'Working with the RTM the ATCOs evaluate that there will be no significant delay as regards the experienced traffic constellation'.

In order to evaluate a potential impact on capacity, ATCOs were asked to provide their feedback on whether they had to delay flights due to workload associated with providing ATS from the RTM. Neither for VFR nor for IFR arrivals or departures a significant delay was imposed on the flights during the demonstration. Question Delay 2 was answered only by 3 ATCOs of which 2 had the need to hold a VFR in the arrival pattern. The debriefing revealed that the delay was due to the specific traffic situation rather than a problem induced by working at the RTM.

As these questions were introduced into the questionnaire for the demonstration, no comparison to the validation VP-640 can be provided.

Item key	Item Short
Delay 1	No need for increased IFR arrival separations
Delay 2	No need to hold VFR arrival in traffic pattern
Delay 3	No need to extend downwind for VFR arrival
Delay 4	No need to hold IFR departure
Delay 5	No need to hold VFR departure

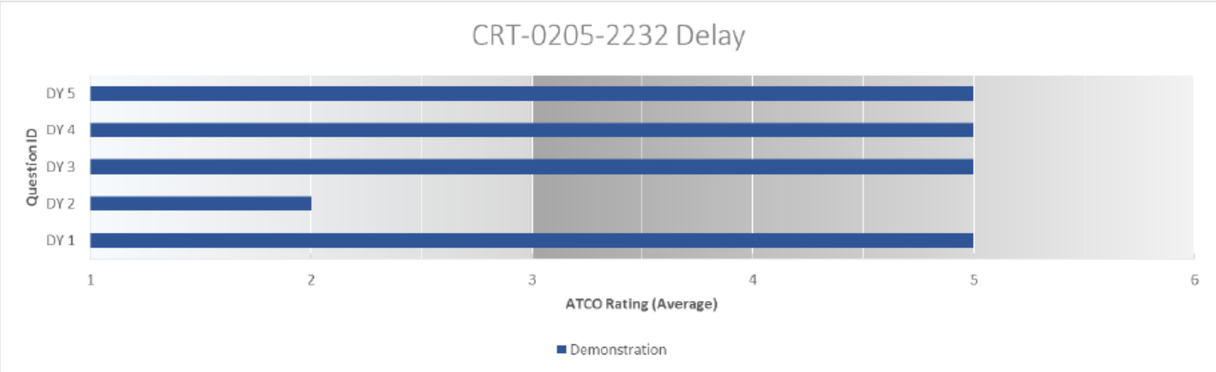


Figure 21: Results – Delay

ATCOs were asked during the debriefing on the potential impact on capacity working with the RTM. While ATCOs felt that their workload was in general higher than working in the ordinary tower, they agreed that this would to a great extent be caused by the fairly new environment and the relatively brief familiarization period (one day of passive demonstration). The general feedback, as well as the traffic numbers achieved during the active demonstration allow for the conclusion, that no significant impact is to be expected on the usual traffic volumes in Saarbrücken.

The pilots from LFT participating in the demonstration were also asked for their feedback on the service provided from the remote position. In total 27 feedback questionnaires were collected during the demonstration run (active and passive shadow mode). No difference in the feedback between service provided from RTM and service provided from local tower could be found.

Item	Item Short
PIL-1	I did not experience differences in ATC procedures or traffic handling (TWR)
PIL-2	I did not realize that the Tower Controller worked from a remote location
PIL-3	I felt that ATCO clearances were given without any delay compared to normal operations
PIL-4	I did not face any unusual delays when approaching the airport
PIL-5	I did not get increased requests (e.g. ‚say again‘, additional position reports) from the ATCO while being controlled

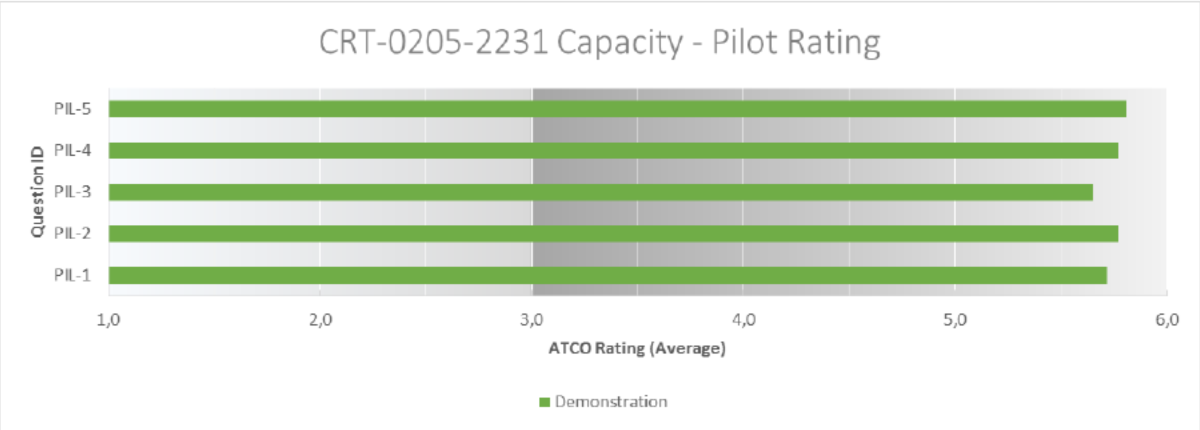


Figure 22: Results – Pilot Rating

Object bounding and automatic PTZ-tracking were explicitly evaluated as they contribute to situational awareness and thus to capacity.

The utility of automatic PTZ-tracking was rated even higher than utility of object bounding. However, PTZ-tracking was suffering from not receiving the correct altitude information which explains the slightly degraded rating compared to VP640. In addition to this automatic PTZ-tracking was negatively impacted by iron bars within the visual field due to the provisional mounting on the top of the local tower (rather than being mounted on a dedicated camera mast). Furthermore with new hardware it is expected that automatic tracking near the runway can further be improved.

Object bounding was in general significantly improved but as there was a coding problem in the approach sector the overall rating was not as high as expected.

The reliability of automatic PTZ-tracking and object bounding was rated as not being sufficient. These items still have to be improved prior to deployment.

Item key	Item Short
General Assessment 10	Utility of object bounding
Assessment PTZ Camera 22	Utility of automatic PTZ tracking
Assessment PTZ Camera 23	Reliability of automatic tracking (colour image)
Assessment PTZ Camera 24	Reliability of automatic tracking (infrared)
Assessment PTZ Camera 51	Reliability of automatic tracking (PTZ map)
Assessment Panorama 33	Relevant objects were bounded

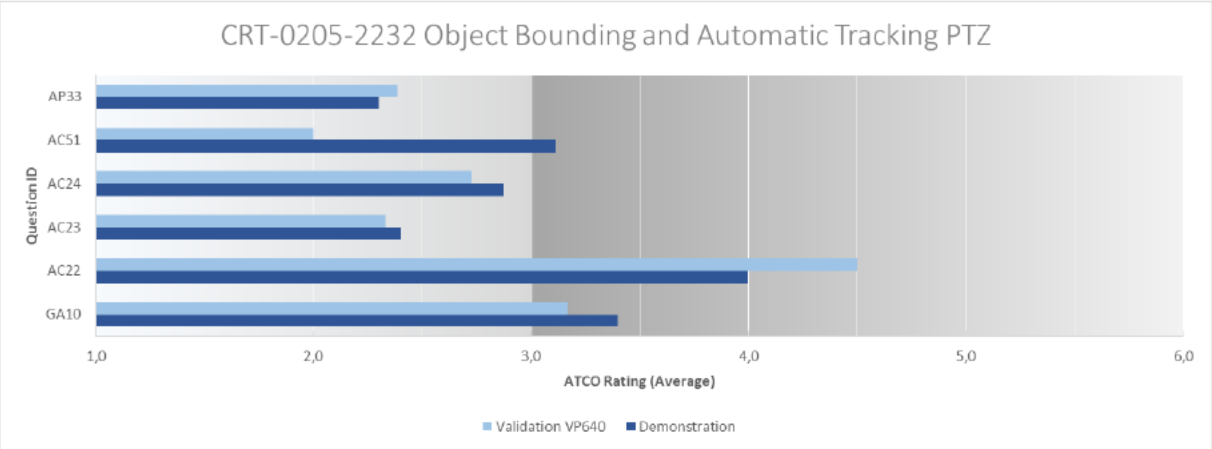


Figure 23: Results – Object Bounding and PTZ-Tracking

Conclusion on Object bounding and automatic PTZ-Tracking:

Object bounding is seen as an important feature, complementing the visual reproduction that was used in the demonstrations for identifying objects and maintaining situation awareness. But the need for object bounding has always to be evaluated in combination with the quality of the visual reproduction and other available features and support functionalities (i.e. the higher the quality of the visual reproduction, the lower the need for object bounding).

Therefore it has to be formulated as a 'should' requirement in the OSED for medium size aerodromes (while being a 'may' requirement for small aerodromes). It is not proposed to formulate it as a 'shall' requirement as future visual reproductions might have a much higher quality and thus reduce the need for object bounding.

Automatic PTZ-Tracking of objects in combination with the display of the viewing sector in the visual representation supports situational awareness and needs to be a 'should' requirement for medium size aerodromes.

Conclusion on Visual Separation:

Visual information was used for the sequencing and separation of Aircraft during the demonstration from the RTM. Like in the local tower the frequency of applying visual separation at medium size aerodromes is rather low as there is seldom the operational need to apply it and if so, the possibility to apply it mainly depends on different factors like aircraft size and visibility conditions. During the demonstration ATCOs did not specifically mention any issue related to applying visual separation or spacing (neither in terms of not applying it due to working remotely nor in terms of increased application of visual separations due to better awareness due to RTM functionalities).

Nevertheless it should be stated that visual separation might be applied less often from the RTM compared to a local tower based on the OTW view as the resolution and quality of the visual reproduction currently available does not provide the same image as the OTW view. But at the same time it can be concluded that visual separation in any case will only be applied when the conditions necessary are met (like in the local tower today) and thus visual separation will be as safe as in current operations from the local tower.

Object bounding and automatic PTZ-tracking increase the probability of detecting an aircraft and positively affects the certainty of the ATCO to re-establish visual contact after looking away. This could increase the probability of visual separation to be applied. Nevertheless, based on the explanation above, these functionalities are no prerequisites for applying visual separation.

Overall result CRT-0205-2232

While the rating of the procedures to be applied for visual separation using object bounding and automatic PTZ-tracking has improved in general but still shows mainly ratings below 3, it seems that the major remaining problems can be solved during deployment phase (the algorithm is built on different areas and just one area needs to be updated).

Considering the high amount of traffic and the ATCO rating which has shown no significant delay that was imposed on the flights and the airspace users feedback which did not show any negative impact, the criteria is evaluated as 'OK'.

6.2.3.1.7 CRT-0205-6001 Standardisation and Regulation

The system used in the demonstration was based on the operational and technical requirements that were produced within OFA 04.01.01. These requirements were already considered by EUROCAE WG 100 for standardisation and EASA RMT.0624 for regulation.

With respect to EASA Decision 2015/14 and the respective EASA Explanatory note to Decision 2015/014/R the following comments can be provided:

- **Approach to Regulatory Level**
  In line with EASE Decision, no need is seen for AMC or Implementing Rule for Remote Tower as existing rules are sufficient. The provision of Guidance Material is welcomed as it supports implementation of remote tower but at the same time avoids overregulating.

  A unit endorsement for remote tower operations offers the required flexibility to ANSPs and ATCOs and is in line with the 'European Manual of Personnel Licensing for Air Traffic Controllers' which states: 'Unit endorsements may also indicate the specific types of surveillance equipment used by the Unit in the provision of air traffic control services on specific sectors, groups of sectors or operational positions.'

- **Basic Equipage and Enhanced Equipage**
  DFS demonstration used object bounding and automated PTZ-Tracking which are considered enhanced equipage. These functionalities were well received by the ATCOs.

- **Level of Safety in comparison to current operations**
  From DFS point of view an adequate Safety level of remote tower operations must be proven with the applicable safety assessment methodology. But there is no need to compare safety assessments to current operations.

- **Impact on airspace users**
  Feedback from pilots indicated that there is no impact on airspace users when ATS is remotely provided. The demonstration has not shown any need for new surveillance technology to be introduced for single remote tower operations.

Based on the demonstration results the following operational requirement has to be formulated as 'should' requirement for medium size aerodromes compared to a 'may' requirement for small size aerodromes:

Identifier	REQ-06.09.03-OSED-VA03.1401
Requirement	The visual presentation ***may*** ('***should'*** for medium size aerodromes) incorporate overlaid information associated with a specific element or target in the visual field, aiding or facilitating detection, recognition, identification and ranging of objects relevant for the service provision - in order to increase ATCO/AFISO heads up time.

The demonstration supports the change of the requirements made in the last update of the OSED. The requirements should be considered in standardisation and regulation:

Identifier	REQ-06.09.03-OSED-VQ03.1220
Requirement	During CAVOK conditions, the ATCO/AFISO ***should*** be able to visually **detect** an aircraft of type A320, ATR72 or similar size on 4NM final, by using the visual presentation (excluding the binocular functionality).

Regarding ratings, endorsements and licensing, no new results have been identified compared to what is already described in the OSED:

A potential suggestion for the way forward regarding the licensing of remote tower ATCOs is that they shall hold an ADI rating with appropriate endorsements (i.e. radar, etc.) and additionally hold an RTC unit endorsement, complemented with specific local endorsements for the appropriate aerodromes that the skills will be applied to. It is however suggested, as part of safety assessments performed, that endorsement training shall be complemented by (or put extra emphasis on) local airport knowledge and conditions (such as local geography, local weather conditions, typical traffic type and mix etc.) in order to compensate for being placed remote. Note: the different aerodromes in an RTC should be treated similarly to the sectors in an ACC, from a licensing point of view.

Cross licensing enables ATCOs to provide ATS to various aerodromes from one location. Hence flexible staffing may be achieved and thus costs may be reduced as ATCOs are not bound to one aerodrome.

Overall result CRT-0205-6001

As DFS actively participated to EUROCAE WG 100 and EASA RMT.0624 this criteria is evaluated 'OK'.

6.2.3.1.8 CRT-0205-7001 Safety

The criterion that was defined regarding safety was 'Safety Assessment will be conducted according to local methodology'.

The safety assessments for single remote tower and the associated training have been conducted according to DFS methodology in parallel to RTM development. The safety assessments have not been finalised yet as the development is still ongoing.

In addition to these safety assessments addressing the implementation of remote tower operations, an additional safety assessment has been conducted for the active shadow mode. This safety assessment was approved by the German NSA in July 2016.

Overall result CRT-0205-7001a

As all the required safety assessments were conducted and no showstopper has been identified, the criterion is evaluated as 'OK'.

