Remotely Provided Air Traffic Service for Single Aerodrome VALR

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Abstract

The present document is the Validation Report for the V2 and V3 Single Remote Tower validation activities of P06.09.03. It will describe the results from three activities that contribute to the validation of the Single Remote Tower application:

- Single TWR Trial 1 – a V2 Passive Shadow Mode (PSM) trial establishing a technical and operational prototype for Remote Provision of ATS to a single aerodrome;
- Single TWR Trial 2 – a V3 PSM trial progressing the technical and operational capability;
- Single AFIS Trial 1 – a V3 PSM and Advanced Shadow Mode (ASM) trial, assessing the Remote Provision of ATS to a single AFIS aerodrome in a range of operational conditions.

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Executive summary

This document provides the Validation Report (VALR) for the Operational Focus Area (OFA) OFA06.03.01 "*Remote Tower*" under Operational Package (PAC) PAC 06 *"Cooperative Asset Management"* and Operational Sub-Package (SPC) SPC06.03 *"Remote Tower with Aerodrome Flight Information Service (AFIS)".* It describes the activities conducted in support of validation for the Remote Provision of Air Traffic Services (ATS) to a *Single* Aerodrome as defined in the P06.09.03 Operational Services and Environment Description (OSED) [7] and P06.09.03 VALP for Remote Provision of ATS to a Single Aerodrome [8]. It does not address any validation activities related to Remote Provision of ATS to *Multiple* Aerodromes or Remote Provision of ATS in *Contingency* situations. The SPC of *"Remote Tower with AFIS"* together with SPC06.01 "*iCWP Airport*" and SPC06.02 *"iCWP En-route and Terminal Control Area (TMA)"* contribute to PAC06.

The main focus of the concept, and therefore the validation, is assessment of human performance, safety, capacity and cost effectiveness.

In keeping with the mappings defined in the OSED, the Remote Provision of ATS to a Single Aerodrome falls under SESAR Operational Step 1 (ATM Service Level 2). This operational service is already mature (V2 maturity), having been developed initially in the Remotely Operated Tower project (ROT) and Advanced Remote Tower (ART) projects [9], [10]. The relevant Operational Improvement (OI) is identified as SDM-0201 "Remote Provision of ATS to a Single Aerodrome."

The concept aims to enable "Aerodrome Control Service or Aerodrome Flight Information Service for an aerodrome to be provided from a remote location, i.e. not from a control tower local to the aerodrome. The ATCO (or AFISO) in this facility would perform the remote ATS for the concerned aerodrome". The main target for the Remote Provision of ATS to a Single Aerodrome application are low to medium density airports, which today very much are struggling with low business margins. These airports are defined in the SWP06.02 Detailed Operational Description (DOD) [11]as being in the "small" size category.

The validation exercises made use of shadow mode trials in candidate target environments in Scandinavia.

Maturity of the concept is V2 with a target maturity at the end of the VP-056 of V3. VP-057 and VP-058 aim to establish and consolidate V3 maturity.

Operational Package	Operational Sub-Package	Operational Focus Area	OIs or Operational Services	Initial Maturity level	Target Maturity level	Reused validation material from past R&D Initiatives
PAC06	Remote Tower with Aerodrome Flight Information Service	Remote Tower	SDM-0201- "Remotely Provided ATS for Single Aerodromes"	V2	V3	ART, ROT

The results from three validation trials are described in this VALR:

EXE-06.09.03-VP-056

Remote Provision of ATC to a Single Aerodrome Trial 1

EXE-06.09.03-VP-057

Remote Provision of ATC to a Single Aerodrome Trial 2

EXE-06.09.03-VP-058

Remote Provision of AFIS to a Single Aerodrome Trial 3

In addition to the actual trials, several activities related to validation were also performed under the Safety and Human Performance Working Areas of the project. Further activities for Rules and

Regulations and Business Transversal Assessments were part of the project but are not yet mature for inclusion in this document.

This VALR is the concluding version and reports on EXE-06.09.03-VP-056 (Remote Provision of ATC to a Single Aerodrome Trial 1), EXE-06.09.03-VP-057 (Remote Provision of ATC to a Single Aerodrome Trial 2 and EXE-06.09.03-VP-058 (Remote Provision of AFIS to a Single Aerodrome). Consolidated results for the exercises within this OI step are also included.

Trials concentrated on Ängelholm-Helsingborg aerodrome and Værøy heliport with Remote Tower Centres being based at Malmö and Bodø respectively. Technical updates were performed mid trial and between trials, so a progression in results can be seen. EXE-06.09.03-VP-057 (Single Aerodrome Trial 2) also investigated the impact of different technical configurations within the Remote Tower Centre; results indicated that the advanced configurations, which included a full set of technical enablers, produced improved results and concept acceptance.

Robust results were successfully produced within a representative environment based on a developing prototype platform. The concept is operationally feasible and acceptable, this being directly correlated to the quality of the visual reproduction, with further operational benefits envisaged with the implementation of advanced visual features. Key findings indicate that remotely provided ATS to single aerodromes is a safe concept, being supported by a robust and mature Pan Tilt Zoom (PTZ) camera functionality (corresponding to the binoculars in a local Tower) in combination with an adequate visual presentation (covering the aerodrome and the traffic circuits). ATCOs were able to detect hazards and conflicts. The concept has the potential to reduce human error due to the addition of technical enablers, which increase situational awareness. Human performance results indicate that overall the systems were enabling participants to perform to high levels. All trials indicated that the reliability and functionality of technical system influenced the perception of safety. Yet the addition of technical systems was highlighted a potential risk factor due to its ability to fail.

Participants felt that the Remote Tower Centre (RTC) when coupled with advanced technical enablers may provide enhanced safety and capacity, in comparison to the local tower environment, during times of reduced visibility. Capacity to handle VFR traffic may be influenced negatively due to an increased need to use VFR holdings to wait for landing/arriving IFR traffic. This negative influence will however decrease with a good quality visual reproduction and with the introduction of advanced visual features.

The tracking overlays gained the highest level of overall acceptance, with the Infra-red camera and PTZ Camera greatly enhancing ability to provide ATS in limited visibilities.

Inclusive results successfully met the success criterions for all objectives that were tested. One objective relating to non-nominal situations was investigated during a workshop; this is presented as a deviation from the original validation plan and appears in Appendix A.

Due to indications from results and the fulfilment of P06.09.03 objectives for this OI step it is recommended by the project that the concept “Remote Provision of ATS to a single Aerodrome” matures to V3.

1 Introduction

1.1 Purpose of the document

This document provides a Validation Report (VALR) for the OFA06.03.01 "*Remote Tower*" under SPC06 "*Remote Tower with AFIS*" and PAC06 *"Cooperative Asset Management"*. It describes the activities that were conducted in support of validation for the Remote Provision of ATS to a *Single* Aerodrome.

This VALR does not address any validation activities related to Remote Provision of ATS to Multiple Aerodromes or Remote Provision of ATS in Contingency situations.

The VALR is produced by NORACON (project leaders). It is based on the OSED produced under Working Area A of the P06.09.03 [7].

This VALR covers EXE-06.09.03-VP-056 (Remote Provision of ATC to a Single Aerodrome Trial 1), EXE-06.09.03-VP-057 (Remote Provision of ATC to a Single Aerodrome Trial 2) and EXE-06.09.03-VP-058 (Remote Provision of AFIS to a Single Aerodrome). Consolidated results for all exercises within this OI step are also included.

1.2 Intended readership

The intended audience for this document are other P06.09.03 team members, and those in the corresponding technical projects of P12.04.06, P12.04.07 and P12.04.08. P06.09.02, P06.08.04, P16.06.0X and P12.04.09 may also have an interest.

At a higher project level, SWP06.02 and WP B are expected to have an interest in this document.

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

- Appropriate NSA;
- ANS providers;
- Airport owners/providers;
- Affected employee unions;
- Airspace users.

1.3 Structure of the document

The structure of the document is as follows:

- **Section 1** describes the purpose and scope of the document, the intended audience, and gives an explanation of the abbreviations and acronyms used throughout the document.
- **Section 2** describes the scope of the validation and a summary of the validation exercises
- **Section 3** describes the conduct of validation exercises including the preparation, execution and deviations away from the planned activities.
- **Section 4** describes the validation exercise results. It includes a detailed analysis of the results including a description of the confidence in results.
- **Section 5** states all the conclusions and recommendations from the validation exercises.
- **Section 6** consists of the validation reports for each exercise individually.
- **Section 7** lists all the applicable and reference documents.

1.4 Glossary of terms

The document uses the following important top level naming conventions:

Where reference is made to the actual Control Tower building, the full word "**Tower**" is used e.g. the local Tower is 87 metres tall.

Aerodrome Control Service (**TWR**) is the air traffic control (ATC) service provided by the Air Traffic Control Officer (**ATCO**) for an aerodrome.

AFIS is the Aerodrome Flight Information Service provided by an **AFISO** (Aerodrome Flight Information Service Officer).

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 (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.

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.

Virtual Tower is where ATS are remotely provided through the use of computer generated images of the aerodrome, aircraft and vehicles and/or surveillance e.g. through the use of terrain mapping and computer modelling of aerodromes.

CWP (Controller Working Position) is the operator (ATCO/AFISO) work station including necessary ATS systems.

Visual Reproduction is the term for the collected visual aerodrome sensor data (from cameras and/or other sensors) and presented to the ATCO/AFISO in order to provide situational awareness.

Remote Tower Module (RTM) is the term for the complete module including both the CWP(s) and the Visual Reproduction display screens.

A **Remote Tower Centre** (RTC) is a building where ATS are provided to one or more aerodromes. It usually includes several RTMs (or only one, if that single Remote Tower Module (RTM) enables ATS to more than one aerodrome).

A **Remote Contingency Tower** (RCT) facility is a facility used to provide remote ATS, including a visual reproduction, to an aerodrome in contingency situations.

Remote and Virtual Tower (RVT) refers to either the RVT Project (this project, P06.09.03 of SESAR) or the RVT Concept. The RVT Concept consists briefly of the system elements as laid out by Figure 3 below (***Please note:*** The system picture below is only an example of an RTC set up, the number and configuration of airports/RTMs/CWPs will/can differ with every implementation):

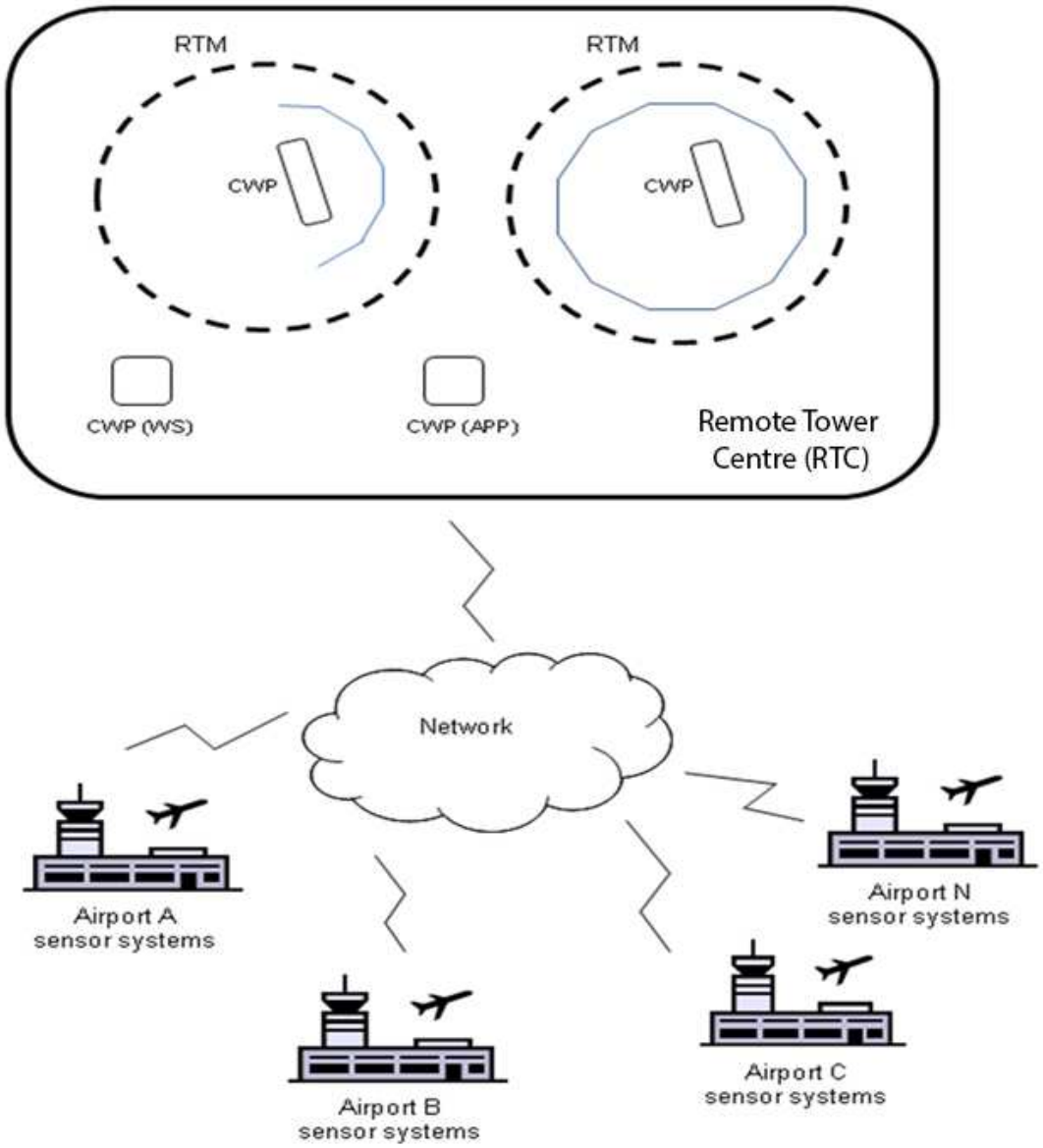


Figure 1 - Remote and Virtual Tower (RVT) concept system overview

1.5 Acronyms and Terminology

Term	Definition
ACC	Area Control Centre
ACFT	Aircraft
ACV	Additional Camera Viewpoints
AFIS	Aerodrome Flight Information Service
AFISO	Aerodrome Flight Information Service Officer
AFTN	Aeronautical fixed telecommunications Network
AIM	Aeronautical Information Management (Future Thales system to provide enhanced trajectories)

Term	Definition
ANSP	Air Navigation Service Provider
APP	Approach Control
ART	Advanced Remote Tower
ASM	Advanced Shadow Mode
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATCEUC	Air Traffic Controllers European Union's Coordination
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATMS	Air Traffic Management Service
ATS	Air Traffic Service
AWOS	Advanced Weather Observation System
CAA	Civil Aviation Authority
CAVOK	Ceiling and Visibility OK
CTR	Control Zone
CWP	Controller Working Position
DEL	Deliverable
DME	Distance Measuring Equipment
DOD	Detailed Operational Description
EFS	Electronic Flight Strips
ENVR	Værøy heliport ICAO Code
ETF	European Transport Workers' Federation
ESTA	Ängelholm Airport ICAO Code
EXE	Exercise
FATO	Final Approach and Take-off area
FDP	Flight Data Processing
FIS	Flight Information Service
FPL	Flight Plan
GNSS	Global Navigation Satellite System
HD	High Definition
HF	Human Factors
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
IDP	Interactive Display Panel
IFATCA	International Federation of Air Traffic Controllers' Associations
IFR	Instrument Flight Rules
IR	Infra-Red
IVT	International Validation Team
KPA	Key Performance Area
LCD	Liquid Crystal Display
LFV	Swedish ANSP

Term	Definition
LVP	Low Visibility Procedures
MET	Meteorological
METAR	Meteorological Aerodrome Report
METOBS	Meteorological Observations
MSL	Mean Sea Level
NAIS	Norwegian Aeronautical Information System,
NASA-TLX	NASA Task Load Index. A subjective workload assessment too
NATMIG	North European ATM Industry Group
NCAA	Norwegian Civil Aviation Authority
NDB	Non-Directional Beacon
NOK	Not OK
NORACON	NORth European and Austrian CONsortium
NSA	National Supervisory Authority
OBJ	Objective
OFA	Operational Focus Area
OI	Operational Improvement
OSED	Operational Services and Environment Descriptions
OTW	Out-The-Window
PAC	Operational Package
PMP	Project Management Plan
PSM	Passive Shadow Mode
PTZ	Pan-Tilt-Zoom
QNH	barometric pressure adjusted to mean sea level
RDP	Radar Data Processing
RNAV	Area Navigation
RNoAF	Royal Norwegian Air Force
RNP	Required navigation performance
ROT	Remotely Operated Tower (Saab and LFV project)
RTC	Remote Tower Centre
RTM	Remote Tower Module
RVR	Runway Visual Range
RVT	Remote and Virtual Tower
RWY	Runway
SASHA	SHAPE measurement technique for Situational Awareness in ATM systems
SATI	SHAPE Automation Trust Index
SCN	Scenario
SESAR	Single European Sky ATM Research
SHAPE	Solutions for Human Automation Partnerships in European ATM
SJU	SESAR Joint Undertaking
SPC	Operational Sub-Package
SSR	Secondary Surveillance Radar

Term	Definition
SVS	Synthetic Vision System
SWP	Sub Work Package
TA	Transversal Assessment
TFC	Traffic
TIZ	Traffic Information Zone
TMA	Terminal Control Area
TWR	Aerodrome Control Service
TWY	Taxiway
UTC	Coordinated Universal Time
V1, V2… V7	Concept Lifecycle Model Phases V1 to V7
VALP	Validation Plan
VALR	Validation Report
VALS	Validation Strategy
VCS	Voice Communications System
VFR	Visual Flight Rules
VIS	Visibility
VMC	Visual Meteorological Conditions

2 Context of the Validation

2.1 Concept Overview

In current operations, the Remotely Provided Air Traffic Services (ATS) does not exist. The range of ATS defined in ICAO Documents 4444, 9426 and EUROCONTROL's Manual for AFIS [13], [14], [15] are provided by *local* Air Traffic Control Officer's (ATCOs) or Aerodrome Flight Information Service Officer's (AFISOs) from local Tower building facilities.

The objective of Remote Provision for a Single Aerodrome is to provide the ATS defined in ICAO Documents 4444, 9426 and EUROCONTROL's Manual for AFIS [13], [14], [15]for one aerodrome from a remote location i.e. not from a Control Tower local to the aerodrome. The full range of ATS should be offered in such a way that the airspace users are given an adequate level of access to the service. The overall ATS will remain broadly classified into either of the two main service subsets of TWR or AFIS.

The visual surveillance will be provided by a reproduction of the Out of The Window (OTW) view, by using visual information capture and/or other sensors. The visual reproduction can be overlaid with information from additional sources if available, for example, surface movement radar, surveillance radar, or other positioning and surveillance implementations providing the positions of moving object within the airport movement area and vicinity. The collected data, either from a single source or combined, is reproduced for the ATCO/AFISO on data/monitor screens, projectors or similar technical solutions.

It is intended that the concept will have minimal or zero negative impact on Instrument Flight Rules (IFR) traffic. Handling of Visual Flight Rules (VFR) traffic may on the other hand be affected somewhat. The methods to separate VFR traffic to IFR traffic (in airspace class C typically) may need additional precautions due to visualisation characteristics in the upcoming solutions. Such precautions may affect the operational methods for separating the traffic and may have some marginal impacts on the capacity for VFR operations, although the aim is that no traffic shall be delayed. For the AFIS application and environment however, the impact on both IFR and VFR traffic is foreseen to be minimal or even none compared with today's operation.

The ATCO/AFISO will not have the ability to perform any tasks that are external to the control facility e.g. physical runway inspection. The primary ATCO/AFISO focus will be on pure ATS tasks, other tasks will be secondary and/or performed by personnel local to the aerodrome.

The Remote Provision of ATS for a Single Aerodrome is expected to be applied mostly to low density aerodromes (where low density is determined as being mostly single simultaneous operations, rarely exceeding two simultaneous movements). In the long-term the concept may also be applied for larger airports or small airports with occasionally more traffic density (for example touristic airports/remote airports during a particular event etc.), however that is not the scope for the concept at this stage.

The Remote Provision of ATS for a Single Aerodrome is defined in such a way that is appropriate and operable for a single aerodrome, but can ultimately be expanded and scaled to apply to more than one aerodrome under the Multiple Aerodromes concept.

It should also be noted at this point that there is an on-going implementation project (outside of SESAR) running in parallel to P06.09.03. This project aims to implement the Remote Provision of ATS to a Single Aerodrome in 2013/2014 in the north of Sweden.

Validation Exercise ID and Title	EXE-06.09.03-VP-056: Single TWR Trial 1 in Ängelholm / Malmö
Leading organization	NORACON
Validation exercise objectives	OBJ-06.09.03-VALP-0060.0010 OBJ-06.09.03-VALP-0060.0020 OBJ-06.09.03-VALP-0060.0030 OBJ-06.09.03-VALP-0060.0040

	OBJ-06.09.03-VALP-0060.0060 OBJ-06.09.03-VALP-0060.0070 OBJ-06.09.03-VALP-0060.0100	
Rationale	The Validation Approach identified in the P06.09.03 recommended a step-wise and incremental approach to validation, beginning with a basic initial prototype system i.e. a starting point on which other P06.09.03 technical systems could be built. With EXE-06.09.03-VP-056 being the first trial in the project it was recommended that this starting point be the focus of the assessment, rather than any specific Key Performance Area quantitative assessments.	
Supporting DOD / Operational Scenario / Use Case	Surface-In; Turn round Management; Surface-Out.	
OFA addressed	OFA06.03.01 “Remote Tower”	
OI steps addressed	SDM-0201 “Remotely Provided ATS for Single Aerodromes”	
Enablers addressed	HUM-SDM-0201	Initial training, competence and/or adaptation of new/active operational staff for the application and use of the enhancements and improvements included of the OI Step Remotely Provided Air Traffic Service for Single Aerodrome
	HUM-SDM-0201-01	New role and responsibilities
	HUM-SDM-0201-02	Social, people management, change and transition management factors for Automated Support for Traffic Complexity Assessment
	HUM-SDM-0201-03	Change and transition management factors for the OI step Network Operation Plan available
	PRO-157	ATC Procedures (Airport) for providing services to a remote location potentially including but not limited to traffic information, separation provision, METEO alerts, and alerting services
	AERODROME-ATC-52	Provide Remote Tower Controller position with visual reproduction of both remote aerodrome views and other sensor data
	AERODROME-ATC-53	Remote Tower controller position enhanced with additional sources for low visibility conditions
Applicable Operational Context	Airport	

Expected results per KPA	Safety, Capacity, Human Performance all maintained.
Validation Technique	Passive Shadow Mode (PSM)
Dependent Validation Exercises	EXE-06.09.03-VP-057, EXE-06.09.03-VP-058

Table 1: Exercise 1 Concept Overview

Validation Exercise ID and Title	**EXE-06.09.03-VP-057: Single TWR Trial 2 in Ängelholm/ Malmö**	
Leading organization	NORACON	
Validation exercise objectives	OBJ-06.09.03-VALP-0060.0010 OBJ-06.09.03-VALP-0060.0020 OBJ-06.09.03-VALP-0060.0030 OBJ-06.09.03-VALP-0060.0040 OBJ-06.09.03-VALP-0060.0050 OBJ-06.09.03-VALP-0060.0060 OBJ-06.09.03-VALP-0060.0070 OBJ-06.09.03-VALP-0060.0080 OBJ-06.09.03-VALP-0060.0090 OBJ-06.09.03-VALP-0060.0100	
Rationale	EXE-056 established an initial prototype. The results showed that a level of service could be provided using this prototype. It was necessary to establish what level of service would be feasible and what the impact would be, when operators were given a more advanced system as well as a true “baseline” system.	
Supporting DOD / Operational Scenario / Use Case	Surface-In; Turn round Management; Surface-Out.	
OFA addressed	OFA06.03.01 “Remote Tower”	
OI steps addressed	SDM-0201 “Remotely Provided ATS for Single Aerodromes”	
Enablers addressed	HUM-SDM-0201	Initial training, competence and/or adaptation of new/active operational staff for the application and use of the enhancements and improvements included of the OI Step Remotely Provided Air Traffic Service for Single Aerodrome
	HUM-SDM-0201-01	New role and responsibilities
	HUM-SDM-0201-02	Social, people management, change and transition management factors for Automated Support for Traffic Complexity Assessment
	HUM-SDM-0201-03	Change and transition management factors for the OI step Network Operation Plan

		available
	PRO-157	ATC Procedures (Airport) for providing services to a remote location potentially including but not limited to traffic information, separation provision, METEO alerts, and alerting services
	AERODROME-ATC-52	Provide Remote Tower Controller position with visual reproduction of both remote aerodrome views and other sensor data
	AERODROME-ATC-53	Remote Tower controller position enhanced with additional sources for low visibility conditions
Applicable Operational Context	Airport	
Expected results per KPA	Safety, Capacity, Human Performance all maintained.	
Validation Technique	PSM	
Dependent Validation Exercises	EXE-06.09.03-VP-058	

Table 2: Exercise 2 Concept Overview

Validation Exercise ID and Title	**EXE-06.09.03-VP-058: Shadow Mode Trial for Remote Provision of AFIS to a Single Aerodrome**	
Leading organization	NORACON / Avinor	
Validation exercise objectives	OBJ-06.09.03-VALP-0060.0010 OBJ-06.09.03-VALP-0060.0020 OBJ-06.09.03-VALP-0060.0030 OBJ-06.09.03-VALP-0060.0040 OBJ-06.09.03-VALP-0060.0050 OBJ-06.09.03-VALP-0060.0060 OBJ-06.09.03-VALP-0060.0070 OBJ-06.09.03-VALP-0060.0080 OBJ-06.09.03-VALP-0060.0100	
Rationale	The Remote Provision of Aerodrome Flight Information Services (AFIS) to a Single Aerodrome, assessed firstly through PSM and secondly in Advanced Shadow Mode (ASM). The PSM part entails the AFISO observing live traffic in a non-intrusive manner and not interacting with the aircraft or providing any service. The ASM will require the AFISO to provide the full AFIS service to the aircraft as the ATCO-in-the-loop using the prototype system.	
Supporting DOD / Operational Scenario / Use Case	Long Term Planning UC 6 01 Long Term Planning UC 6 06	
OFA addressed	OFA06.03.01 “Remote Tower”	
OI steps addressed	SDM-0201	
Enablers addressed	HUM-	Initial training, competence and/or

	SDM-0201	adaptation of new/active operational staff for the application and use of the enhancements and improvements included of the OI Step Remotely Provided Air Traffic Service for Single Aerodrome
	HUM-SDM-0201-01	New role and responsibilities
	HUM-SDM-0201-02	Social, people management, change and transition management factors for Automated Support for Traffic Complexity Assessment
	HUM-SDM-0201-03	Change and transition management factors for the OI step Network Operation Plan available
	PRO-157ATC	ATC Procedures (Airport) for providing services to a remote location potentially including but not limited to traffic information, separation provision, METEO alerts, and alerting services
Applicable Operational Context	Airports	
Expected results per KPA	Safety, Capacity, Human Performance all maintained.	
Validation Technique	PSM and ASM	
Dependent Validation Exercises	-	

Table 3: Exercise 3 Concept Overview

2.2 Summary of Validation Exercise/s

2.2.1 Summary of Expected Exercise/s outcomes

Stakeholder	Stakeholder Validation Expectations
ANSP	ANSP will expect the validation process to provide evidence that the concept: • Validates the major assumption in the business case i.e. that ATS can be provided remotely; • Provides levels of safety that are at least as good as current operations; • Does not negatively impact human performance in any way and is acceptable to all operators and service users; • Allows the same, if not better, levels of service to be provided in terms of predictability, efficiency and flexibility. Network capacity to be understood as the capability to provide services where (e.g. to places where today the cost of ATC does not allow to have services) and when (e.g. services only when required) needed.
ATC/AFIS Officers	ATC and AFIS Officers will expect the validation process to provide evidence that the concept: • Provides levels of safety that are at least as good, if not better than

	current (local) operations; • Allows the same, if not better, levels of service to be provided in terms of predictability, efficiency and flexibility. Network capacity to be understood as the capability to provide services where (e.g. to places where today the cost of ATC does not allow to have services) and when (e.g. services only when required) needed. • Is usable and acceptable;
Industry + WP12.4.6-8	Industry will expect the validation process to: • Generate and assess requirements to help mature and prove the concepts; • Gather evidence to help them decide on continued investment and/or concept implementation; • Promote the benefits of the concept.
SESAR Joint Undertaking	The SESAR JU will expect the validation process to: • Provide evidence that the concept will make a positive contribution to European ATM; • Be completed within timescales and budget.
Regulators (ICAO, EASA, NSA)	The Regulatory Bodies will expect the validation process to: • Assist in understanding the impact of the concept on current and future standards and regulations; • Provide evidence that the concept meets the required performance levels in terms of safety, capacity, access etc.
Airport operators	Airport operators will expect the validation process to provide evidence that the concept: • Is a feasible option for providing ATS in a more cost effective way (where cost effectiveness will be established by a separate business case) ; • To maximise airport capacity under a variety of scenarios.
ATCO trade unions (European Transport Workers' Federation (ETF), International Federation of Air Traffic Controllers' Associations (IFATCA), Air Traffic Controllers European Union's Coordination (ATCEUC))	The Trade Unions will expect the validation process to provide evidence that the concept: • Is acceptable to the operational users; • Does not lead to unwanted changes to procedure, roles or responsibilities for the operational staff
Airspace Users (airlines and pilots)	Airspace Users will expect the validation process to provide evidence that the concept: • At least maintains, and hopefully improves, safety levels; • Is a feasible option for providing ATS in a more cost effective way (where cost effectiveness will be established by a separate business case) ; • Allows the same, if not better, levels of service to be provided in terms of predictability, efficiency, flexibility and Network capacity. This will introduce the capability to be able to provide services where (e.g. to places where today the cost of ATC does not allow to have services) and when (e.g. services only when required) needed.

2.2.2 Benefit mechanisms investigated

2.2.2.1 Cost Effectiveness

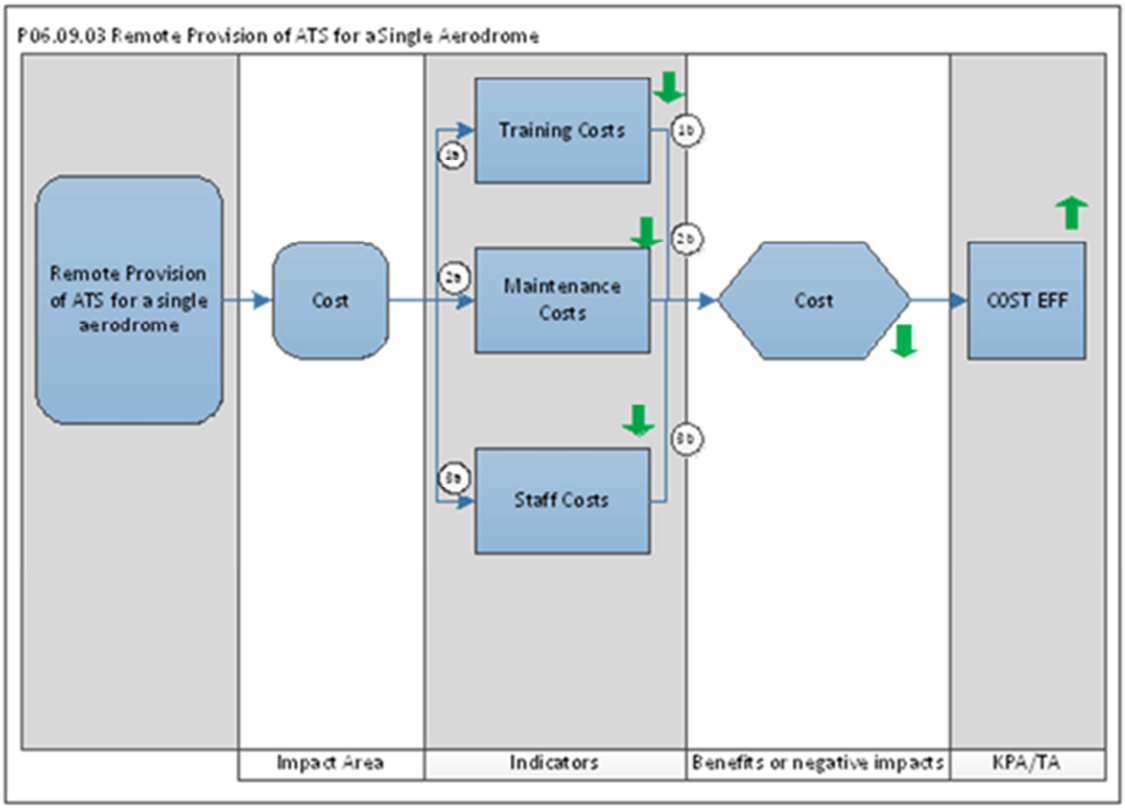


Figure 2 - Cost Effectiveness Benefit Mechanism

Feature Description: Remote Provision of ATS for a single aerodrome

Mechanisms:

(1a) Centralised provision of ATS (through co-located Single Remote facilities) will enable centralised training on standard equipment.

(1b) The concept will reduce the cost of initial and recurrent training by large scale effects and economies of scale, leading to more Cost Effective training.

(2a) Remote facilities will be built, equipped and maintained in place of local airport towers. Replacement towers will not have to be built.

(2b) The remote facilities will be cheaper to build and maintain, leading to more Cost Effective facilities.

(3a) Co-located facilities should reduce the need for extra, local and/or reserve staff. Staffing numbers can be reduced.

(3b) Lower staff costs will lead to more Cost Effective service provision.

Impacted Stakeholders:

ANSP, Airport Operators, Airspace Users

Data Sources:

Training Costs (Basic Training and Recurrent Training): Cost Analysis of Training Costs

Maintenance Costs: Cost Analysis of Maintenance Costs of Local Tower

Staff Costs: Cost of staffing facility including reserve staff

2.2.2.2 Flexibility and Capacity

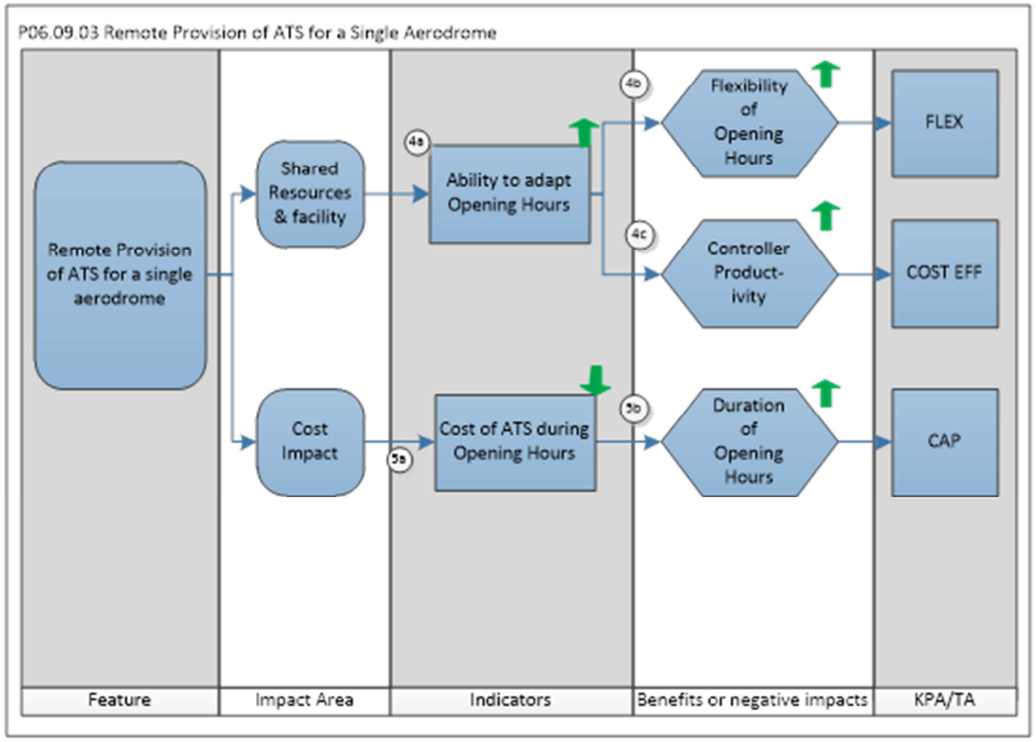


Figure 3 – Flexibility and Capacity Benefit Mechanism

Feature Description: Remote Provision of ATS for a single aerodrome

Mechanisms:

(4a) A centralised facility will allow for use of shared resources to any aerodrome. This will increase the ability to be more flexible with regards changes to opening hours.

(4b) The ability to change opening hours according to demand will increase the flexibility of the opening hours, impacting **Flexibility**. With lower costs for an equivalent service, some additional small airports may benefit from ATS.

(4c) More flexible opening hours will make more use of existing controllers (e.g. during quiet periods at aerodromes) leading to an increase in Controller Productivity. This will have a positive impact on **Cost Effectiveness**.

(5a) With the possibility for centralised/shared resources (human and technical) it may be possible to operate from an RTC for longer periods (and at lower costs) throughout the day. With lower costs for an equivalent service, some additional small airports may benefit from ATS.

(5b) If the RTC is operating for longer hours, traffic could be increased which links to **Capacity.**

Impacted Stakeholders:

ANSP, Airport Operators, Airspace Users

Data Sources:

Number of hours the RTC is in operation

2.2.2.3 Safety and Capacity

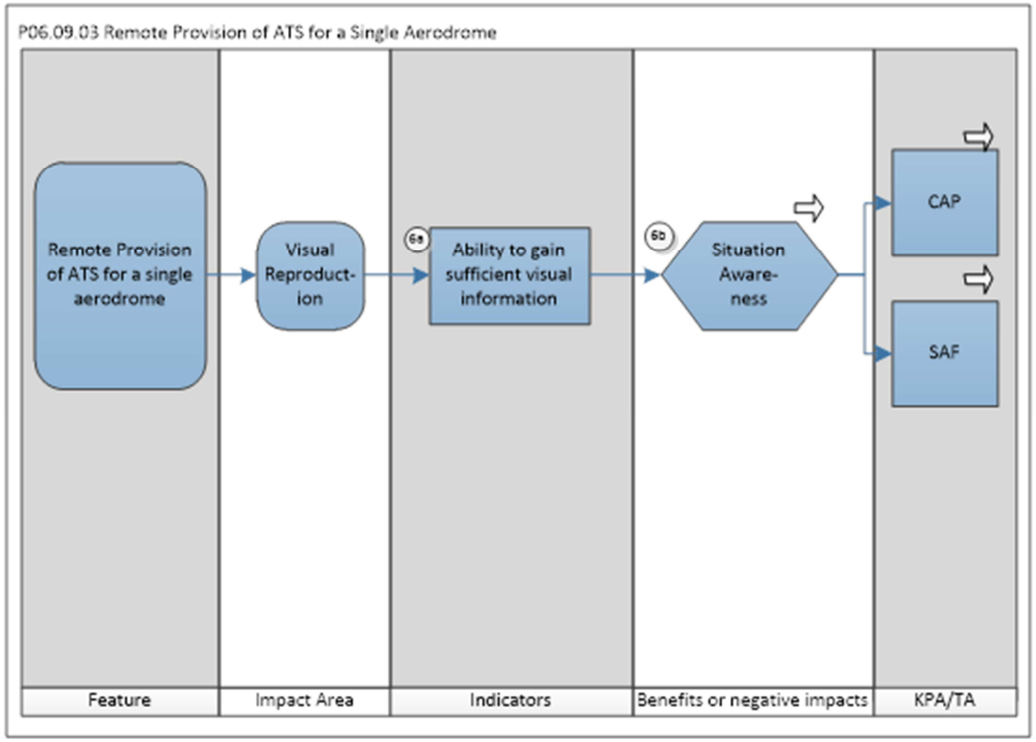


Figure 4 – Safety and Capacity Benefit Mechanism

Feature Description: Remote Provision of ATS for a single aerodrome

Mechanisms:

(6a) The ATCO must be able to gain sufficient information from the visual reproduction in order to make their decisions and provide their services. Their ability in this regard is not yet known and will be a subject of validation.

(6b) Situational Awareness of the controller may increase due to technical enablers or reduce due to differences between remote and local controlling. This may have an impact on **Safety** and **Capacity**.

Impacted Stakeholders:

ANSP, Airport Operators, Airspace Users, Regulators

Data Sources:

Situational Awareness: Human Performance Assessment of the ATCO.

2.2.3 Summary of Validation Objectives and success criteria

All of the validation objectives are taken from the P06.09.03 Validation Plan for Remote Provision of ATS to a Single Aerodrome [8]. These are high level objectives and cover all three exercises within this VALR. Lower level exercise specific objectives were derived from the high level objectives and are specified in Sections 6.x.3.1 (where x differs depending on the exercise; 1 for EXE-056, 2 for EXE-057 and 3 for EXE-058) respectively. For example high level objective OBJ-06.09.03-VALP-0060.0010 is broken down into OBJ-06.09.03-VALP-0060.001X.

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0010
Objective	To assess whether ATS services can be provided for a single airport from a remote location with no degradation of service under a variety of scenarios.
Title	Technical and Operational Capability

Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0010	The ATCO/AFISO is able to use the remote facility to perform a sufficient range of tasks to provide ATS under various operational conditions.

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0020
Objective	Assess whether the levels of safety are maintained or improved under all normal conditions when ATS are remotely provided to a single airport
Title	Safety in Normal Conditions
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0020	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0030
Objective	Assess whether the ATS can safely continue to be remotely provided to a single airport under external abnormal conditions.
Title	Safety in Abnormal Conditions
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0040
Objective	Assess whether the ATS can safely be remotely provided to a single airport during

	degraded modes of operation, and recovered from.
Title	Safety in Degraded Conditions
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0040	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0050
Objective	Assess whether RTC system has sufficient safety functionalities and performance to remotely provide ATS to a single airport, and whether these safety requirements specifying it are realistic
Title	Safety completeness and implementation
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-FN02.5006	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0050	The set of safety requirements specifying the Remote Tower system for a single airport is complete and they can be implemented in a typical physical architecture

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0060
Objective	To assess the impact of the Remote Tower Concept on ATCO/AFISO Human Performance
Title	Human Performance
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-FN02.5006	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0060	Human performance must be shown to be at an acceptable level, in terms of: Situation awareness; Human performance (efficiency) / potential for human error;

	Acceptability; Trust; Workload. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas.

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0070
Objective	To assess the Acceptability of the Remote Tower Concept to ATCO/AFISO, airport operators and pilots.
Title	Acceptability
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0070	The Remote Provision of ATS to a single aerodrome is acceptable to ATCO/AFISO, airport operators and pilots, in terms of: The concept in general; The system; Roles, responsibilities & task allocation; Working methods; Procedures; HMI.

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0080
Objective	To validate information and assumptions that will be used in any Business Case Transversal Assessments, relating to the Cost Effectiveness of Remote Provision of ATS to Single low to medium density airports
Title	Cost Effectiveness
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0009	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0080	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0090
Objective	To assess the impact of the Remote Tower Concept on airport Capacity in terms of: Impact of different weather conditions; Impact of time of day; Impact of varying opening hours.
Title	Capacity
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-BC01.0001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0090	The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.

[OBJ]

Identifier	OBJ-06.09.03-VALP-0060.0100
Objective	To assess the utility of prototype features, functions and technologies for integration into future trial platforms for the Single, Multiple and Contingency applications.
Title	Usefulness
Status	<In Progress>

[OBJ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<V&V Objective>	OBJ-06.02-VALS-0060.0002	<Full>
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-VG03.1001	N/A
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-VG03.1002	N/A
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-VG03.1003	N/A
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-AS03.2001	N/A
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-AS03.2002	N/A
<COVERS>	<ATMS Requirement>	REQ-06.09.03-OSED-FN03.3001	N/A
<COVERS>	<OI Step>	SDM-0201	N/A
<ALLOCATED_TO>	<Operational Focus Area>	OFA06.03.01	N/A
<ALLOCATED_TO>	<Project>	06.09.03	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change Reference	N/A

[OBJ Suc]

Identifier	Success Criterion
CRT-06.09.03-VALP-0060.0100	The utility of proposed/prototype features, functions and technologies is known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.

Table 4: Validation Objectives and Success Criteria

2.2.4 Summary of Validation Scenarios

Since all the validation exercises covered in this report are Shadow Mode trials, it was not possible to script scenarios. The following list contains some of the general operational scenarios that might be expected to occur at the aerodrome.

More than one of the scenarios could occur in combination e.g. IFR flights arriving at, and departing from, an aerodrome (SCN-06.09.03-VALP-0060.0010) during limited visibility (SCN-06.09.03-VALP-0060.0050).

Identifier	Description
SCN-06.09.03-VALP-0060.0010	IFR flights arriving at, and departing from, an aerodrome.
SCN-06.09.03-VALP-0060.0020	VFR flights arriving at, and departing from, an aerodrome.
SCN-06.09.03-VALP-0060.0030	VFR flights in the traffic circuit and e.g. making Touch and Go landings.
SCN-06.09.03-VALP-0060.0040	Remote Provision of ATS during good visibility conditions.
SCN-06.09.03-VALP-0060.0050	Remote Provision of ATS during limited visibility conditions.
SCN-06.09.03-VALP-0060.0060	Remote Provision of ATS during hours of darkness.
SCN-06.09.03-VALP-0060.0070	Ground surface movements at an aerodrome – vehicles and aircraft.
SCN-06.09.03-VALP-0060.0080	Simultaneous service provision of aircraft in flight and on the manoeuvring area by the ATCO/AFISO.
SCN-06.09.03-VALP-0060.0090	Runway Incursion.
SCN-06.09.03-VALP-0060.0100	Obstructions on the manoeuvring area.
SCN-06.09.03-VALP-0060.0110	Occasions or events where lamp signalling by ATCO/AFISO is required.
SCN-06.09.03-VALP-0060.0120	Observation by the ATCO/AFISO of visual communication from the aircraft that are within visual range, such as: - aircraft flashing landing lights or flashing navigation lights (in darkness). - aircraft repeatedly changing its bank angle – “rocking wings” (in daylight).
SCN-06.09.03-VALP-0060.0130	ATCO use of visual navigation aids.
SCN-06.09.03-VALP-0060.0140	ATCO use of non-visual navigation aids.

Table 5: Validation Scenarios

2.2.5 Summary of Assumptions

There are no top down validation assumptions which can be taken from the WP06.02 Validation Strategy.

2.2.6 Choice of methods and techniques

The table below lists the platforms, methods and techniques chosen for the assessments. In some cases (e.g. Human Performance) they were not the ideal technique, but were the best available to the project at the time.

Supported Metric / Indicator	Platform / Tool	Method or Technique
Technical and Operational Capability	NATMIG Remote Tower (Single) prototype	PSM Trials (including an ASM trial for EXE-06.09.03-VP-058)
Safety in Normal Conditions	As above	As above
Safety in Degraded Conditions	As above	As above

Safety completeness and implementation	As above	As above
Human Performance	As above	As above
Acceptability	As above	As above
Cost Effectiveness	As above	As above
Capacity	As above	As above
Utility	As above	As above
Safety in Abnormal Conditions	Stakeholder Workshop	Subjective Feedback gained during a stakeholder workshop.

Table 6: Methods and Techniques

2.2.7 Validation Exercises List and dependencies

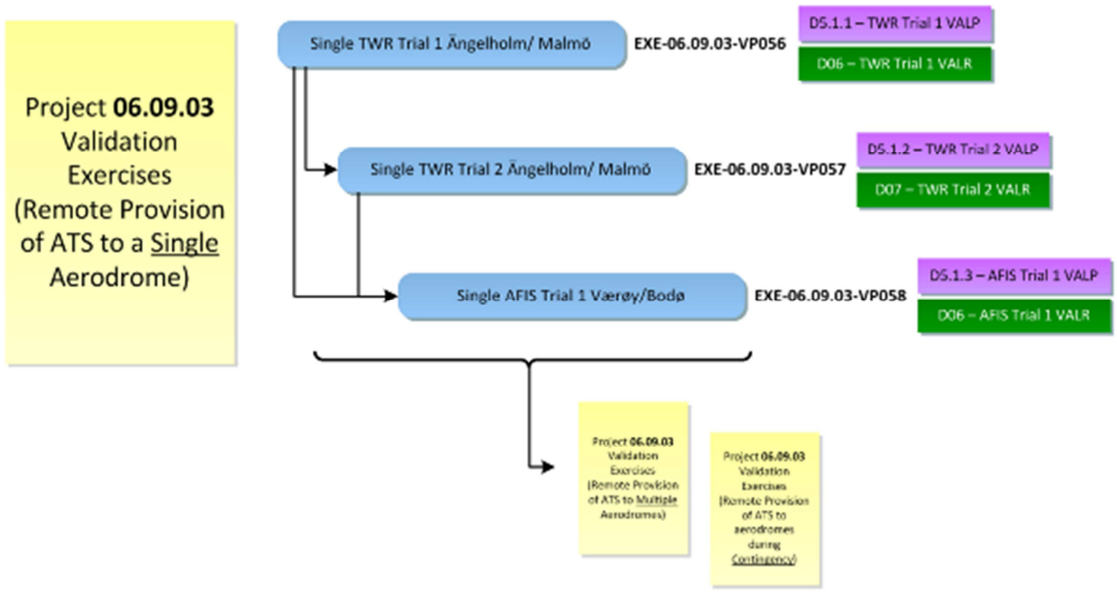


Figure 5: Validation Exercises List and dependencies

3 Conduct of Validation Exercises

3.1 Exercises Preparation

The preparation of each validation exercise is detailed in the corresponding Validation Plan [8].

3.2 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-06.09.03-VP-056	Remote Provision of ATC to a Single Aerodrome Trial 1 Ängelholm/Malmö	25/10/2011	15/11/2011	15/11/2011	28/02/2012
EXE-06.09.03-VP-057	Remote Provision of ATC to a Single Aerodrome Trial 2 Ängelholm/Malmö	07/05/2012	25/05/2012	28/05/2012	30/08/2012
EXE-06.09.03-VP-058	Remote Provision of AFIS to a Single Aerodrome Trial 1 Værøy/Bodö	03/12/2012	15/03/2013	16/04/2013	15/07/2013

Table 7: Exercises execution/analysis dates

3.3 Deviations from the planned activities

A stakeholder workshop for the validation of the Single Remote Tower was held on 8th October 2013 at Göteborg/Landvetter (ESGG) airport. The results of which were intended to supplement this SDM-0201 VALR and appear in Appendix A. The workshop was commissioned to provide analysis of objective OBJ-06.09.03-VALP-0060.0030, regarding safety in abnormal conditions. This objective was not able to be directly assessed within the trials for VP-056, VP-057 or VP-058 as originally planned. The deviation occurred due to a lack of scenarios within the planned exercises containing abnormal events, the occurring due to the nature of shadow mode trials.

The workshop took the form of structured group based questioning using pre-formatted questions together with general discussion. Stakeholders present at the workshop included:

1. Four ATCOs from ESGG;
2. Representatives from Swedavia (*Swedish airports, government owned agency responsible for Sweden's commercial airport operation*);
3. Airspace users in the form of pilot representatives from International Council of Aircraft Owner and Pilot Associations (IAOPA) and Novair;
4. SAAB technical experts;
5. P06.09.03 LFV project management and team members *(whereof two members were senior experienced ATCOs and a further two contributed operational knowledge of ATC and validation)*
6. LFV (*Swedish Air Navigation Service Provider (ANSP))* human factors experts.

In summary a total 14 stakeholders were present at the workshop. This included four operational ATCOs from ESGG, two experienced ex-ATCOs and two airspace users. The ATCOs from ESGG who participated were involved in another part of the P06.09.03 project, contingency remote tower under exercise EXE-06.09.03-VP-059 covering SDM-0204 [20]. Results gained via the workshop are therefore not directly based upon the conditions as seen under Single Remote Tower exercises VP-056, VP-057 or VP-058. This should be taken into consideration when assessing the findings.

3.3.1 Deviations with respect to the Validation Strategy

None.

3.3.2 Deviations with respect to the Validation Plan

Objective OBJ-06.09.03-VALP-0060.0017 was added to EXE-06.09.03-VP-058 during the trial itself.

4 Exercises Results

This section is comprised of the results from all three trials (VP-056, VP-057 and VP-058) for Remote Provision of ATS to a Single Aerodrome.

4.1 Summary of Exercises Results

4.1.1 Context of the Consolidated Results

As was the strategy from the outset, the project treated the three trials assessing SDM-0201 as a set. The idea was to build upon each trial from a technical maturity point of view meaning that the technical capability of the platform used in the 3rd trial was expected to be better, and more representative of an operational platform, than the platform used in the 1st trial.

From an operational point of view, the first two trials (VP-056 and VP-057) shared many of the same characteristics (service, environment, traffic etc.) and were conducted using the same technique (Passive Shadow Mode). The third trial, although using the most technically mature platform, was using a very different environment and a different validation technique (Advanced Shadow Mode).

The results in this section should therefore be considered in this context. The table below summarises the key differences in each trial.

ID	Technique	Date	Service	Aerodrome	Number of Participants	Relative Screen Quality	IR Camera	Pan-Tilt-Zoom (PTZ) Camera	Tracking Labels	Hotspot cameras
VP-056	PSM	Q4 2011	TWR ATC	Ängelholm	12	Good	Yes	Yes	No	No
VP-057	PSM	Q2 2012	TWR ATC	Ängelholm	14	Better	Yes, but some reliability issues	Yes, but quality issues	Yes	Yes
VP-058	ASM	Q1 2013	AFIS	Værøy	1	Best	Yes	Yes	Yes	No

Table 8: Summary of differences across three trials

It was considered acceptable that some objectives would be given a NOK status in early trials, provided that feedback into the technical and operational concept was generated and subsequently used to allow similar objectives in later trials to achieve OK status.

Finally, it should be noted that this report details the results derived from the Validation Exercises. More details results relating to Human Performance and Safety can be found in the Human Performance Assessment Report [18] and the Safety Assessment Report [17].

4.1.2 Status of Validation Objectives

This section tracks the progress of the project against the Validation Objectives given in Section 2.2.3. These are the top level Validation Objectives for Remote Provision of ATS to a Single Aerodrome, and are the objectives from which all individual validation exercise objectives are derived. For example high level objective OBJ-06.09.03-VALP-0060.0010 is broken down into OBJ-06.09.03-VALP-0060.001X. A full interpretation (and rationale for the trial specific status) is given in the sections relating to trial specific results. The expanded Summary of Exercise Results (with respect to the SESAR guidelines can be found in Appendix A.

Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	VP-056	VP-057	VP-058	**Validation Objective Current Consolidated Status**

OBJ-06.09.03-VALP-0060.0010	Technical and Operational Capability	CRT-06.09.03-VALP-0060.0010	The ATCO/AFISO is able to use the remote facility to perform a sufficient range of tasks to provide ATS under various operational conditions.	OK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0020	Safety in Normal Conditions	CRT-06.09.03-VALP-0060.0020	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	OK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0030	Safety in Abnormal Conditions	CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Assessed during Workshop [**Error! Reference source not found.**]			**OK**
OBJ-06.09.03-VALP-0060.0040	Safety in Degraded Conditions	CRT-06.09.03-VALP-0060.0040	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	OK	OK	NOK	**OK**
OBJ-06.09.03-VALP-0060.0050	Safety completeness and implementation.	CRT-06.09.03-VALP-0060.0050	The set of safety requirements specifying the Remote Tower system for a single airport is complete and they can be implemented in a typical physical architecture		OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0060	Human Performance.	CRT-06.09.03-VALP-0060.0060	Human performance must be shown to be at an acceptable level, in terms of: Situation awareness; Human performance (efficiency) / potential for human error; Acceptability; Trust; Workload. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas.	NOK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0070	Acceptability.	CRT-06.09.03-VALP-0060.0070	The Remote Provision of ATS to a single aerodrome is acceptable to ATCO/AFISO, airport operators and pilots, in terms of: The concept in general; The system; Roles, responsibilities & task allocation; Working methods; Procedures; HMI.	NOK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0080	Cost Effectiveness.	CRT-06.09.03-VALP-0060.0080	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.		OK	OK	**OK**

OBJ-06.09.03-VALP-0060.0090	Capacity.	CRT-06.09.03-VALP-0060.0090	The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.		OK		**OK**
OBJ-06.09.03-VALP-0060.0100	Usefulness.	CRT-06.09.03-VALP-0060.0100	The utility of proposed/prototype features, functions and technologies is known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	OK	OK	OK	**OK**

Table 9: Summary of Validation Objective Results (consolidated across all exercises)

4.1.3 Results on concept clarification

4.1.3.1 Operational Feasibility

The results from VP-056 (the first trial) indicate that the concept was operationally feasible under normal conditions, but that the exact level of service which could be provided may be limited. There were concerns over the operational feasibility of providing remote ATS to both IFR and VFR traffic that this may cause a decrease in VFR capacity (due to increased VFR holding and prioritisation of IFR traffic). A primary reason given for this was the quality of the visual reproduction used and the ability to establish and maintain visual surveillance and monitor separation based on that quality of OTW view alone.

In later trials, where the quality of the visual reproduction was improved and the Advanced Visual Features were introduced, results indicated that a system with these qualities was suitable and feasible for the Remote Provision of ATS. Concerns with regards to level of service were reduced, and in some cases removed totally. In particular the Infra-Red camera, additional hotspot cameras and tracking overlays greatly assisted human performance, with comments indicating particular benefits in low visibility and darkness. The operational feasibility was confirmed when the system was used for provision of ATS in a live environment in VP-058.

Working methods for use in the RTM were developed in VP-056 and formally assessed in in VP-057; these included procedures for hand-overs and degraded operations. Working methods for normal conditions were based on the live traffic being observed in Passive Shadow Mode, while working method for a (limited) range of degraded scenarios were assessed via emulation of technical faults. Working methods for abnormal scenarios were assessed during a workshop [**Error! Reference source not found.**]; no significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the provision of having robust and accurate PTZ camera functionality and the potential requirement to provide a 360◦ visual representation were included in ATCO feedback. PTZ camera functionality should allow for quick and accurate manoeuvrability, in line with using standard binoculars. The provision of a 360◦ visual representation during abnormal situations would be dependent on the traffic patterns at individual aerodromes, catering for the ICAO Doc 4444 requirement of a continuous watch on all flight operations on and in the vicinity of an aerodrome (where vicinity is defined as "*aircraft in, entering or leaving an aerodrome traffic circuit"*), hence for some aerodromes a visual representation of less than 360◦ may be sufficient.

Working methods for normal conditions were considered acceptable and operationally feasible since they were based mainly on local tower methods. The only additions were in specifying how best to use the technical features. ATCOs in VP-057 gave a 93% acceptance (strong agree and agree) of working methods for normal conditions and 57% acceptance (strongly agree and agree) of working methods for degraded mode. The AFISO in VP-058 neither agreed nor disagreed with working methods for degraded or abnormal operations as neither occurred in the live environment under the ASM trial. However working methods for normal conditions were strongly accepted.

Task allocation and roles and responsibilities were assessed from a hypothetical point of view in VP-056 and VP-057 (since the ATCO was not in the control loop). It was possible to get a more involved view during VP-058 and Advanced Shadow Mode operations. The AFISO felt that there were slight operational differences in task allocation when providing ATS remotely. This was primarily related to the inability to physically check weather conditions. The AFISO found roles and responsibilities were clearly defined however precise working methods, for example relating to the exchange of information and communication with the local aerodrome, needed improving. ATCOs also highlighted the detection/observation of weather conditions as one of the main differences in their operational tasks. Methods for the visual separation of aircraft were mentioned as a concern, depending on the quality of the visual reproduction. As the maturity and quality of the visual reproduction increased throughout the trial these concerns were decreased. The need to technically troubleshoot systems and coordinate with local aerodrome staff remotely to tackle certain onsite issues was also highlighted as a potential source of increased workload and changed task responsibility. Overall task allocation and working methods were deemed feasible throughout trials.

4.1.3.2 Acceptability

The acceptance of the RTM and the advanced visual features was high, indicating that the ATCOs found them to be operational acceptable. Overall the ATCOs were more critical than the AFISO; scores in VP-058 were statistically higher than VP-056, this due to the relative differences in technical maturity across the trials.

The acceptability of the visual reproduction was generally high across all three trials, with the caveat that the quality had a direct impact on the level of service that the users felt comfortable providing. The tracking overlay feature was the most highly features across all trials, averaging 4.03 out of 5. When operating well, the IR camera and PTZ camera were also considered to be highly acceptable. Scores for CWP and Working Environment were only slightly above average indicating improvement is required in both these areas.

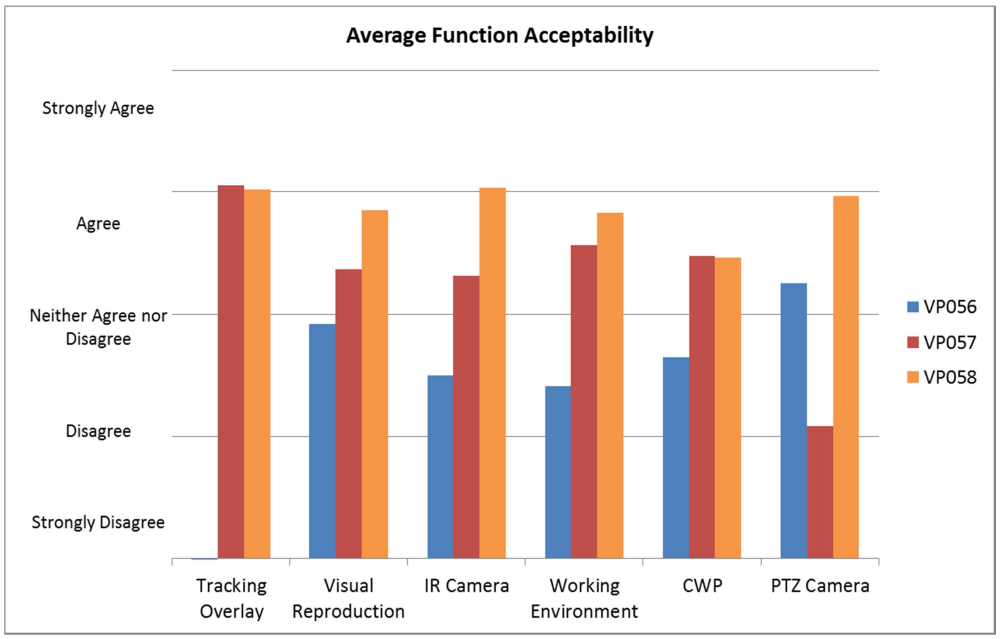


Figure 6: Average acceptability of advanced functions throughout trials

Ambient sound was deemed to provide added benefit within all trials, however there was no consensus that this feature should be viewed as a requirement in an RTM. The acceptance of the concept was not assessed in all weather and visibility conditions and so some further assessment may be required. Comments throughout VP-057 and VP-056 suggest that the technical enablers, with particular regard to the IR camera and PTZ camera (mentioned by the AFISO in VP-058) greatly improved ability to provide ATS and detect FOD in decreased visibility, with benefits highlighted even compared to local tower operations. The IR camera, PTZ camera and Tracking Overlays all

contributed to increased AFISO situational awareness and hazard perception in limited visibilities and darkness.

Pilot acceptance was high with praise and a high level of overall trust in the system reported when being used to provide AFIS in VP-058.

4.1.3.3 Technical Integration

Based on increasing technical maturity and feedback from exercise VP-056 technical improvements were made in advance of VP-057, including additional HD cameras, tracking overlay functionality, E-Strips and an improved visual representation.

There were further improvements in technical maturity and usability from VP-057 to VP-058, notably the AFISO did not detail any issues with the visual reproduction related to depth perception or quality, like the ATCOs had done in VP-056 and VP-057. VP-058 also rated the PTZ camera more highly, most likely as the result of operational and technical improvements to this feature. The tracking overlay function was updated after VP-057 as a result of ATCO comments; however the function still gained a high level of acceptance from ATCOs prior to any technical updates being performed. Hence highlighting that the users appreciated the ability to more easily spot traffic.

During VP-057 the PTZ, IR Camera and additional view point cameras were used by ATCOs during degraded mode to substitute for, or reduce the effect of, the loss of a main camera and display.

The technical enablers had varying levels of functionality throughout trials, with VP-058 having the most technical enablers functioning to a high level. However even in VP-058 the accuracy and correlation of the tracking overlay was malfunctioning when aircraft were close to the aerodrome.

Within VP-056 the PTZ camera raised concerns due to its lack of integration with the main display, thus reducing the usefulness of the PTZ display as it removed ATCO focus from the main OTW view. This was improved upon and results improved for VP-057 and further still due to HMI upgrades and other technical improvements before VP-058.

Overall VP-056, the least technically advanced trial, highlighted the need for a well-integrated technical system through reduced concept acceptance and performance compared to later trials. The additional OTW overlaid views for the IR camera and PTZ camera have improved acceptability of these functions and the overall concept.

Feedback from participants indicated the importance of a robust system in instilling confidence within participants. Good levels of technical integration and improvement to the HMI also increased acceptance scores.

4.1.4 Results per KPA

4.1.4.1 Cost Effectiveness

The primary driver for Remote Provision of ATS is Cost Effectiveness. However, it was never the project's aim to prove this directly through validation trials. Rather, the trials were used to validate the assumption in the business case i.e. that it is operationally feasible to provide ATS from a remote location. Maintaining Operational Feasibility depends most on safety, human performance and capacity and so it is those areas that are further explored.

4.1.4.2 Human Performance

Human Performance throughout the trials was at an acceptable level. The influence of technical issues lowered performance and technical failings that did arise were notably perceived by participants to impact their performance.

Despite this scores for Human Performance still remained high, with technical enablers (when functional) working to enhance performance.

Situational awareness throughout the trials was on average 4.9 (out of 6), indicating that ATCOs and AFISOs were able to achieve a high level of situational awareness within the RTM. The most positive situational awareness results on average were recorded against "ability to keep ahead of the traffic",

thus highlighting the ability of the RTM to provide a clear traffic picture, albeit in the low traffic levels experienced in the trials. The main area for improvement in earlier trials with regards to situational awareness was in the areas of "focusing on a specific problem" and "searching for specific information". This is directly attributable to the influence of the visual reproduction quality and lack of tracking overlays in VP-056.

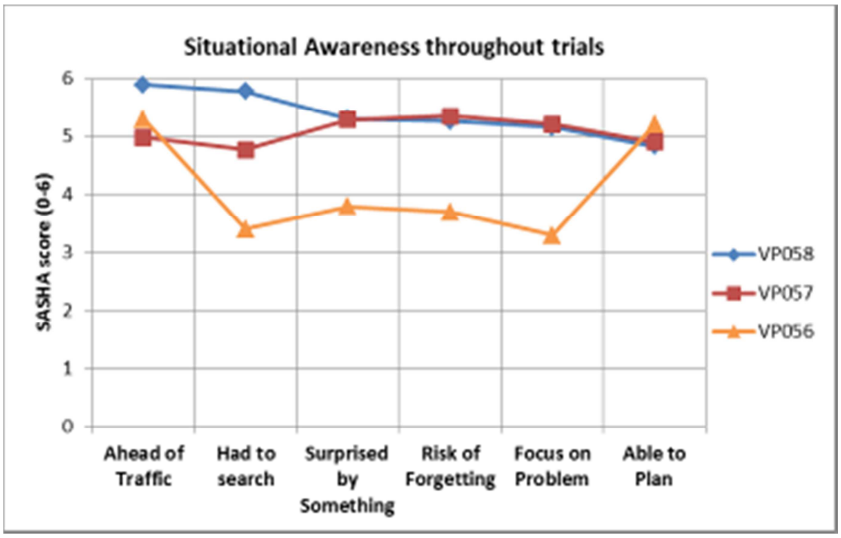


Figure 7: Average Situational Awareness scores per trial and overall

Whilst it is acknowledged that none of the trials had uniform fixed variables, many factors across the trials were very similar and so a comparison can give an interesting, if not statistically robust, comparison. Situational awareness was lowest in VP-056, using the first and least technically mature platform. In VP-058 the AFISO scored slightly lower on average than the ATCOs in VP-057 for ability to plan ahead. It should be noted however that VP-058 was an ASM trial and therefore the AFISO had other duties to perform as operator-in-the-loop, rather than just observe as the ATCO in Passive Shadow Mode did.

The advanced visual features and availability of radar were also found to have a direct link to improving situational awareness (see Figure 8). A direct comparison in VP-057 (comparing when these features were enabled and when they were disabled) highlighted that situational awareness within a remote setting is adequate even without these technical features, with the average situational awareness (Solutions for Human Automation Partnerships in European ATM (SHAPE) measurement technique for Situational Awareness in ATM systems (SASHA) Score) being 4.7 out of 6. As expected, the results show that there was a statistically significant difference between the situational awareness results when the features were enabled and when they were disabled.

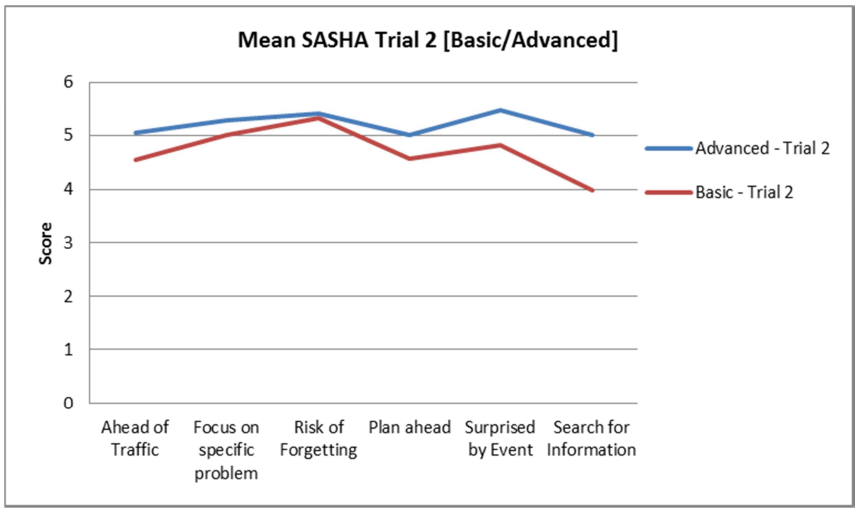


Figure 8: VP-057 SASHA scores for basic and advanced

Features that were highlighted as increasing perceived situational awareness included the IR Camera, Tracking Overlay labels and Radar.

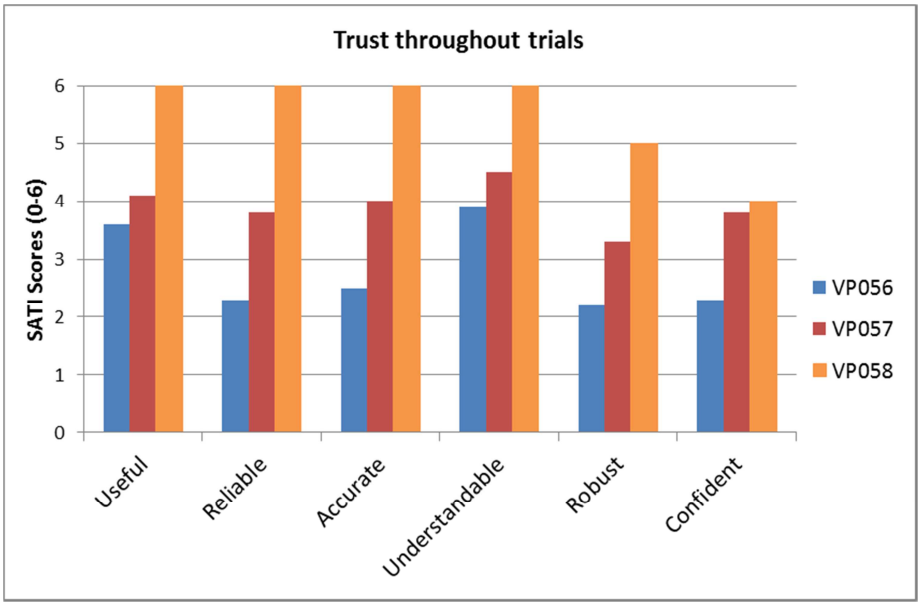


Figure 9: Average Trust scores per trials and overall

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 which will lead to ATCO confidence. Trust (SHAPE Automation Trust Index - SATI) scores were high including categories relating to how robustly the system worked and being confident in using the system.

VP-056 trials scored lowest with regards to overall trust, however controllers felt the system was understandable with the IR camera in particular mentioned as a contributing factor. A very high level of trust for the IR camera was also expressed by the AFISO in VP-058. . The ATCOs in VP-057 lacked trust in the PTZ camera due to poor reliability and difficulties with functioning.

Overall, ATCOs reported a good level of trust in the concept, and in particular when advanced features were enabled in VP-057 where 100% of ATCOs understood and found the system useful. The AFISO rated the system as “very often” understandable, highlighting the ease of use. The least positive responses were related to perceived robustness and confidence in the system especially in earlier trials and perhaps reflecting the prototype nature of the system.

Within VP-056 42% of controllers agreed that they were “In the loop” for providing ATS from the remote tower, however this increased to 71% in VP-057. In VP-057 42% of controllers felt that working in the remote tower made their task less real which was an increase from VP-056. It is possible that this decreased perception of reality may be due to the increased use of advanced visual features and visual aids used with VP-057.

Workload could only be usefully measured within VP-058 as this was an ASM trial. The spread of NASA TLX scores was very narrow, with the mean workload score being 0.84 (out of 10) indicating that the AFISO was not under a high workload.

4.1.4.3 Safety

The trials provided some ability to assess the impact of the concept on safety. In VP-057 86% of the ATCOs indicated that they felt able to detect hazards, and all of the controllers say they were able to detect conflicts. A workshop was held in order to assess safety under abnormal conditions (this was a deviation to the original plan, see section 3.3 and **Error! Reference source not found.** for further information). ATCOs raised no concerns over using the system safely during abnormal events. The only condition on maintaining safety was the provision of robust and easy to use technical enablers, with particular reference to those enhancing vision such as the PTZ camera. Based upon the functionality of the PTZ as seen within VP-059 [20], the PTZ functionality needs to be improved as a prerequisite for easy operation during abnormal situations. This stresses the importance of the OSED service requirement on a binocular functionality, stating: *“..a functionality corresponding to – and being (at least) equally easy and quick to use as – the binoculars in a local Tower..*”[7]. Improvements should be focused around the manoeuvrability and accuracy of the PTZ camera. Workshop participants also felt that a 360° visual representation/aerodrome view would improve their ability to respond in an abnormal situation. However this would be more beneficial at certain aerodromes, dependant on the extent of the traffic pattern and traffic types. Hence requirements should focus on coverage of the traffic pattern at specific aerodromes. Varying the degrees of visual coverage would be required dependant on the traffic pattern at individual aerodromes.

Workshops revealed that safety under certain abnormal scenarios may be increased when using the remote tower compared to the local tower. These scenarios included an aircraft landing without aircraft lights; in this case the IR camera may be used to assist in aircraft detection and navigation to stand. Further to this the tracking labels would assist in the identification of a lost VFR aircraft with a transponder.

The concept has the potential to reduce human error due to the addition of technical enablers, which increase situational awareness. Human performance results indicate that overall the systems were enabling participants to perform to high levels.

The main risk factors were highlighted as being the technical issues and the impact of these technical issues. All trials indicated that the reliability and functionality of the technical system influenced the perception of safety. The technical system was improved upon from trials VP-056 to VP-057 and as a result the overall perceived safety of the system was deemed to improve. Other potential risk factors were the ability to maintain communications with the local aerodrome and awareness of local environmental conditions.

When considering whether the system may induce more hazardous situations, the RTM can have features that a local tower does not have, including the addition of technical enablers such as tracking overlays. Opinion was divided as to the overall safety impact of the advanced features. Some participants saw a positive contribution through better situational awareness and human performance but others could see an added risk through over-reliance and chance of technical failure.

During VP-057 some non-nominal degraded mode situations were investigated. Screen failure was tested multiple times. The results indicated that degraded mode procedures should be tailored depending on which screens fail, the combination of screens that fail and also on the capability of the advanced visual cameras to replicate a lost image. The importance of informing flight crew in such situations was seen by ATCOs to be of high importance.

4.1.4.4 Capacity

Concerns were raised after VP-056 surrounding the ability to provide ATS to mixed IFR and VFR traffic without reducing capacity. Overall ATCO opinion on maintaining IFR capacity was positive, however controllers gave negative responses in relation to whether or not the concept would reduce VFR capacity or lead to increased amounts of VFR holding. Controllers agreed that any potential capacity reductions would be less when using a system with a good quality visual reproduction, advanced visual features and radar. Results from VP-057 confirmed this and in that trial analysis highlighted that the controllers saw no difference in their ability to provide ATS from an RTM compared to a local tower.

A remaining concern with regards to capacity and levels of service was in one particular scenario, namely: "two VFR arrivals, very close behind one another at night". Controllers felt less comfortable providing ATS remotely in this scenario compared to from the Local Tower. Comments indicated the reason for this was due to difficultly with the judgement of distance and decreased vision due to darkness.

Results indicate that simultaneous aircraft movements or aircraft-vehicle movements would not be a problem if using the advanced features. 71% of VP-057 controllers felt that by using the RTM to provide ATS, aerodrome capacity during low visibilities would increase (The remaining 29% neither agreed nor disagreed).

4.1.5 Results impacting regulation and standardisation initiatives

The assessments carried out with regards working methods, particularly in degraded mode, was a direct input into the Standards and Regulations report produced by the project.

4.2 Analysis of Exercises Results

See

Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	VP-056	VP-057	VP-058	**Validation Objective Current Consolidated Status**
OBJ-06.09.03-VALP-0060.0010	Technical and Operational Capability	CRT-06.09.03-VALP-0060.0010	The ATCO/AFISO is able to use the remote facility to perform a sufficient range of tasks to provide ATS under various operational conditions.	OK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0020	Safety in Normal Conditions	CRT-06.09.03-VALP-0060.0020	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	OK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0030	Safety in Abnormal Conditions	CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Assessed during Workshop [**Error! Reference source not found.**]			**OK**
OBJ-06.09.03-VALP-0060.0040	Safety in Degraded Conditions	CRT-06.09.03-VALP-0060.0040	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	OK	OK	NOK	**OK**
OBJ-06.09.03-VALP-0060.0050	Safety completeness and implementation.	CRT-06.09.03-VALP-0060.0050	The set of safety requirements specifying the Remote Tower system for a single airport is complete and they can be implemented in a typical physical		OK	OK	**OK**

			architecture				
OBJ-06.09.03-VALP-0060.0060	Human Performance.	CRT-06.09.03-VALP-0060.0060	Human performance must be shown to be at an acceptable level, in terms of: Situation awareness; Human performance (efficiency) / potential for human error; Acceptability; Trust; Workload. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas.	NOK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0070	Acceptability.	CRT-06.09.03-VALP-0060.0070	The Remote Provision of ATS to a single aerodrome is acceptable to ATCO/AFISO, airport operators and pilots, in terms of: The concept in general; The system; Roles, responsibilities & task allocation; Working methods; Procedures; HMI.	NOK	OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0080	Cost Effectiveness.	CRT-06.09.03-VALP-0060.0080	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.		OK	OK	**OK**
OBJ-06.09.03-VALP-0060.0090	Capacity.	CRT-06.09.03-VALP-0060.0090	The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.		OK		**OK**
OBJ-06.09.03-VALP-0060.0100	Usefulness.	CRT-06.09.03-VALP-0060.0100	The utility of proposed/prototype features, functions and technologies is known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	OK	OK	OK	**OK**

Table 9: Summary of Validation Objective Results (consolidated across all exercises).