Ratings – Safety and Human Performance

In addition to the safety assessments mentioned above, safety and human performance were also addressed in the questionnaires.

ATCOs mainly agree that safety is maintained in terms of overall situational awareness - and even improved - by the use of advanced features like infrared images and object bounding.

Item key	Item Short
General Assessment 4	Overall situational awareness
Safety 1	Increase in safety due to infrared
Safety 3	Increase in safety due to object bounding
Safety 13	Recognition of Go-around / Missed Approach

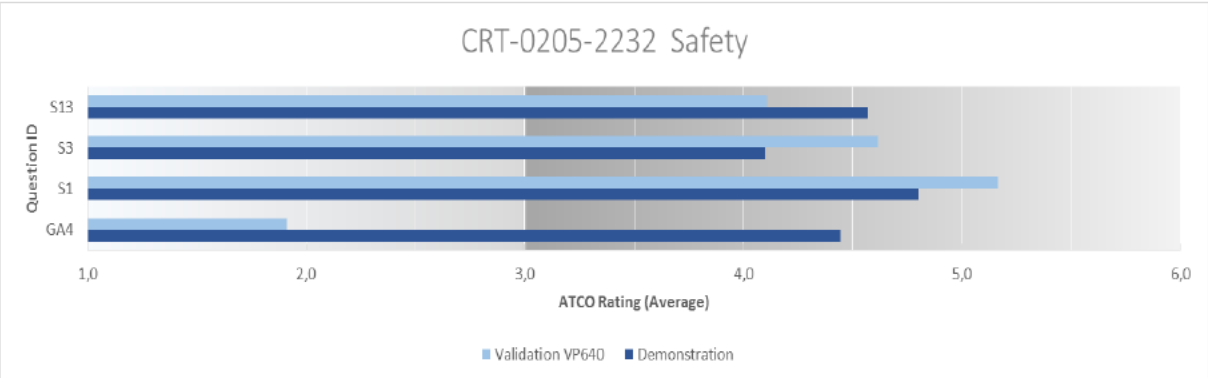


Figure 24: Results – Safety

The results on the questions related to human performance significantly improved in the demonstration compared to the validation VP-640. ATCOs provided mainly positive feedback that aircraft position, aircraft movements can sufficiently be recognised and estimated on ground, on and above the runway and in the arrival and departure sector when providing ATS from the RTM.

Aircraft characteristics could be identified to distinguish a small private plane from a helicopter on the panorama view.

Item key	Item Short
General Assessment 11	Aircraft identification
Assessment Panorama 12	Estimate position of aircraft on RWY
Assessment Panorama 14	Estimate position of aircraft in ARR / DEP sector
Assessment Panorama 16	Recognise ground movement
Assessment Panorama 18	Recognise airborne movement
Assessment Panorama 22	Recognise aircraft characteristics

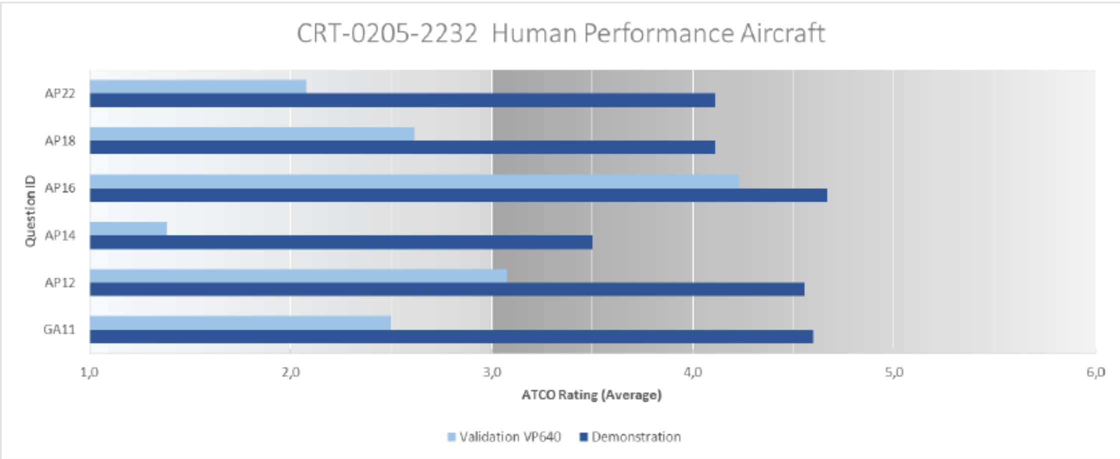


Figure 25: Results – Human Performance Aircraft

ATCOs also provided mainly positive feedback regarding evaluation of weather for switching the airfield lighting according to the ambient needs as well as for providing the operationally necessary information to the pilot based on the information presented in the CWP.

Item key	Item Short
Assessment Panorama 10	Evaluation of weather for switching airfield lighting
Assessment Panorama 11	Evaluation of weather for pilot information

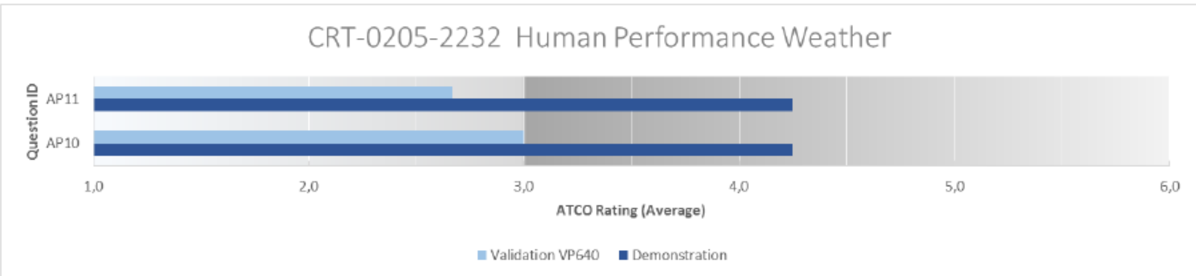


Figure 26: Results – Human Performance Weather

Overall result CRT-0205-7001b

The rating of safety and human performance aspects has significantly increased in the demonstration compared to the VP-640 validation. As almost all of the ratings are now around or above 4, the criteria is evaluated as 'OK'.

6.2.3.1.9 Results per KPA

The KPA Capacity was addressed by CRT-0205-2231 and CRT-0205-2232 (see chapter 6.2.3.1.5 and 6.2.3.1.6 for more details). The demonstration showed that there is no significant impact on capacity for an airport with traffic volumes like Saarbrücken airport (with additional traffic from Lufthansa Flight Training) when providing ATS from a remote location.

The KPA Safety was addressed by CRT-0205-7001 (see chapter 6.2.3.1.8 for more details). The safety assessment for the demonstration period (based on the coach/trainee principle) showed that level of safety is sufficient for providing ATS from a remote location.

The KPA Cost Efficiency could not directly be addressed in the demonstrations as it is an effect of scaling (mostly improved rostering of staff). In order to provide an order of magnitude an internal assessment was made by the ANSPs involved in the project. A range of cost as well as benefit in terms of reduction in staff are provided and can be used as baseline for a local cost benefit analysis (see chapter 5.3.1).

6.2.3.1.10 Results impacting regulation and standardisation initiatives

Results impacting regulation and standardisation were addressed by CRT-0205-6001 (see chapter 6.2.3.1.7 for more detailed information).

The system used in the demonstration was based on the operational and technical requirements that were produced within OFA 04.01.01. These requirements were already considered by EUROCAE WG 100 for standardisation and EASA RMT.0624 for regulation.

6.2.3.1.11 Unexpected Behaviours/Results

No unexpected behaviours or results were recorded during the demonstration.

6.2.3.1.12 Quality of Demonstration Results

The quality of the demonstration results is considered as very high due to the following aspects:

- The exercise results are based on measures of traffic volumes over almost two weeks and ATCOs subjective opinions that have been collected by means of questionnaires and discussions.
- The ATCOs were experienced with single remote operations from previous passive shadow mode trials.
- The ATCOs participating in the demonstration were chosen from different aerodromes. The ATCOs from Saarbrücken held the licence for the demonstration aerodrome and had a deep knowledge of the Saarbrücken environment, ATCOs from other locations (three other medium size aerodromes) could provide feedback on the potential transfer to different aerodromes that are also targeted.
- High number of ATCOs involved
- Lufthansa Flight Training flight programme allowing the ATCOs to evaluate a wide spectrum of procedures
- Normal and abnormal modes were considered

6.2.3.1.13 Significance of Demonstration Results

The operational significance of the demonstration results can be considered as very high since the demonstration took place in an operational environment (either in active or passive shadow mode). This implied the following items:

- Traffic volume was representative for medium size aerodrome comprising a representative mix of VFR and IFR traffic
- ATCOs actively provided ATS from the remote working position (which was based on a mix of operational and pre-operational systems)
- The demonstration was run over a period of two weeks

6.2.4 Conclusions and recommendations

6.2.4.1 Conclusions

Technical Implementation

The RTM used in the demonstration was properly implemented from a technical point of view. Implementation followed the technical requirements from 12.04.07 D09 TS – Technical Specification.

Despite the nature of the trial (the system will be further developed until implementation and ATCOs have a limited working experience with the system), the demonstration showed that ATCOs have a positive trend to trust into this system.

Some improvements are required for object bounding and PTZ-Tracking as explained in the recommendations chapter below.

Capacity

During the demonstration ATCOs actively controlled traffic at Saarbrücken airport. The demonstration was run with a representative mix of IFR and VFR traffic. Due to the additional flight program provided by Lufthansa Flight Training, the number of flights per day during the demonstration was significantly above the average traffic normally operating at Saarbrücken airport.

During the demonstration also quite complex traffic situations with up to 6 simultaneous movements could be handled from the remote tower module.

According to ATCO feedback, no significant delay occurred due to provision of ATS from the RTM during the demonstration and at the same time the airspace users feedback did not show any negative impact.

Visual information was used for the sequencing and separation of Aircraft during the demonstration from the RTM. Like in the local tower the frequency of applying visual separation at medium size aerodromes is rather low as there is seldom the operational need to apply it and if so, the possibility to apply it mainly depends on different factors like aircraft size and visibility conditions. During the demonstration ATCOs did not specifically mention any issue related to applying visual separation or spacing (neither in terms of not applying it due to working remotely nor in terms of increased application of visual separations due to better awareness due to RTM functionalities). Nevertheless it should be stated that visual separation might be applied less often from the RTM compared to a local tower based on the OTW view as the resolution and quality of the visual reproduction currently available does not provide the same image as the OTW view. But at the same time it can be concluded that visual separation in any case will only be applied when the conditions necessary are met (like in the local tower today) and thus visual separation will be as safe as in current operations from the local tower.

Object bounding and automatic PTZ-tracking increase the probability of detecting an aircraft and positively affects the certainty of the ATCO to re-establish visual contact after looking away. This could increase the probability of visual separation to be applied. Nevertheless, based on the explanation above, these functionalities are no prerequisites for applying visual separation.

Safety

ATCO feedback regarding safety in normal and abnormal conditions revealed mainly positive values.

The safety assessments for single remote tower operations and the associated training have been conducted according to DFS methodology in parallel to RTM development and will be finalized during deployment of the concept.

As object bounding and automatic PTZ-Tracking contribute to situational awareness, these functionalities have to be formulated as 'should' requirements for medium size aerodromes.

6.2.4.2 Recommendations

Visual Reproduction - Functionalities

Object bounding is seen as a feature of the visual reproduction for identifying objects and maintaining situation awareness. Therefore it has to be formulated as a 'should' requirement in the OSED for medium size aerodromes (while being a 'may' requirement for small aerodromes). The need for object bounding has always to be evaluated in combination with the quality of the visual reproduction and other available features and support functionalities (i.e. the higher the quality of the visual reproduction, the lower the need for object bounding).

Automatic PTZ-Tracking of objects in combination with the display of the viewing sector in the visual representation supports situation awareness and needs to be a 'should' requirement for medium size aerodromes.

Degraded Modes

Degraded modes should be investigated in more depth once the system functionality is fully available and the ATCOs have some more experience with normal and abnormal modes.

Regulation

In line with EASA Decision 2015/014/R, no need is seen for AMC or Implementing Rule for Remote Tower as existing rules are sufficient being complemented by the guidance material already available.

In addition to the basic equipment addressed with EASA Decision 2015/14/R, DFS demonstration used object bounding and automated PTZ-Tracking which are considered enhanced equipage. These functionalities were well received by the ATCOs.

In contrast to EASA decision, from DFS point of view an adequate Safety level of remote tower operations must be proven with the applicable safety assessment methodology. But there is no need to compare safety assessments to current operations.

Feedback from pilots indicated that there is no impact on airspace users when ATS is remotely provided. The demonstration has not shown any need for new surveillance technology to be introduced for single remote tower operations.

Regarding ratings, endorsements and licensing, no new results have been identified compared to what is already described in the OSED:

> *"A potential suggestion for the way forward regarding the licensing of remote tower ATCOs is that they shall hold an ADI rating with appropriate endorsements (i.e. radar, etc.) and additionally hold an RTC unit endorsement, complemented with specific local endorsements for the appropriate aerodromes that the skills will be applied to."*

Standardisation

Based on the demonstration results the operational requirements mentioned in chapter 6.2.3.1.7 have to be considered for medium size aerodromes.

6.3 EXE-0205-003 (Single – ATS for medium Airport)

The LVNL demonstrations were executed in three main steps: simulated remote tower operations, live single remote operations, and live multiple remote operations. In the simulated remote tower operations both Groningen Airport Eelde (EHGG) and Maastricht Aachen Airport Beek (EHBK) were simulated separately in single remote tower operations, and combined in multiple remote tower operations. This step was carried out, to familiarise the ATCOs and Air Traffic Control Assistants (ATCAs) with the remote tower concept and to build up confidence with the new controller working position (CWP), and to test the procedure design. The results of this step are part of the safety case towards the NSA. The other two steps were used to prove that ATS-services can be provided to one airport in an active shadow mode configuration (EXE-0205-003) and subsequently ATS-service can also be provided to two airports simultaneously in an active shadow mode configuration/ simulation configuration (EXE-0205-004). Figure 27 provides a schematic overview of the demonstration set-up.