4.2.1 Unexpected Behaviours/Results

The technical system throughout trials was intended to represent a technical prototype, starting from V3 and being developed throughout trials. For this reason it was expected that technical issues would surface. This occurred during trials yet is not treated as an unexpected result. The same can be stated with regards to the working environment of the RTM, which despite being operationally realistic is recognised as not being optimal.

4.3 Confidence in Results of Validation Exercises

4.3.1 Quality of Validation Exercises Results

The quality and integrity of validation results has been maintained to the highest level possible through all trials, however the following have been highlighted as noteworthy elements:

- Shadow mode trials do not allow as much flexibility, compared to a simulation, in fixing and pre-determining the range of scenarios that the participants will face. In order to have more control over scenarios certain things were put into place during VP-056 and VP-057. This included greater coordination of exercises across known traffic schedules, the use of a local flight school to fly pre-determined events and the use of pre-recorded scenarios;
- Within the PSM trials the ATCOs/AFISO were not able to interact with aircraft and were not able to provide actual ATS to the aircraft. Therefore any opinion related to ability to provide ATS is based on observation, interpretation and inference, albeit from operational experts with knowledge of the trial operational environment;
- The TWR trials (VP-056 and VP-057) used different sets of ATCOs although some were consistent across both exercises;
- Not all ATCOs from VP-056 and VP-057 were valid for Ängelholm, however local familiarisation was held at the local tower and all ATCOs were questioned to ensure each participant was confident enough to take part in the trial;
- The results from the trials are mainly based on subjective feedback. Industry standard methodologies and techniques such as EUROCONTROL's SHAPE questionnaires have been used to help ensure the results obtained are valid & reliable;
- A sole AFISO actively participated during the single AFIS trials in VP-058. This potentially introduced personal bias into results. Attempts to address this were made in the PSM trial by also recording comments and results from two other non-active participants (see section 6.3.2.2.2.1);
- The single AFIS trials (VP-058) were performed at a heliport and hence some factors that may be present in airports, such as the long distance visual issues, may not have been fully realised.

4.3.2 Significance of Validation Exercises Results

Variations between VP-056, VP-057 and VP-058 mean that direct statistical comparison is not robust. There were a number of variables that were altered between trials; with participants changing, software updates being performed and in the case of VP-058 a different ATS was tested. Although there was a lack of uniform fixed variables, many factors across the trials were very similar and so a comparison offers an interesting, if not statistically robust, insight. Comparisons made between trials are not put under statistical scrutiny, yet still offer valuable robust comparative analysis.

Within trials statistical analysis has been completed, where possible, on qualitative data. All statistical analysis is quoted to a significance level of 95% (alpha =0.05) and are primarily two tailed T-tests, indicating that the directionality of results has not been assumed and decreasing the chances of a false significance being found within results.

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 Conclusions on Concept Feasibility

With regards to the operational feasibility of the Remote Provision of ATS to a Single Aerodrome concept the following conclusions are drawn (listed in order of importance):

- The ability to provide ATS was seen to be directly correlated to the quality of the visual reproduction;
- Concerns about ability to accommodate VFR traffic, as noted in OSED, are deemed to be potentially unfounded when advanced features (advanced visual features and radar) are used in conjunction with a good quality visual reproduction;
- When advanced features are not present, service can still be provided, but perhaps limited to a maximum number of simultaneous movements (depending on quality of visual reproduction);
- Working methods for normal conditions (based on local tower working methods) were acceptable. Working methods for degraded mode were considered acceptable within the limits in which they were tested. Working methods for abnormal situations were not tested directly however discussion revealed that with adequate technical enablers working methods would be accepted;
- There were some reported differences in task allocation and ATCO/AFISO roles and responsibilities. Results in these areas were as expected and do not indicate any specific issues;
- The technical knowledge and skills of ATCO/AFISO may need to be greater with a greater reliance on technical enablers;
- Acceptance of the system and concept:
    - Recognised as being interlinked i.e. acceptance of the *operational* concept depends heavily on the acceptability of the *technical* system;
    - Very dependent on technical maturity and quality of the visual reproduction;
    - Technical integration has a positive correlation with acceptance and human performance.
    - Both system and concept were deemed to be acceptable overall;
- The following features were positively received:
    - Visual Reproduction;
    - Label overlay tracking;
    - PTZ camera (when functioning properly)
    - IR camera;
- The following features require improvement:
    - Controller Working Position;
    - Working Environment;
- The additional cameras viewpoints (hotspots) were favourably received but feedback was not as strong as for other features due to limited use in trials;

5.1.2 Conclusions on Key Performance Areas

With regards to the performance of the Remote Provision of ATS to a Single Aerodrome concept the following conclusions are drawn (each KPA's conclusions are listed in order of importance):

- Human Performance:
  - Human Performance during the trials was deemed to be acceptable;
  - Addition of technical enablers have a direct positive impact on Human Performance;
  - Situational awareness observed in the trials was acceptable;
  - Situational awareness is strongly influenced by technical maturity and visual reproduction in particular;
  - Some situational awareness results must be considered in the context of the low traffic environment and passive shadow mode technique;
  - Trust in the system was acceptable with some caveats. There were some concerns raised about robustness and confidence in the system but provided these are due to the prototype nature of the system and would an operational system would be more stable, then these concerns may be allayed;
  - Workload was not measured in at all for the ATCO and only generally for a single AFISO. Therefore it is not possible to draw conclusions on workload;
  - The trials were successful in facilitating good feedback into the Human Performance assessment;
- Safety:
  - Safety under normal conditions was assessed as was judged to be acceptable;
  - Safety under degraded conditions was partially assessed as was judged to be acceptable for the conditions in which it was assessed;
  - Safety under abnormal conditions was deemed to be acceptable under subjective qualitative assessment;
  - As technical acceptance and robustness increase, perceived safety also increases;
  - Hazards and risks were identified from an operational and technical point of view:
    - Technical – the biggest risk is system failure with the increased complexity of the system;
    - Operational – A potential lack of local knowledge, or ability to judge local conditions (e.g. weather at that instant);
  - The trials were successful in facilitating good feedback into the Safety assessment;
- Capacity:
  - Capacity is strongly influenced by overall technical maturity and visual reproduction in particular;
  - The ability (or inability) to judge visual distance and separation can be a limiting factor with regards the ability to use reduced separation minima (often referred to as "visual separation");
  - Advanced visual features are not essential; however help to maintain traffic levels and capacity comparable with those achievable from a local tower.
  - Advanced visual features can also support the ATCO in applying reduced separation minima (often referred to as visual separation), enabling separation to be provided in a manner more similar to that possible from a local tower;
- Cost Effectiveness:

- o No direct conclusions on Cost Effectiveness are drawn based on the trial results alone.

5.1.3 Overall Conclusions

There were ten top level validation objectives for SDM-0201 (Remote Provision of ATS to a Single Aerodrome). Of those 10 all were assessed and achieved OK status.

The overall conclusion from the three trials is that the Remote Provision of ATS to a Single Aerodrome is acceptable to the controllers and is operationally feasible. Therefore, the proposed maturity of the concept following the validation exercises is the target maturity of V3. Further development of the concept will be addressed in the validation exercises for SDM-0204 and SDM-0205. The project/concept team are responsible for implementing the necessary recommendations regarding the concept and future trials/simulations whilst the technical project P12.04.07 will be responsible for implementing the changes to the technical platform.

5.2 Recommendations

5.2.1 Recommendations on Concept and Procedures

With regards to the concept and associated procedures, the following points are recommended (listed in order of priority):

1. Although the current quality of the visual reproduction was deemed to be acceptable, the trials have shown the strong correlation between quality of visual reproduction and ability to judge distance/separation and thus provide service. Therefore future research should still seek out and identify any opportunities for further improvements in this areas and more formally determine level of service capable using a fully mature and operationally ready visual reproduction;
2. Procedures for degraded conditions and abnormal situations are further developed and tested. Draft procedures were developed and some of those for degraded conditions were tested in VP-057. Results indicated that the procedures may require adjustment depending on type of screen/camera failure and range of view lost. Procedures for abnormal conditions should not vary considerable from those used in the TWR;
3. Further improvements are made to the Controller Working Position to allow for a more integrated HMI for PTZ/IR camera, better integration of radar screens and communication functions and more space for auxiliary systems or notepads etc.;
4. Further improvements are made to the Working Environment;
5. The concept should be recommended for progression to the next stage of maturity once all evidence has been produced;
6. Results from the validation exercises should be used to update the P06.09.03 OSED and the operational / functional requirements. This includes updates to:
    - The levels of service that may be possible;
    - Addition and refinement of operational procedures;
    - Updates to operational and functional requirements.

5.2.2 Recommendations on Key Performance Areas

In order to improve the analysis of KPAs the following is recommended - listed in order of priority (N*ote: it is acknowledged that not all of these will be possible within the scope and duration of P06.09.03*):

1. Certain aspects of Human Performance (such as workload) are assessed in a range of conditions in live trials (e.g. Advanced Shadow Mode);Sensitivity analysis is performed on a range of traffic scenarios, focusing on mixtures of simultaneous VFR and IFR

movements under a range of restrictions to assess the impact of any potential VFR capacity restrictions when using a basic system.

5.2.3 Recommendations on System under Tests

With regards to the System Under Test, the following points are recommended - listed in order of priority:

1. Integrate all aspects of the HMI more thoroughly into a simplified HMI;
2. Perform a thorough shakedown prior to each validation exercise to avoid unexpected technical issues;
3. Maintain stable and constant technical configuration for the duration of each trial;
4. Implement data logging functions to reduce reliance on subjective data.

5.2.4 Recommendations in relation to future exercises in P06.09.03

With regards to the future validation exercises, the following points are recommended - listed in order of priority:

1. Use future exercises for SDM-0204 and SDM-0205 where possible to make up for any assessments not conducted in this series for SDM-0201.
2. Measure as a function of aircraft size and luminosity conditions, what range the tracking function is able to identify and track traffic. Investigate this in detail including if this range includes a typical VFR holding pattern and extend to the VFR entry points. A confidence on the order of value of this tracking functionality can help assess whether an ATC procedure can be modified based on this additional functionality.

6 Validation Exercise Reports

6.1 Remote Provision of ATC to a Single Aerodrome Trial 1 (EXE-06.09.03-VP-056) Report

6.1.1 Exercise Scope

The Remote Provision of ATC to a Single Aerodrome, assessed during a PSM Trial.

The overall aim of this first trial is to assess the technical and operational capability of an initial prototype in an operational environment. VP-056 builds upon the trials and assessments already made in ROT/ART, bringing previous results into the wider European domain; and re-confirming their top-level findings using a more mature technical and operational system with a wider stakeholder involvement.

The three week trial was performed at the Remote Tower test installation at LFV's Malmö Sturup site. The trial assessed live traffic from Ängelholm Airport under a variety of scenarios.

Ängelholm ATCOs as well as ATCOs from other ATS units participated; however, all participants were sufficiently briefed or trained prior to the start of the trial and had to confirm that they were well prepared before starting the trial itself. During and after the shifts, questionnaires were completed in order to obtain feedback which became the main source of the analysis which was carried out in this document

During and after each shift, questionnaires were completed in order to obtain feedback. This, and other subjective feedback, became the main source of the analysis which was carried out in this document. The foundation of the analysis was obtained from the "End of Trial Questionnaire" which every ATCO completed. This was used in addition to other sources of information such as trial observations (by validation experts, ANSP experts, Human Performance and Safety experts), airspace users' feedback, functional requirements questionnaires and SASHA (Situational Awareness).

This covered a large range of questions with a focus on acceptability, visual reproduction, ATCO working position, task allocation and responsibilities, service provision, safety, situational awareness and trust. The aim was to cover the success criterion from the VP-056 validation objectives.

Detailed performance assessments (Safety, Capacity etc.) were not the focus of VP-056.

6.1.2 Conduct of Validation Exercise

6.1.2.1 Exercise Preparation

6.1.2.1.1 Milestones

In line with the Project Management Plan [19], the milestones relevant for this trial preparation were:

Ref.	Milestones	Dates*	Delivering Project
M1	**Requirements produced**	31/03/2011	06.09.03
M2	**Prototype developed**	15/08/2011	12.04.07
M5	**Platform integrated**	15/08/2011	12.04.07
M6	**Platform technically accepted**	15/09/2011	12.04.07
M7	**Platform Configured**	15/10/2011	06.09.03
M8	**Exercise completed**	15/11/2011	06.09.03
M9	**Assessment Completed**	28/02/2012	06.09.03

Table 10: Milestones

6.1.2.1.2 Platform Configuration

The visual reproduction from the nine cameras, situated on top of the Ängelholm tower, was displayed on 50 inches monitors at the RTC, giving a 360◦ visual representation. A PTZ Camera was mounted on top of the camera house. Ambient noise from the airport came from two microphones fitted at the tower, feeding two loudspeakers at the RTC. The ATCO working position was situated about 2 m from the monitors, allowing a 2.5 m radius need for the CWP.

- Cameras:
  - Totally 9 cameras mounted on top of a local tower that covers a 360˚ view. 5 cameras with high resolution covering runway, northern traffic circuit, runway finals and 4 cameras with lower resolution (but still High Definition) covering the remaining area.
  - One PTZ camera, replacing the binocular in a normal Tower
- IR camera:
  - IR camera imaging provides a thermo graphic representation of the focused area. This could be used as a supplement to the regular cameras in a remote tower OTW view, to be used in darkness or in fog
- Display Screens:
  - 9 x 50” LCD monitors
  - Automatically reduce contrast differences in an OTW view
    - Between cameras
    - Between ground and sky

The CWP in the RTC included presentation of various systems to provide aerodrome control:

- Ground-air and ground-ground radio;
- Direct phone to adjacent ATC;
- Flightplan system;
- Flight Progress Board;
- PTZ camera;
- Met information including wind meters;

- Manoeuvring of airport lights and navigational aids;
- Rescue alarm with interface to the airport;

Radar Data Processing (RDP) and radar screen were also given to the ATCOs in this system.

6.1.2.2 Exercise execution

The trial ran from 24th October until 11th November 2011.

6.1.2.2.1 Airport Information

Ängelholm-Helsingborg Airport (ESTA)

- Environment
- Ängelholm 23,200 inhabitants in 2010
- Helsingborg 97,000 inhabitants in 2010

Airport Layout

- 56°17′46″N 012°50′50″E
- 7km from Ängelholm, 34km Helsingborg
- 1 runway 14/32
- 1945m (6381ft)
- Elevation 68ft (21m)
- 12,500 movements at the Airport (Crossing traffic through Control Zone (CTR)/TMA not counted for) and totally 376,000 passengers in 2010

Airport Technologies

- NDB ILS RWY 14
- RNAV (GNSS), NDB DME RWY 32
- 14/32 PAPI
- RWY 14 CAT1 approach, THR, RWY edge, RWY end lights
- RWY 32 THR, RWY edge, RWY end lights

Airspace Characteristics

- Obstacles 6NM SE Airport 2615 FT Mean Sea Level (MSL)
- TMA/CTR Class C

Procedures

- SID and STAR
- VFR Holdings: Hjärnarp, Råbocka, Rönne, Vejbystrand
- Right hand circuit RWY 32

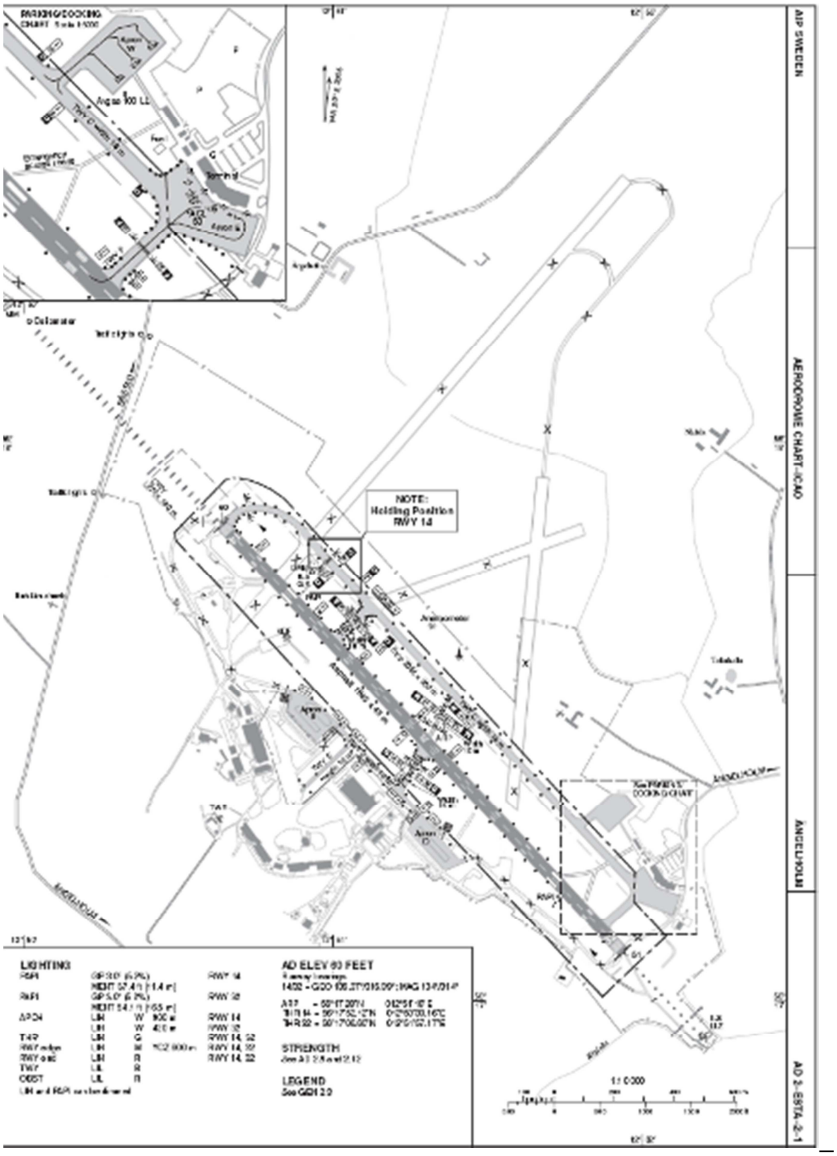


Figure 10 – Map, Ängelholm

Air Traffic Services at ATS Ängelholm (ESTA)

The following services are performed in ESTA TWR:

- Aerodrome control service at Ängelholm airport and within ESTA CTR
- Approach control service, including radar, within ESTA TMA below FL95 in sector A and below FL65 in sector B
- Flight information service
- Alerting service
- Meteorological Observations (METOBS) service

The services are normally accomplished by a single ATCO thus the tower is manned by one ATCO (AD) with the possibility to open up an extra position (T) during periods of higher traffic. It is the responsibility of the AD ATCO to ask for opening of the T position if the traffic demand requires radar vectoring of more than one aircraft simultaneously or due to other activities.

All ATC is performed in the tower, that is located SW of the manoeuvrings area.

6.1.2.2.2 Trial scenarios

The trial was a PSM Trial. Therefore only scenarios actually occurring at the aerodrome could be assessed. However, the shift times chosen for the participants allowed for a range of visibility conditions to be experienced and at times when traffic was relatively high. In addition, a school flight was hired once a day to fly locally for an hour in the control zone and traffic circuits. This hired flight created scenarios with two simultaneous aircraft that otherwise would not have been assessed. The pilot of this flight was given instructions by the Remote ATCO via the local ATCO in order to create these scenarios.

In total, there were 7 different types of traffic: scheduled IFR, IFR school flights, IFR GA flights, IFR hospital flights, VFR GA flights, VFR school flights and ground traffic at manoeuvring area only (i.e. aircraft taxing/towing to/from the hangar area crossing the runway to the terminal apron).

A table is shown below of flight statistics for each trial shift:

Date	Shift	IFR Scheduled	IFR School Flight	IFR, GA	IFR Hospital	VFR, GA	VFR School Flight	Manoeuvring Traffic Only	Total Aircraft
25/10/2011	PM	9	1	2	0	2	0	0	14
26/10/2011	AM	10	1	3	0	1	1	0	16
27/10/2011	PM	11	1	3	0	0	0	0	15
28/10/2011	AM	6	1	1	0	0	1	1	10
29/10/2011	PM	11	1	0	0	1	0	0	13
01/11/2011	PM	8	1	3	0	2	0	0	14
02/11/2011	AM	10	1	0	3	0	0	0	14
03/11/2011	PM	11	2	2	0	0	0	0	15
04/11/2011	AM	10	1	1	0	1	0	0	13
08/11/2011	PM	11	2	1	0	1	0	0	15
09/11/2011	AM	10	1	0	0	0	0	1	12
10/11/2011	PM	11	1	2	0	1	1	0	16
11/11/2011	AM	10	1	1	0	2	0	0	14

Table 11: Flight Statistics for VP-056

6.1.2.2.3 Dependent and Independent variables

Although the trial is a shadow mode trial and a full exercise design is not feasible, some variables and levels are anticipated, including:

- Flight Rules:
  - Instrument Flight Rules
  - Visual Flight Rules
- Meteorological Conditions:
  - Various Visibility and Cloud Base.
- Time of operations:
  - Day Time
  - Dawn and Dusk
  - Night Time

6.1.2.2.4 Trial Participants

The trial used 12 current operational TWR ATCOs, from the following aerodromes:

Code	Tower	Number of ATCOs
ESNN	Sundsvall ATS	2
ESNO	Örnsköldsvik ATS	1
ESNU	Umeå ATS	1
ESNZ	Östersund ATS	3
ESSV	Visby ATS	1
ESTA	Ängelholm ATS	4

Non Ängelholm ATCOs had a one day familiarisation at the local Ängelholm Tower. All ATCOs received a package of information before the trial including WP 6.9.3 OSED and the validation plan. After initial briefings and training each ATCO filled in a questionnaire, to ensure that each individual ATCO felt confident enough to take part in the trial.

6.1.2.2.5 Time planning

The timetable for the trial was as follows.

Validation SESAR WP 06.09.03 VP-056 ATCO Schedule
Ängelholm Tower familiarisation: 09.30-16.30
Malmö RTC pm: 10.30-20.00
Malmö RTC am: 06.15-13.00

Date	Name	Monday	Tuesday	Wednesday	Thursday	Friday
24th Oct - 28th Oct 2011 Week 43	ATCO 1	Ängelholm Tower	RTC pm	RTC am		
	ATCO 2		RTC pm	RTC am		
	ATCO 3			Ängelholm Tower	RTC pm	RTC am
	ATCO 4			Ängelholm Tower	RTC pm	RTC am
	Observer ESTA		13.00-20.00			08.15-13.00
31st Oct - 4th Nov 2011 Week 44	ATCO 5	Ängelholm Tower	RTC pm	RTC am		
	ATCO 6		RTC pm	RTC am		
	ATCO 7			Ängelholm Tower	RTC pm	RTC am
	ATCO 8			Ängelholm Tower	RTC pm	RTC am
	Observer ESTA		13.00-20.00			08.15-13.00
7th Nov - 11th Nov 2011 Week 45	ATCO 9	Ängelholm Tower	RTC pm	RTC am		
	ATCO 10		RTC pm	RTC am		
	ATCO 11				RTC pm	RTC am
	ATCO 12			Ängelholm Tower	RTC pm	RTC am
	Observer ESTA			08.15-13.00	13.00-20.00	

Table 12: VP-056 Timetable

6.1.2.2.6 Data collection methods

The collected data was mainly qualitative, describing the participating ATCOs' notions and feelings concerning the validation objectives.

A validation leader continually noted observations, feedback and comments from the participants, as well as scenario information in the CWP, whilst a second validation team member oversaw the completion of the following questionnaires:

1. Post Training Questionnaire
2. SHAPE SASHA Situational Awareness Questionnaire (completed once immediately after training, once at the end of Day 1, and a final time at the end of the second morning)
3. SHAPE SATI Trust Questionnaire included in the final trial questionnaire
4. Specific and detailed End of Trial Questionnaire

The validation team also held debriefs at the end of each shift, with the outputs of these debriefs noted.

Human Factors and Safety experts also took part in the trial and took observations and comments.

6.1.2.2.7 Additional Analysis Comparisons

Unless otherwise stated, the analysis is shown for all 12 ATCOs as a group. For all analyses, additional comparisons were made, where the 12 ATCOs were categorised according to the following factors:

1. **ATCO Experience.** ATCOs were split into 20+ years' experience, 10-20 years' experience and less than 10 years' experience;
2. **Gender.** There were 9 male ATCOs and 3 female ATCOs.
3. **Ängelholm/Non-Ängelholm ATCOs.** There were 4 Ängelholm ATCOs and 8 Non-Ängelholm ATCOs.
4. **By pairs.** The 12 ATCOs participated in the trials in groups of 2, with Pair 1 being the first set on Days 1 and 2, Pair 2 being there on Days 3 and 4 and so on up to the final pair – Pair 6. This analysis investigated if the technical improvements made during the trial led to more positive response from later Pairs.

These categories were not the primary focus of the analysis but add another layer of complexity which could be an explanation for any variation found in results. The results for these analyses will only be referred to if they highlight an additional relevant result.

6.1.2.3 Deviation from the planned activities

There were no deviations to the planned timetable or schedule. However, some technical changes were made immediately before and during the trial to provide the best possible platform for assessment. These included:

- The PTZ camera controls were not the same as the controls some participants from the Sundsvall Implementation project had experienced. They therefore had quite different pre-conceived ideas about how a PTZ camera should operate.
- The technical project (P12.04.07) planned to change the selection of the HD cameras at the aerodrome. The decision was taken in August (over 2 months before the trial) but it was not possible to install the new cameras until just a few days before the trial commenced. As a result, there was significantly less time for configuration, testing etc.
- The configuration of the image enhancement and compression software was not fully completed prior to the start of the trials. For the first week of trials the visual reproduction was therefore not as good as it should have been – especially at night. There was significant "ghosting" on screen (where a bright object leaves a false trail as it moves across the screen) and pixilation (where the screen becomes covered in large blocks, disturbing the view) at various times during the first days of the trial. Software updates were made during the trial and as a result, the picture quality changed.

6.1.3 Exercise Results

6.1.3.1 Summary of Exercise Results

Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
OBJ-06.09.03-VALP-0060.0011	To assess the completeness and suitability of the functional requirements for	The technical capability of the platform, with regards the functional specifications, is known. The functional	**24 of the 31 applicable Functional Requirements were approved without modification.** The ATCOs asked that **2 requirements be changed from *should*** to ***shall***.

	Remote Provision of ATS to a single aerodrome (as defined in the OSED)	specifications have been approved by the users in a trial environment. Any changes with regards technical capability are captured in the form of changed, additional or removed functional requirements.	"The visual reproduction ***shall*** provide a non-flickering impression to the human eye" "The visual reproduction ***shall*** provide a smooth and regular impression of moving objects to the human eye." The remaining **5 requirements were not able to be tested in the trial.** **1 additional requirement** regarding ambient lighting in the RTC was proposed.
OBJ-06.09.03-VALP-0060.0021	Gain an initial Safety Insight into the Remote Provision of ATS under the normal conditions experienced during the shadow mode trials	The trial has facilitated the gathering of initial safety feedback, to be used as input into the dedicated safety studies, the OSED and future trials.	Under normal conditions, the ATCOs felt that **a safe service could be provided remotely**. Participant opinion was that, using the current technical set-up, **some restrictions may have to be applied** to that service, in terms of number of simultaneous a/c and VFR traffic.
OBJ-06.09.03-VALP-0060.0031	Gain an initial Safety Insight into the Remote Provision of ATS under the abnormal conditions experienced during the shadow mode trials	The trial has facilitated the gathering of initial safety feedback, to be used as input into the dedicated safety studies, the OSED and future trials.	**Results from the workshop are detailed in** Error! Reference source not found.**.** Within this workshop abnormal conditions were discussed In relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having fully robust and accurate PTZ camera functionality and for certain traffic patterns a 360◦ visual representation, were included in ATCO feedback. PTZ functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars.
OBJ-06.09.03-VALP-0060.0041	Gain an initial Safety Insight into the Remote Provision of ATS under the degraded conditions experienced during the shadow mode trials	The trial has facilitated the gathering of initial safety feedback, to be used as input into the dedicated safety studies, the OSED and future trials.	Some degraded (visual) conditions were naturally experienced and also simulated during the trial. The ATCOs that experienced the degraded conditions were **not unduly concerned, and related the scenarios to Low Visibility in today's operations**. The general feedback was that **operational and procedural solutions** (e.g. Low visibility Procedures) **could mitigate against degraded visual conditions**.
OBJ-06.09.03-VALP-0060.0061	To assess the impact of the Remote Tower Concept on TWR ATCO Human Performance under good and limited visibility conditions and during the day	ATCO situation awareness must be shown to be within acceptable limits (the value of the 'acceptable limits' will be defined with regard to the tool employed to assess situation awareness). The Remote ATCO is	**Technical issues including the quality of the picture caused situational awareness to be lower than a local tower**. However, the use of **the IR cameras had positive feedback**, especially in darkness where it could give a clearer view of the aerodrome Situational Awareness scores were acceptable overall but some individual scores bordered on unacceptable.

	and night, in terms of: I. Situation awareness II. Trust	able to detect potential conflicts, hazardous situations and other scripted events that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas. ATCOs reported level of trust must be shown to be within acceptable limits (the value of the 'acceptable limits' will be defined with regard to the tool employed to assess trust).	The **best** situational awareness scores were recorded against ATCO **ability to keep ahead of the traffic** and be **able to plan and organise their work as they wanted**. The main **issues** relating to situational awareness were recorded against the areas of **focusing on a specific problem** and **searching for specific information**. ATCOs found it hard to identify and track aircraft using the visual reproduction. With regards **trust**, the ATCO feedback indicates **a general trust in the concept**, with most saying they found it **understandable and robust**. New tools such as the **IR camera**, as well as traditional systems such as **radar**, helped the majority of **ATCOs feel confident using the system**.
OBJ-06.09.03-VALP-0060.0062	To assess if basic ATC functions / tasks can be performed using the initial prototype, and identify any additional issues that may contribute to the HP Task Analysis.	Changes to ATCOs' current roles, tasks and responsibilities under remote tower operations under normal operational conditions are identified & any potential issues not already captured identified.	The functions and tasks were **limited to those related to building a visual picture**. The ATCOs were **able to build the basic visual picture**, supported by the visual reproduction, PTZ camera and IR camera. Most ATCOs experienced **difficulties in accurately judging depth and separation for airborne aircraft.** The ATCOs were **able to monitor ground movements sufficiently**. Feedback on the **ability to judge MET conditions** (including cloud celling) was **mixed and inconclusive**. Opinion was divided among ATCOs. ATCOs found building an accurate visual picture **easier during day time, compared to night time**, although some of this is due to technical problems early in the trial (later resolved). **Low visibility did not cause any additional problems** due to the IR camera and also the way in which a darker sky / cloud allowed for greater contrast between the aircraft and the sky.
OBJ-06.09.03-VALP-0060.0071	To assess the Acceptability of the initial working environment to ATCO, when providing Remote ATS to a Single	The Remote Provision of ATS to a single aerodrome concept, is usable/acceptable to the ATCO in terms of: • Visual Reproduction	**8 out of 12** ATCOs stated that the overall **quality of the visual reproduction was insufficient** to provide similar levels of service compared to a local Tower. However, several **improvements** (many of which are currently under development) **were suggested** to mitigate this result.

	Aerodromes.	• CWP • Working Environment • Remote Facility Location and resulting social considerations	The ATCOs stated that the **picture of the ground segment** was generally **clearer and easier to interpret** than the air segment. ATCO opinion was that the **picture during day time** was generally **clearer and easier to interpret** than night time. **Frame rates were too low**, and at night time issues with the **video compression caused "artefacts" and "ghosting"** on the visual reproduction. The **PTZ camera was deemed to be a useful tool**, but there were **usability issues** and issue with the picture quality. The **IR camera** was **well received** by the ATCOs with the vast majority finding it a **useful component**. The majority of ATCOs found the **CWP size, layout and range of functions to be acceptable** although some useful feedback was given on how it could be improved. The working environment used in the trial was not representative of an implemented system, but even so, ATCOs suggested that some basic changes could be made to vastly improve the Working Environment. With regards the location of the remote facility, ATCO opinion was split with some strong feelings either side – some having potential objections, others having no problem.
OBJ-06.09.03-VALP-0060.0072	Gain an initial insight into the impact of the Remote Provision of ATS on ATCO tasks, roles and responsibilities.	The trial has facilitated the gathering of initial feedback, relating to the impact of Remote Provision of ATS on ATCO tasks, roles and responsibilities.	ATCOs felt that with the trial prototype **their tasks would change**, potentially becoming more "inefficient", with **increased separation** in the vicinity of the airport for visual separation. On a more positive note, **the IR camera might allow increased opportunities** and **flexibility in working methods**. Overall, ATCOs **do not expect the roles and responsibilities of the ATCO to change** with the introduction of Remote ATS. The ATCOs felt that the **division of roles and responsibilities** when operating from the remote facility **was clear**.
OBJ-06.09.03-VALP-0060.0073	Gain an initial feedback / insight into the impact of the Remote Provision of ATS on ATC procedures	The trial has facilitated the gathering of initial feedback, relating to the impact of remote tower ops on ATC procedures	ATCO feedback suggested that their **procedures under Remote ATS would have a negative impact on VFR/GA capacity**. All ATCOs stated that **GA/VFR aircraft** will have to be **put on hold to wait for landing or arriving IFR traffic.** They felt that capacity for **IFR traffic would be maintained**. ATCOs were **cautious of the** conceivable **benefits regarding flexibility**.

			They responded **positively** to the suggestion that there is **flexibility of procedures** and potential to **lighten up restrictions in Low Visibility Procedures (LVP) with the use of the IR camera**.
OBJ-06.09.03-VALP-0060.0101	To gain an insight into the usefulness and utility of prototype features, functions and technologies for integration into future trial platforms e.g. High Definition Cameras, video compression software, IR cameras.	The usefulness and utility of proposed/prototype features, functions and technologies are known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	The IR camera was the newest component in the trial and it was very well received. **ATCOs felt strongly that the IR camera should feature in future trials.** **Other suggestions for improvements to existing functions and technologies were suggested** including: • Better HMI for PTZ • Reduced seams between screens • Target symbols/labels on the main display • Inlaid PTZ/IR camera images on the main display.

Table 13: Validation Objectives and exercises results.

6.1.3.1.1 Acceptability of the Working Environment

6.1.3.1.1.1 Overall Acceptability

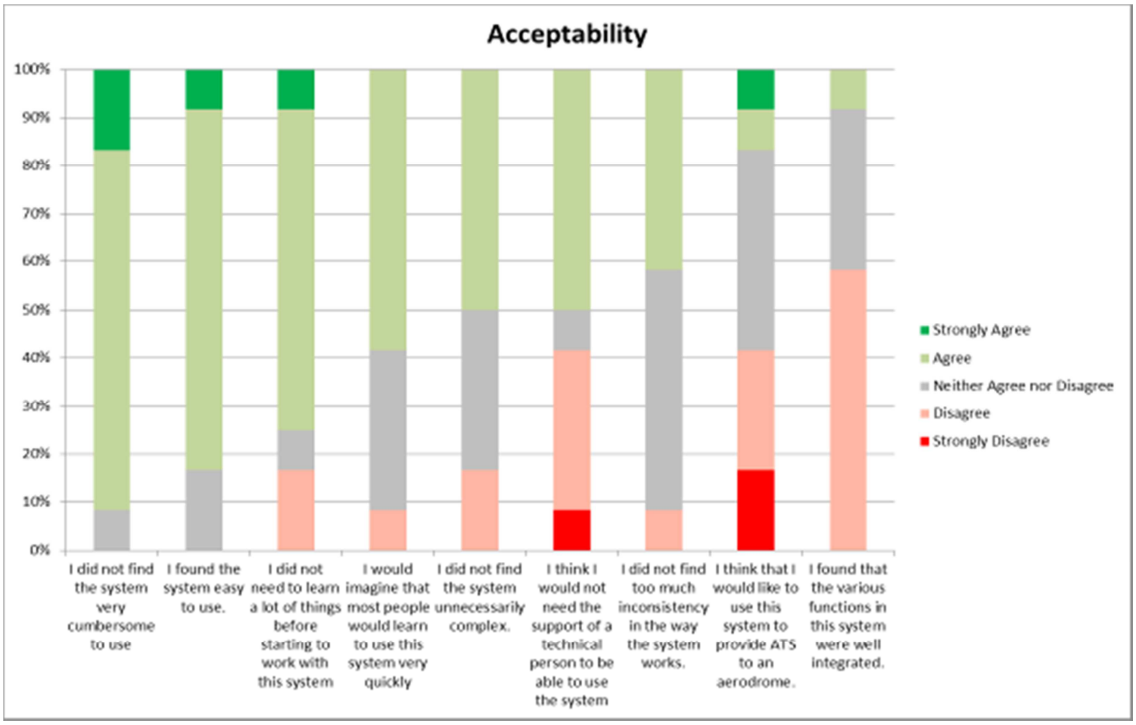


Figure 11 - ATCO Response to Acceptability

ATCOs could see potential in the technical system even though it was not ready for operation in the current state.

- 9 of the ATCOs found the range of systems and functions available via the CWP sufficient. 1 disagreed and 2 neither agreed nor disagreed.
- 9 of the ATCOs agreed they found the system easy to use, 1 strongly agreed and 2 neither agreed nor disagreed.
- 11 of the ATCOs either strongly disagreed or disagreed to finding the system very cumbersome to use, 1 neither agreed nor disagreed.
- 9 of the ATCOs either strongly agreed or agreed to not needing to learn a lot of things before starting to work with the system. 2 ATCOs agreed whilst 1 neither agreed nor disagreed.
- One ATCO stated *"Basic parts of what we've used were decently well integrated; PTZ/IR cameras to a satisfactory level but could use fine-tuning. Only tool somewhat tricky to use was the PTZ that took time to get used to. Didn't have that much time to play around with the tablet, being left-handed it felt a bit awkward trying to use it"*

The ATCOs were able to identify some benefits in the areas in which the Remote Provision of ATS working methods could bring to day-to-day operations.

- One ATCO said *"If the airport is situated in an environment that is unfriendly for humans or too remote to be attractive as a work place then yes, having the possibility to operate remotely would be a nice solution."*

The ATCOs did not score very positively on whether they would like to use the system provided during the trials to provide operational ATS to an aerodrome. Only 2 ATCOs agreed or strongly agreed that they would like to use the system provided during the trial. 5 neither agreed nor disagreed, 3 disagreed and 2 strongly disagreed. However, as noted in Section 6.1.1, this system is an initial, basic prototype system and it may not include all the functionality of the operational system.

One preconception before the trial may have been that the younger ATCOs would be more accepting of the Remote Provision of ATS concept and system compared to ATCOs with more experience. However, the End of Trial Questionnaire results were inconclusive and no link was found between acceptability and ATCO experience.

6.1.3.1.1.2 Visual Reproduction (including screens and cameras)

6.1.3.1.1.2.1 Overall Picture Quality

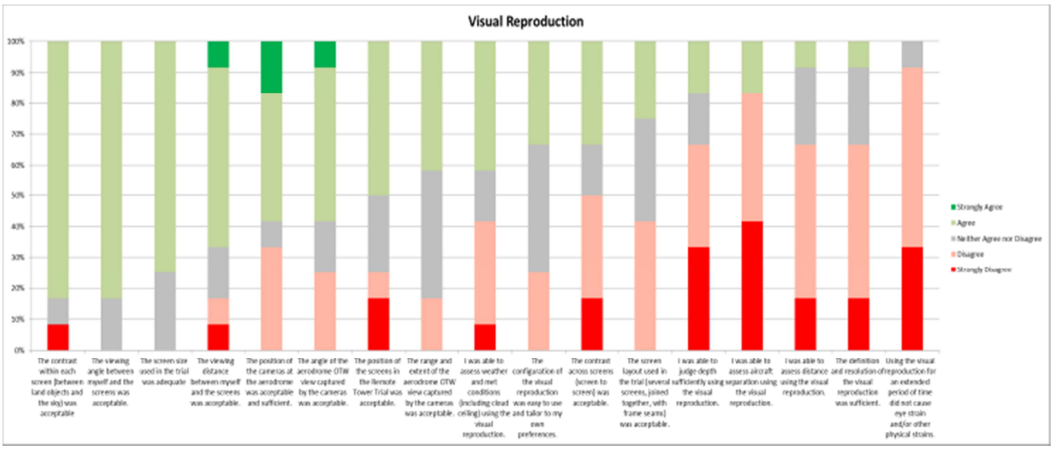


Figure 12 - ATCO Response regarding Visual Reproduction

The 360° view from Ängelholm Tower was presented by 9 50" LCD monitors each showing 40°. These encompassed the CWP in a circle. The elevation of the fixed cameras resulted in a screen view of approximately 40% ground and 60% sky. Each monitor could be individually adjusted so that brightness/contrast could be altered. 5 of the 9 cameras had a higher resolution to cover the "most important areas" of Ängelholm aerodrome.

As shown in Figure 12 the ATCOs were asked to rate the visual reproduction in several ways – the first of which was "resolution and definition". The aim was to gather ATCO feedback on the level of

detail and sharpness of image captured by the cameras and reproduced on the screens. However, the terms “definition” and “resolution” have different meanings in Swedish compared to English and so during the trial the participants came to use the term to mean a more general “quality” of image. In addition, feedback during the trial (including that from the Functional Requirements) identified that resolution questions should have distinguished between observations on the manoeuvring area and the air segment. The results for “Resolution and Definition” should therefore be taken in this context.

As a result, 8 out of 12 ATCOs felt that the “definition and resolution” (i.e. overall quality) of the visual reproduction was insufficient. One ATCO said that out of all the aspects of the technical and operational system, he had least trust in *“screen resolution when finding and identifying aircrafts not in the immediate vicinity.”* This seemed to be a particular issue at night time.

The overall picture quality improved throughout the trial and was better quality compared to the ROT and ART trials. The use of screens as opposed to the projectors which were used in ROT and ART was very well received by all ATCOs. This also eliminated the projector noise which was a problem in the previous projects. The present picture quality (that experienced towards the end of the trial) will be kept for the immediate future and additional cameras at other positions around the aerodrome will be mounted to enable ATCOs to identify and monitor aircraft more easily on the ground (complementing the 360 degree view)

The ATCOs stated that the picture of the ground segment was generally clearer or easier to interpret than the air segment. Cameras were found to be sensitive to direct sunlight such as during dawn and it was harder to detect aircraft when clouds such as stratus occurred. ATCOs visually identified a/c on final later compared to a local tower but still at a distance enough to provide ATC.

6.1.3.1.1.2.2 Frame Rate

During the trial (particularly at the start of the trial during darkness) there were issues with “scrambled” screens where one or more screens would become heavily pixelated and blurred. A low frame rate also led to fast moving objects such as aircraft appearing to jump. The system was continuously tuned by NATMIG engineers as the trial progressed, so results from the ATCOs varied over time. Feedback from the ATCOs included:

- *“[You need to] Increase the video quality significantly. I wouldn't want to rely on the video monitors unless they are close to reality. That means no artefacts from video compression or choppy movement due to low frame rates.”*
- *“Fast moving objects are very "jumpy", gets tiring after a while. Difficult to see things such as wheel/gear out/down. Difficult to see if an aircraft cancels a take-off or loosing parts (falling off).”*
- *Frame rate too low, must be above 30 fps”*

For some of the trial, “artefacts” were present which produced “shadowing” or “ghosting” on the screen. This was reported to engineers and raised as a bug possibly due to compression problems.

- *“Even though the quality of the cameras might be sufficient when it comes to resolution, frame rate, contrast, etc. - the compression (I assume) that is performed has too much of an impact on the final image as I got to see it during my validation sessions. The result is sometimes very disturbing artefacts and the low frame rate becomes a rather significant issue when you are dealing with fast moving objects on screen such as an aircraft.”*

6.1.3.1.1.2.3 Contrast

There were a few issues with contrast and the glare from the sun caused problems. The contrast however, seemed to be mainly an issue at night time. The contrast/brightness could be adjusted manually by the ATCO on each monitor if necessary. ATCOs stated that:

- *“Contrast during darkness was not good, during day light acceptable. The cameras should be placed as close as possible to runway and taxiways.”*
- *“We had an interesting contrast effect from reflected sunlight (off the buildings and aircraft fuselage). It made some objects shine like a light. This was distracting and made you not want to look because it hurts your eyes.”*

It was possible to manipulate the light/darkness of the camera picture transmitted on the screen and this was beneficial to a certain extent as it can give a better view of the aerodrome compared to reality. However, there is a danger that the light levels can be over-manipulated leading to the picture in the remote tower showing higher light levels than reality. This can cause problems such as incorrect information being transferred to pilots regarding light levels.

During darkness, there was a need to dim the ambient lighting in the facility/CWP in order to see things in the screens and improve contrast.

6.1.3.1.1.2.4 IR Camera

The use of the IR camera was a new tool for the ATCOs and was suggested by ATCOs who gave feedback following the ART project.

Overall, the IR camera had positive feedback, especially in darkness, and was found to be useful. It was not as effective during certain weather conditions (which could be linked to moisture content) and also above a certain altitude. This is being investigated by technical system developers.

- 9 out of 12 ATCOs found the IR camera a useful component.
- One ATCO said *"IR camera is a really good tool for night time Met observations. You can see clouds very clearly in darkness, much better than in normal view."*
- Another ATCO said the IR camera lead to *"Increased capacity in reduced visibility, confirmation at holding positions, animals on runway, we saw a rotating light on runway in the dark and thought it was a vehicle, checked with IR* camera *- it was a C500, you could actually see the type of aircraft. Install it today."*

Some ATCOs suggested that they would like to see an overlay of the IR camera on the screens so there are less screens and to reduce the complexity of the system. Having separate screens takes the attention of the ATCO away from the main/overall picture.

A final ATCO comment sums up the overall feedback from the trial participants:

- "*It is possible to follow/track a target longer with help of the IR camera. In vis 2km it was possible to see razor blade sharp! During these two test days it has not been possible to see any negative effect on the visibility of the IR camera. Place the IR-camera in the middle of the airfield! The biggest operational benefit with the IR camera is about what is happening inside the airport fences (on ground)*."

6.1.3.1.1.2.5 PTZ Camera

The overall consensus was that the PTZ was useful but not as *user friendly* as it was in previous trials for the ROT and ART projects. The PTZ camera was controlled using a mouse which was more difficult to control than binoculars which is what the ATCOs are used to. In addition, the PTZ picture was reproduced on a separate CWP screen and so took the ATCO attention away from the large screens and overall picture. If too much time is spent trying to operate the PTZ then this affects workload and could reduce situational awareness.

However, the next version of the remote tower will include a touch pen that will be used to control all the screens and the PTZ zoom function will be integrated onto the screens to amalgamate the overall picture in an attempt to increase usability and situational awareness. The PTZ is an important component in the concept/system since one of the remote functional requirements states that the visual reproduction shall provide functionality corresponding to the binoculars in a local tower. Therefore, it is a vital tool.

- 8 of the ATCOs either disagreed or strongly disagreed to finding the PTZ cameras easy to use. 2 ATCOs neither agreed nor disagreed while 2 ATCOs agreed they found them easy to operate.
- *"Info was easy to find and interpret, although the handling of the PTZ wasn't to full satisfaction, hard to find objects without having it pre-set on an area where you knew aircrafts would show up eventually (this is for airborne traffic). Traffic on the ground quite easy to follow with the PTZ/IR cameras, pre-set holding positions and sweeps excellent."*

- *"The control of PTZ must be improved as well as the autofocus. IR camera is connected to PTZ and has, therefore, the same issues."*

During the early morning on the 2nd November, the humidity on the camera lens made the zoom view very difficult to see as the background was very light. However, in the future, the PTZ camera will be heated which should help avoid such situations.

Finally, it should be noted that the PTZ camera hardware used in the trial was a 5 year old camera first installed for the ROT and ART trials. Image quality may not therefore have been as good as a new camera would provide due to the advances in camera technology and degeneration of the image over time. This coupled with the awkward HMI may have led to the more negative responses. It could also imply an on-going cost for Remote Provision of ATS – the need or desire to upgrade technical equipment. However, the fact is that the equipment, when installed, would be deemed technically good enough and would have a potential operable lifespan of many years. The hardware would not need to be upgraded, only if the provider felt there was a cost benefit in upgrading the hardware and the same can be said for any technical equipment in a local tower.

6.1.3.1.1.2.6 Ängelholm versus ATCOs from other ATS units

A short investigation into the relative feedback between the Ängelholm ATCOs and the ATCOs from the other ATS units was undertaken to see if more familiarity with the Ängelholm aerodrome, had an impact on results. The visual reproduction questions can be divided into 3 main areas:

1. The view compared to Ängelholm;
2. The technical set up of the CWP;
3. The ability to perform tasks using the system.

As shown in figure 8 (overleaf) when the view is compared to Ängelholm with the position, range and angles of the cameras, Ängelholm ATCOs rated the remote facility and visual reproduction better than the Non-Ängelholm ATCOs. This could be because they have a better idea of what they are comparing to and the position of the cameras is in a satisfactory position.

The next section of the Visual Reproduction graph is concerned with the technical set up of the CWP, i.e. the set-up of the actual facility. In this section, since it was new to both sets of ATCOs, the response from the ATCOs was relatively similar.

However, it is when dealing with the ability to perform operationally, i.e. if the visual reproduction is good enough to provide ATS, that the Ängelholm ATCOs score the visual reproduction lower than the Non-Ängelholm ATCOs. Therefore, despite scoring the view higher, and reporting similar scores on technical setup, they felt less confident about the ability of the visual reproduction to provide a service.

6.1.3.1.1.2.7 Suggested Modifications

The limitations of being unable to handle IFR and VFR simultaneously or maintain visual separation between two flights can be overcome in a variety of methods which were suggested by some ATCOs and trial observers.

- *"A higher definition/ability to confirm identity/location further out and higher fps [frames per second] might enable you to use visual separations"*
- *"Increase the video quality significantly. I wouldn't want to rely on the video monitors unless they are close to reality. That means no artefacts from video compression or choppy movement due to low frame rates."*
- *"Procedures, Secondary Surveillance Radar (SSR) tracking in OTW, airspace redesign"* would help. The ATCO trade Union representatives who visited the trial (ATCEUC) consider SSR tracking to be a necessary component.
- To mitigate screen-blackout/white-out risks one ATCO suggested having *"Integrated systems RDP//* Interactive Display Panel (*IDP)/ e-strip and interaction with OTW. Optimised HMI in CWP"*

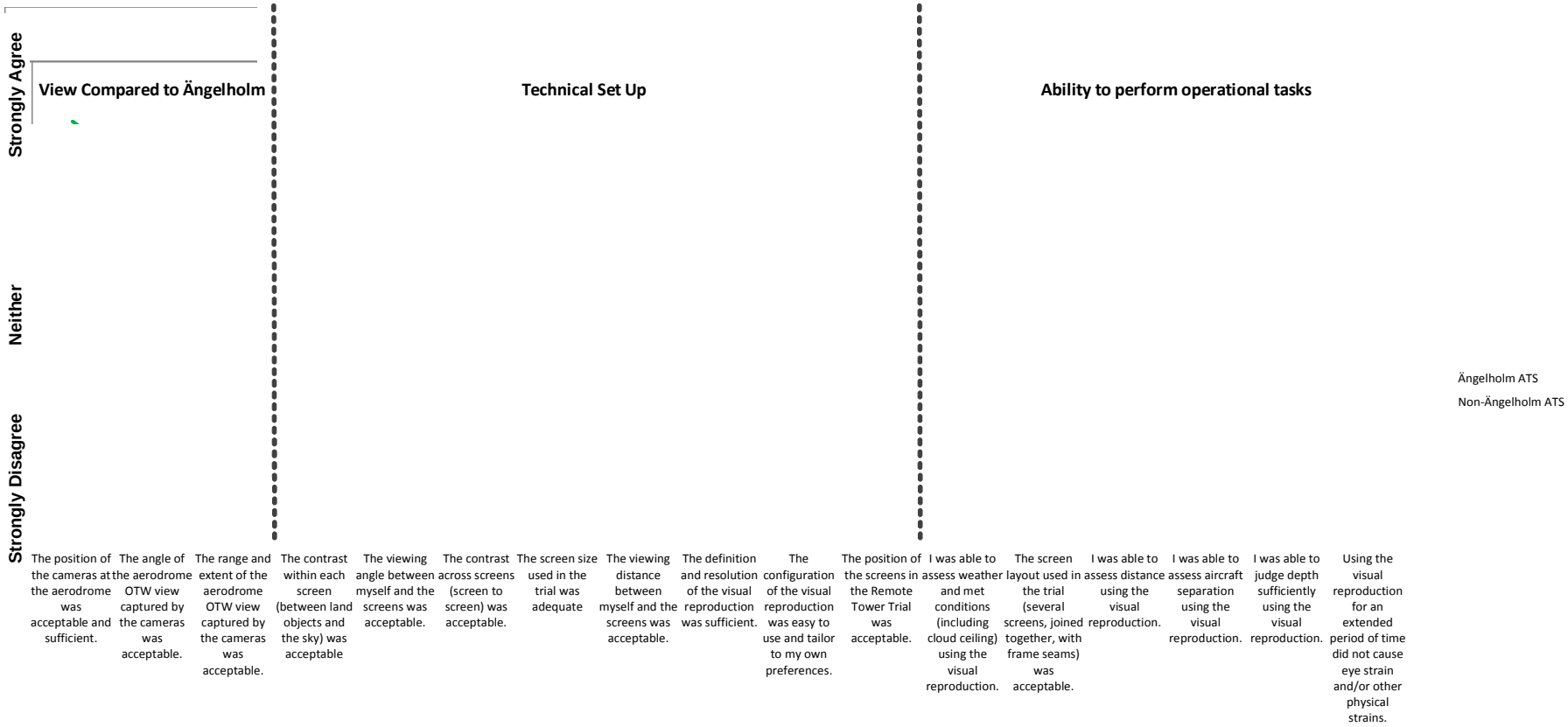


Figure 13 - Response regarding Visual Reproduction for Ängelholm vs. Non-Ängelholm ATCOs

6.1.3.1.1.3 CWP

6.1.3.1.1.3.1 Layout

Figure 14 - ATCO Response regarding ATCO Working Position

There did not seem to be a problem regarding the layout of the CWP although there were a few suggestions on how it could be improved with more integrated ATC systems, PTZ with manual focus, OTW tracking and electronic strips. In addition, more indicators were suggested such as cloud base indicators, visibility indicators and RVR displays on the runway. There was a proposal of having the IR and PTZ cameras overlaid on the main display. This would also have the advantage of keeping the ATCOs "head up".

- 8 of the ATCOs found the CWP layout (size, configuration) was acceptable, 3 disagreed and 1 neither agreed nor disagreed.
- 9 of the ATCOs agreed that the range of systems and functions available via the CWP was sufficient, 2 neither agreed nor disagreed and 1 disagreed.
- One ATCO said "*It would be preferable to have the PTZ view inlaid in the main display or an indication on display of what the PTZ is looking at*."

6.1.3.1.1.3.2 Aural Reproduction

Aural reproduction of the airport ambient sounds was available to ATCOs which most found to be very useful in some circumstances, for example, during poor visibility or low cloud cover. Other ATCOs found the sound was very sensitive and this caused them to turn off the sound since they found it was unnecessary. Feedback included:

- *"Important to hear what is happening if you have your attention elsewhere during low or no traffic at the airport"*
- *"Can be useful in LVP to know if the aircraft is making a full stop or go around."*
- *"The microphone picks up too much sound and needs to have a filter so that birds, cars, lawn mowers and what-not do not act as a source of annoyance and distraction. It's enough to be able to hear the aircraft engines as an aircraft takes off or lands."*

6.1.3.1.1.4 Working Environment

There were suggestions of how the working environment for the ATCO could be improved in order to increase comfort.

- One ATCO stated *"The heat and the noise in the facility enable you to work only shorter period of times. Especially during night time the working environment perceived is bad due to the low quality of the picture/screens. It is not a restful picture for your eyes, makes it difficult to keep concentration. The air quality in this particular facility not acceptable. Height adjustable table/CWP would be desirable. The VCS panel should be angled/pointing more inbound towards/facing the ATCO position."*
- One ATCO mentioned the air conditioning and trial RTC environment. *"Overall environment - narrow and hot and no water."*
- Another ATCO mentioned that in future trials they would want air-conditioning whilst another ATCO complained of "*dry eyes"… "Because the air was too dry or (due to) fatigue"* as *"eyes gets tired of following unfocused, jumping objects for hours."*

Ambient lighting should be considered in the design of the remote tower. It is important to consider the different contrast between the ambient lighting and the screen brightness as this could contribute to eye strain and fatigue. If the lights are dimmed in the facility/CWP at night in order to get a better contrast against the screens then position lights may be needed if using paper strips. Furthermore, the design of the room is important to reduce reflections.

- *"Feels different compared to the normal tower, more exhausting/tiring. This aspect needs to be improved. When operating in darkness, the background lighting needs to be reduced."*

An interesting effect was that when the four screens behind the ATCOs were switched off, it improved the ambient lighting conditions by reducing glare and reflection and hence was said to reduce eyestrain. This opens the question as to the need/benefits of a 360 degree view that encircles the CWP.

One ATCO made a valid point concerning RVT for multiple aerodromes in the future. He suggested "*individual controls / CWP. It can be daylight in one CAB and dark in next beside. South and north Sweden in summer time (Kiruna and Ängelholm)*."

6.1.3.1.1.5 Remote Facility Location and Social Considerations

The main concern amongst the RTC seemed to be regarding the possible loss of personal relationships with airport staff. Also the observed changes in the MET conditions as clouds, cloud base and type of clouds were difficult for ATCOs to judge with the present version of the system.

One ATCO stated *"Being present at the airport - of course- helps put a face on the ATC provider working for the airport. Having a remote service provider might have the same effect you sometimes experience with remotely located call centres. Maybe it will give the airport, our customer, the feeling that "that ATC provider sitting far away doesn't understand us and our needs". This even though that we still provide the same service and at the same or a higher quality!"* However, another ATCO stated that today, ATC and airport personnel do not meet that much anyway since they are housed in different parts of the aerodrome. Other feedback included:

- *"Today ATS is responsible for a number of tasks that probably must be transferred to the airport organisation. ATS will have less influence/knowledge about how upcoming work on the airport will be carried out. ATS will generally have less knowledge on what goes on at the airport. ATS will lose the local appeal/connection to the airport and e.g. knowledge about certain Met conditions at the airport."*

The issue of staff relocation seemed to have two sides. For current staff, initially there is the issue that they would have to relocate, however, one ATCO mentioned that "…*later on it could be easier to recruit personal. Positive: Less single person work." Another ATCO said "I am against it. Not against the concept, but against the fact that I will be forced to move my family to the new place*."

6.1.3.1.2 Completeness and Suitability of the Functional Requirements

The ATCOs were presented with questions based on the OSED Functional Requirements relevant to this particular trial (technical platform setup and operational scope) and asked to comment on it in terms of:

- Importance – is it a “shall”, “should” or “may”
- General phrasing of the requirement
- Completeness of the overall set of requirements.

Feedback was positive overall and ATCOs agreed to most of the Functional Requirements.

24 out of 31 functional requirements were agreed without modification. These included

- The function of the RVT *shall* allow:
  - continuous watch of flight operations,
  - the prevention of collisions,
  - observe visual communications in the air and on the ground,
  - coverage of visual reproduction of manoeuvring area and vicinity of aerodrome.

One ATCO said *“Picture quality (including resolution, white balance ground and sky, inter-screen balance) is good, can hardly expect much more. This goes especially for day light conditions and the ground segment. Night conditions can probably be improved some more, the sky segment is and will probably always be an issue, that “never” can beat the OWS reality (without any pixels).”*

It was also agreed that the visual reproduction *shall* be designed to:

- avoid unnecessary discontinuities,
- Include functionality to reduce negative impact caused by counter light, variable light, precipitation, insects and birds.

Also, the ATCOs overall agreed that during Ceiling and Visibility OK (CAVOK) or where conditions permit, the visual reproduction:

- *shall* enable the ATCO to perform their duties,
- *should* judge the position of a light aircraft and gear down.
- *should* incorporate features that improve the visual range compared to unaided viewing
- *shall* provide functionality corresponding to the binoculars in a local Tower. This binocular functionality was agreed by ATCO that it *should* include predefined positions and automatic scanning patterns.

The ATCOs approved the requirement for distributing the actual outdoor sound from the airport but decided that the volume shall be adjustable by the operator.

2 functional requirements were commented by ATCOs that they should be changed from should to shall.

- The visual reproduction **shall** provide a non-flickering impression to the human eye
- The visual reproduction **shall** provide a smooth and regular impression of moving objects to the human eye.

Some functional requirements (5 out of 31) were either unable to be tested or inapplicable for trial one but ATCOs were still able to comment on some of them. For example, it was agreed that the RVT shall include functionality that reduces the negative impact caused by precipitation although this situation did not occur during the validation.

In addition, it was agreed that the RVT shall enable the ATCO to visually detect irregularities during take-off and landing that requires the ATCO to perform an alerting service (even though it was not tested). Another requirement which was not fully tested was that in low visibility conditions, the RVT

may enable the ATCO to monitor aircraft entering or vacating the runway. When low visibility conditions were not present in the day, this could be tested at night.

A common response was highlighted in the comment of one ATCO who stated *"Thanks to the IR camera it was possible to see aircraft leaving the RWY although it was not possible to see them in the normal visual presentation."*

The working conditions of the RTC were not tested in depth although comments on the requirements were made based on personal experience. The requirements that working conditions should equal ordinary office establishments and shall be according to national regulations for normal office establishments were agreed. An interesting finding was however that during darkness operations, it was necessary to establish a dark working environment at and around the CWP, to be able to perform the ATS tasks with acceptable visual references via the screens.

6.1.3.1.3 Functions under variety of scenarios

The concept behind RVT states that functions and tasks should, where possible, be the same as a local tower. The main change is to how the visual picture is being built and this is the focus of many results. Assessing the actual task of controlling aircraft was not possible due to the limitations of a shadow mode trial. However, the ability to monitor aircraft was assessed.

6.1.3.1.3.1 Build Visual Picture of Aerodrome and Traffic

The PTZ camera replaced the binoculars that would be used in a local tower but purpose of the task remained the same i.e. the ability to obtain a close up view. This was found to be awkward to operate and more difficult to use than the binoculars used in the on-site tower.

- *"PTZ as a tool is very good and a must, but present PTZ function is not good enough."*

  Operating the IR camera is an additional tool which created an additional task. However, ATCOs accepted this change since it was found to be helpful.

- *"During darkness and mist, the IR camera helped a lot, especially on the manoeuvring area."*

More information about the IR camera is stated in Section 6.1.3.1.1.2.4.

As mentioned in Section 6.1.3.1.1.2.6, Ängelholm ATCOs found it easier to search for information compared to non Ängelholm ATCOs. The visual reproduction quality meant that due to *"screen resolution I had least trust when finding and identifying aircrafts not in the immediate vicinity"* as one ATCO stated.

As a side issue, the seam between screens was 4cm (2cm per screen). In the future versions, this will be significantly reduced to a few millimetres, rather than centimetres. However, these seams should not be placed over important "hotspots". During the trial, no areas were hidden but cameras should be arranged so that important areas such as short final/threshold are not split between two screens. As a side issue, the seam between screens was 4cm (2cm per screen). In the future versions, this will be significantly reduced to a few millimetres, rather than centimetres. However, these seams should not be placed over important "hotspots". During the trial, no areas were hidden but cameras should be arranged so that important areas such as short final/threshold are not split between two screens.

- One ATCO stated "*The position of the screens was not good due to the fact that the frame seam from one screen and another was right in front of an important lookout point and the frame seams are too big*."

6.1.3.1.3.2 Ability to judge depth/separation

The ability to judge depth and separation was mostly difficult to judge for flight in the air, but was easier on ground since you have references around each object at all times. The ability to judge depth/separation was a serious complaint which impacted upon the ATCOs' feelings about the level of service they could provide:

- 8 of the ATCOs either disagreed or strongly disagreed to being able to judge depth sufficiently using the visual reproduction. 2 agreed and 2 neither agreed nor disagreed.

- 10 of the ATCOs were not able to assess the aircraft separation using the visual reproduction. 2 ATCOs agreed they were able to assess separation using visual reproduction.

6.1.3.1.3.3 Monitoring of Ground Movements

Specific questions regarding visual reproduction and service for ground movements were not directly asked which in hindsight could/should have been. This could be a potential improvement for the questionnaires in future trials. However, in response to other questions such as which part of the technical/operational system they had the most trust in, ground movements were mentioned:

- One ATCO said that their situational awareness was best *"on the ground."*
- One ATCO said they were able to pick up on all the visual and audible clues that they would normally pick up in the normal tower *"on the ground but not in the air"*

Not all responses were positive regarding ground movement; however, this included other factors as well such as time of the day and IR cameras.

- One ATCO said that during darkness and without the IR camera, "*ground movement was difficult with present visual reproduction as it was difficult to identify all lighting on the airport*"

6.1.3.1.3.4 Ability to assess weather and MET conditions

5 of the ATCOs found they were able to assess weather and met conditions (including cloud ceiling) using the visual. 2 ATCOs neither agreed nor disagreed, 4 ATCOs disagreed and 1 ATCO strongly disagreed. The negative responses could have been caused by the brightness and contrast of the screens. One ATCO said there was *"too much gain on the camera makes evening brighter than in reality."* In addition, the mixed responses could have been affected by the varying weather conditions which impacted the visual reproduction.

- *"Surprisingly I had the easiest time following the traffic in 9km VIS and 1500ft ceiling. It was much easier to find aircrafts on final when you know when they'll break through clouds and their approximate position when doing so. It is slightly easier to follow traffic in the circuit as well; there were tendencies in very light conditions for the aircrafts to disappear in turns."*

6.1.3.1.3.5 Impact of different visual scenarios:

6.1.3.1.3.5.1 Day, night

The day time picture again seemed better than at night time. During night, the resolution was poorer, the picture was "pixelated" and the screens flickered. However, during the day of the 26th October, a school flight did a simulated engine failure on take-off. The ATCO could clearly see the slow angle of climb with a change to a steeper climb angle when both engines were re-introduced.

- *"I would say that the visual reproduction during daylight is ok, but in darkness there is more problem to detect objects. The eye is so much better than a screen. The lack of 3D (depth) is a problem for visual separations."*
- *"During darkness there is no 3-D feeling. Colour is missing on obstacle lights. It is difficult to see any difference between TWY and RWY lights. Some artefacts during darkness. (There was) white out on two monitors during sun rise."*

6.1.3.1.3.5.2 CAVOK, low visibility

The contrast appeared better in some weather scenarios compared to others. During CAVOK the colours on the monitors appeared to be duller/colder. However, when there was low visibility and cloud, the colours appeared more realistic to the outside view they would normally see. The moving objects also seemed to move less smoothly during sunny conditions which could be caused by the shorter exposure time.

- *"Definition of objects on/around the manoeuvring area and in the vicinity of the airport was very dependent on time and weather; it was a lot easier to see and confirm objects with 9km VIS and 1500ft ceiling than in CAVOK. Judging distance without help of RDP is close to impossible on distances further than 2nm. The scenarios where Visual Separation would be*

used in real life would probably require different working methods in an RTC, losing some efficiency."

6.1.3.1.4 Human Performance

6.1.3.1.4.1 Situational Awareness

The issues with the technical problems caused situational awareness to be lower than a local tower. However, the use of the IR cameras had positive feedback, especially in darkness where it could give a clearer view of the aerodrome.

- *"Overall acceptable, ability to use IR* camera *definitely good. IR in dark was perfect."*
- *"Since I had access to radar my situational awareness wasn't impacted that much. It's when you try to follow events purely via the video monitors that you feel a bit behind at times."*
- Situational Awareness was worst, according to one ATCO, during *"dusk when you got an absurd amount of reflection from the setting sun on white objects, felt distracting."*
- *"It was harder to find the aircraft -> focus on another task -> find the aircraft again. It felt like this took much longer time than usual.*

Another new aspect to the ATCOs which increased the situational awareness was the ambient sound from the aerodrome.

- "*You don't actually need sounds, but the moment when it could be beneficial is when you have a go around with bigger aircraft in low visibility and you can hear engines being turned up. But you don't separate with sound. Overall it is information and the more you have the more accurate you can do stuff, but not needed. It is a useful addition*."

6.1.3.1.4.2 SASHA Results

The SASHA test results, in addition to the End of Trial Questionnaire, were the sources of the quantitative data regarding situational awareness that was used for analysis. SASHA tests were completed on 3 separate occasions by ATCOs during their 2 shifts – once after the afternoon traffic peak, then again after the evening peak during darkness and during the second shift after the morning traffic peak. The mean score of each question was calculated for each session run and in the analysis, the higher the result, the more positive/better the situational awareness.

The results showed that there was very little difference in situational awareness throughout the 3 sessions. The most positive situational awareness results were recorded against ATCO ability to keep ahead of the traffic and be able to plan and organise their work as they wanted. This was an improvement on the ART project where the integrated ART functions did not enable the ATCOs to stay ahead of the traffic. The main area for improvement with regards situational awareness was in the areas of focusing on a specific problem and searching for specific information. Average situational awareness ratings bordered on the unacceptable and feedback gained from the ATCOS suggests that this could be due to the quality of the visual reproduction during the trial. Another reason could be the usability issues with the PTZ camera.

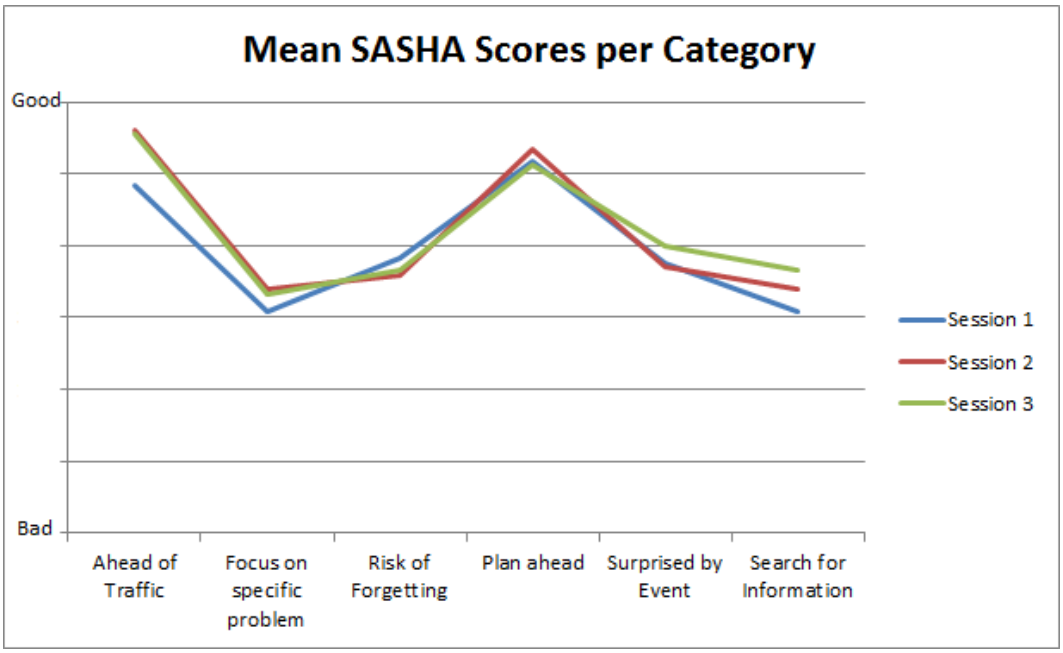


Figure 15 - Mean SASHA Scores by Category (Session)

6.1.3.1.4.2.1 Ahead of traffic

Based on the SASHA test, ATCOs felt able to be generally ahead of the traffic. The results are the same for Sessions 2 and 3 but are considerably better than Session 1 which tends to suggest that as the ATCOs got more accustomed to the CWP and tools, their situational awareness improved.

6.1.3.1.4.2.2 Focus of single problem or specific area

ATCOs expressed concern with regards focusing on a specific problem or specific area. This could be due to the picture quality meaning ATCOs spent longer searching for aircraft as well as the HMI of the PTZ and IR camera. One ATCO said *"the IR camera and zoom functions are too complicated to manoeuvre, it takes too long and you lose focus on your actual job to separate planes. They could be useful if they are simplified. For example, have the on/off button only on the runway for IR* camera *when needed to detect objects"* and *"an alert system if object/objects are detected."*

6.1.3.1.4.2.3 Risk of forgetting something important

Scores relating to the "Risk of forgetting important" were generally good, indicating that ATCOs did not perceive this to be a high risk.

6.1.3.1.4.2.4 Ability to plan and organise work

The ability to plan ahead scored relatively highly during all 3 sessions implying ATCOs in the trial were presented with enough information to be able to plan and organise their work. The IR camera may also have contributed as one ATCO mentioned *"IR camera during night time/low visibility was a big help."*

6.1.3.1.4.2.5 Surprised by an event

Although this was also a mainly positive response from the ATCOs, one ATCO said that the quality of the visual reproduction led to a brief, but unexpected, "visual false alarm." He said *"I was surprised that visually, in darkness, the vehicle on the runway with lights on seemed to have caught fire (rotating beacon)."* This was later attributed to the technical problems with the visual reproduction.

6.1.3.1.4.2.6 Search for information

In this category, as shown in Figure 11 overleaf, scores were low, but still generally acceptable. The Ängelholm ATCOs scored slightly higher in the ability to search for information. This could be due to

the fact that they are more familiar with the overall picture from the view at Ängelholm Tower so know where to look when expecting traffic.

- One Ängelholm ATCO mentioned "I know the airport well and therefore know where to look e.g. ACFT on final and specific places at the airport."
- Another ATCO said *"Ängelholm tower is far away from the apron compared to my airport, resulting in difficulty to observe activity on apron"*

Situational Awareness will also be impacted by the fact that some ATCOs were using new equipment. This focuses their attention giving them less eyes up time to look out for traffic.

- *"Because I´m not fully trained on the CWP, I lose focus sometimes and therefore I don`t follow the traffic."*

This seemed to improve as ATCOs became more accustomed to the system.

- "*As this was my second session in the working position, that fact alone gave me more capacity to focus on traffic thus increasing my overall feeling of situational awareness. My main issue was that I didn`t feel like I could rely as much on the video monitors for information as I wanted since both the low frame rate and the sometimes rather heavy artefacts were on the screens*."

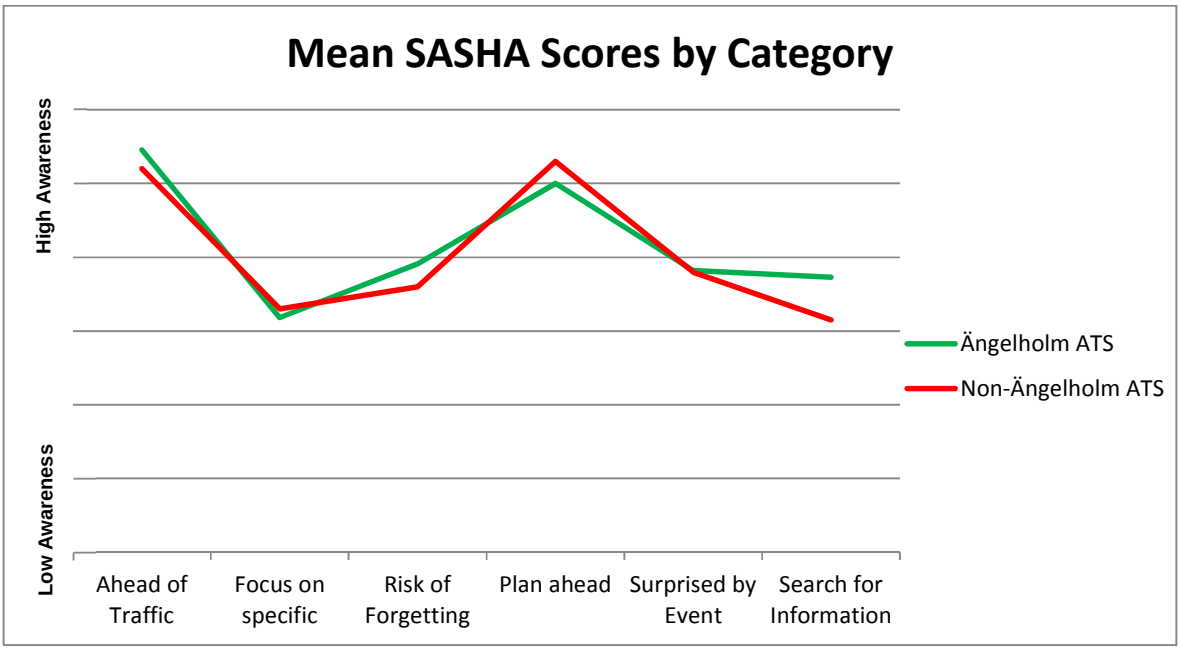


Figure 16 - Mean SASHA Scores by Category (ATCO Rating)

6.1.3.1.4.3 ATCO Involvement

It is essential that the ATCOs feel sufficiently "in the loop" for providing ATS to the aerodrome site using the Remote Tower. The End of Trial questionnaire therefore sought ATCO feedback on this issue. Feedback included:

- *"I have not yet seen enough good solutions/equipment but if as good equipment as promised will be delivered, there are large possibilities to reach it."*

In addition it is important that by working in the Remote Tower and providing ATS, the ATCO job does not seem less real. There was a mixed response.

- *"Even when shadow-observing it felt real, I do feel like it could be even more "hands on" with the availability of new, fresh equipment."*

- *"It´s difficult get a feeling of reality, i.e., that you really have a feeling of control. With this, I was passive as an ATCO. If it had been an active operation, it probably would have been very tiring to serve air traffic. In this demo there were far too many temporary errors and not yet fully developed tools… like PTZ, camera filter, gain on camera etc."*

6.1.3.1.4.4 Trust

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 which will lead to ATCO confidence. The EUROCONTROL SATI questionnaire was included as part of the End of Trial Questionnaire in order to capture ATCO feedback on trust.

- 11 of the ATCOs said that more often/often the system was understandable.
- 5 ATCOs mentioned the IR camera as being the technical/operational system they have the most trust in.
- In answer to whether the system worked robustly, 3 said seldom, 5 answered sometimes, 3 said often and 1 said more often.
- In relation to whether ATCOs were confident when working with the system, 3 said seldom, 5 said sometimes, 2 stated often, 1 stated more often and 1 said very often.