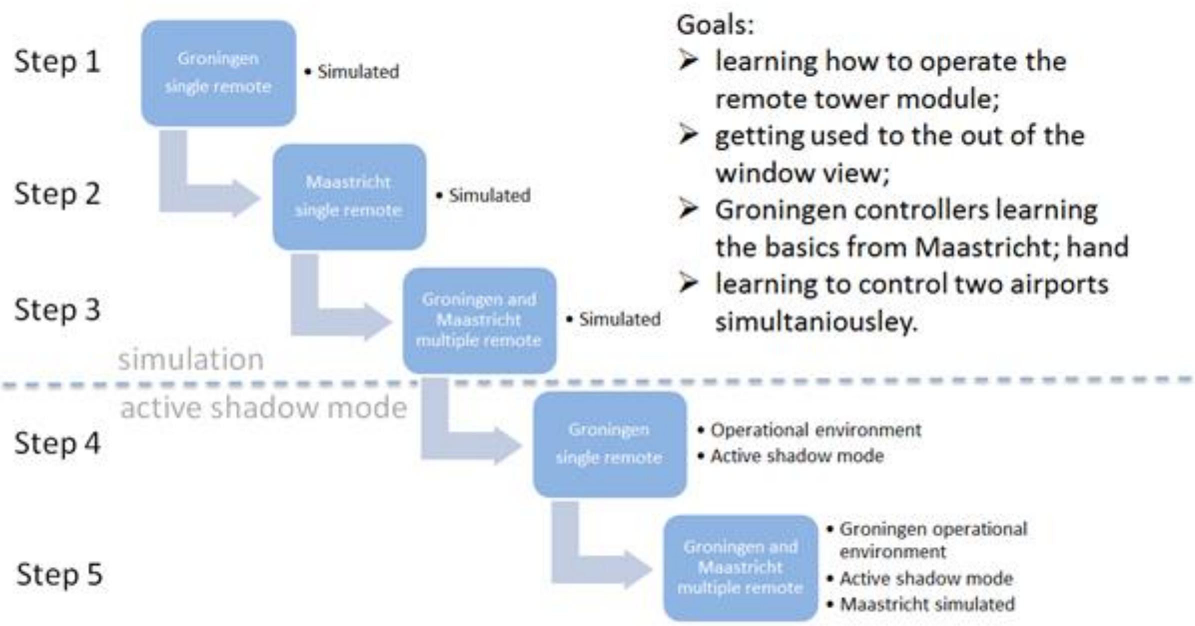


Figure 27: Demonstration set-up EXE-0205-003 and EXE-0205-004

6.3.1 Exercise Scope

EXE-0205-003 comprises the provision of ATS-services in an active shadow mode configuration to a medium size airport from a Remote Tower facility.

Eelde Airport (EHGG) is a medium-sized airport with approximately 46,000 aircraft movements annually, consisting of approximately 40,000 VFR flights and 6,000 IFR flights. The airport has two dependent and crossing runways: runway 01-19 (length 1500 meter, width 45 meter) and runway 05-23 (length 2500 meter, width 45 meter). Both runways are hard-surfaced with asphalt. The layout of Eelde Airport is depicted in Figure 28.

All VFR flights in the Eelde CTR have to submit a flight plan and they have to maintain two-way radio communication with Eelde TWR. All VFR operations in the Eelde CTR require prior permission from Eelde TWR.

The set-up (system-under-test) used in the demonstrations consisted of a Controller Working Position (CWP) including a Radar Display System (RDS), Electronic Data Display (EDD), Closed Circuit

Information System (CCIS), Voice Communication System (VCS) and paper flight data progress strips. A visual reproduction of the Out-The-Window-View (OTW-view) enabled visual observations in the aerodrome area with sufficient resolution to provide safe and expeditious aerodrome ATS. In addition to the OTW-view obtained from 9 stationary cameras, a Pan-Tilt-Zoom (PTZ) camera was provided to replace the conventional Binocular. The VCS provided communication facilities equivalent to those required for conventional Aerodrome ATS. The VCS was used for ground-ground and air-ground communications. Non-flight-critical systems which are not directly related to controlling aircraft in the air or on the ground, such as the runway and ground lighting control system, light gun, navigation-aid control, were not controlled from the RTC.

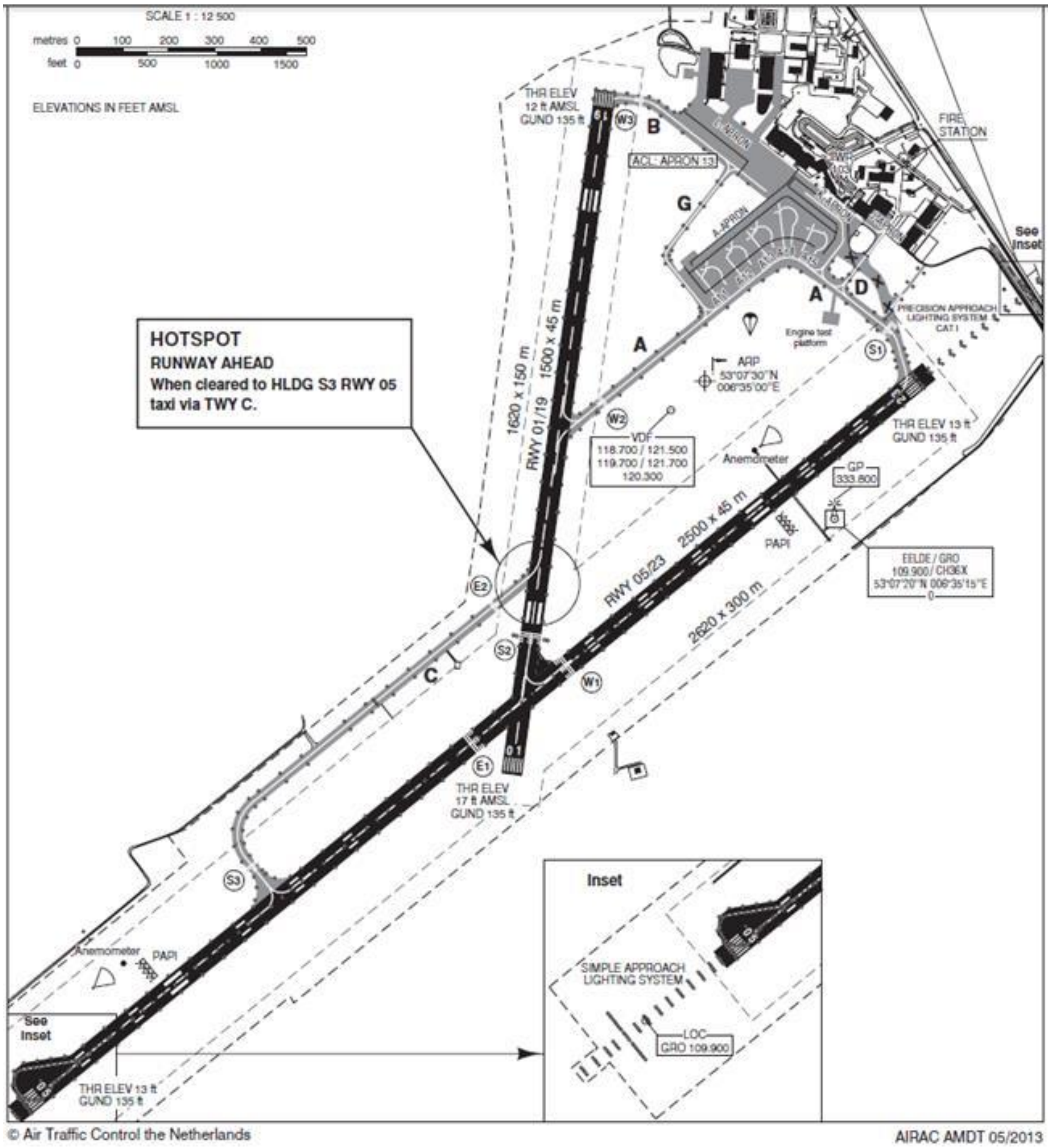


Figure 28: Groningen Airport Eelde aerodrome chart (Source: AIP The Netherlands)

The system-under-test as well as the used procedures had the approval of the NSA for the demonstrations in active shadow mode configuration. ATS-services were provided from the RTC in Amsterdam with a 'shadow' crew available at Eelde Airport. The shadow crew was available as fall-back for the RTC, but also performed some non-flight related tasks, such as receiving non-ATC related phone calls.

During EXE-0205-003 remote ATS were provided to air traffic at Eelde Airport in an operational environment. EXE-0205-003 was executed in both a simulation set-up and a live trial environment.

First, Eelde Airport was simulated on the NLR ATC Research Simulator (NARSIM), which provided all data required for the Remote Tower Facility. During this part of the exercise the operational concept for providing ATS to a medium-sized airport was demonstrated. To build up experience and confidence, the amount of aircraft to be controlled was increased gradually during the different scenarios. This was done in such a way that, in the final scenario, traffic densities were comparable to a busy day at Eelde with a highly complex operational situation. During each scenario information was collected to reach the objectives concerned. In this first part, it was demonstrated and confirmed that the operational concept and procedures for Eelde were appropriate to provide ATS-services. Besides this, the tower controller gained confidence in performing ATS-services for Eelde from the Remote Tower working position.

Similarly, Beek Airport was simulated (in step 2) on NARSIM with different amounts of traffic, but within the limits that were set for carrying out operations simultaneously with Eelde Airport.

Live trials were carried out after the simulation steps 1 to 3. In these trials (steps 4 and 5), remote ATS were provided to live traffic on Eelde Airport. ATS were provided from the Remote Tower working position, while a ‘shadow’ tower controller and assistant were available in the tower at Eelde Airport for back-up purposes. The flights for Demonstration exercise EXE-0205-003 included live flights performed by KLM Flight Academy.

After completion of EXE-0205-003 it was confirmed that the Remote Tower controller is able, from his remote working position, to control the normal amount of live air traffic for Eelde Airport.

The demonstration was carried out in line with the Demonstration Plan for LSD.02.05.

6.3.2 Conduct of Demonstration Exercise

6.3.2.1 Exercise Preparation

The LVNL RTC was set up for the simulation exercises, training and operational trials at the LVNL main building at Schiphol-Oost. The NLR ATC Research Simulator (NARSIM) platform was used for simulation exercises in preparation of the operational trials in a special configuration for integration into the LVNL RTC controller working position (CWP). Figure 29 shows the general set-up of the CWP at the LVNL RTC.

Figure 29: CWP Set-up in the LVNL Remote Tower Centre

The following displays were available for provision of (simulated or live) outside view:

- There were two rows of displays to provide an outside view (simulated or live) for a maximum of two airports.
- One PTZ camera was available for the ATCO and ATCA. The picture of this camera was shown on top of the OTW view. The camera was controlled via mouse input on the outside view displays in the operational system provided by SAAB. For the simulations carried out on the NARSIM platform, a touchscreen control panel for semi-automatic operation of the PTZ camera was built. This interface allowed placing the picture of the PTZ on pre-determined positions in the outside view. It also contained a number of pre-sets for the direction and zoom factor of the PTZ. Furthermore, the PTZ could be set to follow each active aircraft in the simulation.

Constraints in the operational trial set-up had consequences for the display system. It is expected that an eventual implementation will lead to a different set-up. For the current trial set-up, it means that the camera mast was placed on top of the control tower at Eelde. This had an impact on the maximum size and weight of the camera mast. In the trial therefore a smaller camera house with fewer cameras was used for each airport. This obviously meant that:

- There were only 9 instead of 14 displays per airport
- Displays were placed horizontally (in landscape mode) instead of vertically (in portrait mode) in order to achieve a 360-degrees horizontal view.
- Displays being placed horizontally result in a smaller vertical field of view.

The (virtual) position of the simulated cameras at Beek airport was different from the actual tower position. The chosen position was behind the actual tower position in order to have a better view on the taxiways directly in front of the tower. Otherwise the smaller vertical field of view would have cut off an essential part of the manoeuvring area.

Furthermore, there was no coupling between radar data and the outside view (no correlation, thus also no flight labels in the outside view).

The Eelde CWP included:

- Displays with EDD Eelde, CCIS Eelde and RDS Eelde
- VCS Eelde
- Paper flight strip bays for Eelde

The Beek CWP included:

- Displays with EDD Beek, CCIS Beek and RDS Beek
- VCS Beek
- Paper flight strip bays for Beek

The working position for the Eelde ATCA included:

- CCIS display
- VCS

Not all elements of a regular working position in a control tower were implemented in the RTC. The shadow crew available at Eelde control tower could therefore carry out tasks for which the necessary systems were missing in the RTC. In a real implementation of remote tower operations, it will be necessary to design the CWP in such a way that all tasks can be carried out.

The most important constraints of the CWP in the trial set-up were:

- Missing ADAS in the RTC / CWP
- Missing panels for switching of the runway and taxiway lights
- Missing VHF Direction Finder (use of bearing lines via RDS).

The systems that were left out of the RTC were chosen in such a way that it did not influence the execution of the primary task of the ATCO and ATCA.

Simulation environment

The simulations of both Eelde and Beek airports on the NARSIM platform were carried out for training purposes. For both airports, emulated versions of EDD, CCIS and RDS were available. Flight strip bays for both airports were available as well. The traffic and OTW view for the simulation scenarios was generated by NARSIM. The internal VCS of NARSIM was used for radio communication with the pseudo-pilots. Four working positions were set up in an adjacent room for the pseudo-pilots. These working positions included a special interface to control aircraft and apply the instructions given by the controllers. Pseudo-pilots were required to use proper R/T terminology for communication with the controllers. Therefore, only actual pilots with sufficient working experience were chosen as pseudo-pilots.

Besides expected simulator effects, the main difference between the NARSIM and the live RTO environment of SAAB was the way to control the PTZ camera. As described above, camera control on NARSIM was accomplished via a touchscreen interface on which the desired camera position, scan patterns and aircraft to follow could be chosen.

In contrast to the live environment using the SAAB system, the PTZ picture could only be projected at a number of pre-determined positions on the outside view. However, there was an option to attach the picture to an aircraft to be followed. Furthermore, information overlays were not shown on the NARSIM outside view.

The NARSIM platform set-up in the LVNL Remote Tower Centre is shown in Figure 30. The aim of the mentioned real-time simulations was to familiarize controllers with the new situation regarding systems, working position and the available camera images as well as the additional functionality provided by the PTZ camera.

The PTZ camera allowed for projection of a picture-in-picture image on top of the 360-degree outside view. With this additional camera, the image could be zoomed in on an aircraft or even be linked to an aircraft position in order to monitor aircraft movements.

Figure 30: LVNL Remote Tower Centre Displays with Groningen Airport Simulation

The following tables give an overview of the different scenarios that were available for simulation on the NARSIM platform in Single Remote Tower configuration (for Eelde and Beek respectively).

Per trial step, different types of scenarios were defined with a gradual increase in air traffic. Scenarios also differed in the type of traffic and runway configurations in use.

For each simulation step and scenario, the following overview gives a short description and summarises the aims.