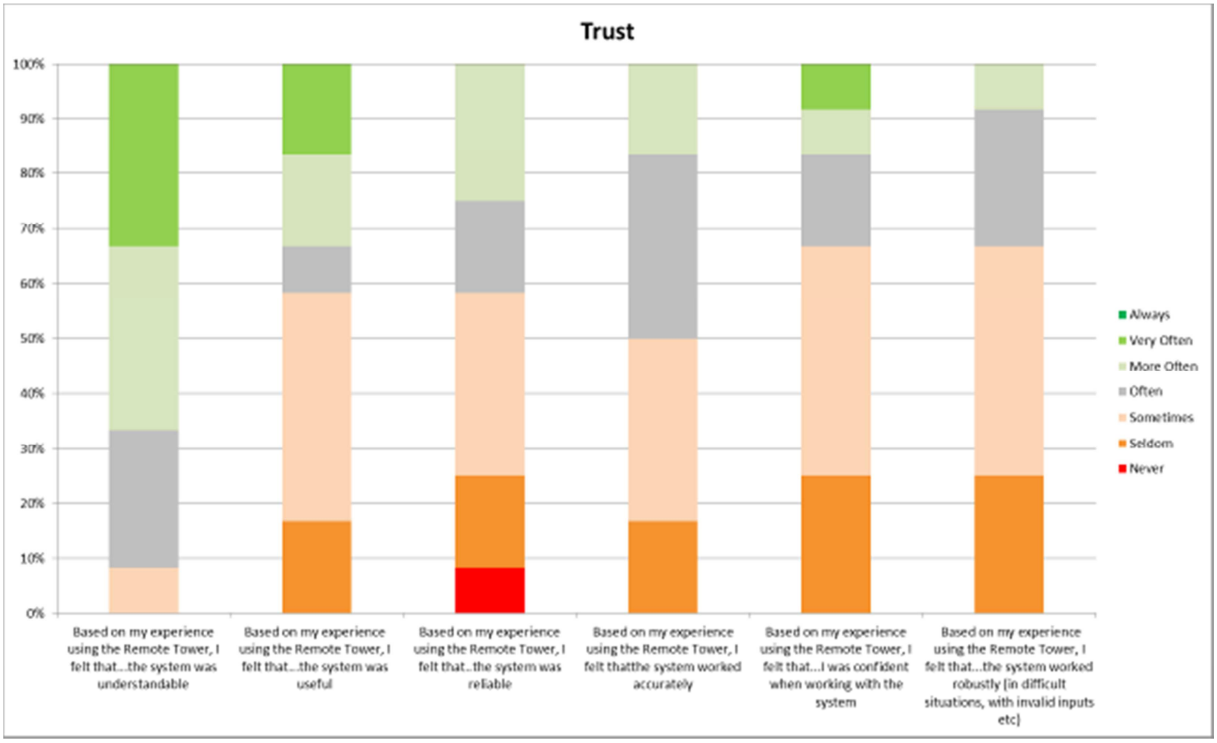


Figure 17 - ATCO Response to Trust

- One ATCO had the most trust in *"The radar since the information there is something tried and proven. It was also something familiar."*
- In relation to the technical/operational system with the least trust, one ATCO stated "*Once again the video is lacking too much and it is too obvious that it is processed heavily. The video should be of much higher quality and the augmentations that are made must not be distractions in their own. Everything needs to be done seamlessly so that I buy it even on a subconscious level..."*

6.1.3.1.5 Safety

6.1.3.1.5.1 Safety Summary

Since this was an initial, basic prototype RTC system and not a fully advanced set of equipment and tools the system safety can only be assessed at a high level and relative to the system provided during the trials.

During the day, it was easier to follow single movements compared to night time. However, smooth moving images were not present. The IR and the PTZ cameras seemed to add to situational awareness and thus safety as it allowed ATCOs to track aircraft which otherwise would be very hard and/or impossible. Feedback included:

- *"I think that RTC can be run in a safe way."*
- *"I think it could be ok with a single aircraft following from short final down to ground, maximum two. The possibilities to cover the manoeuvring area during daytime are also satisfying."*
- *"There is still a little way to go before I would consider the system mature enough to provide a safe service."*
- *"Proven methods of separating using visual separation might have to be rethought, going back to more procedural separation or using radar in a bigger extent to ensure separation to the threshold. I feel that there are possibilities for a higher amount of safety and technical ways to reduce the risk (less of a human factor with proper equipment)"*
- [the visual reproduction is] *"Unable to produce smooth moving images. Objects are not sharp and the focus not optimal. Gives fatigue, then it's a safety issue. Frame rates have to increase, but not with synthetic updates. Landscape reproduction is ok. Difficult to detect aircraft especially with clouds in background. Sometimes difficult to see if the aircraft moves from or towards me."*
- *"We work generally with current rules in the system and there are a number of safety levels and it is those that give me confidence that the RTC is still not certified."*

6.1.3.1.5.2 Loss of Visual Contact

During the trial the ATCOs often commented that it took some time to first identify an aircraft in the air. Once spotted, it was easier to follow, but if sight was lost, it took some time to re-establish visual contact. In a shadow mode trial, when other operational distractions were not taking the ATCOs' eye off the aircraft, it was possible to maintain continuous watch on an aircraft. This would not be the case operationally where the ATCOs' time is divided among many systems both head up and head down.

ATCOs suggested that the type of tracking and overlays seen in the ART project would be a suitable mitigation against this.

6.1.3.1.5.3 PTZ Camera

The usability of the PTZ camera raised some concerns that could have an impact on safety:

- *"IR* camera *is a "zoomed out" picture of the PTZ camera view. It is side by side with PTZ but the screens do not match. They are similar but not the same. So part of you is expecting to see the same thing, but it can actually be very different and objects can be hard to find relative to both IR and PTZ* camera *screens. It can be hard to relate the PTZ view to the main display. With binoculars you are physically pointing the same way for "zoomed out" and "zoomed in". Here, the PTZ screen is in a fixed position (the 2 o' clock position relative to seating), even when the focus of what is being shown is e.g. behind the ATCO. The areas it refers to changes, but the area it is displayed in never changes. This creates a miss-match between zoom view and head up view."*

On full zoom, the PTZ camera cannot keep up with a moving aircraft on the runway/taxiway. In addition the PTZ camera obtained raindrops during one day which obscured the ATCO view and could have caused the problems present when obtaining focus when in zoom.

6.1.3.1.5.4 Safety during visual reproduction disturbances

The screen displaying the runway threshold became unusable on the 25th October due to a software bug which caused several screens to become scrambled. The visual presentation also had technical problems during night and artefacts on the screens during some instances. Frozen screens were also observed on the 3rd November. This led to feedback such as:

- *"A new type of problem occurs with screen-blackout (or "white-out" that we had happen), which feels like a real risk (electric shortage, backup failure or something along those line). Guesswork is that it might lead to a quite "messy" recovery depending on amount of aircraft in the vicinity of the airport"*

The ATCOs who experienced the screen "scrambling" were asked to describe how this might impact their tasks. The ATCO said:

- *I check Strips first. Is anything meant to be there [on screen] now or soon? Do I need to see that screen now? If not, I'll call tech support. If yes, I'll use the PTZ camera.*
- *I wouldn't use the PTZ if there was no reason (i.e. if nothing was there). It's an extra task that isn't necessary.*
- *I had looked at that [scrambled] screen maybe only 10 seconds before so I knew there was nothing in that area. No aircraft, no vehicles. So I was OK with that. If there was a vehicle in that area, and an aircraft on short final then I would initiate a go-around. I have no time to do anything else.*
- *I therefore establish a new scenario and a new situational awareness. I do instruction first, information second.*
- *Then I assume we are working with no visual on **some** area, therefore LVP for **all** areas.*
- *A screen failure is different to camera failure for better and worse. It is better in that I can replace a screen (we have spares) myself in about 10 minutes, or my colleague can help me. It is expected to happen more often* (screen life is maybe some forty thousand hours; camera life is maybe 3-4 times that).
- *The screen I want to lose least is the runway threshold. The runway here is on 3 screens: RWY threshold, RWY mid, RWY end and terminal. I don't want to lose any of these screens. I don't mind the others as much. I don't mind the behind view at all (I don't have that view today anyway). If I lose 1 of the 3 RWY cameras, I pick the middle one as the one I mind least."*

The picture quality was occasionally perceived as negatively affected when birds were sitting on the camera house. Their tail feathers covered parts of the upper image; however, they were easily scared away by rotating the PTZ.

6.1.3.1.5.5 "Dead zone"

The external view (as shown in the screens) stops at a certain upper level and distance away from the Tower. When an aircraft flies directly over the tower, it flies through this "dead zone" where you cannot see it. This dead zone is similar to the tower roof in a local tower. However, the use of aural reproduction can help identify the distance and direction of the flight relative to the tower.

The go-around procedure (power on, climb, right turn at RWY 14) flies into the dead zone. However, the ATCO can track aircraft using the PTZ/IR.

6.1.3.1.5.6 Engine failure after take off

A school flight did simulated engine failure on take-off. The ATCO could clearly see slow angle of climb and the change to higher angle when both engines we re-introduced.

6.1.3.1.5.7 Physical Risks

11 out of 12 ATCOs agreed/strongly agreed that the use of visual reproduction for an extended period of time caused eye strain and other physical strains. 1 ATCO neither agreed nor disagreed.

The eye strain/fatigue could have been due to the low update rate at the beginning of the trial which caused flickering of the screen. The update rate was increased as the trial proceeded.

6.1.3.1.6 Acceptability of the Roles, tasks and responsibilities

6.1.3.1.6.1 Tasks and Working Methods

Due to the fact this was a PSM trial, the ATCOs were not asked in detail about their working methods since it is hard to judge. However, feedback was obtained:

- *"Visual information is not as detailed and flexible in the remote tower as in reality. When applying visual separations these limitations actually make it impossible. It would result in pure use of radar or procedural separations being applied in the air."*
- *"Working methods seems like they will have to be more "inefficient" seeing as it will be hard to reduce separation in the vicinity of the airport with visual separation."*

The IR camera was an additional tool which the ATCO does not have in a local tower. It appeared that the use of the IR camera could lead to increased opportunities and increased flexibility in working methods.

- *"You would not need to cancel maintenance works in the vicinity of the runway as early as you have to do today in low vis. (It) would give the possibility to have two simultaneous movements during LVP. Generally it would improve flexibility in LVP, both for departing and arriving traffic. You would be able to save taxing times of 5-6 minutes as would be able to let two aircraft taxi at the same time since it would be possible to see/confirm the latter one stopping at a holding point."*

6.1.3.1.6.2 Roles and Responsibilities

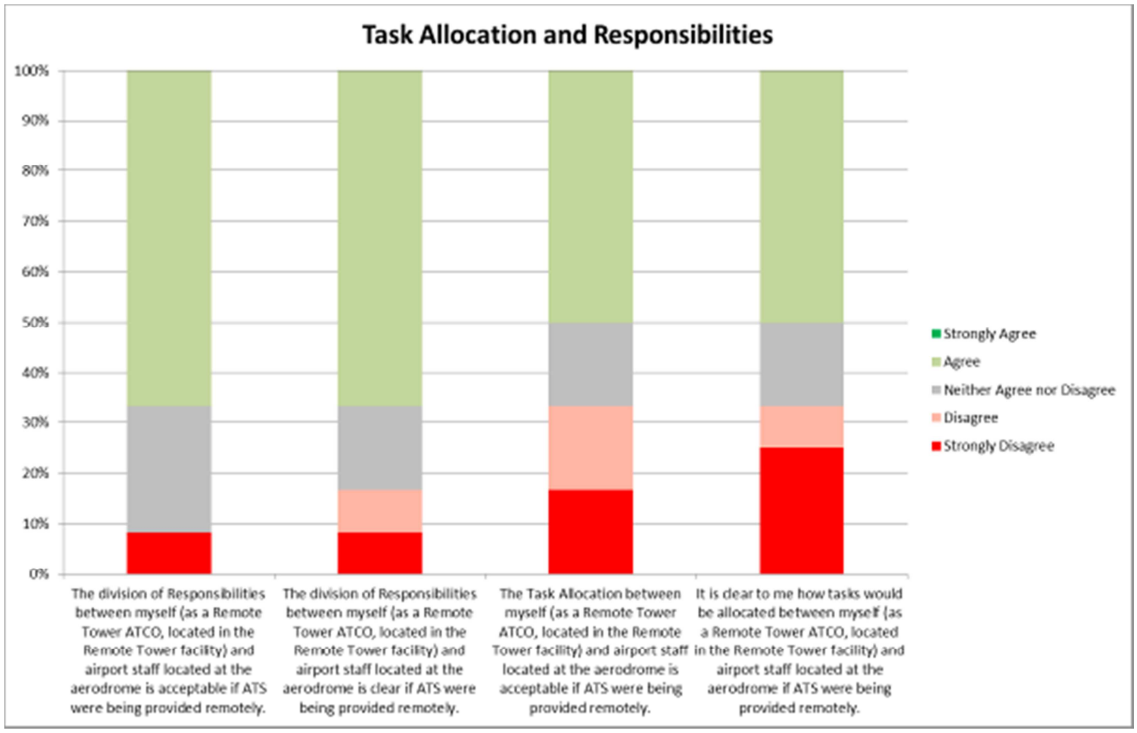


Figure 18 - ATCO Response to Task Allocation & Responsibilities

Overall, it was not expected that the roles and responsibilities of the ATCO would change with the introduction of the RVT. They will still remain responsible for the provision of the required services. A higher reliance may be placed on technical equipment to perform tasks such as runway inspections and local agents may be used to perform tasks originally completed by the local ATCO.

In this trial, the task allocation and division of responsibilities were not clearly defined to the ATCO since it was not the primary concern for the trial. This may have impacted the results and in future trials there should be an effort to ensure this information has been presented to ATCOs to avoid perplexity. In spite of this, there did not seem to be confusion over the task allocation and division of responsibilities by using the RVT.

- One ATCO suggested that the tasks allocated between a Remote Tower ATCO, (located in the Remote Tower facility) and airport staff located at the aerodrome if ATS were being provided remotely could be defined *"by letter of agreement"*
- 8 ATCOs agreed to the division of the responsibilities between the ATCO and the airport staff being acceptable if ATS was to be provided remotely.
- 8 ATCOs agreed to the division of the responsibilities between the ATCO and the airport staff being clear if ATS was to be provided remotely. Of the other 4, 2 neither agreed nor disagreed, 1 disagreed and 1 strongly disagreed.

6.1.3.1.7 Impact on ATC Procedures

6.1.3.1.7.1 Capacity

The capacity was believed to not affect IFR traffic but only became an issue when VFR traffic was involved since it involved maintaining visual contact which was a problem at times.

- 8 of the ATCOs agreed/strongly agreed that capacity will be maintained concerning IFR traffic when provided ATS remotely. 1 ATCO disagreed and 3 ATCOs neither agreed nor disagreed.
- 5 ATCOs strongly disagreed to the idea of access improving for both GA/VFR and IFR aircraft due to more flexible opening hours when ATS is provided remotely.
- Every ATCO either disagreed or strongly disagreed that capacity will not be reduced for GA traffic when provided ATS remotely (dependent of whether VFR can be applied when operating remotely)
- *"When VFR traffic is involved, it will probably be a must to set restrictions hence the number of movements within the airspace. It is at present, not possible to visually separate IFR and VFR."*
- All ATCOs felt (half "strongly") that GA/VFR aircraft will have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (depending amongst others whether VFR can be applied)
- One ATCO stated *"It will be necessary to limit the amount of VFR when you have IFR-traffic at the same time."*

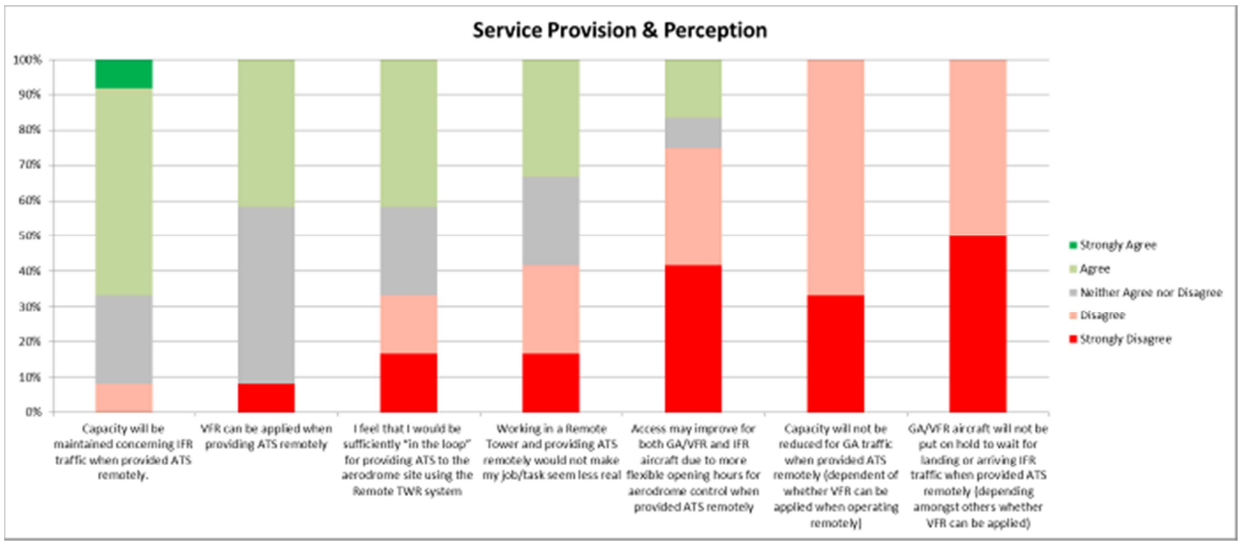


Figure 19 - ATCO Response to Service Provision & Perception

6.1.3.1.7.2 Flexibility

Overall, ATCOs were cautious of the conceivable benefits regarding flexibility – whether this meant more flexible access to airspace for the users, more flexible opening hours or more flexible working conditions for the ATCO. In addition, there is flexibility of procedures (especially LVP) and potential to lighten up restrictions in LVP with the use of the IR camera improving visibility which seemed to have a positive response. Overall feedback can be summarised as follows:

- Only 2 of the ATCOs agreed that access may improve for both GA/VFR and IFR aircraft due to more flexible opening hours for aerodrome control when provided ATS remotely. 9 out of 12 either disagreed or strongly disagreed.
- *"In Sweden we have C airspace and as the cameras are now you cannot separate visually between aircraft in traffic circuit. More flexible opening hours?? At ESTA today we are 6½ staff handling opening hours from 05z-2140z Mon-Fri and 07z-16z Saturday 10z-2140z Sunday. Tower and Approach and positive staff working overtime if needed. Also each of us has desk jobs whenever time is left over. For instance I'm in charge of education/improvement/assessment also. How will you be able to beat that?? This may be the case though if an airport needs to be open short times seldom and reported long before because even if air traffic ATCO may be in place quickly the airport staff may not."*
- "*Concerning if 4NM is a relevant lower level limit to use: In low traffic density 4NM is reasonable. Distance 4 feels as a very minimum; during CAVOK it should be possible to see a Medium aircraft more far out. The earlier you can visually see an aircraft, the more flexible service you can provide."*

6.1.3.1.8 Future Trial Platform

6.1.3.1.8.1 Future Developments

Some future enhancements are already being planned as part of P06.09.03 on-going development work, the LFV RVT-implementation project and lessons learned from projects such as ART and ROT. This section summarises those planned improvements as well as including suggestions from ATCOs during the trial.

The system is continuously being developed to provide more advanced software with fewer malfunctions and increased usability. For example, the seams between the screens will be decreased, the PTZ camera will be controlled by a touch pen, the resolution is being increased, the PTZ and IR camera views will be integrated into the main panoramic screens and the CWP will be

more integrated so that it will include EFS (Electronic flight strips)

There may also be target symbols and labels to improve easy tracking and thus situational awareness and safety. The number of labels could be limited/filtered and only applied to relevant /specific objects to avoid clutter.

The ATCOs were asked for their input for what future developments they would like to see added or changed.

- One ATCO suggested *"A zoom device more similar to a real set of binoculars. At least one that is as easy and fast to use. Remove the separate IR* camera *display and add it as a selectable layer on top of the video displayed on the large monitors. Maybe reduce the IR coverage to only the ground - RWY and TWYs. It's cumbersome and slow to sit there and pan with the camera over large areas. In the air, it was pretty much useless."*
- One ATCO requested a "left-handed" user friendly PTZ. There was one left handed ATCO in the trial and he referred to the LFV RVT-implementation project, which has facilitated a right-handed and left-handed configuration which the RTC did not. The RTC must consider left-handed ATCOs in the layout of the next version of the CWP.
- One ATCO recommended *"better camera quality, better IR with on/off button for runway...and with a continuously running IR* camera *over running* (Visual Reproduction) *to detect objects and alerting when so. Easier ways to handle the zoom camera. Invent something similar to binoculars."*

Airspace users and ATCO unions who observed the trial also suggested from features that could be improved:

- Some level of augmented reality should be available in the basic module to balance the limitations derived by the remote concept (also in day light time).
- Visual tracking functions.
- Integration with other sensors (radar, ADS-B)
- Development of an integrated approach for building situational awareness (mixing a map view beyond camera visual range and real images for close in operations (short final and ground operations)).
- The effect of the sun dimming the displays (and the blur) must be improved
- The redundancy in the transfer of data between the airport and the RTC must be considered.
- The fatigue of the operators must be evaluated when operating in the RTC with the visual displays.

6.1.3.1.8.2 Future Trials

Apart from suggestions to improve the system, the ATCOs expressed that they were content with the trial set up and would all be willing to participate in the future trials. The environment is important to ensure ATCOs are comfortable in the RTC as one ATCO complained it was *"narrow and hot and there was no water*"

- One ATCO stated "Involve technicians directly in to the trials";
- One ATCO stated "There was a clear lack of versioning. Before the next trial it would be nice if we would have a system that is not tampered with during the trial so that we can get consistent testing";
- Many of the project team recognised the limitations of the PSM trials as a means for assessment and suggested that future research must include ASM.

6.1.3.2 Analysis of Exercise Results

Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results	Validation Objective Analysis Status per Exercise
OBJ-06.09.03-VALP-0060.0011	To assess the completeness and suitability of the functional requirements for Remote Provision of ATS to a single aerodrome (as defined in the OSED)	The technical capability of the platform, with regards the functional specifications, is known. The functional specifications have been approved by the users in a trial environment. Any changes with regards technical capability are captured in the form of changed, additional or removed functional requirements.	**24 of the 31 applicable Functional Requirements were approved without modification.** The ATCOs asked that **2 requirements be changed from *should*** to ***shall***. "The visual reproduction ***shall*** provide a non-flickering impression to the human eye" "The visual reproduction ***shall*** provide a smooth and regular impression of moving objects to the human eye." The remaining **5 requirements were not able to be tested in the trial.** **1 additional requirement** regarding ambient lighting in the RTC was proposed.	OK
OBJ-06.09.03-VALP-0060.0021	Gain an initial Safety Insight into the Remote Provision of ATS under the normal conditions experienced during the shadow mode trials	The trial has facilitated the gathering of initial safety feedback, to be used as input into the dedicated safety studies, the OSED and future trials.	Under normal conditions, the ATCOs felt that **a safe service could be provided remotely**. They felt that, using the current technical set-up, **some restrictions may have to be applied** to that service, in terms of number of simultaneous a/c and VFR traffic.	OK
OBJ-06.09.03-VALP-0060.0031	Gain an initial Safety Insight into the Remote Provision of ATS under the abnormal conditions experienced during the shadow mode trials	The trial has facilitated the gathering of initial safety feedback, to be used as input into the dedicated safety studies, the OSED and future trials.	Picture quality was occasionally affected when birds were sitting on the camera house, resulting in parts of the upper image being covered; however, birds were easily scared away by rotating the PTZ. **Results from the workshop are detailed in** Error! Reference source not found.**.** Within this workshop abnormal conditions were discussed In relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having fully robust and accurate PTZ camera functionality and for certain traffic patterns a 360◦ visual representation, were included in ATCO feedback. PTZ functionality should allow for quick, accurate	OK

			and easy manoeuvrability, equivalent to using standard binoculars.	
OBJ-06.09.03-VALP-0060.0041	Gain an initial Safety Insight into the Remote Provision of ATS under the degraded conditions experienced during the shadow mode trials	The trial has facilitated the gathering of initial safety feedback, to be used as input into the dedicated safety studies, the OSED and future trials.	Some degraded (visual) conditions were naturally experienced and also simulated during the trial. The ATCOs that experienced the degraded conditions were **not unduly concerned, and related the scenarios to Low Visibility in today's operations**. The general feeling was that **operational and procedural solutions** (e.g. Low visibility Procedures) **could mitigate against degraded visual conditions**.	OK
OBJ-06.09.03-VALP-0060.0061	To assess the impact of the Remote Tower Concept on TWR ATCO Human Performance under good and limited visibility conditions and during the day and night, in terms of: III. Situation awareness IV. Trust	ATCO situation awareness must be shown to be within acceptable limits (the value of the 'acceptable limits' will be defined with regard to the tool employed to assess situation awareness). The Remote ATCO is able to detect potential conflicts, hazardous situations and other scripted events that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas. ATCOs reported level of trust must be shown to be within acceptable limits (the value of the 'acceptable limits' will be defined with regard to the tool employed to assess trust).	**Technical issues including the quality of the picture caused situational awareness to be lower than a local tower**. However, the use of **the IR cameras had positive feedback**, especially in darkness where it could give a clearer view of the aerodrome Situational Awareness scores were acceptable overall but some individual scores bordered on unacceptable. The **best** situational awareness scores were recorded against ATCO **ability to keep ahead of the traffic** and be **able to plan and organise their work as they wanted**. The main **issues** relating to situational awareness were recorded against the areas of **focusing on a specific problem** and **searching for specific information**. ATCOs found it hard to identify and track aircraft using the visual reproduction. With regards **trust**, the ATCO feedback indicates **a general trust in the concept**, with most saying they found it **understandable and robust**. New tools such as the **IR camera**, as well as traditional systems such as **radar**, helped the majority of **ATCOs feel confident using the system**.	NOK
OBJ-06.09.03-VALP-0060.0062	To assess if basic ATC functions / tasks can be	The trial has facilitated the gathering of initial feedback,	The functions and tasks were **limited to those related to building a visual picture**.	OK

	performed using the initial prototype, and identify any additional issues that may contribute to the HP Task Analysis.	relating to the range of ATC functions and tasks that can be performed using the initial prototype. Any additional issues that may contribute to the HP Task Analysis and/or be used as input into the OSED and future trials are identified.	The ATCOs felt **able to build the basic visual picture**, supported by the visual reproduction, PTZ camera and IR camera. Most ATCOs experienced **difficulties in accurately judging depth and separation for airborne aircraft.** The ATCOs were **able to monitor ground movements sufficiently**. Feedback on the **ability to judge MET conditions** (including cloud celling) was **mixed and inconclusive**. Opinion was divided among ATCOs. ATCOs found building an accurate visual picture **easier during day time, compared to night time**, although some of this is due to technical problems early in the trial (later resolved). **Low visibility did not cause any additional problems** due to the IR camera and also the way in which a darker sky / cloud allowed for greater contrast between the aircraft and the sky.	
OBJ-06.09.03-VALP-0060.0071	To assess the Acceptability of the initial HMI, CWP and working environment to the ATCO, when providing Remote ATS to a Single Aerodromes.	The Remote Provision of ATS to a single aerodrome concept, is usable/acceptable to the ATCO in terms of: • Visual Reproduction • CWP • Working Environment • Remote Facility Location and resulting social considerations	**8 out of 12** ATCOs felt that the overall **quality of the visual reproduction was insufficien**t to provide similar levels of service compared to a local Tower. However, several **improvements** (many of which are currently under development) **were suggested** to mitigate this result. The ATCOs stated that the **picture of the ground segment** was generally **clearer and easier to interpret** than the air segment. The ATCOs stated that the **picture during day time** was generally **clearer and easier to interpret** than night time. **Frame rates were too low**, and at night time issues with the **video compression caused "artefacts" and "ghosting"** on the visual reproduction. The **PTZ camera was deemed to be a useful tool**, but there were **usability issues** and issue with the picture quality. The **IR camera** was **well received** by the ATCOs with the	NOK

			vast majority finding it a **useful component**. The majority of ATCOs found the **CWP size, layout and range of functions to be acceptable** although some useful feedback was given on how it could be improved. The working environment used in the trial was not representative of an implemented system, but even so, ATCOs felt that some basic changes could be made to vastly improve the Working Environment. With regards the location of the remote facility, ATCO opinion was split with some strong feelings either side – some having potential objections, others having no problem.	
OBJ-06.09.03-VALP-0060.0072	Gain an initial insight into the impact of the Remote Provision of ATS on ATCO tasks, roles and responsibilities.	The trial has facilitated the gathering of initial feedback, relating to the impact of Remote Provision of ATS on ATCO tasks, roles and responsibilities.	ATCOs felt that with the trial prototype **their tasks would change**, potentially becoming more "inefficient", with **increased separation** in the vicinity of the airport for visual separation. On a more positive note, **the IR camera might allow increased opportunities** and **flexibility in working methods**. Overall, ATCOs **do not expect the roles and responsibilities of the ATCO to change** with the introduction of Remote ATS. The ATCOs felt that the **division of roles and responsibilities** when operating from the remote facility **was clear**.	OK
OBJ-06.09.03-VALP-0060.0073	Gain an initial feedback / insight into the impact of the Remote Provision of ATS on ATC procedures	The trial has facilitated the gathering of initial feedback, relating to the impact of remote tower ops on ATC procedures	ATCOs felt that their **procedures under Remote ATS would have a negative impact on VFR/GA capacity**. All ATCOs felt that **GA/VFR aircraft** will have to be **put on hold to wait for landing or arriving IFR traffic.** They felt that capacity for **IFR traffic would be maintained**. ATCOs were **cautious of the** conceivable **benefits regarding flexibility**. They responded **positively** to the suggestion that there is **flexibility of procedures** and potential to **lighten up restrictions in LVP with the use of the IR camera**.	OK

OBJ-06.09.03-VALP-0060.0101	To gain an insight into the usefulness and utility of prototype features, functions and technologies for integration into future trial platforms e.g. High Definition Cameras, video compression software, IR cameras.	The usefulness and utility of proposed/prototype features, functions and technologies are known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	The IR camera was the newest component in the trial and it was very well received. **ATCOs felt strongly that the IR camera should feature in future trials.** **Other suggestions for improvements to existing functions and technologies were suggested** including: • Better HMI for PTZ • Reduced seams between screens • Target symbols/labels on the main display • Inlaid PTZ/IR camera images on the main display.	OK

Table 14: Validation Objectives Analysis Status in this exercise

6.1.3.2.1 Unexpected Behaviours/Results

N/A

6.1.3.3 Confidence in Results of Validation Exercise

6.1.3.3.1 Quality of Validation Exercise Results

The results from the trial are mainly based on subjective feedback, with many captured using tried and tested methodologies such as SHAPE Sasha and SATI have been used to help ensure the result obtained are valid & reliable.

6.1.3.3.2 Significance of Validation Exercise Results

The operational significance of the validation exercise results is heavily influenced by several factors, mainly due to the trial platform and validation technique:

- PSM – ATCOs were not able to interact with aircraft and were not able to provide actual ATS to the aircraft. Therefore any opinion related to ability to provide ATS is based on observation, interpretation and inference, albeit from operational experts with knowledge of the trial operational environment.
- Prototype platform – Overall, the system was intended to represent a technical prototype – a V3 starting point upon which future enhancement could be built. V3 concept maturity was also required to allow the trial to be considered in the SESAR Release 1 Plan. This meant that some more advanced functions, such as those seen in projects like ART (tracking symbols, visual enhancements etc.), were not included in this trial as they were not technically mature enough. Some participants felt this was a backward step but recognised that such functions may be available in future trials or an operational implementation
- Working Environment – the Remote Facility is located in a “dome” at Malmö ACC. It is recognised that this is not an optimal environment in which to locate an RTC, but historical and practical reasons meant that, for this trial at least, a more representative facility could not be used.

Statistical significance has not been quoted for any of the results so is therefore not applicable.

6.1.4 Conclusions and recommendations

6.1.4.1 Conclusions

The overall aim of this first trial was to assess the technical and operational capability of an initial prototype in an operational environment.

It can be said that the trial was successful in achieving that aim, with a basic initial prototype platform assessed against various objectives. The functional requirements were confirmed by operational staff in the context of assessing the platform in a representative environment

Experience during the trial has given an indication of what tasks and functions can be performed using the platform. Building the basic visual picture required is possible, in the air and on the ground. The picture during day time is especially good and building a picture during low visibility conditions did not pose a significant problem due to tools such as the IR camera benefitting the ATCOs.

The ATCOs felt that the IR camera was a useful component both at night time and during low visibility due to weather. They would prefer it to be integrated into the main display for easier use.

Likewise, the PTZ camera was deemed to be a useful component but it should be integrated into the main display and the HMI should be improved. The hardware for the PTZ camera should be at least as good as the main cameras in terms of quality of visual reproduction.

The ATCOs reported no significant issues with the CWP size, layout or functions available.

The ATCOs felt they could trust the system, finding it understandable and robust. The ATCOs had no issues regarding the roles and responsibilities when providing Remote ATS.

An initial safety insight for normal and degraded conditions was gained during the trial. The ATCOs and the project team were able to identify what they might consider risks (and therefore areas for further assessment) and what they considered to be less of an issue.

Overall the ATCOs stated that they would be able to accommodate IFR traffic through Remote ATS with no negative impact on capacity.

Feedback on some areas and objectives was less positive, highlighting the need for refinements to the concept and technical platform, and the need for further assessment.

The ATCOs found it difficult to use the visual reproduction for assessment of depth and visual separation in the air. This is an issue particularly when dealing with more than one simultaneous VFR movement, or a simultaneous VFR/IFR movement. In such scenarios the ATCO tasks and working methods may have to change, with VFR aircraft being asked to hold in the air.

The visual reproduction requires improvement in overall quality, with attention paid to the frame rate, ability to handle glare, and the impact of using video compression. Visual reproduction during darkness is not as good overall as the reproduction during day.

ATCO situational awareness could be further improved, particularly with regards the ability of the ATCOs to keep track of aircraft on the screens without continuous watch, and the risk of focusing on a specific area.

6.1.4.2 Recommendations

The recommendations from VP-056 include the following:

- Recommendations for the Validation Planning:
  - Future trials should test the remaining Functional Requirements to complete the assessment of the corresponding Validation Objective;
  - Scenarios for Abnormal Conditions and Degraded modes should be planned into future trials under this project to allow for a quantitative assessment;
  - The planning should allow for installation and acceptance of the platform well before the trial to avoid the last minute changes experienced for VP-056;
  - A full shakedown (Dry Run) should be planned to test the platform, data collection and trial design principles;
  - The shift patterns used for VP-056 (p.m. shift followed by an a.m. shift) were useful to give exposure to varying conditions. A similar pattern should be used in future trials;
  - The validation team should investigate ways in which the participants can become more “involved” in the operations, to help overcome the known limitations of a PSM trial and the impact this has on operational significance of results. This may include ASM as a validation technique in future research;
- Recommendations for the Concept:
  - The OSED for Remote Provision of ATS to a Single Aerodrome should be reviewed and, if necessary, updated in light of the findings from VP-056;
  - Situational Awareness should be more clearly addressed to gain a better understanding of the issues;
  - The IR camera should be considered as an essential component, given the relatively low cost compared to the benefits it can bring;
  - The impact of the concept on VFR capacity should be more clearly and explicitly addressed, with mitigations (operational and/or technical) proposed if possible;
  - The actual working environment (the remote facility) should be more clearly addressed in the concept to highlight considerations on aspects such as room temperature, ambient lighting etc.

  - The concept should be assessed with and without various sub-systems (such as Radar) to help establish which are necessary to provide ATS, and which are optional.

- Recommendations for the Trial Platform:
  - Some form of tracking could be implemented to help with identification and tracking of aircraft;
  - The PTZ camera should be updated to a “state of the art” camera more in line with the high definition cameras used for the main reproduction;
  - The HMI for the PTZ camera should be improved to make it more usable;
  - The IR camera and PTC camera reproductions should be integrated more with the main displays;
  - The seams between the main display screens should be reduced as far as possible;

The working environment in the Remote Facility should be improved to something more resembling a target operational facility.

6.2 Remote Provision of ATC to a Single Aerodrome Trial 2 (EXE-06.09.03-VP-057) Report

6.2.1 Exercise scope

The Remote Provision of ATC to a Single Aerodrome, assessed during a PSM Trial.

The overall aim of this second trial is to build upon the technical and operational findings of EXE-06.09.03-VP-056 and address objectives and scenarios not already addressed or concluded upon in VP-056. The trial also looked at various technical configurations to gain an understanding of the different operational service levels possible using different technical enablers.

The three week trial was performed at the Remote Tower test installation at LFV's Malmö Sturup site. The trial assessed live traffic from Ängelholm Airport under a variety of scenarios. In addition to scenarios actually occurring at the aerodrome, recorded scenarios of the aerodrome could be used for assessing ATCO's opinion. These scenarios were recorded images.

The main foundation of the analysis was obtained from the "End of Trial Questionnaire" which every ATCO completed after all sessions on day 2 of their trial. This covered a large range of questions with a focus on acceptability, visual reproduction, ATCO working position, task allocation and responsibilities, service provision, safety, situational awareness and trust.

Many of the questions included a scalar, or categorical response option. Responses from all 14 ATCOs to these questions could be tabulated and descriptive statistics and graphs could be prepared. Where appropriate, subjective feedback from the ATCOs has been included to provide additional explanation. This includes contradicting comments among ATCOs which are included to show a variety of opinion. The comments selected for inclusion in this document are believed to be representative of the overall view of ATCOs or have been included as they have been seen as individually important.

The results presented in this document are not in a numerical order (according to Validation Objective Identifier) but run in a logical order to make it as easy as possible to follow for the reader.

6.2.2 Conduct of Validation Exercise

6.2.2.1 Exercise Preparation

6.2.2.1.1 Milestones

Ref.	Milestones	Dates*	Delivering Project
M1	Requirements produced	15/07/2011	P06.09.03
M2	Prototype developed	17/03/2012	P12.04.07
M3	Prototypes Integrated	N/A	N/A
M4	Platform modified	03/04/2012	P12.04.07
M5	Platform integrated	03/04/2012	P12.04.07
M6	Platform technically accepted	17/04/2012	P12.04.07
M7	Platform Configured	28/04/2012	P06.09.03
M8	Exercise completed	25/05/2012	P06.09.03
M9	Assessment Completed	29/09/2012	P06.09.03

Table 15: Milestones

6.2.2.1.2 Platform Configuration

This was a PSM validation trial in which the new system was given live feeds in the operational environment and ran in parallel to the operational system. The new system was non-interfering and did not play an active part in the ATM system.

The platform was based on the platform used in VP-056 and described in 6.1.2.1.2 Platform Configuration. It was further modified for VP-057.

Visual Reproduction:

- Display Screens:
  - 9 x 42" LCD monitors;
  - Arranged in a "broken circle" around the CWP;
  - 6 monitors to the front were placed together continuously;
  - 3 monitors to the rear were placed apart from the other 6 to allow extra space around the ATCO as well as a gap for entry/exit.
- Main Cameras:
  - 9 cameras in total (corresponding to one per display screen) mounted on top of a local tower and providing a 360˚ view;
  - 6 cameras (corresponding to the front 6 screens) with high resolution covering runway and the manoeuvring area, northern traffic circuit, runway finals. These had a frame rate of 30 frames per second;
  - 3 cameras (corresponding to the front 6 screens) with lower resolution (but still High Definition) covering the remaining rear area. These had a frame rate of 20 frames per second;
- Supplementary Cameras:
  - One (new) High Definition PTZ camera;
    - Replacing the binoculars used in a local tower;
    - "Picture in Picture" display showing zoomed image of selected area;
  - IR camera:
    - IR camera imaging provides a thermo graphic representation of the focused area. This could be used as a supplement to the regular cameras in a remote tower OTW view, to be used in darkness or in fog;
    - "Picture in Picture" display;
- Video Software
  - Automatically reduce contrast differences in an OTW view:
    - Between cameras;
    - Between ground and sky;

Advanced Visual Features (Advanced Configuration only):

A set of additional hardware and software options for use during selected periods in the trial:

- Label overlays:
  - Digital overlays on the main displays to highlight aircraft position;
  - Visual tracking to detect moving objects in certain areas of the screen;
  - Radar tracking to show position based on radar;
  - Different label overlay symbols to indicate whether it represents radar tracking, visual tracking or both.

- 5 additional camera views at hot-spots:
  - Additional fixed camera views at selected positions around the aerodrome;
  - Picture in Picture display;
  - Toggle on/off;

Controller Working Position:

The CWP in the facility included presentation of various additional systems to provide aerodrome control. The CWP was situated about 1.5 m from the display screens, allowing a minimum 2m radius inside the CWP. The following systems were included:

- Ground-air and ground-ground radio;
- Direct phone to adjacent ATC;
- Flightplan system;
- Electronic Flight Progress Board (E-strip);
- Pan Tilt Zoom camera;
- Met information including wind meters;
- Manoeuvring of airport lights and navigational aids;
- Rescue alarm with interface to the airport;
- Surveillance Radar presentation (Advanced Configuration only).

Ambient noise from the airport came from two microphones fitted at the tower, feeding two loudspeakers at the RTC.

A selection of images showing the VP-057 trial platform is given below and overleaf.

Figure 20 - Remote Tower Facility at Malmo ACC, showing room layout and "open circle" screen layout

Figure 21 - Remote Tower Test Facility (showing CWP and front 240^{o} screens)

Figure 22 - CWP showing screens (top), e-strips (bottom centre), radar (centre middle), IDP (bottom right) and communications panel (bottom left)

Figure 23 - PTZ camera Picture in Picture Display

Figure 24 - IR camera Picture in Picture Display

Figure 25 - Label overlays showing visual tracking (left) and radar tracking (right)

6.2.2.2 Exercise execution

The trial ran from 7th May until 25th of May 2012.

6.2.2.3 Trial Design

6.2.2.3.1 Airport Information

See section 6.1.2.2.1 Airport Information.

6.2.2.3.2 Scenarios

The current trial was done in a Shadow Mode Trial. It was therefore not possible to interact with the traffic, nor was it always possible to script events to occur. To overcome the limitations this placed on the range of scenarios an ATCO would experience, two methods were used to increase variety of scenarios.

1. A school VFR flight was hired each day to fly locally in the control zone and traffic circuits. This flight performed various manoeuvres such as departure, circuits, arrival, touch and go, engine off;
2. The cameras were installed at Ängelholm prior to the trial taking place. It was therefore possible to record (on digital video) some scenarios that were considered interesting. Whilst it was not possible to interact with the scenarios during playback (e.g. move the PTZ camera), the selection and de-selection of advanced visual features such as additional camera views and label overlays was possible. These recorded scenarios were replayed during breaks in the live traffic. The recorded scenarios included:
    a. Arrival during darkness (since the trial was mainly in daytime);
    b. Departure into bright / direct sunlight;
    c. Severe fog;
    d. Recording of the school flight flying circuits.

6.2.2.3.3 Timetable

A detailed trial timetable is shown in Table 16. To minimise influence of one ATCO over another, only one ATCO was allowed into the facility at a time for the majority of the time. When not in the facility, the other ATCO was interviewed by Safety, HP and Procedures experts. The ATCO used the facility first in Basic mode, then in advanced mode in order to gradually build up the learning. At the end of day 2, during breaks in the traffic the ATCO were subjected to some non-nominal technical scenarios, mainly based around screen failure.

	Time	Main Session	System	Scenarios
Day 1	10:30	Introduction		
	11:30	Lunch		
	12:15	Rules & Proc.		
	13:00	Practice in RTC ATCO1 + ATCO 2		
	14:30	Validation ATCO 1	Basic	
	15:30	Validation ATCO 2	Basic	
	16:30	Validation ATCO 1	Basic	Recorded Runs
	17:15	Validation ATCO 2	Basic	Recorded Runs
	18:00	Validation ATCO 1	Advanced	
	18:45	Validation ATCO 2	Advanced	
	19:30	Debrief		
	20:00	End of day		
	Time	**Main Session**	**System**	**Scenarios**
Day 2	06:30	Validation ATCO 1 + ATCO 2	Advanced	
	07:00	Validation ATCO 2	Advanced	Recorded Runs
	07:45	Validation ATCO 1	Advanced	Recorded Runs
	08:30	Validation ATCO 2	Advanced	
	09:30	Validation ATCO 1	Advanced	
	10:30	Validation ATCO 2	Advanced	Non-nominal
	11:15	Lunch		
	12:15	Validation ATCO 1	Advanced	Non-nominal
	13:00	End of Trial Questionnaire		
	15:00	Debrief		
	16:00	End of day		

Table 16: Daily Schedule for VP-057

6.2.2.4 Context of the Results

The results should be interpreted in the context of the conditions experienced during the trial, both technical and operational.

6.2.2.4.1 Operational

In this trial participating ATCOs were engaged in a Shadow Mode; in other words, they were not required to actively manage traffic or provide ATS. However, they were asked to participate in the trial as if they would be providing active ATS. ATCOs' full attention therefore was needed, in practice however, they did not need to do as much as a live running ATCO. All the answers given by the ATCOs to the questions were in such a way that it captured how they would react/behave/operate if they were running live ATS.

In total, there were 7 different types of traffic: scheduled IFR, IFR school flights, IFR GA flights, IFR hospital flights, VFR GA flights, VFR school flights and ground traffic at manoeuvring area only (i.e. aircraft taxing/towing to/from the hangar area crossing the runway to the terminal apron).

Table 17 (overleaf) shows the scheduled traffic for each trial shift and per day. It does not include any additional traffic or VFR flights.

Day 1			Day 2		
Kullaflyg	1500	Arr	Kullaflyg	0630	Dep
VFR Local	1520	Dep/Arr	SAS	0645	Dep
SAS	1555	Arr	Kullaflyg	0715	Dep
SAS	1620	Dep	SAS	0910	Arr
Kullaflyg	1620	Dep	Kullaflyg	0915	Arr
Kullaflyg	1735	Arr	VFR Local	0920	Arr/Dep
Kullaflyg	1755	Dep	SAS	0930	Dep
SAS	1910	Arr	Kullaflyg	0945	Dep
Kullaflyg	1910	Arr	Kullaflyg	1000	Arr
Kullaflyg	1930	Dep	Kullaflyg	1020	Arr
SAS	1935	Dep	Kullaflyg	1045	Dep
Kullaflyg	2040	Arr	Kullaflyg	1115	Dep
Kullaflyg	2215	Arr	Kullaflyg	1200	Arr
SAS	2235	Arr	Kullaflyg	1235	Dep
			SAS	1235	Arr
			SAS	1300	Dep

Table 17: Flight Schedule for VP-057 per day

6.2.2.4.2 Technical

The ATCOs are asked to assess the general operational concept and their opinion on specific components of the system during the trial. Some technical considerations therefore have to be accounted for in respect of the feedback from the ATCOs:

- Technical systems varied throughout the trial, between a Basic System (basic visual reproduction) and Advanced System (all technical enablers included).
- For this trial a new PTZ camera was installed along with an updated HMI compared to VP-056.
- New high definition cameras giving a 240^{o} view along the runway were used, and the images from these were displayed with an increased frame rate of 30 frames per second (compared to 20).
- Recordings were used to represent degraded modes, including fog, night time and other recordings of limited visibility.
- Advanced visual features were provided such as:
  - Aircraft radar/visual tracking with label overlays;
  - Additional camera viewpoints – fixed cameras were placed giving a view of “hotspots”, such as the apron and several angles of the runway and taxiway.
- The e-Strip Bay was also included but no validation was done for this tool.

The assessment of the Basic System therefore included:

- New PTZ camera;
- IR camera
- New HD cameras with increased frame rate;
- E-Strip bay;
- Use of recorded scenarios.

The assessment of the Advanced System therefore included all of the above, *plus*:

- Additional Camera Viewpoints;

- Aircraft radar/visual tracking with label overlays;
- Radar display.

6.2.2.4.3 Additional Analysis Comparisons

Unless otherwise stated, the analysis is shown for all 14 ATCOs as a group.

Comparisons were made between the two systems to check for a significant difference.

The comparison between the two systems (Basic and Advanced) was not made for every result. This comparison was made where it was relevant and could add further insight into the differences between these two systems.

In some of the additional graphs, averages in each category were used in an attempt to make the results as fair as possible.

6.2.2.5 Adopted Recommendations from VP-056

Many of the proposed future developments as described in the Validation Report from VP-056 were taken into account while planning VP-057. The following changes were suggested by ATCOs during VP-056 and were adopted in VP-057:

- The PTZ camera interface was changed;
- The (old) PTZ camera was replaced with a new HD camera;
- The separate IR camera/PTZ display was removed, and placed as a selectable layer on top of the video displayed on the main displays (Picture-In-Picture or PiP);
- The main display screen resolution was increased to 30 frames per second;
- The CWP was integrated and now includes the Electronic Flight Strips (EFS);
- Visual/Radar tracking functions and target symbols were added in the form of Tracking Label Overlays to improve easy tracking;
- Consistent testing during the Trial was assured by providing a clear timetable with structured sessions for each day and each ATCO;
- The working environment was adjusted by making sure the room temperature was acceptable and also cooled water was available at all times;
- The lighting and screen layout was changed to allow for a more spacious working environment.

ATCOs were encouraged to state their opinion on as many components as possible because they will contribute to the future design improvements.

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
OBJ-06.09.03-VALP-0060.0073	Assess the acceptability of single remote tower operations for ATCOs, in terms of: • The concept in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	The Remote Provision of ATS to a single aerodrome concept, is usable/acceptable to the ATCO in terms of: • The concept in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	The ATCOs were satisfied with the majority of technical aspects relating to the visual reproduction provided, including: contrasts, the screens, the screen distance, the resolution, the viewing angle, the screen layout, the general view, the screen size, the picture quality, and the camera positions: between 64% and 93% of the ATCOs agreed with their acceptability. The concept in general: o 9/14 agreed they would like to use the system to provide ATS HMI visual reproduction: Overall, ATCOs found the picture quality acceptable but also that it could still be improved. o Depth: **2/14** agree ability to judge o Night time: 3/14 agree it is as good as daytime o Distance: 5/14 agree ability to judge Advanced Visual Features: o **IR camera**: mainly positive from those who were able to use it during the trial. Some concerns about procedures and contribution to workload. o **PTZ**: generally negative feedback, mainly related to usability and quality of picture. o **Additional Camera Viewpoints (ACV)**: Mainly positive feedback, but number and location of cameras could be improved. o **Tracking labels**: Overwhelmingly positive feedback all round. **HMI CWP**: In general the ATCOs found the work environment acceptable in the current state.

			o 10/14 agree on acceptable layout **The Working Environment**: o 9/14 agree on pleasant place (3 disagree)
OBJ-06.09.03-VALP-0060.0102	To assess the utility and usability of enhanced visual features e.g. automatic a/c identification & tracking function, etc.	The ATCO can easily use the enhanced visual features and consider them to be useful for their tasks.	Usefulness: o **IR camera**: 11/14 useful o **ACV**: 13/14 agree useful o **Tracking Labels**: 13/14 useful Intuitiveness: o **IR camera**: **6/14** agree intuitive (3 disagree) o **ACV**: 10/14 agree intuitive o **Tracking labels**: 7 agree intuitive (2 disagree)
OBJ-06.09.03-VALP-0060.0051	Assess the utility of enhanced visual features, by determining their impact on: • the human performance, in particular in terms of situational awareness • the working methods and procedures, in particular for visual separation and for the use of the IR camera	The enhanced visual features have a positive impact on human performance.	The main enhanced features potentially supporting "air operations related tasks " were first the radar tracking one (15% of the total use of enhanced features), closely followed by the radar-based surveillance display and the video tracking (11% each). Concerning the "ground operations related tasks", the two enhanced features potentially to be used were video tracking (25%) and the additional cameras (23%). For most of the ATCOs the IR camera functionality was not used, mainly because the scenarios experienced were in daylight. Only some recorded scenarios were presented to some of them, but no interaction with the system was possible. When asked, ATCOs reported the opinion that the main ground tasks that IR camera could support are: o identification of aircraft and vehicles on the ground; o detection and resolution of conflicts in the manoeuvring area; o runway related operations.
OBJ-06.09.03-VALP-0060.0061	To assess the impact of the Remote Tower Concept on TWR ATCO Human Performance under **good and limited visibility** conditions and during the day and night, in terms of: I. Situation awareness II. Trust This objective differs from objective OBJ-06.09.03-VALP-0060.0051 and OBJ-06.09.03-VALP-0060.0033 in the	The Remote ATCO is able to detect potential conflicts, hazardous situations and other scripted events that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in	In general, ATCOs were experiencing high Situational Awareness. There was a statistically significant difference between Basic and Advanced System for Situational Awareness. **SASHA Basic System average**: 4.72 (out of 6) **SASHA Advanced System Average**: 5.21 (out of 6) Overall, ATCOs reported a good level of trust in the concept, and

	nature of the viewpoint for Situational Awareness: The current objective looks at the Human Performance aspect rather than user experience.	other areas.	in particular when using the Advanced System. For the Basic System, ATCOs felt that they could understand the system but were less trusting of the reliability and robustness of the system and this had a negative impact on ATCOs' confidence when working with the system, with only 35% of participants saying that they often, or very often felt confident using the system. For the Advanced System the results are much more positive. 100% of the ATCOs gave a positive response to the ability to understand the system and also to finding the system useful (Often to Always). **Trust - Basic System**: reliable 8/14 'often' or higher **Trust - Advanced System**: reliable 13/14 'often' or higher
OBJ-06.09.03-VALP-0060.0033	Assess, from a safety viewpoint, the impact of the ATCO Situations Awareness on: • detecting hazardous situations on the area of control • inducing more or additional hazardous situations This objective differs from objective OBJ-06.09.03-VALP-0060.0051 mentioned in the nature of the viewpoint for Situational Awareness: The current objective looks at a safety aspect rather than user experience.	The ATCO situational awareness is not decreased or has no negative impact on: • the ability to detect hazardous situations in the area of control • inducing more or additional hazardous situations	**Results from the workshop are detailed in** Error! Reference source not found.. Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having excellent PTZ functionality and a 360^{o} degree visual representation were included in ATCO feedback. PTZ functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars. The provision of a 360^{o} visual representation may be required to enable the ATCO to maintain a continuous visual view of aircraft, and would be dependent on the traffic patterns at individual aerodromes.
OBJ-06.09.03-VALP-0060.0012	To gather ATCO opinion on the level of service that can be supplied under a range of technical system options.	The requirement for the various technical enablers with respect to service levels provided is known for the scenarios experienced during the trial.	ATCOs feel that they can handle an increased traffic load in the Advanced System compared to Basic (thanks to the additional functionalities). When asked if Remote provision of ATS would increase the aerodrome capacity for GA traffic using the **Basic System**: o 11 out of 14 disagreed that it would increase capacity for GA; o 13 ATCOs disagreed with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (1 ATCO indecisive).

			When asked if Remote provision of ATS would increase the aerodrome capacity for GA traffic using the **Advanced System**: o 3 ATCOs agreed on the statement that capacity may be increased for GA traffic (6 disagree) o 3 ATCOs agreed with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (6 disagree). Most ATCOs only narrowly rated a local tower as being best for providing a service with Advanced system very close behind. For scenarios with only one aircraft the Advanced system rated higher compared to a local tower. The Basic system rated lowest when there was more than one simultaneous aircraft or vehicle movement. However ATCOs still felt they would be able to provide a service but it would place more demand on mental workload.
OBJ-06.09.03-VALP-0060.0074	Obtain feedback relating to the remote provision on ATS on ATCO roles, responsibilities & task allocation	Trial feedback indicates that ATCO find the roles, responsibilities & task allocation acceptable.	Feedback from the trial indicated no major issues related to roles, responsibilities & task allocation. Some less critical feedback was obtained, mainly centred on issues such as direct MetObs collection, local influence and technical troubleshooting.
OBJ-06.09.03-VALP-0060.0091	To assess the perceived capacity of the Remote Tower prototypes, relative to a local tower operation in terms of: • Time of day (daytime/CAVOK, night-time) • Functionality of the prototype (Basic System, Advanced System)	The ATCO are able to provide feedback on what they perceive to be the relative capacity under various operating scenarios. The ATCO perceive that the remote provision of ATS does not have a significant impact on capacity.	ATCOs responded that they did not feel capacity would be *increased* when providing ATS remotely. However, an increase in capacity is not the aim; more that capacity is not negatively impacted. ATCOs felt that when using the Basic System, they would be able to conformably provide service to 1 movement at a time. Introducing a second or even third aircraft would be possible under some scenarios, but it would require much more mental workload and potentially degradation of quality of service to airspace users. They therefore perceive this system to have a lower capacity than a local tower. ATCOs felt that when using the Advanced System they would be able to comfortable provide service to the same number of aircraft as they would in a local tower. It was only for once specific scenario where ATCOs felt that capacity would be reduced (two aircraft closely following behind during darkness). This is countered by feedback from some scenarios suggesting slightly higher capacity when using the Advanced system along with its advanced functionalities but this was not statistically significant.

			The ATCOs therefore perceive the Advanced system to be at least as good as the local system in both day time and night time hours.
OBJ-06.09.03-VALP-0060.0022	Support the development of working methods & procedures for **normal situations** related to Visual Separation application, use of IR camera, and weather observations	The working methods & procedures for normal situations related to Visual Separation application, use of IR camera, and weather observations have been reviewed. The working methods & procedures for normal situations related to Visual Separation application are accepted or, where not, suitable suggestions for improvement have been identified.	ATCOs did not feel comfortable with applying visual separation in the Basic System. Thus, when using the Basic System vertical and procedural separations are to be remotely applied based on OTW displays, but reduced separation could not be applied. ATCOs felt more comfortable with the Advanced System but were still not comfortable with reduced separation. When asked, ATCOs reported the opinion that the main ground tasks that IR camera could support are: • identification of aircraft and vehicles on the ground; • detection and resolution of conflicts in the manoeuvring area; • runway related operations. The ATCOs commented that improvement is still needed in order to remotely perform the following weather related tasks: • Assessing weather conditions; • Assessing runway conditions
OBJ-06.09.03-VALP-0060.0032	Support the development of working methods & procedures for **abnormal situations** potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft)	The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) have been reviewed. The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) are accepted or, where not, suitable suggestions for improvement have been identified.	**Results from the workshop are detailed in** Error! Reference source not found**..** Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having excellent PTZ functionality and a 360^{o} degree OTW view were included in ATCO feedback. PTZ functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars. The provision of a 360^{o} degree OTW view was to enable the ATCO to maintain a continuous visual view of aircraft, and would be dependent on the traffic patterns at individual aerodromes.
OBJ-06.09.03-VALP-0060.0042	Support the development of working methods & procedures in **degraded mode situations** related to the failure of the visualisation system (black-out, frozen, corrupted information)	The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information) have been reviewed. The working methods & procedures for degraded mode situations related	Some degraded mode scenarios were simulated in the trial on an opportunistic basis, mainly related to screen failure or out of date MET information. The main proposed procedure was to revert to One Movement Mode in case of loss of visual reproduction. This mode is a replication of the commonly used Low visibility procedures (LVP)

		to the failure of the visualisation system (black-out, frozen, corrupted information) are accepted or, where not, suitable suggestions for improvement have been identified.	with regards to the ATCO tasks. Other feedback included: • All ATCOs said there was a need to inform flight crews that the control is remote and that the ATCO has lost visual contact. • The ATCOs would like to see a system that always is able to generate alerts when there is a malfunction of any kind. And a back-up system should always be available at a “click of a button”; • A procedure for hand-over between ATCOs is needed.

Table 18: Validation Objectives Analysis Results Summary

6.2.3.1.1 Visual Reproduction

6.2.3.1.1.1 Resolution

The 360° view from Ängelholm Tower was captured by nine 50" LCD monitors each showing 40°. These encompassed the CWP in a (detached) circle; having 6 screens at the front and 3 screens at the back. 6 of the 9 cameras had a higher resolution (30 frames per second) to cover the "most important areas" of Ängelholm aerodrome, which covered the approach and runway/ taxi area. These screens were placed in the front of the ATCO. The three cameras behind the ATCO were 20 frames per second.

ATCOs were asked to give their opinion on the visual reproduction, and also for the separate visual tools namely the PTZ camera, the IR camera, the tracking label overlays, and the Additional Camera Viewpoints. The results are shown in Figure 26 below overleaf.

Compared to VP-056 the frame rate was increased enhancing the overall picture and screen quality and ATCOs indicated being most happy about the contrast between areas (ground and sky). The ATCOs were satisfied with the majority of technical aspects relating to the visual reproduction provided, including: contrasts, the screens, the screen distance, the resolution, the viewing angle, the screen layout, the general view, the screen size, the picture quality, and the camera positions. The acceptability of these aspects (i.e. ATCOs either agreed or strongly agreed with a statement) was good: Between 64% and 93% of the ATCOs agreed with their acceptability as shown in Figure 26.

However, ATCOs were less satisfied with the more operational aspects of the visual reproduction, including the ability to assess distance and depth: 50% and 64% of the ATCOs respectively either disagreed or strongly disagreed to be able to judge distance acceptably, wither fewer than 15% feeling they were able to judge depth. They commented that the image quality was sufficient but could still be improved: 50% of the ATCOs thought the resolution was sufficient for airborne movements.

Opinion was divided on the ability to assess aircraft separation in the air using just the visual reproduction (i.e. no advanced visual features or radar). The majority of the ATCOs (8 out of 14) felt able to assess separation, but 4 out of 14 disagreed or strongly disagreed that they were able.

ATCOs were unsure about the ability to assess weather and MET conditions using the visual reproduction Only some (36%) of the ATCOs say that they could assess MET conditions with the rest undecided or feeling that they could not assess MET conditions.

The picture quality during night time was in general less well received however no live darkness scenarios were encountered (only recorded) so many ATCOs simply felt unable to comment. When the ATCOs were asked to comment on the visual reproduction, they said the following:

- **Picture quality related comments**:
  - "*The frames on the front screens were sufficient. The way to sense the depth was by the size of the object: I was able to see the clouds but it was hard to see the ones at 700ft were FEW or SCT and it's also hard to see the second layer and how much it covered*."
  - "*Deep sight and judging distance is not a visual skill, rather experience, check science*"
  - "*Image quality could be improved: I think the objects are not sharp during daylight, especially on the screens covering the manoeuvring area*."
  - "*Eyes are strained because of unharness*"
  - "*3D presented as 2D makes it difficult to judge depth*"
- **Position related comments**:
  - "*I would like to be able to see a little bit more 'up'* "
  - "*I found the position of the cameras a little bit displaced (far) from the thr32, txy F, and apron E.*"
  - "*Maybe there could be more distance between operator and screens, 0.5 m.?*"
  - "*The camera house needs to be moved to a position closer to the manoeuvring area, to facilitate ATC*"
  - "*Try portrait mode*"

Overall, ATCOs found the picture quality acceptable but also that it could still be improved. In addition, several suggestions were made by the ATCOs: One ATCO suggested putting a windsock to increase wind awareness and it being clearly visible on one of the additional cameras. ATCOs also thought that the apron area was visually not represented well in terms of where the cameras were positioned. Although note has been taken of the less-than-perfect placed positions of the additional cameras, there have been some difficulties to capture the entire area because of public privacy regulations.

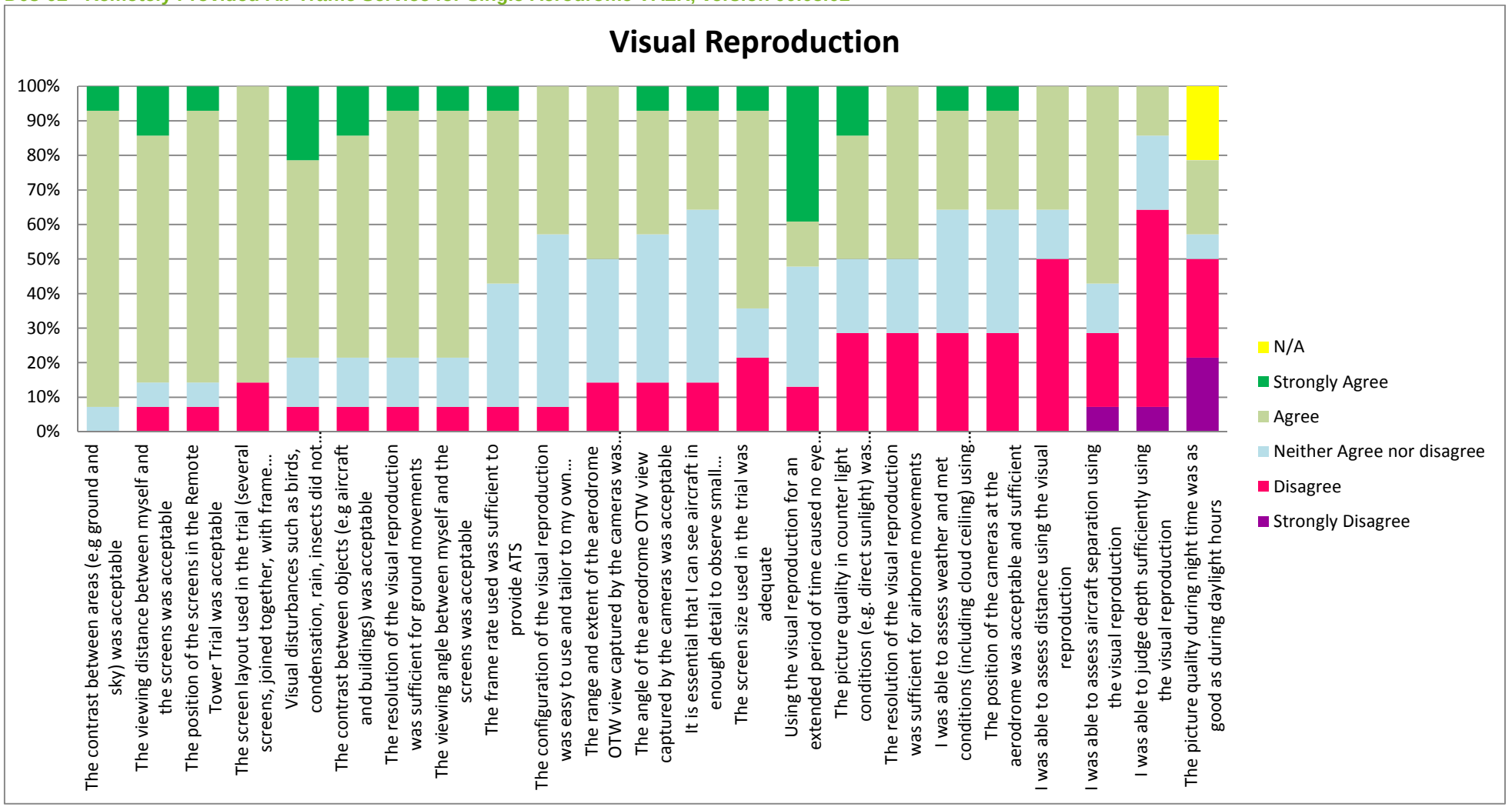


Figure 26 - ATCO Response regarding Visual Reproduction

6.2.3.1.1.2 IR Camera

The inclusion of the IR camera was suggested by ATCOs who gave feedback following the ART project [10] and was first introduced to this project in VP-056. It was also included for validation in VP-057 as well. The idea behind the IR camera is that it could be particularly useful during darkness however the IR camera appeared to be not working some of the time, and some ATCOs were unable to experience it in all scenarios such as fog and night time. Some ATCOs therefore felt unable to comment on usefulness of the IR camera during darkness and/or decreased visibility. Moreover, some ATCOs experienced dead pixels in the IR camera that are being dragged around continuously. The results for the IR camera therefore need to be taken in this context.

As shown in Figure 27 below, the general ATCOs' opinion on the IR camera was positive and an addition to the overall system, although the usability of it could be improved. Over 80% of the ATCOs felt that the IR camera would increase their situational awareness, and over 60% of the ATCOs found the IR camera to be useful for searching and detecting aircraft and vehicles. Over 40% found the use intuitive, but 30% said the IR might increase their workload.

In addition, the ATCOs commented the following:

- "*A bit unfocused and hard to use but otherwise a good complement*"
- "*The produced image is good*"
- "*It has to be better tested and preferably with zoom function*"

The results suggest that ATCOs can appreciate the concept of the IR camera, but also that the operability of it could be improved.

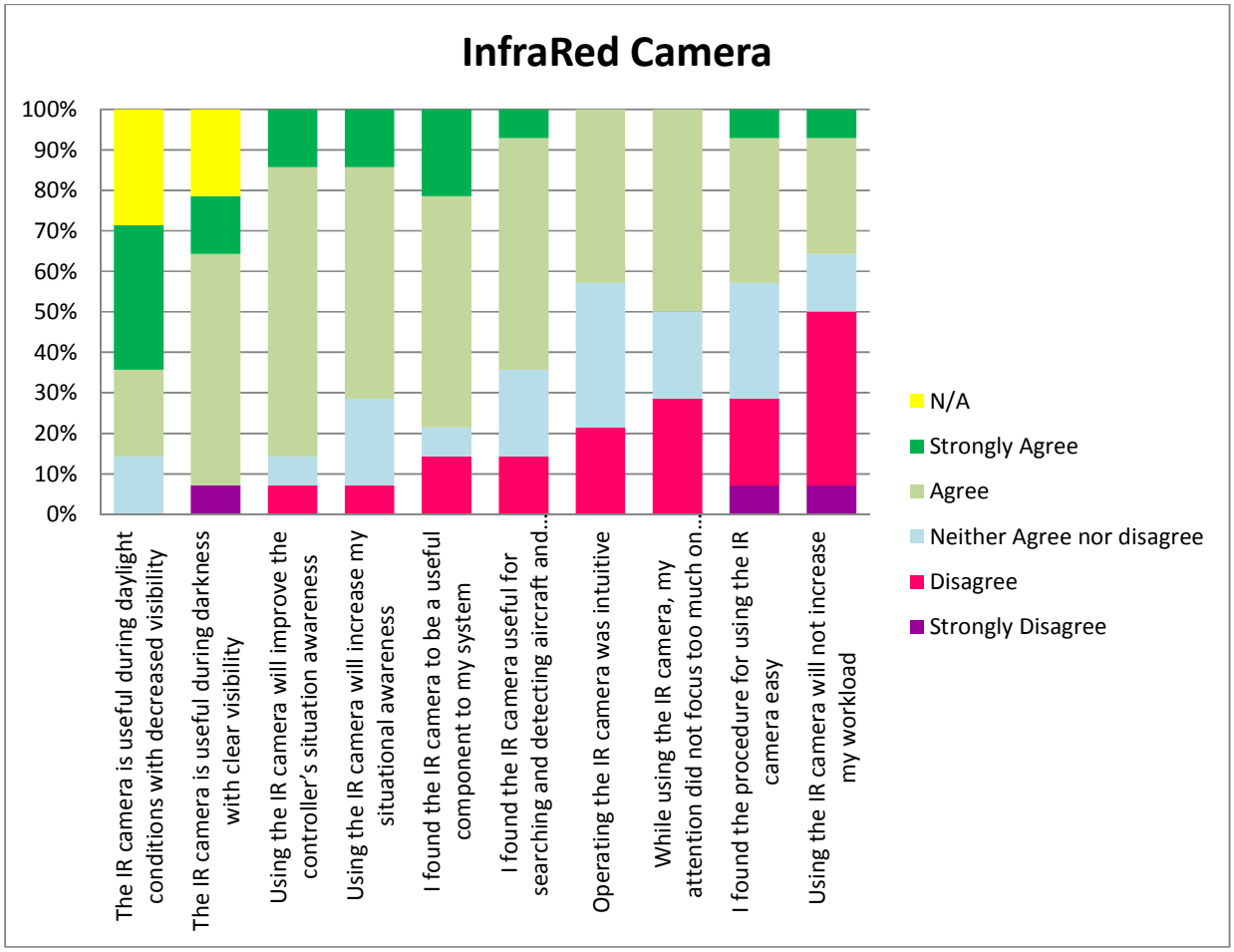


Figure 27 - ATCO Response regarding IR Camera

6.2.3.1.1.3 PTZ Camera

In VP-056 ATCOs responded positively to the PTZ camera as it provided sufficient picture quality in relation to the picture quality of the screens. Also, in VP-056 the PTZ was controlled by a mouse and some of the ATCO suggestions have been implemented in this trial, such as including a pre-set area that the PTZ scans automatically.

In VP-057, even though the quality of the picture has increased for the main display screens, the ATCOs were left with a PTZ camera that did not meet their expectations in various ways.

For this trial the PTZ camera was operated by using a pen on Wacom-screens on the IDP. On the RDP were 6 small displays screens over which the ATCO could manoeuvre the pen to zoom in that area. Near the thumb point on the pen were 2 buttons; one for zoom-in, the other to zoom out.

In general, ATCOs appreciated the concept of the PTZ and the (potential) benefit of it. The ATCOs stated that it is a "*useful*" or "*great*" tool that complements the system. Also, the pre-set positions were also viewed as a beneficial feature of the camera. However, out of all the additional tools and the overall system, the PTZ had the most negative feedback from the ATCOs, mostly due to its manoeuvrability. Results show that 12 out of 14 ATCOs did not find the procedure for using the PTZ easy (only 1 agreed on finding it easy, 1 ATCO was indecisive), 13 out of the 14 ATCOs found that using the PTZ might increase their workload (1 ATCO was indecisive). Furthermore, only 1 ATCO agreed that the PTZ to be a useful component to the system, and 9 did not agree that using the PTZ was intuitive. When it comes to improving situational awareness 8 out 14 ATCOs did not agree that the PTZ could improve that, while only 3 agreed and the remaining 3 did not agree or disagree.

As shown in Figure 28 overleaf, the ATCOs' opinion on the PTZ camera tends to be overwhelming negative in responses. The reason for this is explained by ATCO comments as categorized below:

- **Picture Quality**:
  - "*The resolution compared to the OTW was unacceptable*"
  - "*Bad image, difficult to find object and follow it*"
  - "*Blurry image*" and "*The image quality was awful (fizzy)*"
  - "*Slow in focussing on objects*"
- **HMI**:
  - "*The PTZ was extremely hard to operate, to hold in place, and to get focus*"
  - "*User-unfriendly*" and "*Total disaster*"
  - "*Over-sensitive*"
  - "*PTZ is too nervous/touchy, it must be more firm, and sharp*"
  - "*PTZ felt very unsharp, not trimmed as it should be*"
  - "*It's difficult to follow objects*"
- **Technical Issues**:
  - "*The PTZ did not work most of the time and got stuck*"
  - "*PTZ image was frozen at many occasions and needed a restart*"
  - "*It happened too many times that the PTZ didn't work and needed a restart*"
  - "*PTZ unusable most of the time*"

The functionality of the PTZ is intended to replicate binoculars in local tower. However, some ATCOs commented that they were not able to use the tool in the same way, for example, to affirm whether the aircraft gear was down. Some ATCOs suggested that their proficiency in using the PTZ HMI could improve after a while of practice, although a prolonged exposure for all ATCOs was not possible in the limited time available in the simulation.

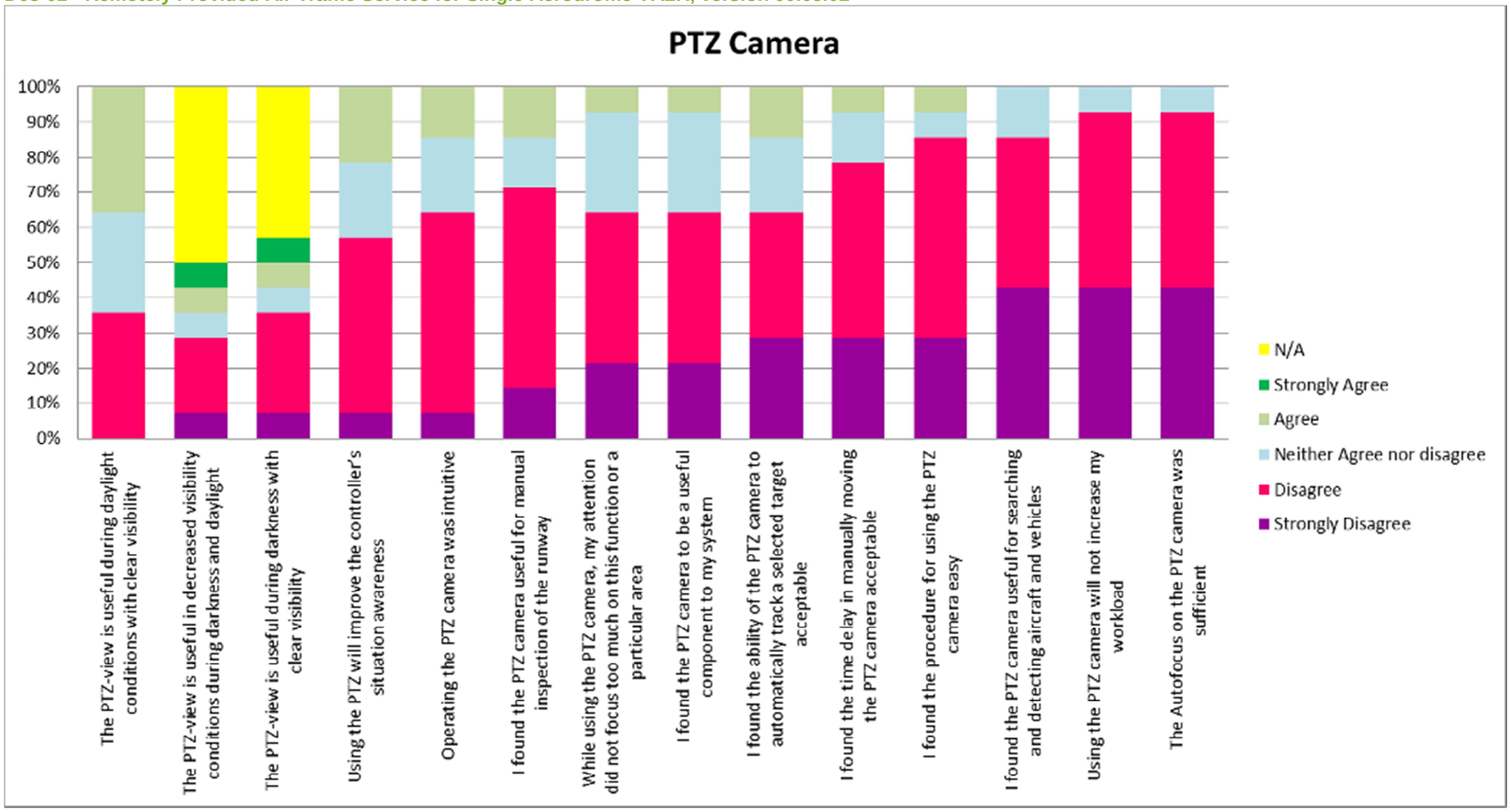


Figure 28 - ATCO Response regarding PTZ Camera

6.2.3.1.1.4 Additional Camera Viewpoints

A new tool for this trial was the Additional Camera Viewpoints (ACV). There were 5 fixed cameras placed at various points nearby the apron, taxiway and runway. To view the image from these cameras, the ATCO had to tap the desired ACV camera on the Interactive Display Panel (IDP) and the image would appear on one of the main display screens (Picture in Picture). These cameras were fixed and not manoeuvrable, but were able to show an image from the particular aerodrome area in one click.