Trial Step 1: EHGG Single

Scenario	Description of the Scenario
1a	Taxiing and ground traffic and control of standard IFR and VFR traffic on a single runway (05).
1b	Taxiing and ground traffic and control of standard IFR and VFR traffic on a single runway (23).
2a	Control of VFR circuit traffic, departing and landing VFR traffic and the integration of that traffic with circuit traffic with simultaneous use of two crossing runways (23 and 19).
2b	Integration of landing and departing VFR and IFR traffic with airfield circuit traffic with simultaneous use of two crossing runways (05 and 01).
3	Control of landing and departing VFR traffic in combination with changing runway directions and opposite approaches, with successive use of runways 05, 01 and 23.

Scenario	Aim of the Scenario
1a / 1b	• Familiarization of controllers and assistants with the Remote Tower concept • Gaining experience in working with the Remote Tower Module including the Controller Working Position (CWP)
All	• Testing of traffic scenarios (for trial steps 3 and 5, see chapter 6.4)
2a / 2b / 3	• Finding answers to the identified research questions
All	• Collecting information for safety assessment

Trial Step 2: EHBK Single

Scenario	Description of the Scenario
1	Two (short scenario) or three (long scenario) IFR flights (one arriving and one/two departing flights) with use of runway 21.
2	Three (short scenario) of four (long scenario) IFR flights (one/two arriving and two departing flights) with use of runway 21.

Scenario	Aim of the Scenario
All	• Familiarize EHGG controllers with controlling EHBK traffic • Investigate role definition of controller and assistant for EHBK • Testing of traffic scenarios (for trial step 3)
All	• Collecting information for safety assessment

In order to better prepare the actual live trials, it was decided to have an additional passive shadow mode test in the days before the live trial with the involved air traffic controllers. This was a deviation from the planned activities and is therefore mentioned in chapter 6.3.2.3.

6.3.2.2 Exercise execution

The first live trial was carried out in the Remote Tower Centre of LVNL at Schiphol Airport on September 8, 2016. It consisted of two time periods during which control of the flights was completely delegated from Eelde tower to the RTC controller team in Amsterdam. The controller team consisted of the ATCO and ATCA (both from Eelde).

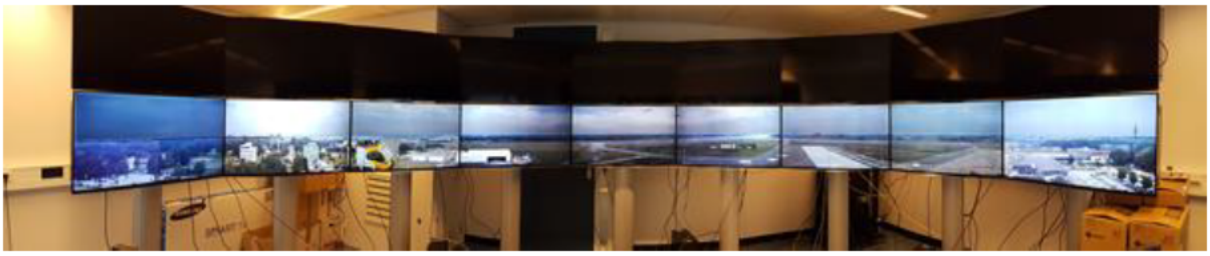


Figure 31: Single Remote Tower operation set-up for Groningen Airport Eelde

Generally, single remote tower operations were continuously carried out in both time periods (see Figure 31). To assess multiple remote tower operations, three additional flights (two landings and one departure) were carried out in simulation on the NARSIM platform for Beek (see also chapter 6.4).

The first live trial control period lasted from 11:39 hrs. until 13:24 hrs. The second period lasted from 15:01 hrs. until 15:31 hrs. All times are in UTC.

The following table gives an overview of the flights carried out at Eelde.

Flight ID	Aircraft type	Arrival/ Departure	Dep. Airport	Arr. Airport	IFR/VFR	Time 1	Time 2	Remarks	# of Movements
DEHUF	C175	ARR	EHAL	EHGG	VFR	11:44		None	1
PHKDN	C172	DEP	EHGG	EDWR	VFR	11:48		None	1
PHBYB	BE58	DEP/ARR	EHGG	EHGG	VFR	11:53	12:50	2 x touch-and-go	6
PHTOO	C206	OVER FLIGHT	ZZZZ	ZZZZ	VFR	11:55		None	1
OOAIS	BE20	DEP/ARR	EHGG	EHGG	IFR	07:31	12:01	departure not remotely controlled	1
PH2Z7	P92	OVER FLIGHT			VFR	12:00		None	1
PHAIS	TAMP	OVER FLIGHT	EHLE	EDWR	VFR	12:05		None	1
LIF004	EC35	DEP	EHGG	AZGZ	VFR	12:06		None	1
PHHLM	PA34	DEP/ARR	EHGG	EHLE	IFR	12:12	12:49	2 x touch-and-go	5
PHTGL	P28A	DEP	EHGG	EDWR	VFR	12:24		None	1
OHGSC	SR22	DEP/ARR	EHGG	EHGG	VFR	12:28	13:02	None	2
PHSTP	C172	DEP/ARR	EHGG	EHGG	VFR	12:51	15:24	4 x touch-and-go	10
WHS3AD	A139	DEP	EHGG	ZZZZ	VFR	13:06		None	1
PHKDN	C172	ARR	EDWR	EHGG	VFR	13:17		None	1
OOAIS	BE20	DEP/ARR	EHGG	EHGG	IFR	13:24	13:38	arrival not remotely controlled	1
STK637G	AT76	DEP	EHGG	EGMC	IFR	15:21		None	1

LIF004	EC35	ARR	AZGZ	EHGG	VFR	15:29		None	1
WHS3AD	A139	DEP	EHGG	ZZZZ	VFR	15:29		None	1

Table 15: Flights carried out at Groningen Airport during live trial on September 8, 2016

6.3.2.3 Deviation from the planned activities

The only major deviation from the planned activities was an additional passive shadow-mode test that was executed for two reasons. First of all, controllers had to be familiarised with the controller working position and the system functionality (mainly the PTZ interface) for the live trial. Secondly, it had to be assessed whether there were gaps regarding the visibility of VFR flights in the different circuit patterns. The latter was achieved by carrying out all these flights with the help of a pilot on Eelde Airport during the passive shadow-mode tests. The corresponding ground tracks are shown in Figure 32.

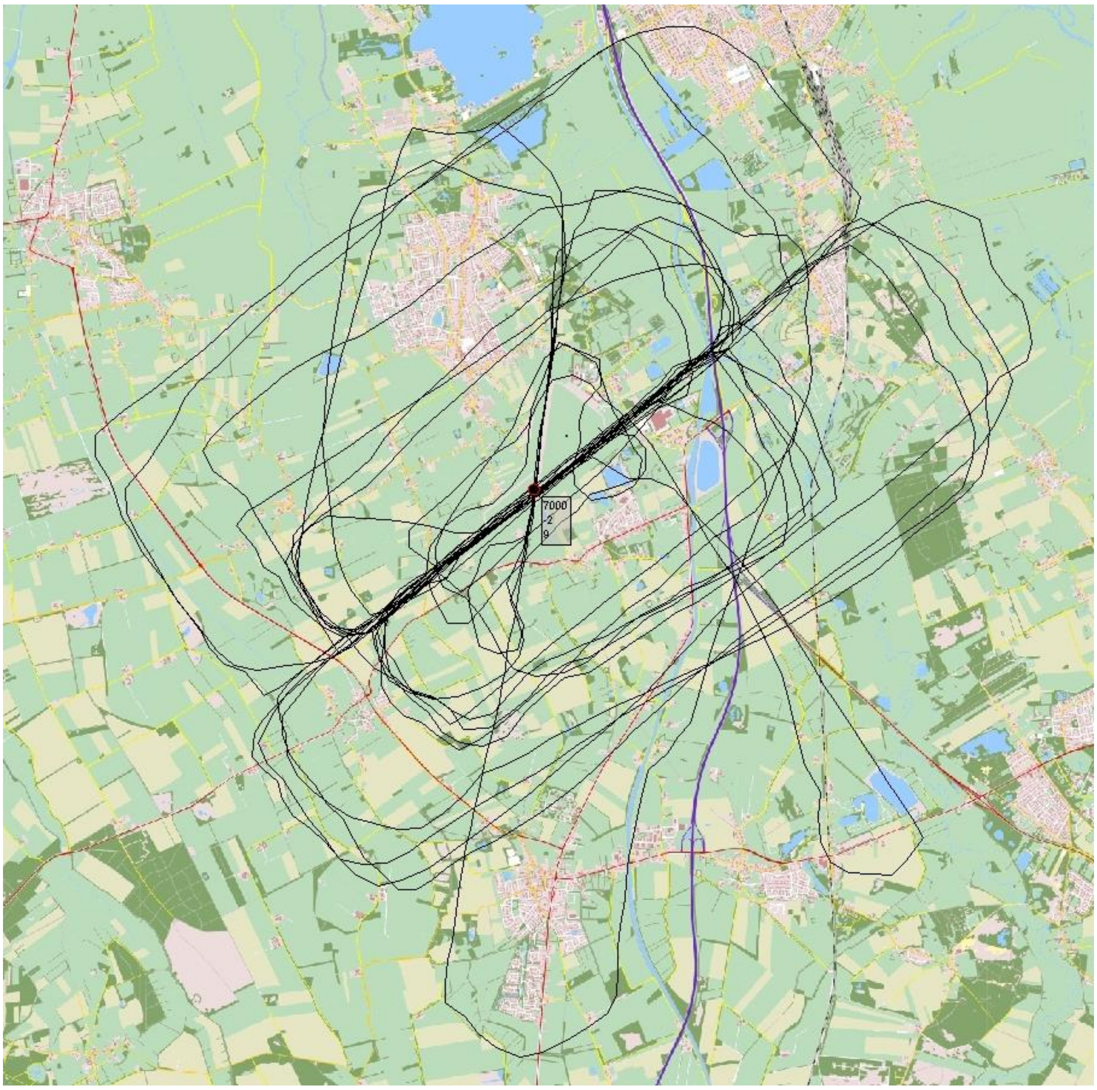


Figure 32: Ground track of VFR pattern test flight during passive shadow-mode test on Eelde

6.3.3 Exercise Results

6.3.3.1 Summary of Exercise Results

This section provides answers to OBJ-0205-300, which was to demonstrate that remote ATS can be provided to a medium-sized airport both from a technological and an operational point of view. Above that, it had to be demonstrated that the ATCO could, from the RTM, provide sufficient capacity to that airport.

Sections 6.3.3.1.1 to 6.3.3.1.6 describe the results that were found. Statements in these sections are the outcome of debriefing sessions or questionnaires. Opinions from ATCOs are given without a thorough analysis, as the data basis for such an analysis is not always available. Whenever researchers have made an analysis based on their own experiences and observations this has been indicated separately.

6.3.3.1.1 Reliable and applicable for medium size airport

This section provides answers to OBJ-0205-331, which was to demonstrate that RTO is reliable and applicable at a medium size airport, such as Eelde.

Simulation trials

At the end of the debrief after the simulation trials the ATCOs and assistants were asked whether they had seen and learned enough in order to move on to the next step (or phase). Every time they were asked this question, all operational experts confirmed that they were ready to take the next step. So for each simulation trial it can be concluded that it was the right preparation for the next simulation trial and all simulation trials together were considered sufficient preparation for the live trials. Note, that after the simulation trials the ATCOs have asked for an opportunity to participate in a passive shadow mode trial prior to controlling the traffic in live trials.

These passive shadow mode sessions would allow them to get used to the level of detail that the cameras plus monitors provide and it would allow them to get used to the interface of the PTZ camera. After all, this camera is operated in a different way than the PTZ that was used in the simulation trials.

6.3.3.1.2 Switch between RTO and conventional tower

This section provides answers to OBJ-0205-332 to demonstrate that it is possible to switch between RTO and the conventional way of controlling from the tower.

Besides switching the controls, there is more that needs to be transferred. Within the conventional tower the same procedure applies. Examples of what needs to be transferred and exchanged are: tasks, NOTAMS, report of what happened during the shift, OPS forms, etc. This was considered unnecessary for the special situation of a live trial. If such a transfer would need to be happening more frequently, a solution may be a tablet containing all information necessary for a proper transfer of control.

6.3.3.1.3 Impact on KLM Flight Academy

This section provides answers to OBJ-0205-333 to demonstrate that the live trials have no impact on the operations of the KLM Flight Academy.

Air traffic movements were measured and there was no impact on traffic levels for medium size aerodromes. No reduction in capacity was noticed. However, it was remarked that during high traffic demand there may be a need to reduce complexity. Such reduction of complexity can be made by ATCOs by simplifying traffic patterns whenever needed, for example just clearing all traffic in the same traffic pattern (no opposite patterns). This would mitigate risks and ATCO concerns but also decrease flexibility for airspace users.

Capacity will depend on the quality of the visual reproduction, in particular for smaller vessels. A reduced viewing angle, as in this demonstration, or lower image quality will affect capacity as ATCO will need to adjust working methods by reduction of number of simultaneous aircrafts (similar reductions are made during conventional operations when visibility is lowered).

Suggestions from debriefs and questionnaires show that quality of the visual reproduction is important for capacity and flexibility. Technical tools and features will help ATCOs to keep up capacity, such as radar labels, visual tracking and all of those has to work accurate.

6.3.3.1.4 Capacity under RTO

This section provides answers to OBJ-0205-334 to demonstrate that no decrease in capacity is experienced regardless of operational procedures while operating the RTC.

From step 1 – simulation trials

The traffic offered in simulation step 1 is handed off flawlessly by both ATCOs. In step 1, a number of scenarios (which also included vehicle movements) were offered with increasing complexity:

- 1a: 16 VFR, 4 IFR = 20 a/c per hour
- 1b: 16 VFR, 6 IFR = 22 a/c per hour
- 2a: 16 VFR, 2 IFR, 4 local = 22 a/c per hour
- 2b: 18 VFR, 2 IFR = 20 a/c per hour
- 3: 12 VFR, 16 IFR, 4 local = 32 a/c per hour

Scenario 1 and 2 took approximately 30 minutes and scenario 3 approximately 45 minutes.

The traffic that was offered in all scenarios of the first step is described in more detail in Section 6.3.2.2. Due to simulation issues a few flights were cancelled. This was very rare. Therefore based upon the performances in step 1 there is no reason to assume that the capacity required cannot be realised.

During the debriefing session, ATCOs indicated that capacity will be reduced slightly. The main cause for this is the visual reproduction. This was caused by the specific set-up of the cameras used in the demonstration (e.g. 9 instead of 14 cameras and the sub-optimal location of the camera mast) and can be mitigated. Mitigation can be accomplished by installing more (14) cameras in portrait mode, which increases the vertical field of view, higher resolution cameras, and cameras with a wider optical lens angle. Unfortunately no accurate assessment about the effect of such an improved visual system could be made. As a result of this limitation, aircraft at higher altitudes cannot be acquired visually. This makes it difficult to provide visual separation for aircraft flying in circuits. Also mixing of circuits will become more complicated due to the specific local procedures in combination with the airport layout with two crossing runways. So the capacity of circuits is expected to decrease under RTO.

The answers to the questionnaire support these statements. In the questionnaire the ATCOs expect a capacity that is lower or even much lower than under the current conditions.

All operational experts agreed that an ATCA for controlling vehicles and start-up was really needed. In addition, the ATCA performs support tasks for the ATCO, such as preparing flight plans and co-ordinating with other organisations such as the airport authority.

One ATCO indicated that he expected that weather conditions under RTO had less impact on capacity than under normal operations. So he predicted less capacity reduction due to poor visibility. But this statement is made, assuming that additional features like IR cameras and digital strips combined with the tracking function of the PTZ will be provided. The features mentioned will allow the ATCO to see aircraft earlier and spend more time looking up under poor visibility conditions. Thus, the impact of poor visibility conditions should be reduced in the remote tower when compared to conventional towers. It should be noted that for the set-up that was used in the trials, such features were not foreseen.

From step 4 – live trials

Air traffic movements were measured and there was no impact on traffic levels for medium size aerodromes. No reduction in capacity was noticed. However, it was remarked that during high traffic demand there will be a need to reduce complexity.

Due to visual limitations of the system that was used during the demonstrations, especially when separating visually, there will be a need to reduce complexity, e.g., to reduce the number of VFR aircraft flying simultaneously in VFR circuits. The mix IFR/VFR is important with respect to complexity and capacity but could not be tested thoroughly in the live trials.

In the current set-up, certain circuit-altitudes will be beyond range of the cameras, which results in capacity reduction. After all, if ATCOs cannot visually acquire the aircraft in the circuit all the time, they need to apply larger separation distances so that the circuit capacity reduces. This may be mitigated with better (wider optical lens angle, or portrait-mode set-up, and higher resolution) cameras.

Also, and more importantly, aircraft (especially the smaller ones) are sometimes more difficult to see (and will therefore be spotted later) than during normal operations. This traffic might need to be limited by the ATCO in order to be able to sufficiently monitor all traffic. This was experienced in the demonstration at Eelde Airport with smaller aircraft using various patterns and procedures at different altitudes at the same time. As mitigation, researchers and observers suggest that visual tracking should be used to enhance smaller objects.

In fact, the safety buffer is slightly increased during remote operations, comparable to operations with slightly poorer visibility conditions. That, of course, has potential consequences for the capacity.

6.3.3.1.5 RTO for normal operation

This section provides answers to the question: *"Is the RTO environment sufficient for execution of normal RTO tasks?"*

From step 1 – simulator trials

Between the different scenarios during the simulator trials, the CWP was adjusted according to the preference of ATCOs or ATCAs. See also section 6.4.3.1.3 for the adjustments that were suggested for the multiple RTO.

The possibilities of pre-sets for the PTZ (as modelled in the NARSIM platform) were highly appreciated and also frequently used. One of the ATCOs focuses the PTZ by default on S2/S3 or final of RWY 05. In fact, he thereby creates a view zoomed in on an area that he wants to monitor repeatedly.

More difficult is an assessment of what the relative position between two aircraft in the circuit is. This difficulty has a negative impact on the ability to visually separate aircraft. This is especially true when considering that aircraft could potentially be flying outside the viewing angle of the cameras. A mitigation strategy for ATCOs is to apply larger separations. If aircraft are constantly visible and easy to spot, the additional separation will not be necessary. Therefore, the ideal mitigation is to apply technology that ensures that aircraft in the circuit are constantly visible on the OTW view.

ATCOs suggest that possibly the RDS bearing line is a useful tool to help detect aircraft in the OTW view. Just like in reality, sometimes the pseudo-pilots in the experiment reported an erroneous position. By using the RDS de ATCO maintained his situational awareness. In reality the bearing of the direction finder is often used for localising aircraft.

The visibility of a number of small (circuit) aircraft was too poor. Aircraft were too small to visually detect them. In the simulation the size of an aircraft could be increased to a level that ATCOs could easily spot them. This was actually done on the NARSIM platform. In reality, however, increasing the size of an aircraft on the OTW view monitors is not an option. Researchers and observers suggest that, instead, highlighting features in the OTW view, such as a clearly visible square around every aircraft, e.g. based on infrared pictures or radar data, could be applied. It is important that such a system only highlights relevant objects.

From the questionnaires, it could be concluded that ATCOs did not have a complete overview of the traffic that they are responsible for. One ATCO indicated that the OTW view was not sufficient. He stated that aircraft were sometimes flying out of view, in particular for a start from RWY 05, on the final of RWY 01 and a departure from RWY 01.

The PTZ camera was a good / acceptable replacement of the binoculars and absolutely necessary for a number of critical aspects of the ATCO's job.

The ATCOs always knew which aircraft they were communicating with. But they suggested that it should be made sure that loudspeakers will be installed in such a way that there is a clear distinction between air and ground frequencies. The current configuration in the normal tower is a good example.

One ATCO considered RTO a feasible commercial concept. After completing the step 1 simulation trials, he stated that it was safe, reliable, robust, fast-to-learn, and acceptable. He thought that performance was not impaired by the concept.

From step 4 – live trials

The subjects reported about changes in tasks and opportunities to execute those tasks. Below an overview of their remarks is given.

Detection of audio (volume, direction of audio source, intercom, R/T speaker) was more difficult compared to the conventional tower. In this remote tower set-up audio came from one direction, which creates a kind of “noise” that hinders the communication and might result in missing transmissions. A better separation of audio sources, like in the normal tower, in R/T plus intercom versus monitoring and telephone would improve the situation. Then it would still be possible to hear the pilots, even when a telephone call is received. Sometimes the assistant has quite long calls. During the trials a headset solved the problem partly, but a truly different setting of the loudspeakers would be the ideal solution. A nice-to-have, though not a necessity, was the ability of hearing the aircraft noise via the loudspeakers.

The ATCO and ATCA stated that relevant objects and locations could be observed from the remote tower OTW view. Visibility was considered acceptable, although not as good as from the normal tower. For example, there was an aircraft near RWY 05 at Eelde Airport that was visually detected from the normal tower while it was not visible for the remote tower outside view. The remote tower crew did detect the aircraft on their RDS.

Altogether, the traffic at Eelde Airport was considered easy to handle without informational use of the radar screen. ATCO and ATCA were both very positive about this.

The additional features, like the PTZ camera are improvements. The PTZ offers opportunities to see things that one normally cannot see from the tower, or are not the core responsibility of the ATCO but can aid his understanding of the on-going processes at the airport. For example: at the platform within the red-line boundary, the J-apron, and intersection S3. The PTZ camera can also be used for highlighting hotspots. It would be desirable to have a panel with pre-set buttons to swipe the PTZ camera quickly to these hotspots.

The visual tracking (squares around moving aircraft) was very useful. A normal landing is, at the video wall (without the PTZ camera), more difficult to see in detail compared to the normal situation. The squares around the aircraft make it easier and faster to detect them in the outside view. This is especially relevant, if an ATCO has to monitor multiple areas of interest in the OTW view, e.g. if an aircraft is supposed to make a turn in departure when the ATCO also has other (taxiing) aircraft to monitor. In that situation, the square is very useful for determining the position of that turning aircraft quickly and easily.

Sometimes, however, there are too many squares (for example, the ones around the shade of an aircraft on the ground when the aircraft is landing), and this is considered confusing. After all, too many moving squares make the situation look more complicated than it actually is. Researchers and observers suggest putting more effort into developing a system with visual tracking squares that don´t miss an aircraft and that do not highlight irrelevant objects such as clouds or shadows. Such a system would mitigate a lot of confusing situations that happened during the trials and that would reduce ATCO mental workload and increase ATCO effectiveness. Ideally, the tracking should be linked to the surveillance system, ensuring that all relevant objects are highlighted at all times.

The workshare between ATCO and assistant during the RTO trials was the same as in the normal tower.

The CWP is not the same as in the normal tower. Location of strips, loudspeakers, possibilities with the telephone horn, how instruments are divided over the desks were in this setup different from the normal tower. These changes require adaptation from the ATCO, and that adaptation takes time and reduces ATCO workload. Note that the ATCO needs to get used to such a new situation and that after a longer period, the ATCO will probably be able to cope better with that new situation. Therefore the suggestions and recommendations that were described in section 6.3.4.2 should be taken into account when designing an operational remote tower.

The step 4 trial quality of the OTW view on the monitors was good. There was slightly less contrast than in the normal tower. For example, on the monitor there are no clouds of dust visible when the wheels of a landing aircraft touch the ground. The ATCO thinks that due to that slightly poorer contrast it may so that he might respond later in case he needs to push the alarm button. A solution may be to automatically zoom in on landing aircraft just before weight-on-wheels, e.g. in an inset that does not block the view on the rest of the runway.

The fact that the 360 degrees OTW view is projected on the monitors in a 180 degrees set-up, is no problem for ATCO and ATCA.

Operating the PTZ camera was something that ATCO needed to get used to, in particular, due to the many computer mouse movements that were needed. The ATCOs prefer a system with buttons and pre-defined locations that guides the PTZ camera directly to a particular position.

In general, information should come to the controller, and should not have to be looked for.

6.3.3.1.6 Impact on human / team

This section provides answers to the question: *"What is the impact of RTO on human / team performance?"*

From step 1 – simulation trials

The additional tools, in particular the PTZ camera, have added value for the human operator. The ATCO's overview on RWY 05 was improved compared to the situation without PTZ camera. Operating the camera required more attention than the ATCOs preferred. Possibly the ATCO needs to build experience with the system after which operating the PTZ camera may become more intuitive. One ATCO said: "I use it for 60% of the time to monitor critical spots, the other 40% to track aircraft". Note that the user interface for the simulated PTZ camera on the NARSIM platform is different from the real PTZ camera provided by the SAAB system.

As long as aircraft disappear from the monitors at certain altitudes, it will not be possible to mix them into circuits. That would reduce capacity in the live trials and is comparable to a situation in the tower when an aircraft is flying overhead.

Aircraft were sometimes difficult to spot and sometimes remarkably easy to identify. It has happened that the pixels of an aircraft on final were not clearly visible. This could be a simulation issue. This phenomenon was checked upon during the live trials.

Workload

Basically the workload is influenced because the normal routine at the tower is interrupted and the ATCO has to 'think again' about where information may be found, hardware is placed, landmarks in the outside world are located etc. A particular example that was mentioned was the location of the loudspeaker for co-ordination with approach. Note that approach at Eelde is in the same room as the tower controller. Therefore, approach has more information available than what is communicated by intercom. It should be noted, that in the live trials the locations of some hardware will slightly change again. The traffic load was mild and was not mentioned as a factor that influenced workload.

One ATCO said that most workload was caused by aircraft that disappeared from the OTW view. Workload was also caused when they reappeared. Sometimes they had an unrealistic approach profile where they descended too steep and too fast or they pulled up too late from the runway. Thus, workload ratings have been influenced by this.

Situational Awareness (SA)

SA was reduced due to aircraft that sometimes disappeared from the OTW view as has been described above. It was suggested to set the angles of the cameras a bit higher. After all, what happens on the platform is more predictable than what happens in the air.

6.3.3.1.7 Results per KPA

The KPA Capacity was addressed by CRT-0205-3341 and CRT-0205-3342. The demonstration showed that there is no significant impact on capacity when providing ATS from a remote location. However, it was remarked that during high traffic demand there may be a need to reduce complexity. Capacity numbers demonstrated during the live trials were comparable with or above the numbers associated with medium-size airports.

ATCOs explained that capacity will reduce slightly, but that performing operations like opposite approaches and good planning and scheduling of (VFR) flights, and mixes of VFR and IFR flights capacity may remain almost the same at the cost of flexibility (and possibly efficiency).

During the simulation and the live trials, safety was never an issue. ATCOs claimed that operations can be made safe as long as overly complex traffic-mixes, such as opposite approaches, are avoided. The same applies in conventional operations where operators reduce number of complex patterns with increased levels of traffic.

6.3.3.1.8 Results impacting regulation and standardisation initiatives

The system used in the demonstration was based on the operational and technical requirements that were produced within OFA 04.01.01. These requirements were already considered by EUROCAE WG 100 for standardisation. No further activities or results had an impact on regulation or standardisation. Possibly, feedback given regarding the set-up of the controller working position will contribute to standardisation of a Remote Tower Centre working position. Items like location of loudspeakers and interface for controlling the PTZ are examples. Also the position of the cameras in relation to the runways might contribute to improved standardisation of the interface and the work in remote tower centres.

6.3.3.1.9 Unexpected Behaviours/Results

During the trials no major unexpected behaviours or results were identified.

6.3.3.1.10 Quality of Demonstration Results

Both sources of information (i.e. simulation and live trials) provided different kinds of information about the feasibility of the remote tower concept. In the simulation, there were more opportunities for the controllers to ‘experiment and try things out’ which would not be acceptable in a real setting. The live trials provided a more realistic visual and included some aspects like transfer of control between normal tower and remote tower that were not covered in the simulations.

The quality of the demonstration results is considered to be very high due to the following aspects:

- The exercise results are based on measured traffic volumes;
- ATCOs provided feedback that was collected in a structured way by means of questionnaires and debriefs;
- Airspace users provided a flight programme allowing the ATCOs to evaluate a wide spectrum of procedures;
- Simulation trials were used to familiarise ATCOs with the second airport to be controlled during the multiple remote trials;
- Eurocontrol’s standardised indicators SASHA and SATI were used during the trials.
- The NASA-TLX scale was used for workload ratings.

6.3.3.1.11 Significance of Demonstration Results

Two different teams of ATCO and ATCA participated in the trials. Each team participated in a number of trials, often even several trials within each step. Therefore levels of statistical significance could not be calculated. However, the subjects have experienced quite a number of different situations within both passive and active trials and were therefore hands-on experts who were very well able to discuss the advantages, disadvantages and items to take into account before actual implementation of the concept. Furthermore, the ATCOs were also involved in the project for a longer period of time, and they are normally working at Eelde airport. Therefore, they were the ideal subjects to provide their comments in a relevant operational perspective.

The operational significance of the demonstration results can be considered as very high since the demonstration took place in an operational environment in active shadow mode. This implied the following items:

- Traffic volumes were representative for the (medium size) aerodrome comprising VFR and IFR traffic;
- ATCOs actively provided ATS from the remote working position (which was based on a mix of operational and pre-operational systems).

6.3.4 Conclusions and recommendations

6.3.4.1 Conclusions

From step 1 – simulation trials

The RTO concept is feasible and acceptable for ATCOs. Situational awareness (SA) and workload remained acceptable during the trials. ATCOs think that the current capacity will still be feasible, though a number of remarks about the impact on capacity were made as well. Most importantly, opposite approaches and a complex mix of (VFR/IFR) traffic have the biggest impact on capacity. There are also a few situations that can be executed under normal tower operations but which are foreseen to be more difficult to execute under RTO without proper mitigation actions.