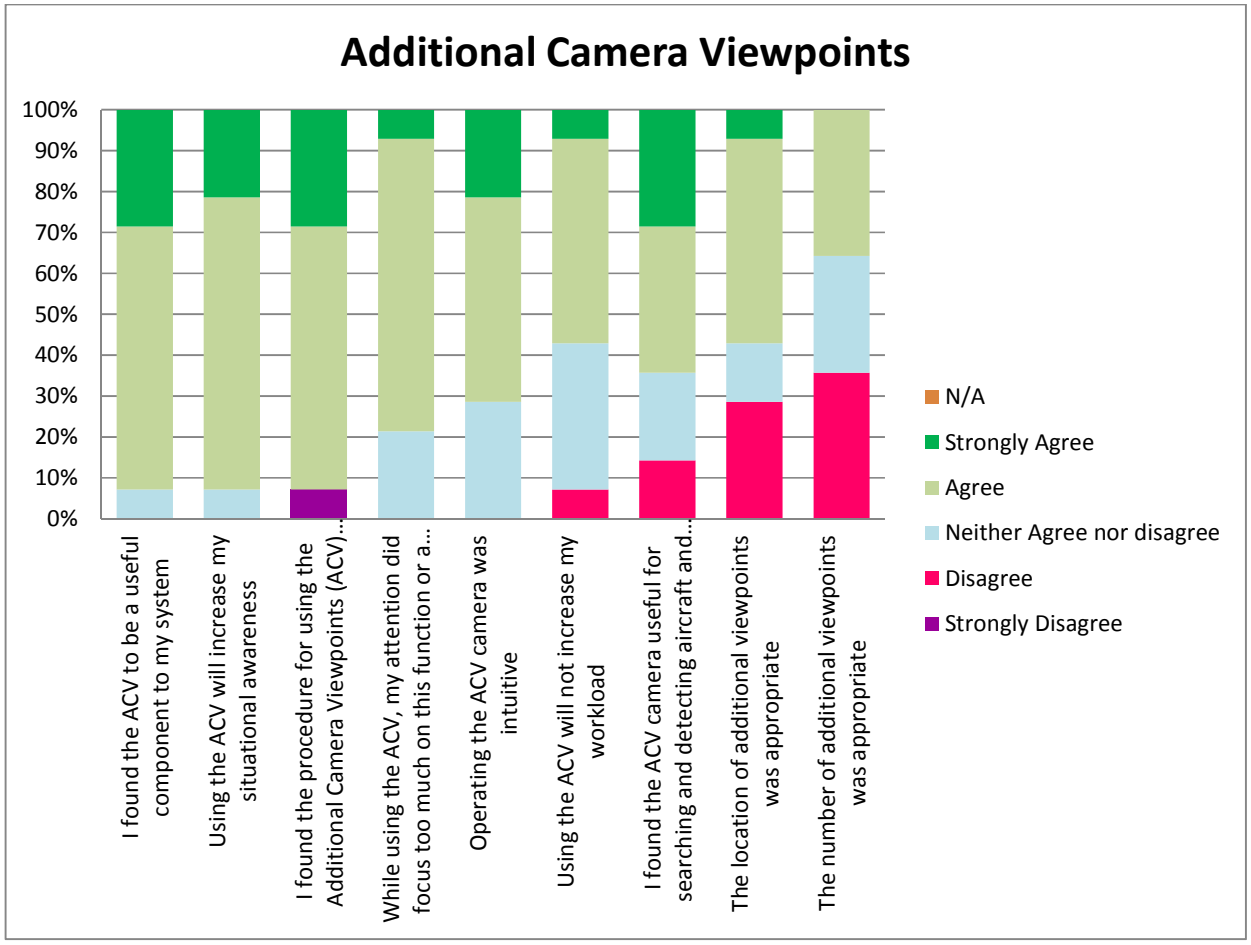


Figure 29 - ATCO Response regarding Additional Camera Viewpoints

Prior to the trial, it was not expected that the Additional Camera Viewpoints would be used as much as they were. The idea was that they would be used as selectable views that were turned on and off on demand. Alternatively it was hypothesised that they might be used more during low visibility. In fact, people seemed to be using them all the time. Over 90% of the ATCOs were positive about the usefulness of the additional cameras, and agreed they would increase Situational Awareness, and over 70% found their use intuitive. Over 30% of the ATCOs found the amount of cameras could be increased and placed elsewhere. Figure 29 shows a tendency for positive response to ACV among ATCOs. In addition, ATCOs appreciated the ACV concept and its possibilities in limited visibility.

Other feedback for this tool included:

- **Position related comments**:
  - "*Apron area could be covered more as it is not visible enough via OTW*"
  - "*More cameras*"
  - "*Very good, but the position could be even better; such as runway entry points and apron*"
  - "*I missed two more cameras: headed towards final/approach of both runways*"

  - "*There are better location to be found for ACV*"
- **Picture Quality related comments**:
  - "*The main problem at present is the general image quality*"

Some ATCOs commented that they would prefer to be able to manoeuvre the ACV cameras, such as a tilt or zoom function. Also, the ATCOs commented that the images of the camera could be placed better on the LCD screens.

One ATCO suggested that the number of ACV should be tailored to the airport and its runway size.

One difficulty that was faced when looking for suitable spots to place these cameras, apart from the previously mentioned public privacy regulations, was that one of the 5 cameras was placed facing the opposite direction; This resulted in the situation whereby, when an aircraft passed this particular camera it appeared to show the aircraft going in the opposite direction (from right to left instead of from left to right on the screen). ATCOs commented that this relatively contradicting camera viewpoint was not of a major concern to them.

6.2.3.1.1.5 Tracking Label Overlays

The tracking finds both visual moving objects as well as radar objects and can display them in the main displays by putting boxes with relevant information around them. Visual observed tracks have a square box around them. Radar tracks have an octagon shaped box and fused tracks (confirmed by both visual observation as well as radar) has the octagon inside of a square.

Radar tracks also have a label containing information regarding SSR-code, distance from the tower and FL. The tracking is filtered to disregard certain radar tracks and moving objects e.g. To only show radar tracks within 70 km from the tower.

Figure 30 overleaf suggests that ATCOs were very positive about this particular function. On average, 80% of the ATCOs were satisfied with the tool, including easy use of the tool (93% of the ATCOs agreed) and usefulness of the component (86% of the ATCOs agreed).

Some difficulties with the tracking label overlays included the tracking of birds, some road traffic such as cars and trucks, and other moving objects. ATCOs thought that this could distract them, because it is mistaken for being airborne traffic at a first glance.

ATCOs were least satisfied with how intuitive the tracking label overlays were to use however it should be noted that only a small minority of participants reported negative feedback.

ATCOs' comments included:

- "*This is what I liked most, and it made me feel more confident when running the RT*"
- "*I found the tracking system a very good complement to the OTW, you easily discover ground traffic and there is no need to scan*"
- "*HMI ok*" and "*A good tool*"

Several valuable suggestions were made on how the tracking could be improved:

- "*Radar label should include the type of aircraft instead of ADEP/ADES*"
- "*Speed of aircraft should be available in the label*"
- "*The possibility to choose the label size*"
- "*The distance for radar labels should be shorter, approximately 15 NM*."

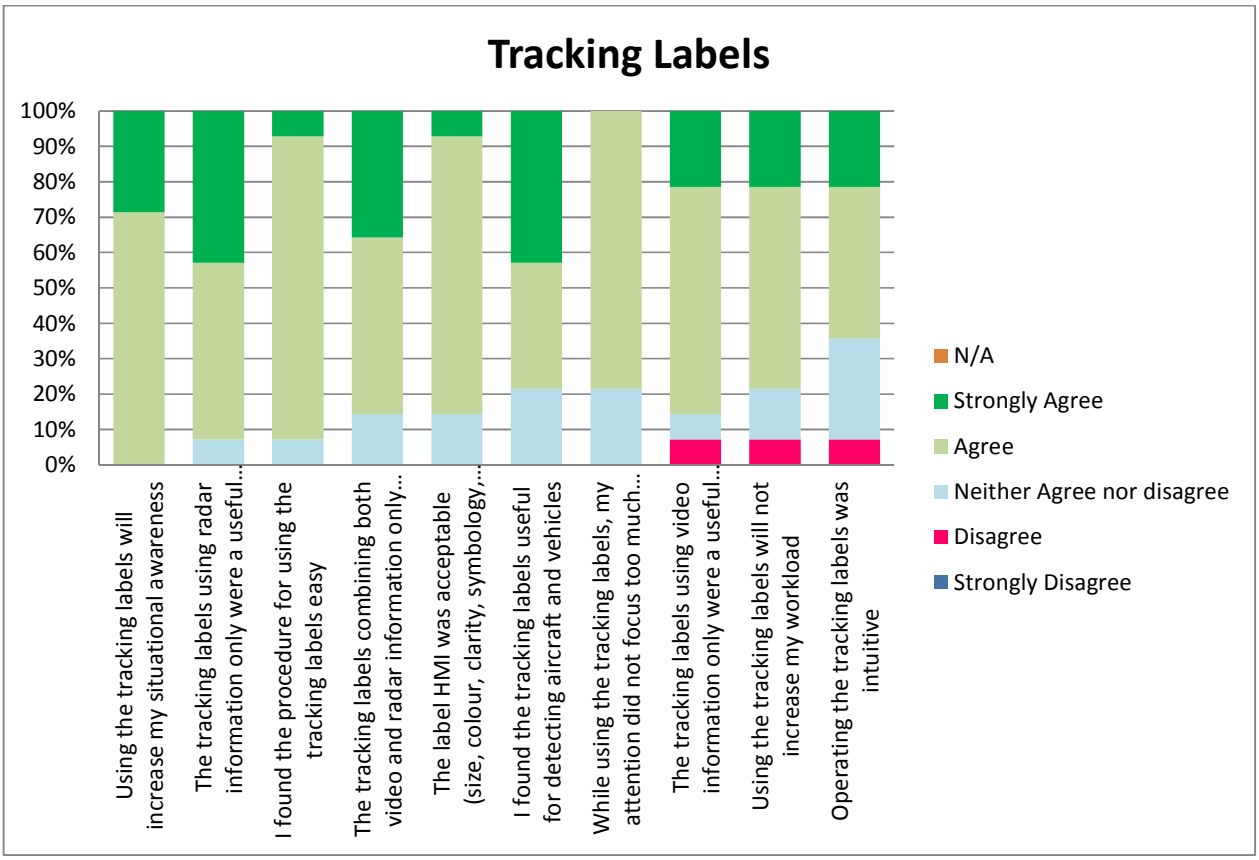


Figure 30 - ATCO Response regarding Tracking Label Overlays

6.2.3.1.2 Work Environment

6.2.3.1.2.1 Overall Work Environment/CWP

In general the ATCO found the work environment acceptable in the current state. Figure 31 shows the quantified opinion ATCOs have about the CWP. As visible in the graph, ATCOs were most satisfied about the range of systems and functions availability and the e-Strip system being an appropriate system for preparing and updating flight plan info. Similar to VP-056, ATCOs were slightly more satisfied about the CWP with 71% of the ATCOs agreeing to an acceptable CWP layout, and 64% of the ATCOs agreed on all information being available to perform their services. Furthermore, 9 out of 14 ATCOs agreed the CWP was a pleasant environment to work in, while 3 ATCOs disagreed and 2 ATCOs were indecisive. For those ATCOs who disagreed, it might be that area space in the CWP was problematic, as ATCOs commented: "*Too small work area in the CWP (desk*)" and "*Area for mouse and keyboard was missing*". Noise might have also been a source of unpleasantness, ATCOs said: "*Too high noise level in the room, noise from air condition is distracting and tiresome*". Section 6.2.3.1.2.2 explains ATCOs' thoughts on ambient noise in more detail.

Only 5 out of 14 ATCOs felt that they had access to all the required MET information, with the same number (5 from 14) either disagreeing or strongly disagreeing. Some of the negative feedback may be related to the way in which the MET information was presented to the ATCOs during the trial. The MET information was not automatically updated directly at the CWP. Instead, the trial validation leader had to manually enter the data in a separate workstation and it would then be populated through to the remote CWP. With the demands of running the trial, this was not always performed in a timely fashion and sometimes the MET information presented to the ATCO was not accurate.

ATCO comments back up this explanation and a more realistic method for including MET information in future trials should be considered:

- "*During the trial the MET report wasn't working correctly; and since you are reading the MET report to all aircraft, I think I should have a screen with that info all the time without having to swap between the arrival/departure list and MET info.*"
- "*MET reports should be in the same form as usual*"
- "*MET information was missing*"

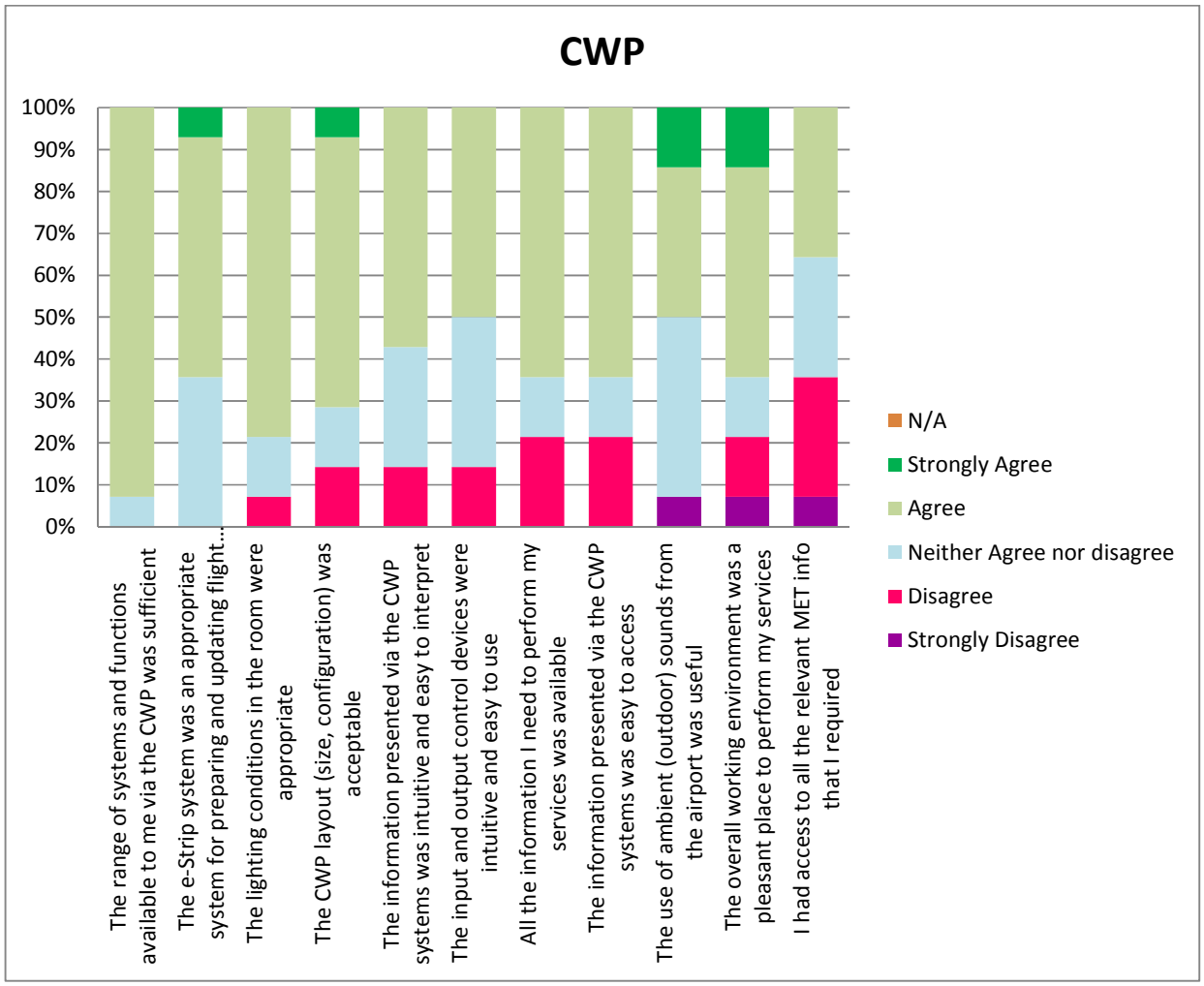


Figure 31 - ATCO Response to CWP

6.2.3.1.2.2 Ambient Sound

The usefulness of ambient (outdoor) noise reproduction divided opinion amongst the ATCOs. As shown in Figure 31, one ATCO strongly disagreed that it was useful with 7 ATCOs agreeing (some strongly) that it was useful. However, almost as many ATCOs could not decide with 6 neither agreeing nor disagreeing that it was useful.

Some ATCOs said the ambient sound was a useful addition to them to be able to perform their job and as an auditory cue to check on the aircraft. One ATCO says: *"The sound was helpful with some type of traffic, but was very helpful with over flights, traffic on the manoeuvring area*." However, one ATCO admits that they mistook a revving motorbike near the tower for an ATR revving its engine. In addition, there were some technical difficulties with the sound as it was not working at all times. Therefore not all ATCOs felt able to give their opinion on this component. It is therefore not possible to conclude if the aural reproduction is an essential component or not in the remote tower system.

One factor which may have impacted the ATCOs' opinion on noise reproduction was the general noise in the prototype remote facility. Several ATCOs commented that the noise in the facility from equipment and trial participants was too much. Comments included:

- "*The working environment was alright except all the noise from the computers farthest in the room*"
- "*Noise from ventilation was too loud and tiring*"
- "*Too high noise level in the room, noise from air conditioning is distracting and tiresome*"
- "*For the working environment, I would prefer a calm, sterile place. In the trial there were loud conversations and distractions in the cab*"
- "*The ventilation in the room was very noisy*"

Some of this noise was due to the large fans required to keep the room cool. It was known prior to the trial (partly from experiences in VP-056, partly from testing activities) that the temperature in the room could get quite high. Installing the air conditioning system in the test facility was on-going as part of some building works throughout the building (over the course of the whole year) and so some large fans were installed.

6.2.3.1.2.3 Remote Facility Location and Social Considerations

In VP-056 it has already been mentioned that the loss of social relationships with local airport staff were a concern for the ATCOs. VP-057 did not include specific questions about the social side since it was not an objective. However, similar to the VP-056 concerns, there was some concern amongst the participants regarding the possible loss of personal relationships with airport staff.

One ATCO stated "*Every day at work, I meet all the sections of the airport on my way in and out. I talk to the traffic office, security, ramp, operations, field duty officers and rescue services. Sometimes I even meet and talk to flight crews. I can't imagine how much I would have lost by not getting this extra "feeling" and information*."

Other feedback on social considerations was not collected.

6.2.3.1.3 Situational Awareness

6.2.3.1.3.1 SASHA Results

The SASHA test results, in addition to the End of Trial Questionnaire, were the sources of the quantitative data regarding situational awareness that was used for analysis. SASHA tests were completed four times by each ATCO during their 2 shifts – once after a session using the Basic system, then again after each session using the Advanced System. The scores were, where appropriate, inverted in lined with the EUROCONTROL SASHA instructions. The mean score of each question was then calculated for each session run and the higher the result, the more positive/better the situational awareness.

The results of the two ATCOs from Day 1 and Day 2 of the trial could not be used, because the schedule for the first two days varied in terms of basic and advanced system compared to the remaining days and could therefore not be used in direct comparison.

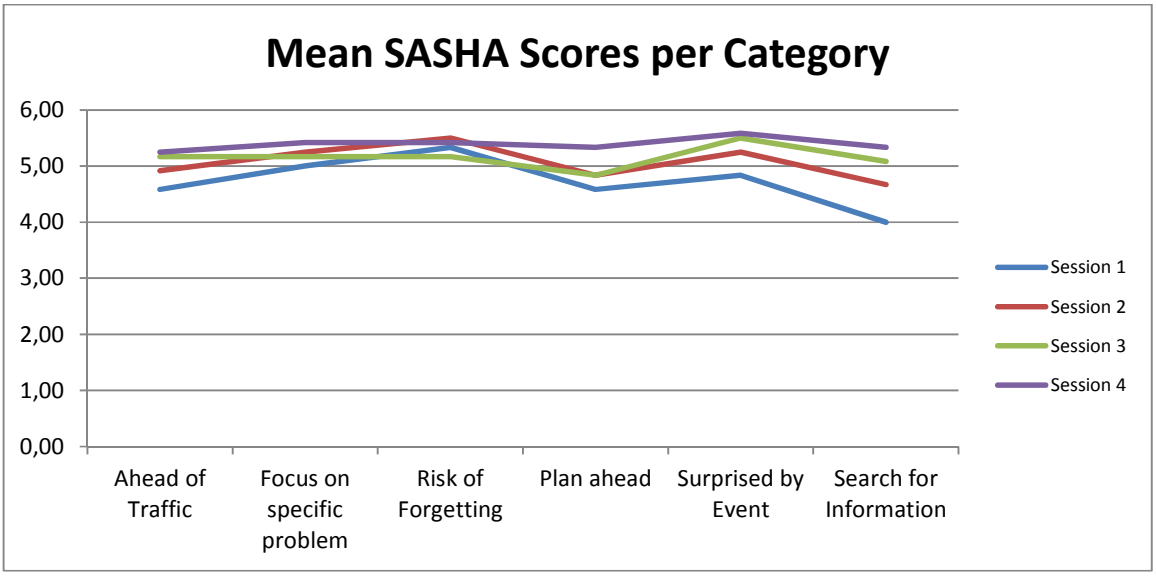


Figure 32 - Mean SASHA Scores per Category (by Session)

The results in Figure 32 show that there were differences in situational awareness throughout the four sessions, with the first session (basic system) being lowest on 5 of the 6 categories. Only one Advanced System result (Session 3, Risk of Forgetting) resulted in a lower score than the basic system.

Figure 33 shows that when taking an average of Session 2, 3 and 4 to represent all Advanced System sessions the Advanced System always returns higher situational awareness scores. The ATCOs scored Situational Awareness to be lower for the Basic system compared to the Advanced System on all six categories.

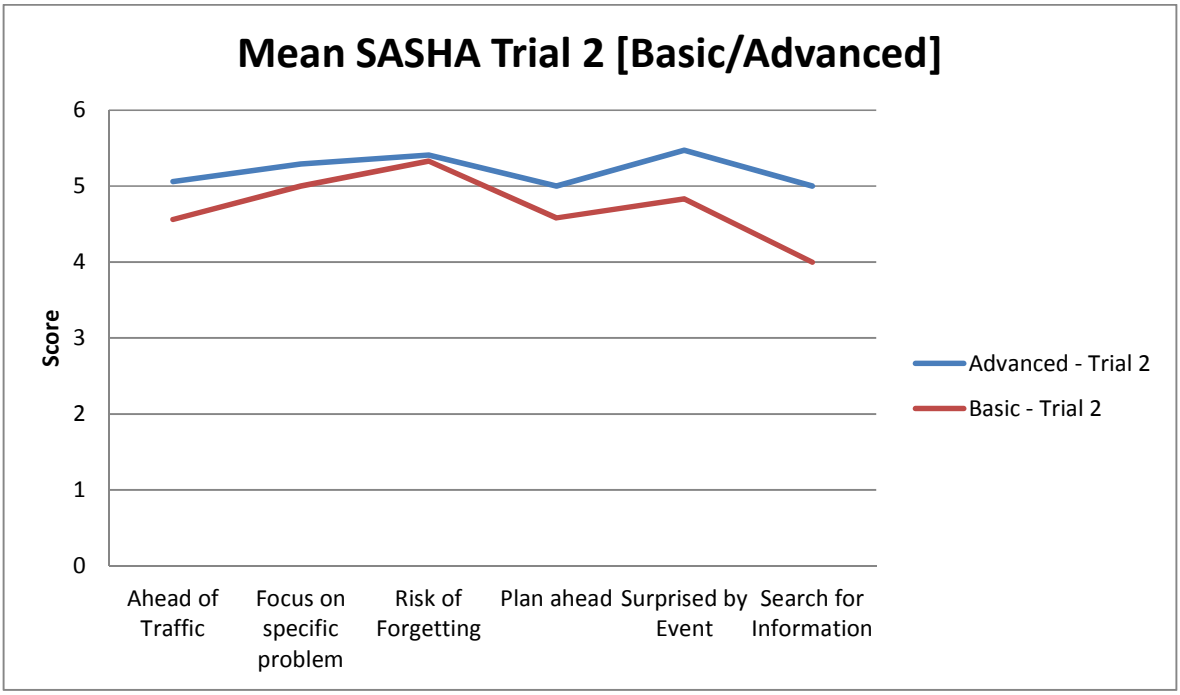


Figure 33 - Overall Mean SASHA Results per Category

Testing for statistical significance between the two systems, the results show that there was a statistically significant difference between the situational awareness results for the Basic and the

Advanced System. In other words, this difference is attributed to the different system rather than to chance.

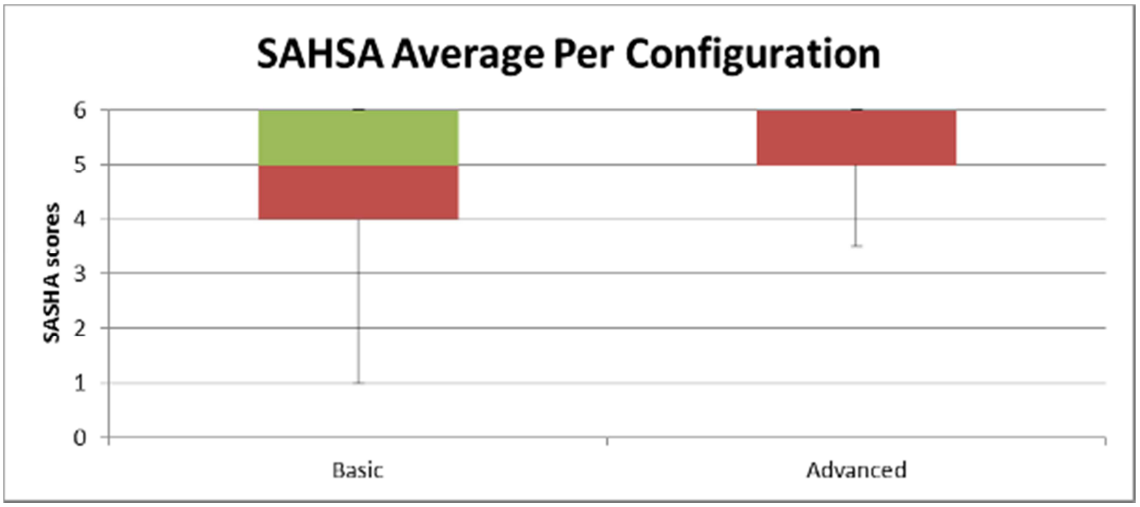


Figure 34 - Distribution of SASHA Scores per System

	basic	advanced
High	6	6
Quartile 3	6	6
Median	5	6
Mean	5	5
Quartile 1	4	5
Low	1	3.5
Range	5	2.5

Table 19: Descriptive Statistics for SASHA scores (Advanced vs. Basic)

A shown in Figure 34 and Table 19 the distribution of SASHA scores for the Advanced System is different to the distribution for Basic system. With the Advanced system, the median[1] score is 6 – the highest possible score. The lower quartile (represented by the red area in the graph) is between 5 and 6, with the lowest value calculated to be 3.5. With the Basic system, the median is still good (5) but the spread is much greater with some values being higher (6) and the range going as low as 1.

6.2.3.1.3.2 Ahead of traffic

Based on the SASHA test, ATCOs felt able to be generally ahead of the traffic. The results tend to increase slightly with each session, which tends to suggest that as the ATCOs got more accustomed to the CWP and tools, their situational awareness improved. They would also have become more familiar with the aerodrome layout helping them understand traffic patterns, approach paths etc.

6.2.3.1.3.3 Focus of single problem or specific area

ATCOs gave relatively high scores with regards focusing on a specific problem or specific area meaning they did not see a risk in this area. This result is quite surprising considering the comments ATCOs had about the PTZ camera, with regards to its operability. ATCOs mentioned several times that the PTZ was difficult to manoeuvre and therefore they spent a long time adjusting it to zoom the object they wanted to see, saying: *"The PTZ is useless."* Another ATCO commented "*It was difficult to manoeuvre the PTZ camera to the spot I wanted to see, was also blurred*" and "*It is bouncing in and out when zooming. It is difficult to follow a/c when taxiing, not to mention when airborne*". Those HMI struggles could have affected their focus and shifted it towards using the PTZ while they would be

[1] The midway score separating the first half of the data from the remaining half.

looking to zoom into an object. However, the results indicate that for both Basic and Advanced Systems the ATCOs were able to look beyond the trial specific technical issues and respond how they felt that the risk of focussing on a single problem was low.

6.2.3.1.3.4 Risk of forgetting something important

Scores relating to the "Risk of forgetting something important" were generally good, indicating that ATCOs did not perceive this to be a high risk.

6.2.3.1.3.5 Ability to plan and organise work

The ability to plan and organise work rating was relatively average for both systems. This might be due to various technical issues the ATCOs experienced with the e-Strip Bay. One ATCO mentioned that during his session "*The e-bay had no strips due to reset and then they could not be reloaded*" and "*lack of flight plans in the e-Strip Bay*". It will also be related to the nature of the trial – PSM where the ATCOs were not able to perform all functions they would if carrying out the tasks in a live environment. In VP-057 participants were asked to follow normal working methods as closely as possible, but often this could not be achieved due to not being in control. By contrast, in VP-056 participants were not asked to emulate normal working practices but mainly to observe and this is a contributing factor to the relatively high scores for this category in VP-056.

6.2.3.1.3.6 Surprised by an event

Although this category scored relative highest positive responses from the ATCOs in the Advanced system, this category had a significant difference between the Basic and Advanced system. An explanation might be that the Basic system did not provide any information that would enable an ATCO to anticipate in upcoming traffic such as radar, advanced camera viewpoints or tracking labels. The Advanced system, however, did provide these tools and naturally the ATCOs were more aware of what was happening and going to happen. For example, in Basic system, an ATCO might be looking out to identify an aircraft in the circuit for a while, and when the ATCO does identify it, he/she might be surprised to see that the aircraft is closer/nearer to the airfield, has a lower altitude, etc. The Advanced system is able to provide this information ahead.

ATCOs reflect on their session by saying:

- *"I was surprised when a/c taxi E,J,G, cross runway and M. This was not tracked until crossing the RWY*".
- Another one states "*I was surprised by a car on the runway. I forgot to look at it. This might be because I am not used to the environment*"
- *"I was surprised by not seeing a C172 outside D3 on final runway 14."*

Also on the ground ATCOs felt there was more potential for surprises, as one ATCO stated that they were surprised to see an a/c on the apron on one of the fixed cameras during heavy fog.

6.2.3.1.3.7 Search for information

In this category the ATCOs scored relatively lowest in the Basic system in the ability to search for information, compared to the Advanced System. This difference is marked by a whole scoring point. Because the Advanced system has the ability to provide the ATCOs with more information through the tracking labels and radar, the ATCOs can spend less effort and time looking for information. The differing results from the SASHA might reflect the availability of these tools in the Basic and Advanced system. In Advanced system, tracking labels provided the visual location of the aircraft on the main display screens and even if the ATCO looks away from the screens for a moment, the tracking labels would still keep track and the ATCO does not have to look for it. In Basic system the ATCOs do not have these functionalities nor do they have the advantages of radar, implying that they need more time to look up the information they need.

Furthermore, ATCOs experienced the Basic system in the first session, which was also their first encounter with the system. Naturally, familiarity with the system is not as good as it would be in the later trials. This could also reflect the difference between the four sessions in the SASHA results, and consequently the SASHA results for Basic and Advanced system.

ATCOs say:

- "*Windsock took 11 minutes to find!*"
- "*Radar tracking was turned off. Visual tracking was lost on base leg (P28A flying circuits). Lots of bird activity creating visual tracking targets similar to aircraft. That was a bit confusing and took time to identify the aircraft in the traffic circuit*."
- "*Two arriving IFR a/c. Having trouble of finding the FPLs and getting the strips. (searched for it, found it eventually)*"

6.2.3.1.3.8 Comparisons with VP-056

Figure 35 overleaf shows the results from Figure 33 but with the VP-056 results overlaid on the same graph. The VP-056 platform most closely resembled the Basic system from VP-057. Whilst it is acknowledged that VP-056 had different participants and a slightly different technical configuration (and thus different subjective responses), many factors across the trials were very similar and so a comparison of VP-056 scores with VP-057 scores can give an interesting, if not statistically robust, juxtaposition. These results are therefore only for indicative purposes.

It can be seen that in 4 out of 6 categories, the VP-057 Basic system scores higher than the most comparable system in VP-056. The improvements are most probably due to the increase in quality of visual reproduction between VP-056 and VP-057 and how progress against the core functions of the technical system. The two categories where VP-056 scored higher are the ability to stay ahead of traffic, and the ability to plan ahead. Whilst a definite answer cannot be determined due to the nature of the comparisons it may be that the way in which the trials were conducted had an impact. In VP-057 the ATCOs were more involved in maintaining their systems and working more as they would in a real tower. In VP-056 ATCOs were much more passive, meaning all they had to do was observe. This was noted in VP-056 and was used as a partial explanation in the variable SASHA scores. The VP-057 SASHA scores are more consistent across categories.

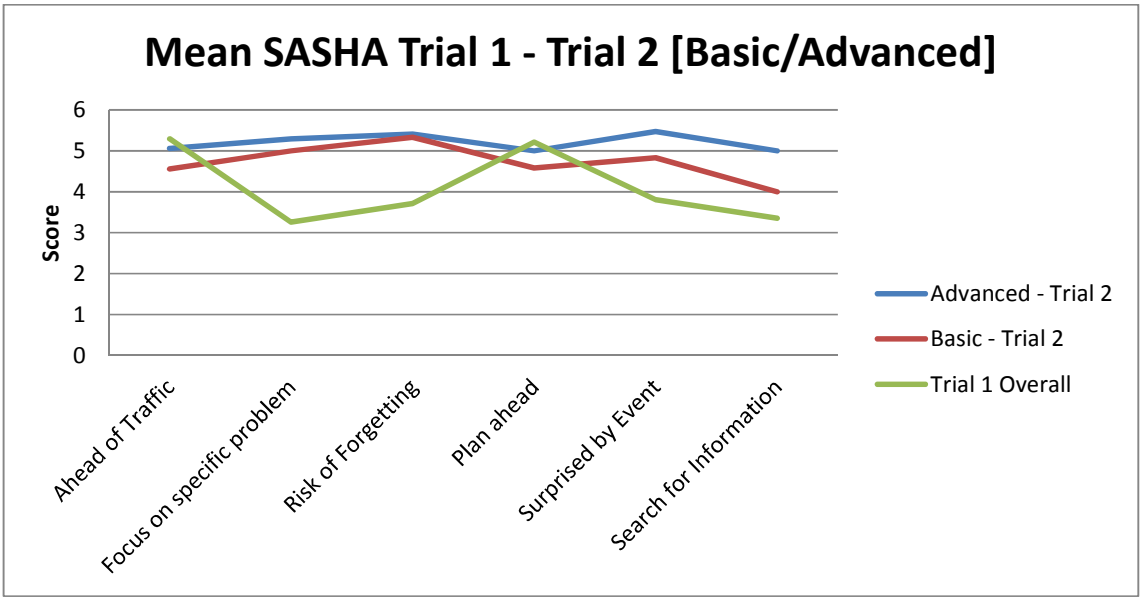


Figure 35 - Overall Mean SASHA Results per Category (including VP-056)

6.2.3.1.3.9 Summary of ATCO Feedback on Situational Awareness

ATCOs were questioned extensively on their perceived situational awareness during the trial in order to understand fully how they experienced it. ATCOs commented the following on their perceived Situational Awareness in the Remote Tower:

- "*Feels almost like in a real tower*"
- "*As good as ever!*"

- "*The SA is good*" and "*When it works it's good*"
- "*Your SA will be different from local tower, but it doesn't mean to a negative impact: just a new environment to work in, you will learn how to get and maintain SA*".
- "*It is workable and I feel confident when handling traffic not further from around 2 or 2,5 NM, hence it is good enough for the traffic circuits and manoeuvring area, but less reliable beyond that and under poorer weather conditions, and less reliable in Basic mode*"
- "*There is a vast difference between sitting in a 'basic' system compared to the 'advanced'. The feeling of a lack of situational awareness in the 'basic system' is very real*."
- "*What differs between basic and advanced is the safety buffer around each aircraft. In basic you cannot do much until you see the aircraft*."
- "*A little more difficult to identify movements in basic, to judge distance in both basic and advanced, even if there are good tools to detect movements in advanced*."
- "*Depth perception is impeded*"
- "*It is clearly uncomfortable if/when a screen goes suddenly regardless of the type of facility*"

When asked when situational awareness was best, ATCOs responded the following:

- **Tools/Features**:
  - "*When tracking was turned on*"
  - "*With advanced features applied*"
  - "*Radar tracking was helpful to get good SA*"
  - "*All tools available*" and "*When everything works OK, including PTZ*"

- **Weather**:
  - "*When the sky was pretty bright and high clouds*"
  - "*CAVOK*" and "*good MET conditions*"

- **Traffic**:
  - "*At occasions when I got movements that were already separated*"
  - "*Inbound TFC, TFC in pattern, on RWY, both cars and ACFT*"
  - "*When Eva [a local TWR ATCO] worked, because I heard all her instructions given to pilots*"
  - "*When there were relatively few movements*"

When asked to describe in what scenarios situational awareness was worst, ATCOs responded that it was worst in the Basic system (mentioned by 7 of the 12 ATCOs), followed by night-time (5 of the 12 ATCOs). Technical problems and weather conditions were both named once. One ATCO responded his situational awareness was worst in "*none*" of the scenarios. Other feedback included:

- "*When two VFR was close or in line with each other, I found it very difficult to judge distance and decide who will be number one and two*"
- "*More TFC at the same time, this due to not familiar with the CWP/e-Stripboard*"

Contributions enhancing ATCOs' perceived Situational Awareness were named as well, and ATCOs mentioned **Visual Tracking** most often (mentioned by 10 of the 12 ATCOs), followed by **Radar** (7 of 12 ATCOs), and **IR camera** (6 of 12 ATCOs).

ATCOs were also asked to identify main risk contributors from a technical point of view, and one ATCO sums up "*Now there are plenty of contributors between reality and my eyes. At a local tower there is nothing in between. Particularly I find it dangerous when the system is degraded that I am not aware of*." Other feedback includes loss of equipment, cameras, and screens, frozen screens, and the "*lack of a backup system*".

6.2.3.1.4 Perception

It is essential that the ATCOs feel sufficiently "in the loop" for providing ATS to the aerodrome site using the Remote Tower. The End of Trial questionnaire therefore sought ATCO feedback on this

issue. ATCOs answered two questions on this as described in Figure 36 below. The results show that 10 out of 14 ATCOs agreed that they would be sufficiently "in the loop" for providing ATS using the Remote tower system, although here it has not been specified whether it is in Basic or Advanced system.