From step 4 – live trials

The live trials supported the findings from the simulation trials. The ATCOs reported that controlling traffic from a remote CWP is possible. With respect to the capacity a small decrease is expected due to the specific local procedures (e.g. overlapping traffic circuits, opposite approaches), but not as much as anticipated earlier during the simulation trials.

Visual tracking and automatic PTZ-tracking increase the probability of detecting an aircraft and helps an ATCO to re-establish visual contact after looking away. Nevertheless, based on the explanation above, these functionalities are no prerequisites for applying visual separation.

As object bounding and automatic PTZ-Tracking contribute to situational awareness, these functionalities have to be formulated as ‘should’ requirements for medium size aerodromes.

6.3.4.2 Recommendations

A number of minor issues were reported by the controllers and also recommendations (suggestions for mitigation) were given. Below these recommendations are described:

From step 1 – simulation trials

An improved OTW view must be provided to the ATCOs for complex operational situations. Improvement could be in the form of an increased number of cameras in portrait mode to increase the vertical field of view, and a wider optical lens angle. The vertical field of view is too small to be able to monitor circuits well enough and to merge aircraft into the circuits. When observing downwind approaches, it is difficult to see whether aircraft are turning towards the RWY at the right moment. For the live trials, it is recommended to carefully monitor whether this issue is acceptable for real operations or the same as in the simulations.

From step 4 – live trials

Suggestions made by the controllers were:

An improvement in the OTW view regarding both the vertical field of view and camera picture resolution, as well as certain augmentations, such as better tracking and integrated radar data, will help mitigate the expected reduction in capacity due to complex traffic patterns and flight procedures (e.g. opposite approaches).

Easily accessible pre-set buttons to quickly point the PTZ camera to certain predefined hotspots as well as a simpler interface for the PTZ camera are desirable.

A tablet or other means to exchange documents and information for switching control between conventional tower and remote tower is helpful.

Position the loudspeakers in such a way that the controller can always focus on the audio that s/he is interested in. That can be done by using different speaker positions for R/T with the aircraft and all other audio like telephone calls and communication with vehicles.

Regarding the situation at Eelde Airport, the recommendation is to investigate the feasibility of opposite approaches with early (4NM on final) visual contact under remote tower operations in order to bring capacity and flexibility more in line with normal tower operations.

6.4 EXE-0205-004 (Multiple – ATS to small and medium Airport)

6.4.1 Exercise Scope

In this paragraph, only additional information to EXE-0204-003, see chapter 6.3, will be inserted.

In EXE-0205-004, the concept for Multiple Remote Tower was demonstrated for providing ATS-services to a medium-sized airport and a small-sized airport simultaneously. Both airports are operated from one Remote Tower facility at Schiphol Airport (LVNL). The airports that were remotely controlled from the Remote Tower Centre were Groningen Airport Eelde (active shadow mode) and Maastricht Aachen Airport Beek (simulated).

Eelde Airport (EHGG) has been described in the previous section (chapter 6.3.1). The layout of Beek Airport is depicted in Figure 33 below.

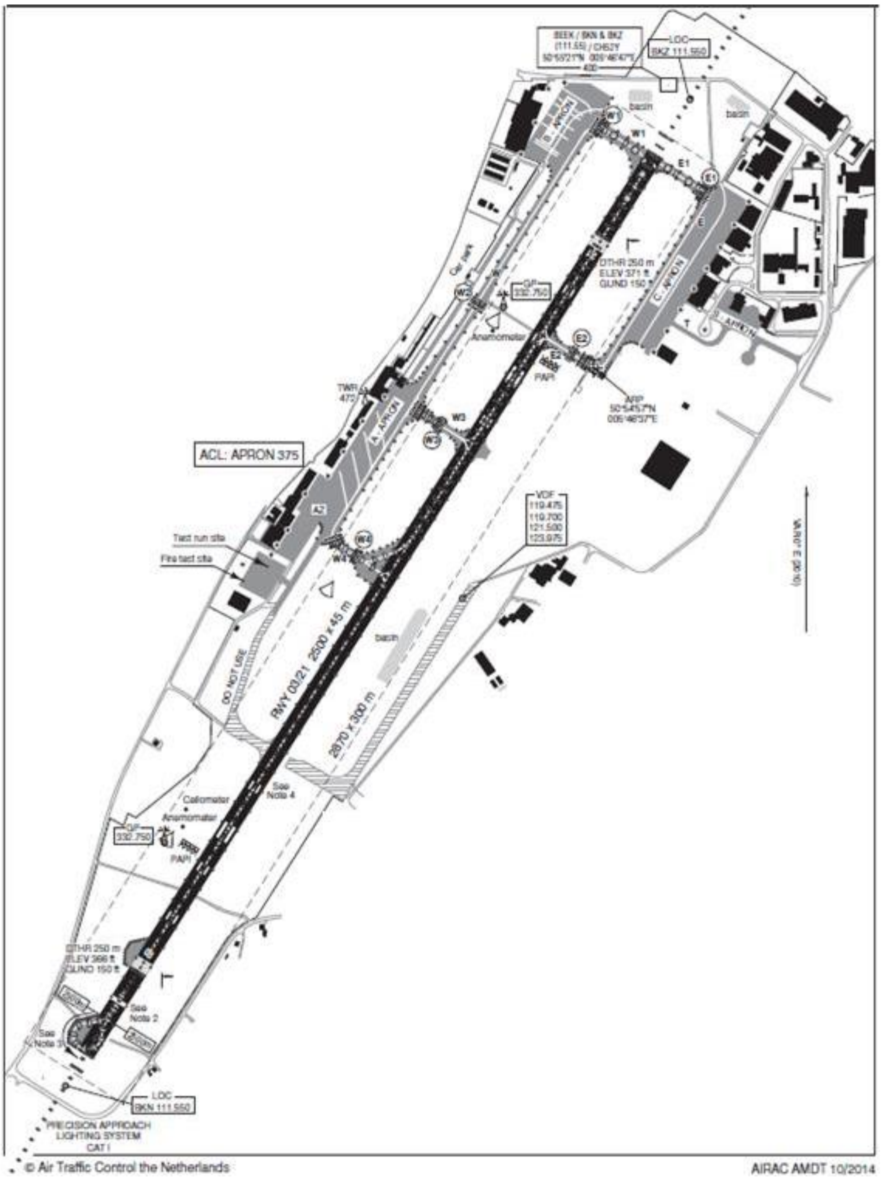


Figure 33: Maastricht Aachen Airport Beek Aerodrome Chart (Source: AIP The Netherlands)

Maastricht Aachen Airport (EHBK) aims at the transport of passengers and freight and is designated as an airport of national importance in the central government's aviation policy document. Beek Airport is considered a medium size airport.

Beek Airport has one runway: RWY 03-21 (length 2500 meter, width 45 meter). The runway is hard-surfaced with asphalt.

All VFR flights in the Maastricht CTR have to submit a flight plan and they have to maintain two-way radio communication with Beek ATC. All VFR operations in the Maastricht CTR require prior permission from Beek TWR.

During the live trial, Eelde Airport was remotely controlled in an operational active shadow mode configuration while the simulated airport Beek was controlled simultaneously. Beek Airport was simulated on the NLR ATC Research Simulator (NARSIM) platform which fed the required information to the Remote Tower Module. Although this airport is considered a medium size airport, for the purpose of the demonstration project this airport was considered a small size airport, as far as amount of air traffic is concerned.

The set-up (system-under-test) used in the demonstrations consisted of a CWP including a Radar Display System (RDS), Electronic Data Display (EDD), Closed Circuit Information System (CCIS), Voice Communication System (VCS) and paper flight data progress strips. A visual reproduction of the Out-The-Window-View (OTW-view) enabled visual observations in the aerodrome area with sufficient resolution to provide safe and expeditious aerodrome ATS. In addition to the OTW view obtained from 9 stationary cameras, a Pan-Tilt-Zoom (PTZ) camera was provided to replace the conventional Binocular. The Voice Communication System (VCS) provided communication facilities equivalent to those required for conventional Aerodrome ATS. The VCS was used for ground-ground and air-ground communications. Non-flight-critical systems which are not directly related to controlling aircraft in the air or on the ground, such as the runway and ground lighting control system, light gun, navigation-aid control, were not controlled from the RTC.

The system-under-test as well as the used procedures had the approval of the NSA for the demonstrations in active shadow mode configuration. ATS-services at Eelde Airport were provided from the RTC in Amsterdam with a ‘shadow’ crew available at Eelde.

After having demonstrated the operational concept and procedures for the small size airport in step 2 (see chapter 6.3), a simulation exercise for multiple remote tower operations was executed (step 3). During this part of the demonstration exercise, remote ATS-services were provided to two airports simultaneously in a simulated environment. This concerns the medium size Eelde Airport and the small size Beek Airport. During this part of the exercise, the operational concept for providing ATS to two airports simultaneously was demonstrated.

After demonstration of the operational concept and procedures for providing ATS-services to two airports simultaneously in a simulated environment, the final part of the demonstration exercise was executed (step 5). During this part, remote ATS-services were provided to real traffic at Eelde Airport and, simultaneously, to simulated traffic at Beek Airport. ATS was provided from the Remote Tower working position, with a ‘shadow’ tower controller and assistant being present at Eelde Airport for back-up purposes. To build up experience and confidence, the defined scenarios gradually increased the amount of flights to be controlled. The flights for EXE-0205-004 partially consisted of live flights performed by KLM Flight Academy.

The demonstration covered daylight operations. Specific traffic scenarios incorporating IFR as well as VFR traffic were defined. For the simulations, good visibility conditions were assumed. The demonstration of the concept under different weather conditions was subject to the actual weather conditions during the live trials. Furthermore, the reversion between conventional mode of operations in the local tower and the remote tower centre were demonstrated.

The demonstration focused on normal operating conditions (i.e. not on contingency operations or degraded modes).

The demonstration was carried out in line with the Demonstration Plan for LSD.02.05 (see Ref. [1]).

6.4.2 Conduct of Demonstration Exercise

6.4.2.1 Exercise Preparation

Generally, the same set-up and configuration of the LVNL RTC CWP and the NARSIM platform in special configuration for use in the LVNL RTC was accomplished. This set-up was described in detail in Chapter 6.3.2.1.

For the set-up of multiple remote tower operations, two design decisions were made:

- There were separate communication systems/frequencies in use on two different microphones (one for each airport). This decision was taken in order to avoid confusion among pilots. Above that, obtaining approval from the NSA would have been much more difficult due to a major change in operation.
- Beek Airport was displayed in the upper row and Eelde Airport was presented below. Controllers did not indicate a clear preference for having one or the other field in a particular row, however, as the lower row was at eye level for the ATCO, it made sense to them to have the live (and busier) airport, Eelde, in the lower row.

In the Multiple Remote Tower operational situation with live pictures from Eelde Airport and use of the original EDD, CCIS and RDS displays, the EDD, CCIS and RDS of Beek Airport as well as the outside view of Beek were presented on separate displays emulated by NARSIM in the same way as during the training. The internal VCS of NARSIM was used in addition to the VCS of Eelde Airport for communication with pseudo-pilots at Beek Airport. Due to this separation of systems, two different microphones were used, one for communication with Eelde Airport traffic and one for Beek Airport. Two different flight strip bays were available as well.

In preparation of the active shadow-mode trial for Multiple Remote Tower Operation at Groningen Airport Eelde, several simulation exercises were carried out on the NARSIM platform which was set up in the LVNL Remote Tower Centre (Figure 34). Again, the aim of these simulations was to familiarize controllers with the new situation regarding systems, working position and the available camera images as well as the additional functionality provided to a remote tower working position by a pan-tilt-zoom (PTZ) camera. Additionally, the special operational condition of controlling two airfields simultaneously could be trained and investigated.

Figure 34: NARSIM Simulated Outside View of Beek and Eelde in the LVNL RTC

The following tables give an overview of the different scenarios that were available for simulation on the NARSIM platform in Multiple Remote Tower configuration (for Eelde and Beek respectively).

Per trial step, different types of scenarios were defined, which differed in the amount of traffic available (low/medium/high levels). The scenarios also differed in the type of traffic and runway configurations in use.

For each simulation step and scenario, the following overview gives a short description and summarizes the aims.

Trial Step 3: EHGG-EHBK Multiple

Scenario	Description of the Scenario
1a	Eelde: Taxiing and ground traffic and control of standard IFR and VFR traffic on a single runway (05). Beek: Two IFR flights (one arriving and one departing flight) with use of runway 21.
1b	Eelde: Taxiing and ground traffic and control of standard IFR and VFR traffic on a single runway (23). Beek: Two IFR flights (one arriving and one departing flight) with use of runway 21.
2a	Eelde: Control of VFR circuit traffic, departing and landing VFR traffic and the integration of that traffic with circuit traffic with simultaneous use of two crossing runways (23 and 19). Beek: Four IFR flights (two arriving and two departing flights) with use of runway 21.
2b	Eelde: Integration of landing and departing VFR and IFR traffic with airfield circuit traffic with simultaneous use of two crossing runways (05 and 01). Beek: Four IFR flights (two arriving and two departing flights) with use of runway 21.
3	Eelde: Control of landing and departing VFR traffic in combination with changing runway directions and opposite approaches, with successive use of runways 05, 01 and 23. Beek: Two IFR flights (one arriving and one departing flight) with use of runway 21.

Scenario	Aim of the Scenario
All	• Proceeding with investigations after trial step 1 and trial step 2 (see chapter 6.3)
1a / 1b	• Familiarization of controllers and assistants with the Remote Tower concept • Gaining experience in working with the Remote Tower Module including the Controller Working Position (CWP)
2a / 2b / 3	• Finding answers to the identified research questions
All	• Collecting information for safety assessment

6.4.2.2 Exercise execution

The first live trial was carried out in the Remote Tower Centre of LVNL at Schiphol Airport on September 8, 2016. It consisted of two time periods during which control of the flights was completely delegated from Eelde tower to the RTC controller team in Amsterdam. The controller team consisted of the ATCO and an ATCA (both from Eelde).It should be noted, that there is no ATCA in the Beek in the real tower. Nevertheless, the ATCA supported the ATCO for the Beek operation by co-ordinating the departing flights via intercom.

During the first period, three additional flights (two landings and one departure) were carried out in simulation on the NARSIM platform for Maastricht Aachen Airport (Beek) in order to assess multiple remote tower operations (see Figure 35).

Figure 35: Multiple Remote Tower operation set-up with NARSIM simulation on top

The first period, which covered the multiple remote tower operations, lasted from 11:39 hrs. until 13:24 hrs. All times are in UTC.

An overview of the flights carried out at Groningen Airport Eelde is given in Table 15.

The following table gives an overview of the additional flights carried out in the NARSIM simulation of Maastricht Aachen Airport Beek.

Flight ID	Aircraft type	Arrival/ Departure	Dep. Airport	Arr. Airport	IFR/VFR	Time 1	Time 2	Remarks	# of Movements
CLX711	B744	ARR	HKJK	EHBK	IFR	12:51	N/A	None	1
THY6306	A310	DEP	EHBK	LTBA	IFR	13:10	N/A	None	1
CLX715	B744	ARR	HKJK	EHBK	IFR	13:20	N/A	None	1

Table 16: Flights carried out at Maastricht Aachen Airport during live trial on September 8, 2016

6.4.2.3 Deviation from the planned activities

Regarding the planned activities for the multiple remote tower operations, there were no deviations.

6.4.3 Exercise Results

6.4.3.1 Summary of Exercise Results

This section provides answers to OBJ-0205-400 to demonstrate that remote ATS can be provided to a medium size airport in an operational and technical environment and a small size airport simultaneously in a simulated environment. Further, it is shown that the ATCOs agreed that the ATS-service can be provided to both airports at the same time with a sufficient level of capacity.

Note that Beek was not simulated with normal traffic levels. The number of aircraft that was simulated was significantly lower than in reality. The aim was to demonstrate that operating according to simultaneous multiple RTO principles is feasible.

Sections 6.3.3.1.1 to 6.3.3.1.6 describe the results that were found. Statements in these sections are the outcome of debriefing sessions or questionnaires. Opinions from ATCOs are given without a thorough analysis, as the data basis for such an analysis is not always available. Whenever researchers have made an analysis based on their own experiences and observations this has been indicated separately.

6.4.3.1.1 No loss of capacity

This section provides answers to OBJ-0205-431, which was to demonstrate that no decrease in capacity is experienced for any of the current operational procedures while operating the RTC.

From step 3 – simulation trials

The aim of the simulation trials primarily was identifying technical and human factors issues that needed to be taken into account prior to the live trials. Therefore, only brief discussions about capacity took place. However, a number of remarks related to capacity issues were already made after the simulation trial.

In step 1, the vertical viewing angle of the cameras was already mentioned because aircraft at higher altitudes were more difficult to monitor. But even if there is no circuit or anything else that the aircraft needs to merge with, it will still require extra attention from the ATCO. This will be at the cost of attention that can be given to the other airport. Therefore, the reduced vertical field of view also limits the capacity when operating two airports simultaneously.

Every now and then the ATCA pointed out issues to the ATCO. Two ATCAs is considered too many and will not contribute to increased capacity. In one of the trials the ATCA reported that he was more intensely monitoring the airport because he felt that the extra pair of eyes was desired by the ATCO.

Operations that demand the attention of the controller, like landings and departure operations that take place at exactly the same time on both airports, have the theoretical possibility of multiple conflicts taking place simultaneously. With two different airports involved, this is more complex when compared to multiple areas of interest on one airport. Therefore, these situations should be mitigated.

The explanation for that phenomenon is, besides the earlier mentioned vertical viewing angle, that every time that an ATCO focusses on an airport it takes some time before the mental picture of that airport is complete again. Switching between airports seems to bring the ATCO out of the loop for a brief moment, so that additional time is needed to regain full situational awareness.

In case of an emergency, for example, the ATCO at Beek needs to alarm others and co-ordinate. That would be at the cost of attention that he would otherwise be able to give to Eelde. All other traffic would immediately be stopped in order to give full attention to the emergency. Such an action would be difficult to comprehend for the traffic at Eelde. So in case of an emergency at one airport, the capacity of the other airport is reduced drastically as well.

The researchers and observers share the opinion that the situation described above indicates that there is a relationship between the capacity of the airport and the workload of the ATCO. Thus, if the workload of the ATCO increases, the capacity of the airport decreases. It goes without saying that not just the capacity but also the provision of ATS might suffer from such a situation. Thus, if the ATCO is occupied by monitoring aircraft in the circuit and shifts attention from one airport to the other, there is less time / resources available for provision of ATS and the execution of other tasks at the moment that aircraft need it.

From step 5 – live trials

All flights at both airports were handed off correctly. So the live trials gave no indication of capacity reduction. Specific (complex) operations like opposite approaches, departures from both airfields at the same time, etc. were not executed during the live trials. As already learned from the simulation trials, these complex operations are foreseen to be too demanding for a Multiple Remote Tower environment. No mitigation means were identified.

6.4.3.1.2 Does dual panorama visualisation work for multiple airports?

This section provides answers to OBJ-0205-432 which was *“to assess if a dual panorama visualisation of the OTW view works while controlling two airports simultaneously”*.

From step 3 – simulation trials

One controller preferred the busiest airport to be placed in the row below, so that most of the time he could keep his head under a normal angle, and not tilted backwards.

It was noticed that one of the ATCOs constantly tracked one aircraft at each airport by using the PTZ camera, even when taxiing. He explained that this way of operation enabled him to switch back rapidly to a field and immediately focus at the point that probably required his attention first.

Another ATCO indicated that he was never confused about which video image belonged to which airport. However, in case of more traffic, e.g. a medium traffic load on both airports, it might be harder. During the simulation trials, it was easy to switch between airports. If that turned out to be different in the live trials, a solution, according to one of the ATCOs, might be a technological approach like lines or labels on the monitor that support orientation.

Step 3 gives no reason to assume that providing ATS to two airports simultaneously is not possible. However, there are exceptional circumstances (like actions that happen simultaneously on the runways of both airports, opposite approaches, the total amount of traffic on both airports, aircraft that are regularly not visible on the monitor due to a high altitude, or calamities) that need a different way of processing compared to the current operation. If this is not possible, these operations can no longer be executed under multiple RTO. Conflicts at both airports at the same time definitely need to be avoided. As mitigation, integration of planning and scheduling must be performed.

The upper row of monitors attracts a lot of attention in the simulation. That has to do with the different perspectives from which both airports are looked at. At Beek, the viewpoint is close to the middle of the runway and comprises a lot of asphalt. At Eelde, the runways are actually further away and also extend away from the position of the cameras. According to the ATCO, who mentioned this issue, it would be nice if this can be solved, though it is not a high priority issue.

From step 5 – live trials

The positioning of Beek Airport in the upper row and Eelde Airport in the lower row of monitors worked fine. ATCO and ATCA did not find it confusing and also do not have a strong preference for a particular order, although they would like a consistent approach so that the same airport remains at the same position for a prolonged period of time. It should be noted that Beek was a computer-simulated image that may be easier to distinguish from the real camera output from Eelde, compared to a situation where OTW views of both airports are camera-based.

6.4.3.1.3 Is RTO suitable for the normal operation?

This section provides answers to the question: *"Is the RTO environment suitable and sufficient for normal operation?"*

A number of proposals were made for optimizing the CWP even further for Multiple Remote Tower operations. The picture below (Figure 36) illustrates some of those optimisations. For example, all hardware (including audio) related to Beek is situated on the left side. The Beek hardware is also marked with yellow-and-green tape. For Eelde everything is placed on the right and no markings are used.

Such a distinction could, for the eventual CWP, be brought to a higher level. For example, the shapes of hardware could be made different in order to minimize the likelihood of confusion.

One controller indicated that during the trials, at one moment, he has attempted to use the wrong microphone. Because he received no answer from the pilot, he deduced that he was using the wrong microphone.

Other suggestions that were made:

- Combi-strip-printer which can print strips for both airports. In order to minimize the likelihood of mixing up strips for the different airports, an alternative may be to use two separate printers next to each other or use one printer with two different outputs, one for each airport. The researchers recommend thinking through carefully which setup minimizes the likelihood of strips ending up on the wrong strip bay.
- A headset for the airport that requires most attention (probably the busiest airport) and a separate microphone for the other airport.
- Less monitors on the CWP (not the OTW view monitors, but the monitors that are actually part of the CWP). That can be accomplished by a more optimal integration of data (per airport), and a more efficient information presentation.

- Data in addition to (not instead of) integration of monitors in the CWP, on the OTW view. In particular during busy and complicated situations, the ATCO should mostly be looking head-up / out-of-the-window. By integration of CWP information (lines for orientation, labels, weather, etc.) the ATCO can indeed spend more time head-up.
- Avoid possible confusion between airports regarding the use of names for runways, and regarding callsigns, etc. Maximise the differences between both airports, in order to minimise the likelihood of confusion.
- Put the busiest airport on the lowest set of monitors by default so that the ATCO will not have to tilt his head backwards too often.
- Split the strips over two bays in a kind of V-shape. Possibly also use colour coding to make sure that strips will not end up on the wrong bay.
- Have the ATCA sit on the Eelde side. Provide the ATCA also with two complete ATCA working positions, one for each airport, next to each other (just like the ATCO). But make sure that the ATCO really sits in the middle of all OTW view monitors.
- The positioning of the RDS in the middle of the CWP was fine, though placing the RDS less prominent in the middle would also work out nicely.
- The loudspeaker (LVNL) blocks the optimal use of the CWP a bit. Place it further away from the CWP-desk.

Figure 36: CWP for step 1 trials, to the left is Beek and to the right is Eelde

It is preferred to have all hardware for each airport available, as opposed to one set of hardware (microphones, loudspeakers, monitors, etc.) and a switch to toggle between both airports.

Runway inspections at Eelde and take-off operations at Beek could perfectly be carried out and controlled simultaneously. From this, one can learn that it is indeed feasible to have activities taking place on both airports at the same time. Important is that the ATCO must be able to make sure that no processes are executed on both airports that might require his immediate action at the same time.

From step 5 – live trials

There was less traffic than normal at Beek, and therefore the ATCO said that Beek could be combined with Eelde Airport. The sound from (simulated) Beek is very different from the sound from Eelde. Due to that sound, the ATCO instantly knows which message comes from which airport. Thus, during the current trials, it was easier to discriminate between the two airports than in the case of two real airports.

The tasks at Beek are mainly tasks that have to do with co-ordination with other fields and activity can increase rapidly. For example, during the trials there was a flight at Eelde Airport without a flight plan. This costs ATCO time / capacity. The ATCO wondered what would have happened if Beek Airport was busier at that moment. He suggested that it may be useful to check / test the workload limits.

The ATCA is of pivotal importance as to how the work is executed under multiple remote operations. It is difficult to assess what would happen to the ATCA's workload when operating two airfields simultaneously with realistic task load on both fields. If it turns out that the workload is too high for one ATCA, the solution would be to deploy two ATCAs and one ATCO for two remotely controlled airfields. The ATCA takes a load of work from the ATCO's shoulders. For example, the ATCA takes over longer telephone calls that definitely need to be made in the multiple remote situation since the ATCO may need even more attention for the two airfields than in the normal (one airfield) tower.

In case the ATCA's workload increases too much, the first thing that will happen is a reduction in efficiency, for example, no immediate reaction upon a start-up clearance request. Safety has the highest priority (e.g. vehicles on the RWY), so ATCA and ATCO expect no direct impact on the safety.

In case of an emergency with alarms both the ATCO and the ATCA should only focus on that emergency situation. Together they monitor and react to all critical issues at the airfield. Therefore, all other actions on both fields would need to stop immediately. There would still be a multiple remote operation, but all aircraft would either be in holding, departing or staying on the ground.

Another important reason to act in such a way, is to avoid ending up in a situation with multiple emergencies.

The workshare between ATCO and ATCA was slightly different from the normal operation. At Beek all work is normally done by one ATCO without an ATCA. In the multiple remote situation, a couple of small tasks were given to the ATCA that normally would be taken care of by the ATCO. So for the ATCO, who came from Eelde, this situation was quite comparable to the normal operation.

The double interfacing of the CWP (for Eelde and Beek) is still a challenge. There are (in reality) quite a number of monitors and other hardware, all double. That is a lot of hardware and during high peak load situations one has to look at the right location for the information that is needed. No mistakes may be made. The ATCO thinks that technical solutions exist to mitigate this potential risk. Examples of these solutions are a PTZ camera interface that allows for quickly looking at a particular point of interest, visual tracking squares around relevant objects, contrast enhancing features like filters or IR cameras, merging visual data with radar information, etc.

6.4.3.1.4 Impact on human/team

This section provides answers to OBJ-LVNL-434 “What is the impact of RTO on the human/team performance.”

From step 3 – simulation trial

One ATCO found that the simulation trials were solely suited for verifying whether hardware or procedure changes were needed, but not for other kinds of assessments. He does think that the multiple RTO concept is safe, robust, easy-to-learn and acceptable. He also thinks that his performance is not deteriorated due to the RTO concept. However, his opinion on these topics was stronger (on the rating scales) and more explicit after the single RTO trial than after the multiple RTO sessions.

If, at Eelde Airport, multi-runway or other complex operations will be executed, than there will be potential conflicts. In the simulation, a take-off at both airports at exactly the same time was tested. This is something that the ATCO would not do in reality. Even during the simulation it did not feel completely ‘safe’ due to the small likelihood of two incidents or worse taking place at the same time. The combination of operations would make it really complicated for the ATCO since the number of potential conflicts that the ATCO might have to respond to is simply too much.

For the trials, a team of one ATCO and one ATCA was perfect. Sometimes the ATCA pointed out relevant items that were taking place to the ATCO. Two ATCAs would be too many for these scenarios. In other words, it would not increase the capacity. For busier situations it may be possible to find a workshare with two ATCAs, one for each airport. Two ATCAs for one airport would be too complex.

Situational Awareness (SA)

Using the PTZ camera on both airports at the same time, even during taxiing, is helpful for retrieving the aircraft that requires attention first. This is an example of how the PTZ enhances situational awareness.

One ATCO received two calls simultaneously. He then decided, based upon what he could see at both airports, which call had the highest priority.

Both ATCOs assessed their own SA a bit better during the trials in which they served one airport, compared to the sessions in which they controlled Eelde and Beek at the same time.

Workload

The ATCOs were asked to rate their workload on a rating scale (NASA-TLX). This revealed that, when serving two airports simultaneously, ATCOs were required to spend more mental and physical effort than when serving one airport. However, there was no difference between single or multiple remote operations as to how they rated the level of frustration or their own performance.

Figure 37 below visualises these findings. Later the data from the live trials were added. It should be noted, that the ratings concerning the live trials are more similar to the step 1 (single RTO) simulation trials than to the step 3 (multiple RTO) simulation trials.

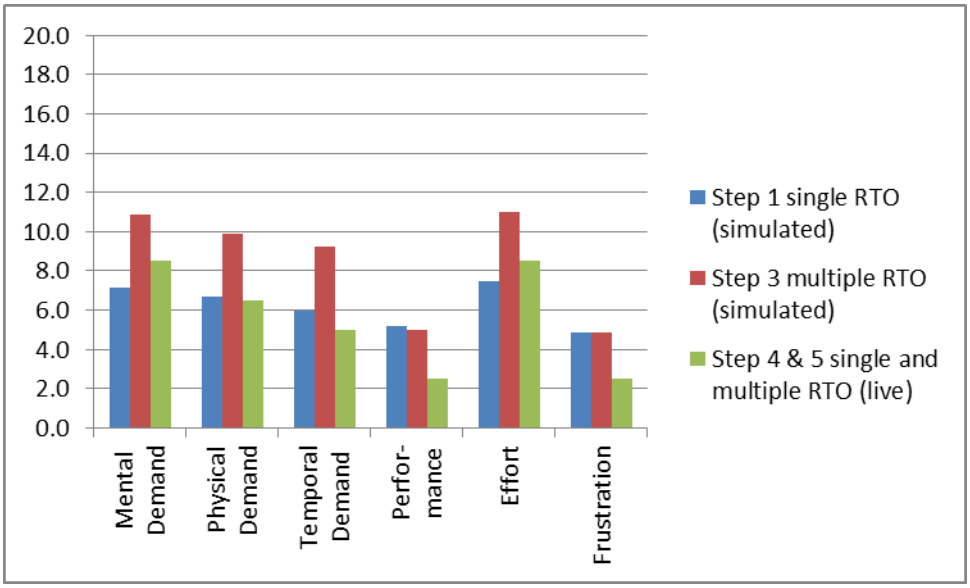


Figure 37: NASA TLX (workload) ratings averages over all trials.

6.4.3.1.5 Results per KPA

The KPA Capacity was addressed by CRT-0205-3341 and CRT-0205-3342. The demonstration showed that there is no significant impact on capacity when providing ATS from a remote location. However, it was remarked that during high traffic demand there may be a need to reduce complexity. Capacity numbers demonstrated during the live trials were comparable with or above the numbers associated with medium size airports.

ATCOs explained that capacity might reduce slightly, but that care needs to be taken not to execute two potential risky tasks at both airports the same time.

During the simulator and the live trials, safety was never an issue. ATCOs claimed that operations can be made safe by adequate planning and anticipation.

6.4.3.1.6 Results impacting regulation and standardisation initiatives

No activities or results were identified that had an impact on regulation or standardisation. Controllers made a number of remarks regarding the design and layout of the CWP. These might be used for standardisation since a standardised CWP, in particular when ATCOs need to control several airports at the same time, might contribute to less confusion and likelihood of making mistakes and errors. Examples of what controllers suggested are: loudspeaker locations that allow a clear distinction between both airfields, and hardware that is associated with an airport, in general, by colour or shape.

6.4.3.1.7 Unexpected Behaviours/Results

During the trials no major unexpected behaviours or results were identified.

6.4.3.1.8 Quality of Demonstration Results

Both sources of information (i.e. simulation and live trials) provided different kinds of information about the feasibility of the remote tower concept (see also 6.3.3.1.10). In the live trials, Eelde Airport was actually live while Beek Airport was simulated. Controllers were, of course, aware of this, and that might have influenced their behaviour.

6.4.3.1.9 Significance of Demonstration Results

There was only small number of subjects (i.e. two teams of an ATCO and ATCA). However, they participated in several simulated trials, they experimented with the equipment for the live trails in passive shadow mode, and finally they participated in the live trials. Therefore, levels of statistical significance could not be calculated, but the subjects were quite experienced with the concept and technology, which made them very relevant for discussing advantages, disadvantages and items to take into account before actual implementation of the concept.

The operational significance of the demonstration results can be considered as very high since the demonstration took place in an operational environment in active shadow mode. This implied the following items:

- Traffic volumes were representative for the (medium size) aerodrome comprising VFR and IFR traffic;
- Traffic volumes were representative for the (small size) aerodrome comprising and IFR traffic;
- ATCOs actively provided ATS from the remote working position (which was based on a mix of operational and pre-operational systems).

6.4.4 Conclusions and recommendations

6.4.4.1 Conclusions

From step 3 – simulation trials

The Multiple Remote Tower concept is feasible and acceptable for ATCOs. SA and workload remained acceptable during the trials. There are also a number of situations that can be executed under normal tower operations but which are foreseen not to be feasible anymore under multiple RTO. When implementing multiple RTO there are a few items to take into account:

- Several suggestions were made to improve the CWP. They will contribute to making the RTO concept more efficient and to reducing the likelihood of confusion and eventually to making mistakes (see also chapter 6.4.3.1.3.)
- Care needs to be taken to show how conflicts can be managed that happen at the same time on two airports.
- ATCOs need to be able to (re)gain their SA as quickly as possible when shifting their attention from one airport to the other.

From step 4 and 5 – live trials

The live trials generally supported the findings from the simulation trials. A very important finding for the multiple remote CWP was that all items (hardware and software) were arranged in such a way that it is natural to retrieve and to send information without mixing up both airports.

6.4.4.2 Recommendations

A number of minor issues were reported by the controllers and also recommendations (suggestions for mitigation) were given. Below is an overview of these recommendations:

From step 3 – simulation trials

For the parallel execution of several tasks on the two airports, mitigations are needed. For example, taking off at the same time from both airports does not seem possible with the current set-up. Techniques or procedures are needed to manage two activities that demand a lot of attention and may result in conflicts happen accidentally on both airports at the same time.

Confusion between both airports is a potential issue. A list of measures was suggested in section 6.4.3.1.3. More suggestions might be needed.

A suggestion that may result in even more concrete information about how effective different measures are is running simulation experiments in which the workload of the ATCOs is increased beyond what would be acceptable in real life.

From step 5 – live trials

All items (hardware and software) should be placed in such a way that it is natural to retrieve and to send information without confusing both airports. An often mentioned example is the placing of loudspeakers. It should be ensured that the ATCO can always, with minimal effort, focus on the relevant audio source. Note that aircraft in the air are more important for the ATCO to monitor than any other movement.

7 Summary of the Communication Activities

The RTO communication activities were performed in support of the communication objectives of both the SJU and the project consortium. The majority of the activities were performed towards the end of the project, during the time when the trial demonstrations were executed, and the period following the demonstration execution. In fact communication activities about the RTO project will continue after project closure, but this is outside of the scope of the demonstration report. Activities that will take place before November 1, 2016 are considered part of the RTO project and are treated as such.

7.1 Activities using the demonstration test suites

The most powerful means of communication in the RTO project has been demonstrations of the RTO concept on the demonstration test suite itself. This has contributed to the buy-in of the controllers, but has also been beneficial for a wider audience of stakeholders. Showing the demonstration test suite literally is a matter of "Seeing is believing".

Open day

DFS, LFV and LVNL held open days during the trial execution phase. These open days were held on:

DFS, Saarbrücken: August 24, 2016

LFV, Sundsvall: September 10, 2015 for SJU. October 19, 2015, official Open day, besides that a continuous open invite during the demonstration including 2 weeks before and after.

LVNL, Schiphol: September 23, 2016

Beside the open days many stakeholders visited Saarbrücken, Sundsvall and Schiphol to visit the remote tower test suite. A visit is defined as: a meeting consisting of an overview PowerPoint presentation, followed by a visit to the test facilities for further demonstration and explanation.

Visitors

In summary the following stakeholders visited the DFS test facilities at Saarbrücken:

LVNL, LVF, HungaroControl, IAA

In summary the following stakeholders visited the LFV test facilities at Sundsvall:

LVNL, DFS, SJU, Union (member of ETF), Staff associations (member of IFATCA), airspace users, engineers, Kramfors Airport, LFV CISM crew, ATS Örnsköldsvik and ATS Sundsvall.

In summary the following stakeholders visited the LFV test facilities at Sundsvall:

LVNL, DFS, SJU, Union, Staff associations, airspace users

In summary the following stakeholders visited the LVNL test facilities at Schiphol:

LFV, DFS, NLR, KLM (management, staff & pilots), IAA, ATMB, Groningen Airport Eelde, Amsterdam Airport Schiphol, IFATCA, London Heathrow Airport, Dept of Transport, Dept of Defence, National Supervisory Authority

7.2 Publications

To reach a wider audience various publications about the RTO project have been made. Publications (e.g. press release) were made in local newspapers and internal magazines and interviews were given for TV- and radio stations.

7.3 Internet Publications

Project Video Publication of SJU YouTube channel

LFV Gällivare remote tower trial video (released March 2016)

LVNL Schiphol remote tower trial video (released October 2016)

7.4 Seminars

The RTO project supported SJU in their communication about remote tower development at World ATM Congress, March 2016. Furthermore the RTO project presented itself at the SESAR Closure Event in Amsterdam, June 2016.

As part of the dissemination of remote tower trial experience the RTO project facilitated a seminar in October 2016. During this seminar lessons learned were shared with other LSD remote tower trials.

7.5 Deviations from the communication objectives

The RTO project deviated from its original plan to produce four project trial videos (one for each trial, and one for the project as a whole). The reason for this deviation is the decision of DFS to not produce a Saarbrücken trial video. As a consequence the overall video could also not be produced.

8 Next Steps

All demonstration activities have improved the possibility to deploy remote towers from very low to medium sized aerodromes as well as multiple remote towers. Results show that conclusions already stated from previous activities on small aerodromes are ready for implementation without significant changes also to very small and medium size aerodromes.

The very low density trial showed that Single Remote Towers can be deployed with a low cost solution for aerodromes with limited traffic levels. Next step to enable implementation is to receive approval for a new system. Timeframe for such a process risks being very time consuming wherefore an already existing system has other advantages. The system still shows that Remote Tower Systems can be evolved towards cheaper solutions.

Remote Tower at medium sized aerodromes has been proven ready for implementation and results show that enhanced features are highly rated by ATCOs. Potential impacts on capacity might result from specific local procedures and local implementations of the visual reproduction.. Any new system need further work on degraded modes in order to define the mitigating features required for the visual reproduction/PTZ. The system used has shown that the concept of Remote Towers is functional for medium sized aerodromes.

Multiple Remote Towers was tested and comments showed that the situation of screens as well as equipment has a high impact of ATCO possibility to provide Air Traffic Service to the airports simultaneously. ATCOs controlled traffic as in conventional towers by avoiding complicated operations as opposite approaches or departures at both airports simultaneously in critical situations.

8.1 Conclusions

All different remote tower solutions from very small to medium size aerodromes were demonstrated with no significant shortcomings. ATS can safely be provided from a remote location and capacity can be maintained. Initial CBAs have shown positive results but for each aerodrome a specific CBA considering the local factors is required being the baseline for a deployment decision.

During all demonstrations operators (ATCO and/or AFISO) where able to work on the basis of existing rules and regulations for providing Air Traffic Service.

Different solutions of both camera tower and Controller Working Position were demonstrated showing that there are several ways to make Remote Tower Service a reality. Cameras covered 360 degree at all demonstrations, the image was either completely displayed continuously or just a selected field of view (e.g. 240 degrees) were shown to the ATCO continuously with the feature to pan the viewing direction.

The different solutions were all set up on the operational and technical requirements that were provided from SESAR 1 (OFA 06.03.01). These requirements were already considered in rulemaking and standardisation by EUROCAE WG 100 and EASA RMT.0624. Only minor adjustments are proposed as a result of the demonstration. The same requirements are valid for all investigated solutions ranging from very small to medium size aerodromes.

8.2 Recommendations

The four demonstration activities show that remote tower technology can be deployed at airports varying from very small to medium size:

- During all demonstrations operators (ATCO and/or AFISO) where able to stick to current rules and regulations for management of Air Traffic Service, wherefore the recommendation is to keep current rules and regulations and only adapt local methods.
- Recommendation is to work on a high quality visual reproduction system and/or to implement enhanced tools and features, such as visual tracking, overlays, radar. A better image, more similar to a conventional tower, reduces the need for adapted methods for ATCOs and AFISOs. The impact and importance of each tool and feature is described in more detail in chapter 6.
- Regarding ratings, endorsements and licensing, no changes are suggested. The ATCOs and AFISOs should hold a license for the requested service. In addition to that a local endorsement

for the appropriate aerodromes. A complement of the airports local conditions is suggested as a way forward in the beginning.

- The demonstrations showed that training is required before providing ATS in a Remote Tower CWP. The operators need to get used to all new equipment. That kind of familiarisation is a must in any new working environment. Knowledge of local circumstances is recommended as it was shown positive for operators without a rating at the tower tested during the demonstrations.
- The position of the camera tower is crucial. This to ensure that all relevant areas such as runways, taxiways, aprons and airspace (e.g. VFR patterns, relevant waypoint, entry and exit points) are visible for the controller. Local circumstances such as runway layout and geographical orientation of the camera mast can differ for every site.
- The vertical viewing angle must ensure that all relevant areas are covered in the visual representation. This must be considered especially if the cameras are placed in landscape orientation. Additional cameras might be used to cover manoeuvring area or other areas of interest.
- PTZ is a replacement to a binocular in a conventional tower wherefore usage must be easy and intuitive. Automatic PTZ tracking and focus enables an easier usage but it was still shown that manual inputs were needed at times. Recommendation is to have both automatic and manual possibility.
- When controlling two airports at the same time, some measures to reduce complexity of operation may need to be taken, depending on local circumstances. Additional research is needed on maintaining controller situational awareness when controlling more than one airport.
- Additional research is needed related to controlling two airports at the same time: On design and equipage of controller working position, integration of tools, and new mitigative procedures for complexity reduction. E.g. traffic synchronisation for geographically non-related (but combined in multiple remote operations) airports.

9 References

9.1 Applicable Documents

[1] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

[2] SESAR ATM Master Plan
https://www.atmmasterplan.eu

[3] EUROCAE ED-240, 'MINIMUM AVIATION SYSTEM PERFORMANCE SPECIFICATION FOR REMOTE TOWER OPTICAL SYSTEMS', September 2016

[4] EASA Minimum aviation system performance specification for remote tower optical systems. ED-240.

9.2 Reference Documents

The following documents are referenced in the demonstration report:

[1] Demonstration Plan RTO, Edition 00.02.00, dated 2016-04-29

[2] 06.08.04 D93 Validation Report, Edition 00.01.00 (30.05.2016)

[3] 06.08.04 D94 OSED – Operational Service and Environment Description
Edition 00.07.00 (30.05.2016)

[4] 06.08.04 D108 SAR – Safety Assessment Report, Edition 00.02.00 (30.05.2016)

[5] 06.08.04 D109 HF – Human Factors Assessment Report, Edition 00.02.00 (30.05.2016)

[6] 12.04.07 D09 TS – Technical Specification, Edition 01.00.00 (07.03.2016)

Appendix A KPA Results

Information already added to chapter 5.3.1 Results per KPA

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