Furthermore, 4 ATCOs agreed that the remote tower would **not** make their job seem less real, while 5 ATCOs disagreed, and another 5 ATCOs had no opinion. This is an interesting split in opinion among ATCOs and it might suggest that ATCOs might lose a sense of reality in their daily tasks, as one ATCO puts it: "*The young people today are far away from reality, behind the screens. There is a risk that the young would see it as a game*." Indeed, one ATCO did state that "*It may be that you view the concept more as a video game*".

In addition, although not explicitly mentioned by the ATCOs, the social considerations might have an influence on ATCOs' perception of their job seeming real: they would lose some of their social relationships in the Remote Tower, which gives a different dimension to their job.

Finally, as this trial was in Shadow Mode requiring little action and ATCOs were aware of that, these results might have been influenced by that passiveness. If the ATCOs would be more engaged in providing ATS in Remote Tower, their perception on the "realness" of their job might increase.

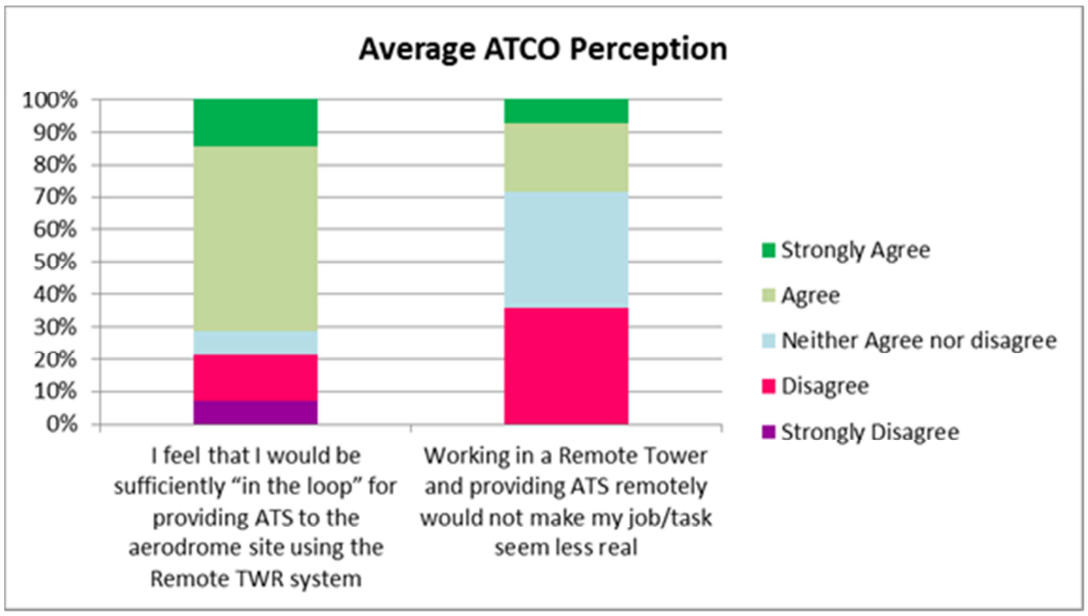


Figure 36: ATCO Perception

6.2.3.1.5 Trust

6.2.3.1.5.1 Measuring Trust using SATI

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 ATCO confidence in the system.

ATCOs were asked to fill in the SATI trust rating questionnaire; this questionnaire measures the levels of trust the ATCOs have in components of the system. Figure 37 below shows the results for the Basic System, and Figure 38 shows the results for the Advanced System.

Overall, ATCOs reported a good level of trust in the concept, and in particular when using the Advanced System. For the Basic System, ATCOs felt that they could understand the system but were less trusting of the reliability and robustness of the system and this had a negative impact on ATCOs' confidence when working with the system, with only 35% of participants saying that they often, or very often felt confident using the system.

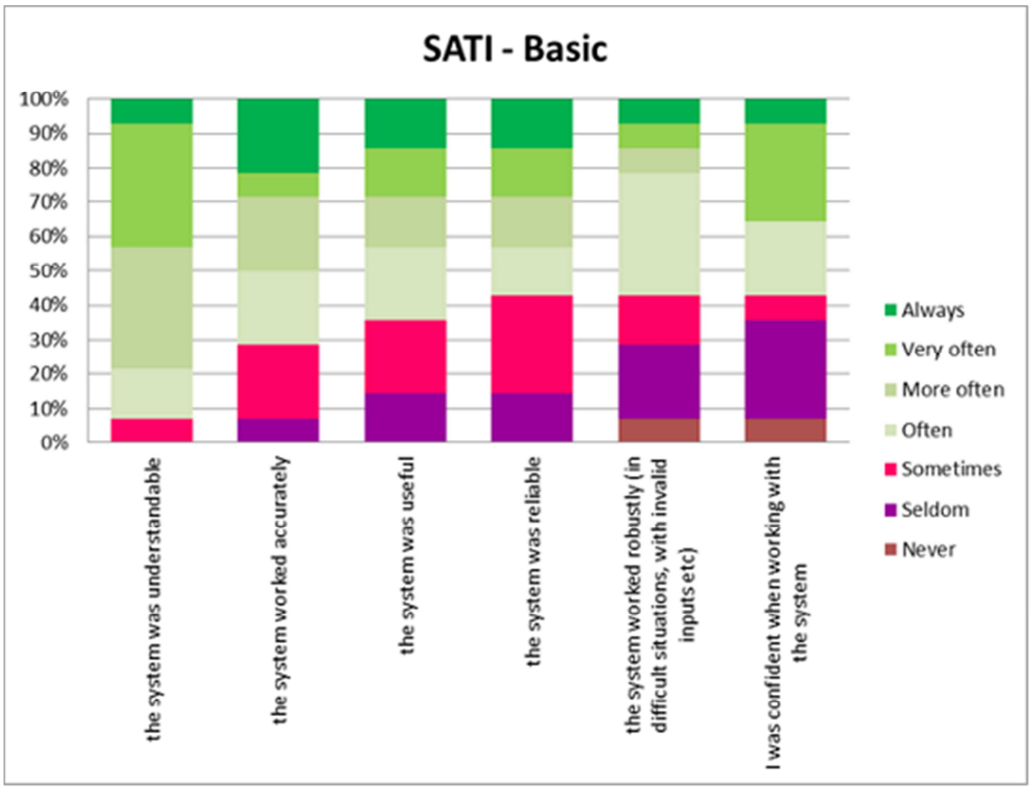


Figure 37 - ATCO Response to Trust in BASIC System

For the Advanced System the results are much more positive. 100% of the ATCOs gave a positive response to the ability to understand the system and also to finding the system useful (Often to Always). In fact, 60% of the negative responses (Sometimes and Seldom) were from a single ATCO who had particularly cautious opinions and felt particularly unwilling to give any kind of "approval" based on a short exposure to the system. If this one ATCO's results are omitted, the results for Trust for the Advanced System are almost universally positive. (Note: There were no other instances where one person's responses so heavily influenced the overall scores).

When asked what component ATCOs had most trust in, they said the Radar/RDP/ Flight Data Processing (FDP) (mentioned 10 times) followed by the Cameras (mentioned 6 times) and Tracking Labels (mentioned 3 times).

The positive response to the radar/RDP/FDP is to be expected since it is the most familiar system to the ATCOs:

- "*Always provides the best support*"
- "*The tool I am most familiar with*"
- "*Old and well-proven equipment*"
- "*RDP and FDP are equipment well proven by a list of ATS*"
- "*RDP is a well-known product, easy to use*".

ATCOs had the least trust in the PTZ camera (mentioned 14 times), followed by Visual Tracking (mentioned 3 times), and Radar and IR camera (both mentioned 2 times).

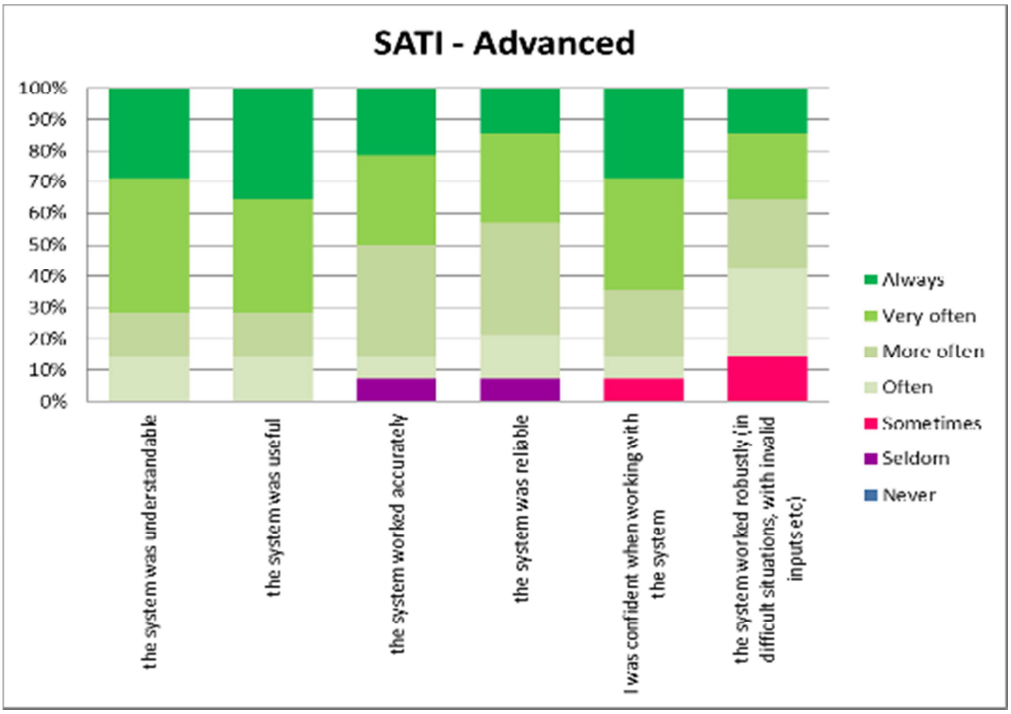


Figure 38 - ATCO Response to Trust in ADVANCED System

ATCOs explain:

- **PTZ Camera**:
  - "*Failed completely 6 times, failed partially a couple of times, when it did wok it provided no useful information*"
  - "*Not sharp and too touchy to work with*"
  - "*Worked bad and unreliable*"
  - "*u/s and difficult to manoeuvre*"
- **Visual Tracking**:
  - "*Worked now and then*"
  - "*Had a delay sometimes*"
- **IR Camera**:
  - "*Difficult to manoeuvre*"

As with the SASHA results, the VP-057 SATI results can be juxtaposed with the VP-056 results for a purely indicative illustration. The trust scores recorded by VP-057 ATCOs using the Basic system was slightly higher than the scores recorded by the ATCOs in VP-056, with the scores for the Advanced system being higher still.

6.2.3.1.6 Service Level Provision & Capacity

6.2.3.1.6.1 End of Trial Questionnaire

The concept behind Remote Provision of ATS states that tasks and service should, where possible, be the same as they would in a local tower. The main change is to how the visual picture is being built and this is the focus of many results.

In the End of Trial questionnaire ATCOs were asked to describe their thoughts on airport capacity in Remote Tower. The results for their perception can be found in Figure 39 (Basic System) and Figure 40 (Advanced System). The results show that the majority of the ATCOs felt VFR could be applied in Basic System (12 out 14 ATCOs agreed, 2 indecisive) and that all ATCOs agreed VFR could be applied in the Advanced System. In Advanced System all ATCOs also agreed that they could handle simultaneous aircraft and vehicle movements and 2 simultaneous aircraft (arrival) movements. In Basic system however, fewer (9) ATCOs agreed they could handle simultaneous aircraft and vehicle

movements while 2 disagreed and 3 were indecisive, with very similar results for two simultaneous aircraft (arrival) movements.

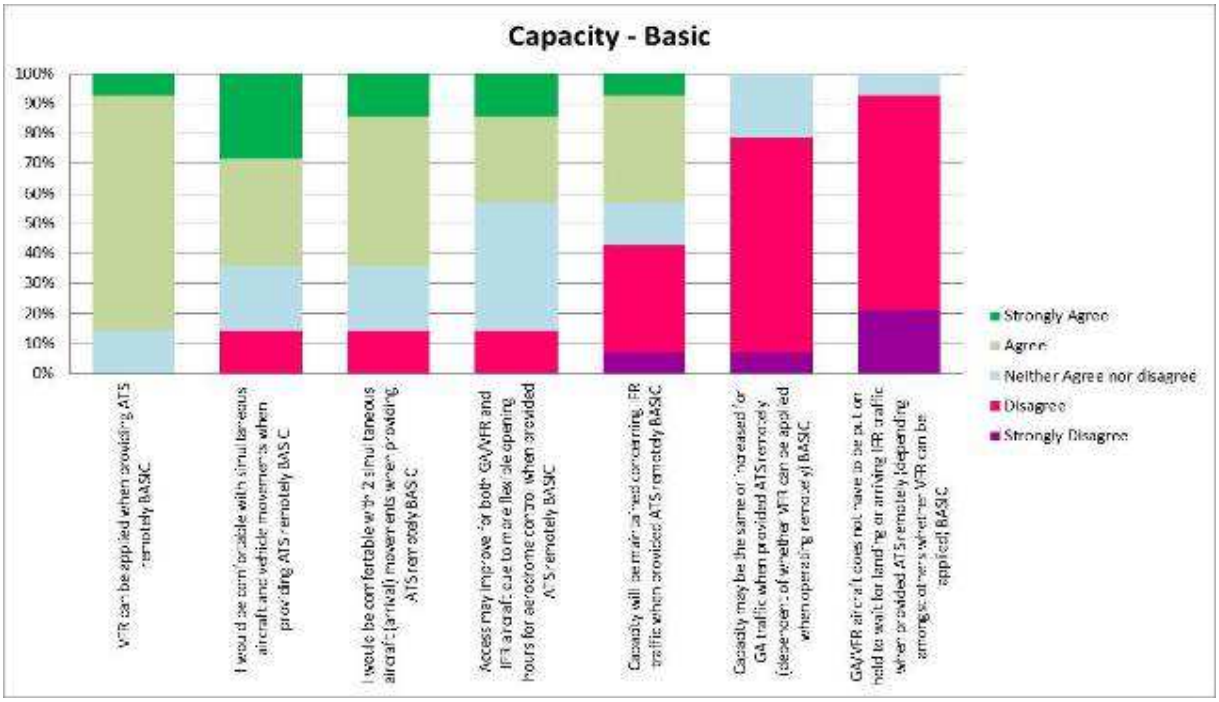


Figure 39 – Airport Capacity for Basic System

Once again, the functionalities in Advanced System contribute to ATCO awareness of traffic to make them feel more comfortable in handling traffic, whether aircraft movements or vehicle movements. Tracking label overlays and radar are very useful tools to identify moving objects quickly allowing the ATCO to advise and control multiple objects at the same time.

When it comes to ATCOs' opinion on increasing the aerodrome capacity for GA traffic, in Basic System they did not feel that comfortable: 11 out of 14 disagree on the statement that capacity may be increased for GA traffic while providing ATS remotely (3 ATCOs indecisive), and 13 ATCOs disagree with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (1 ATCO indecisive). For Advanced System, these numbers tend to shift towards more a positive result: 3 ATCOs agree on the statement that capacity may be increased for GA traffic while providing ATS remotely (6 ATCOs disagree, 5 ATCOs indecisive), and 3 ATCOs agree with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (6 disagree, and 1 ATCO indecisive).

These results indicate that ATCOs feel that they can handle an increased traffic load in Advanced System compared to Basic (thanks to the additional functionalities). The results between the Basic and Advanced System are statistically significantly different. However, the results also show that ATCOs do not overwhelmingly agree that capacity can be increased with the Advanced System. Perhaps this has to do with some visual limitation of the system, such as not being able to judge depth and distance, or the troubles experienced with the PTZ.

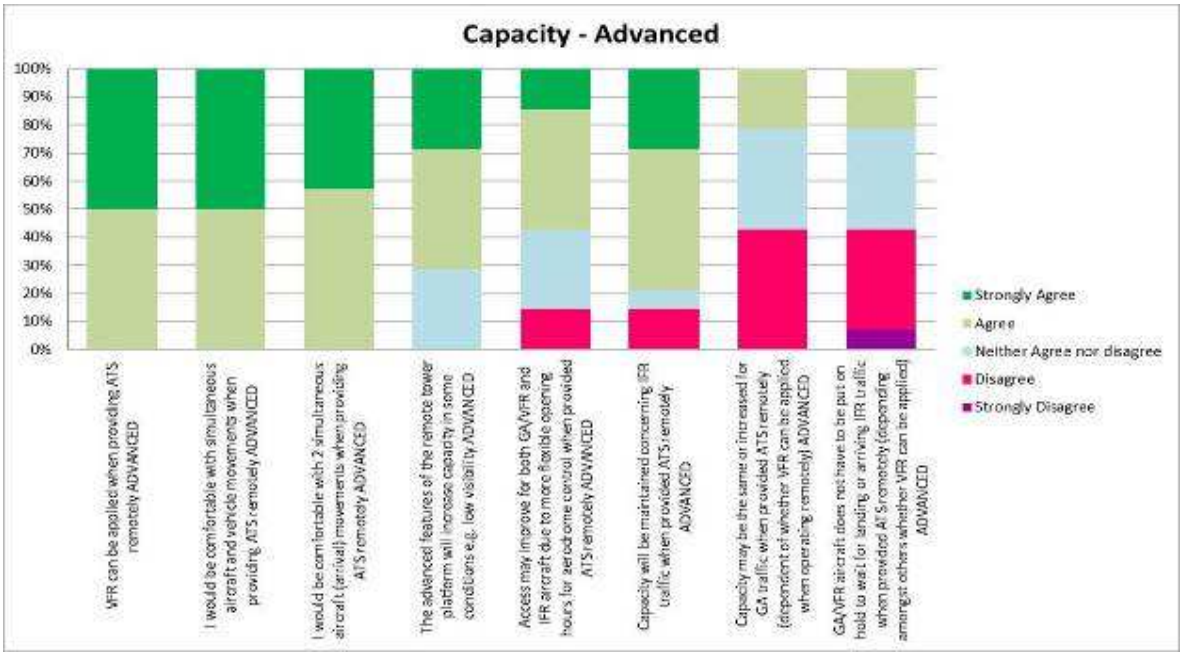


Figure 40 – Airport Capacity for Advanced System

6.2.3.1.6.2 Scenario Assessments

Assessing the actual task of controlling aircraft was not possible due to the limitations of a shadow mode trial. However, the ATCOs' experiences in the trial could be used by them to form opinions on hypothetical scenarios. In addition to the End of Trial capacity section, a new questionnaire was designed for this trial to assess how the ATCOs would rate their perceived ability to provide ATS to various numbers and types of aircraft simultaneously. The main objective of this questionnaire was to further research questions that arose following VP-056 where some ATCOs felt that it would not be possible to provide remote ATS to more than one aircraft at a time.

Table 20 below summarises the18 scenarios presented to each ATCO.

Scenario Number	Description	Total # of objects
1	1 IFR departure	1
2	1 IFR arrival	1
3	1 VFR departure, Left Circuit	1
4	1 VFR departure Right Circuit	1
5	1 VFR arrival Left Circuit	1
6	1 IFR departure on taxiway, 1 airborne IFR departure	2
7	1 IFR departure on taxiway, 1 IFR arrival	2
8	1 airborne VFR departure, 1 IFR arrival on short final	2
9	1 VFR arrival (No. 1), 1 IFR arrival (No. 2)	2
10	1 IFR departure on taxiway, 1 airborne IFR departure, vehicle on taxiway	3
11	1 IFR arrival at touchdown, 1 IFR departure on taxiway, vehicle on taxiway	3
12	2 VFR arrivals one behind another	2
13	2 VFR arrivals, very close behind one another	2
14	2 VFR arrivals, #1 requests priority from left circuit while #2 is on final	2
15	1 VFR touch and go, 1 vehicle on runway	2
16	1 VFR crossing, 1 IFR arrival	2
17	3 VFR arrivals from the Left Circuit	3
18	1 IFR departure, 1 IFR arrival, 1 VFR crossing	3

Table 20: Scenarios from the Capacity questionnaire described

In the questionnaire, the ATCOs were asked if they would feel comfortable providing ATS services in that particular scenario from:

- A local tower in CAVOK;
- A local tower at night time;
- A Remote Tower (Basic System) in CAVOK:
- A Remote Tower (Basic System) at night time:
- A Remote Tower (Advanced System) in CAVOK:
- A Remote Tower (Advanced System) at night time.

Answers could be Yes, No, or Maybe and sample scenarios are shown below in Figure 41 and Figure 42

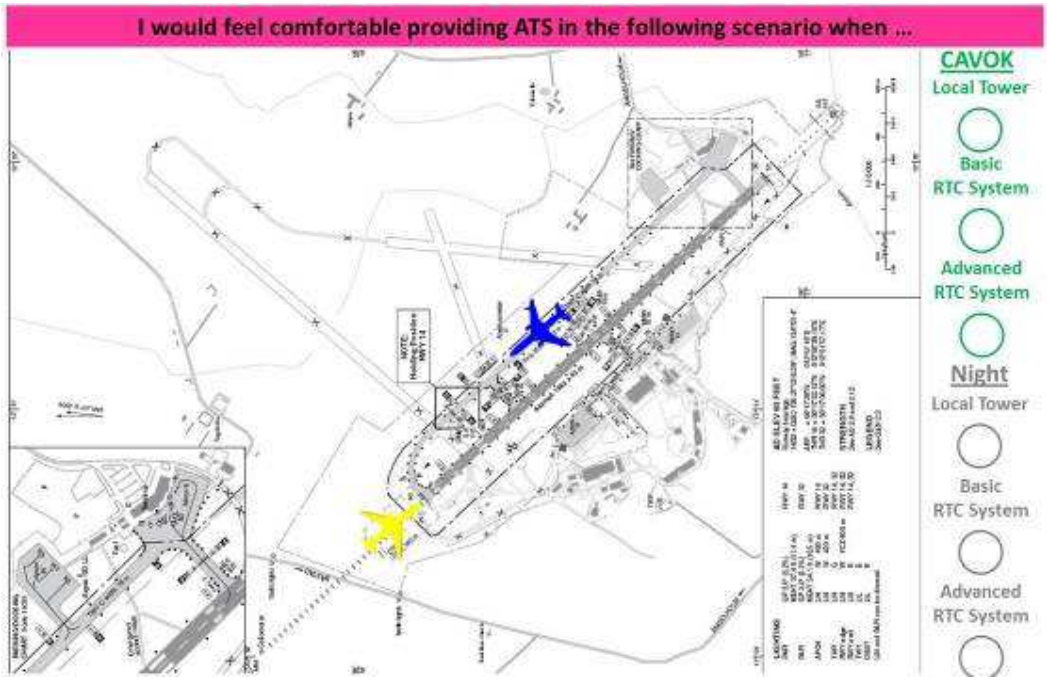


Figure 41 - Scenario showing Aerodrome and Apron

Figure 42 - Scenario showing Aerodrome and surrounding areas

The questionnaire is a qualitative one but an attempt has been made to quantify the results to enable comparison between systems and tower and scenarios in order for statistical testing to be done.

During the first two days of the trial this new questionnaire was tested on the first two ATCOs in order to get feedback on the suitability of the questionnaire. Modifications were suggested by those ATCOs and the questionnaire was amended for subsequent participants. This means that the results from the first two participants are not included in the analysis, leaving a sample size of 12 ATCOs.

The results suggest that as the complexity increases, there is a statistically significant difference between local towers, basic system (remote) and advanced system (remote) in terms of how comfortable the ATCOs would be with providing ATS in the respective situations. However, most ATCOs stated that the Advanced System would enable them to comfortably handle more aircraft simultaneously compared to the Basic system.

The difference between a local tower and Basic system becomes evident when testing for a significant difference. The results show that for the following scenarios there was a significant difference between how comfortable the ATCOs would feel in local tower and **Basic** system, with ATCOs saying they would not be as comfortable using the basic remote system compared to a local tower:

- Scenario 6: 2 IFR departures – **night**
- Scenario 7: 1 IFR departure on taxiway, 1 IFR arrival - **night**
- Scenario 8: 1 airborne VFR departure, 1 IFR arrival on short final - **night**
- Scenario 9: 1 VFR arrival, 1 IFR arrival - both **CAVOK** and **night**
- Scenario 10: 2 IFR departures (one at take-off, 1 on taxiway), vehicle on taxiway – **night**
- Scenario 11: 1 IFR arrival at touchdown, 1 IFR departure on taxiway, vehicle on taxiway – both **CAVOK*** and **night***
- Scenario 12: 2 VFR arrivals one behind another - both **CAVOK*** and **night**
- Scenario 13: 2 VFR arrivals, very close behind one another - both **CAVOK** and **night**
- Scenario 14: 2 VFR arrivals, #1 requests priority while #2 is on final - both **CAVOK*** and **night**

(* = one-tailed significance only)

The results show that the significant difference between Local Tower and Basic (remote) setup start from Scenario 6 onwards. As shown in Table 20, this corresponds to the increase in complexity since from Scenario 6 onwards there are two or more objects instead of one. Even more so, the averages drop for the Basic system as the amount of objects increase.

Table 21 shows the average score for scenarios with 1, 2 or 3 objects for Local Tower, Basic and Advanced System. These results imply that providing ATS in Remote Tower is more difficult using the Basic system compared to both Local Tower and Advanced System. The maximum score is 2.

1 object		
Tower	Basic	Advanced
1.98	1.87	1.99

2 objects		
Tower	Basic	Advanced
1.92	1.27	1.86

3 objects		
Tower	Basic	Advanced
1.94	1.073	1.86

Table 21: Average scored for Capacity Test per number of objects

These results underline the earlier mentioned comment from ATCOs that the Basic system can be used sufficiently for one aircraft movement. However, ATCOs mentioned several times while looking at the scenarios that the Basic system would take them more work to provide ATS (compared to Local Tower and Advanced System), but would be manageable.

Remarkably, there was only one scenario in which there was a significant difference between Local Tower and **Advanced** system i.e. ATCOs felt less comfortable providing ATS remotely from the Advanced System compared to from the Local Tower:

- Scenario 13: 2 VFR arrivals, very close behind one another – **night**

Some of the comments for this particular scenario (13) are outlined below:

- "*Can't judge altitude and distance*."
- "*Hard if you can't see nr 2. Otherwise, comfortable but spending more calories*"
- "*Decisions here would be severely affected by the weather*."
- "*So much harder to see during night-time than IRL*."
- "*Generally cautious. Hard to judge distance*."

The results suggest that providing ATS in Remote Tower would be at the same level of comfortableness among ATCOs as in local tower, with the exception of one situation. As there was a significant difference between Local Tower and Advanced system in only one scenario, the conclusion would imply that for the rest of the scenarios the operation would be the same in the Remote Advanced system as in a local tower, when it comes to how comfortable ATCOs would feel in providing ATS. In addition, in some of the scenarios the Advanced System had a higher average than local tower, even though these differences were not statistically significant. Nevertheless, this may imply that ATCOs would feel slightly more comfortable providing ATS with all the functionalities the advanced system has to offer such as tracking labels compared to local tower.

6.2.3.1.7 Safety

6.2.3.1.7.1 General Perception

At the end of the two day trial, ATCOs were asked to describe their initial thoughts on providing Remote Provision of ATS to a Single Aerodrome in the End of Trial questionnaire, and before reporting on the detailed responses for each of the systems' components further down this document. Here is what the ATCOs had to say on their initial thoughts of the system:

- "*I think it's safe enough to provide from a single aerodrome*"
- "*My initial perception is that I depend more on how well the system is working and that I must rely on the information that is provided because it's all that I can have*"
- "*As always I'm sceptical about new things. That nothing worked when I tested it first time didn't make it better. Difficult to imagine that it's always as if you sit in a normal tower*."
- "*RTC could work at airports with not too many movements at the same time. Due to lack of depth perceptions, it is difficult to apply visual solutions and reduce separation – to apply visual separation would be a risk*"
- "*My perception regarding safety is that it will be sufficient*"
- "*I think it's safe as the normal operations in a real tower*"
- "*With adjusted methods/procedures, safety demands will be met*"
- "*Safety is the same as for local tower*"

6.2.3.1.7.2 Safety Scenario Observations

For this trial an observation sheet was introduced with regards to ATCOs applying safety procedures during the sessions. The ATCOs were also given checklists of procedures to use during various non-nominal events. The observation forms were named Safety Scenario capture forms and were filled in by observers during the trial. The Safety Scenario capture form allowed observers to make notes on the safety occurrence, the technical functions that ATCOs used, the risks that were (potentially) involved, and the way the ATCOs verbalised the occurrence. Below are some results from the observations mainly related to simulated screen failure where:

Screen 1. Final approach

Screen 2. First section of RWY14

Screen 3. Touchdown RWY14

Screen 4. Middle RWY14 / VFR holding point North

Screen 5. End section RWY14 and Apron/Terminal / left hand departures RWY14

Screen 6. Right Hand departures RWY14 / Final approach RWY32

One ATCO experienced a Screen 4 blackout. The ATCO used the PTZ and RDP and the observer wrote the following:

- **Safety occurrence**: "*Screen blacked out. Runway lights turned on? Disagree with checklist, on the runway light point. One movement mode fully usable if made sure airport maintains checks*."
- **Risks**: "*Critical screen failure, screen #4 on the runway. Actually missed one VFR through CTR as it was in the black every time ATCO checked. Lose all screens -> full LVP procedure as agreed with aerodrome*."
- **Verbalisation**: "*You need arrangements with the airport with inspection before every operation. Phrase 'OVE to system failure' is too vague for pilots*".

For another ATCO there did not seem to be a problem with having one main display screen off (the one that was covering the runway). The ATCO explains: "*I would like to inform pilots and ask them to land at their own discretion. I would not issue a normal clear to land*."

Contradicting the procedures the previous ATCO would apply, one ATCO would do the following:

- **Safety occurrence**: "No air traffic allowed, divert to holding/other airport. Ground traffic u/s."
- **Verbalisation**: "*No problem -> no traffic allowed. Rules to be delivered. I suppose if screen 1 or 6 becomes u/s traffic could still be allowed (both in basic and advanced)*."

When another screen (screen #3) failed, one ATCO followed the following procedure:

- **Function used**: "*Checklist A1 used & very useful. Tried to use ACV – not working. PTZ – not working in the blackout area. ATCO gave info to pilot & ground staff. ATCO decided to be able to manage 1 movement at a time*."
- **Safety occurrences**: "*ATCO followed checklist. Frustration arise over the fact that the PTZ couldn't be used to cover for the malfunctioning screen*."
- **Risks**: "*Cannot verify that RWY is free. Cannot monitor that particular part of the RWY*"
- **Verbalisation**: "*1 movement at a time can be managed with 1 screen out of service. Checklist A1 was supportive*."

When screen #5 failed one observer noted the following during a session:

- **Functions used**: "*PTZ and fixed cameras couldn't be used because […] presented in black screen*"
- **Safety occurrence**: "*one movement: allow departure*."
- **Risks**: "*Wild life, vehicles on main area*"
- **Verbalisation**: "*Pilot informed, inform duty officer -> implement one movement operation. Local instructions and checklists used*".

Similarly, when screen #1 failed, the observer wrote down how another ATCO would handle the situation:

- **Functions used**: "*Advanced system*"
- **Safety occurrences**: "*Screen #1 u/s is non-critical. Clear to land, D1. D4 screen #2 then would do a go-around. CAVOK? LVP blind, if pilot takes responsibility. First inform. D1 too close go-around*."
- **Risks**: "*Within D4 -> clearance to land has been given. What kind of monitoring to determine if camera or screen busted*?"
- **Verbalisation**: *"In a real tower you can go outside. Contingency should include configuration button to handle the change to 4 screens. Where is the responsibility if missed [euk] in black screen, LVP, CAVOK? Inform pilot, let them decide. Go-around should NOT be default mode. Let flight crew decide. [OVE] to system failure? LVP allows only one movement. Runway lights -> can create go-around while there […]. Do not manoeuvre lights on final approach. Adjust regulations to activity. Pilot should know secure level. Remote IF there is any kind of problem*."

Informing the flight crew about a screen failure was mentioned several times by the ATCOs during a screen failure. There seems to be a division in opinion among ATCOs when it comes to having a default procedure when screens fail, as some would prefer a mandatory go-around and some ATCOs would not. For the ATCOs who would not prefer a mandatory go-around procedure mentioned that they would leave the discretion to land up to the flight crew. However, one tool that might have had an effect on this opinion of a mandatory go-around could be the PTZ camera as it has been mentioned several times that ATCOs were not able to point the PTZ camera to display the image on the blacked out screen. In addition, it might be that the procedures would differ depending on what screen fails e.g. a screen covering the runway or for example screen #6 which is far on the right, as screen #6 does not cover critical areas. In sum, there seems to be a personal preference per ATCO whether to allow aircraft to take-off or land when a screen failure occurs. Even though this result has not been linked to ATCO amount of experience, it might be that this could have an effect. Also, familiarity with certain tools (radar, PTZ) could have had an effect on the ATCOs' preference.

6.2.3.1.7.3 Detecting Hazards

ATCOs were asked to give their opinion on their ability to detect hazards and conflicts while providing remote ATS, and their answers are outlined in Figure 43 and Figure 44 below. Most (86%) of the ATCOs answered positive on being able to detect hazards, and all of the ATCOs say they were able to detect conflicts. It is worth mentioning that these questions should be interpreted as *would* an ATCO be able to detect hazards/conflicts, as there were no hazardous situations during the trial. In other words, the questions refer to the ATCO feeling he/she would be able within the Remote Tower to detect these situations.

Figure 43 - ATCO Response detecting hazardous situations

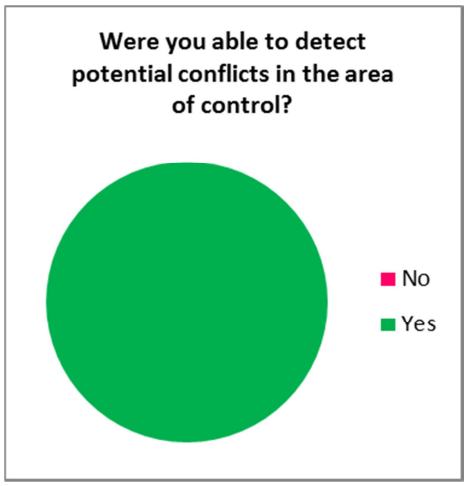


Figure 44 - ATCO Response detecting potential conflicts

A. Detecting hazardous situations on the area of control

The several types of hazardous situations that have been addressed in the safety questionnaire are:

- potential conflict on the air between aircraft (8)
- potential conflict on the air with respect to restricted areas (9)
- potential conflict on the manoeuvring area (16)
- runway instructions (27)
- potential controlled flight into terrain (29)
- intruder inside landing-aid protected area (34)

Results for the Basic System (comparison with respect to current tower facilities)

ATCOs felt able to detect potential conflicts on the manoeuvring area as in current operations (7 out of 10). Concerning the other hazardous situations, the feedback from ATCOs is not conclusive (divided opinions).

Results for the Advanced System (comparison with respect to Basic System)

In the Advanced system ATCOs felt more able (9 out of 12) to detect potential hazardous situations on the air between aircraft than in the Basic system. This was mainly thanks to the radar surveillance and the tracking functionality (both radar tracking and video tracking).

The detection of potential conflicts on the manoeuvring is also improved in Advanced System, in particular for runway incursions detection (11 out of 12). This improvement is mainly due to the video tracking and the additional cameras.

The feedback from ATCOs was not conclusive with respect to the other hazardous situations listed above.

6.2.3.1.7.4 Inducing Additional Hazards

Similarly, ATCOs assessed subjectively whether they could have missed a hazardous situation and 21% said Yes, while 42% of the ATCOs think the Remote Tower Concept will induce more hazardous situations, as outlined in Figure 45 and Figure 46 overleaf.

Some comments from the ATCOs included:

- "*Hard to say if it would feel less real, the spontaneity is yes. It should not really be so but maybe. Maybe I say so because I only validate the shadow mode, Difficult to answer simply*!"

"The responses to these should be viewed in perspective of the system was partially down, and improvements must be made in the operation of PTZ and other image quality. In the current situation, it is doubtful if I could viewers the settlement, anyway not with more aircraft involved at the same time"

When it comes to inducing more hazardous situations, looking at the Advanced System there are features that a local tower does not have, including the technical components such as the main display screens, cameras and tracking functions. It may be possible that ATCOs found that some of those features might be inducing more hazards than they are reducing, simply because they have the possibility of failing, while in a local tower the ATCO will always be able to look outside and use binoculars.

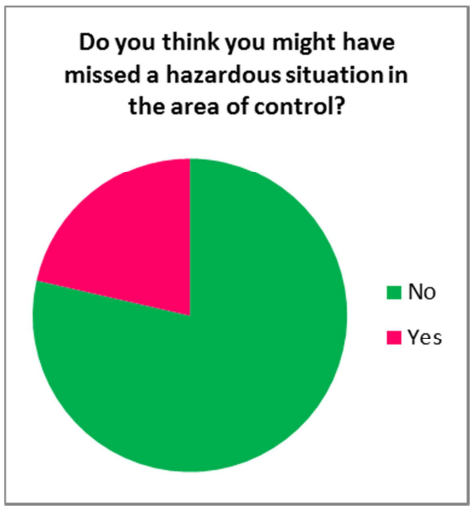


Figure 45 - ATCO Response to risk of missing hazardous situations

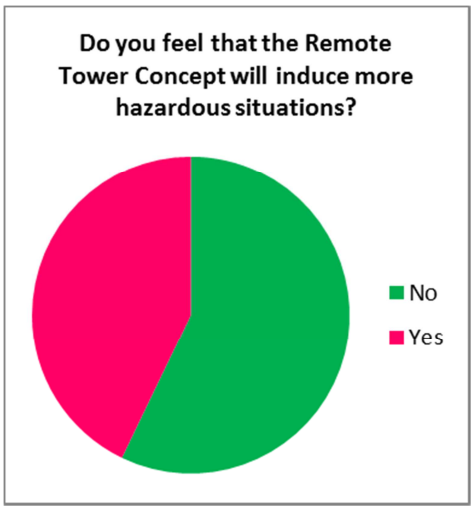


Figure 46 - ATCO Response to inducing more hazardous situations

B. Inducing more or additional hazardous situations

Except for the ones mentioned in (A.), all the other ATC tasks performed by the ATCOs have the potential to induce hazardous situations when they are incorrectly executed.

The analysis is then done taking into account which tasks ATCOs feel less able to perform than in current operations, and so for which there is a higher potential for a mistake.

Any additional hazardous situation induced because of equipment or system features failures have not been taken into account in this analysis.

Results for the Basic System

The main task that ATCO felt less able to perform using the Basic system was the "Identification of an aircraft in the vicinity of the aerodrome (1)".

In some cases this was due to problems in the PTZ functionality, but in most of the cases was related to the use of displays for the OTW view.

Comments included:

- *"Normally I use the binoculars, but I was unable to use the PTZ camera during the trial"*
- *"Easier to discover aircraft in current tower"*
- *"Identification depends on the quality of the picture, and at the moment there is some kind of motion effect blurring"*
- *"In all cases easier in reality"*

Apart from this, there are some other tasks for which the opinion on the ability to perform them in the Basic system was divided (listed in item 3 of the results from the safety questionnaire); they are

mainly tasks related to the provision of instructions or the management of a specific situation. These tasks could also induce additional hazardous situations, but the results were not conclusive on that.

Results for the Advanced System

It seems to be an improvement on the capability to perform specific tasks, and thus a reduction on the number of potential tasks that eventually could induce additional hazardous situations when they are incorrectly executed.

The main task significantly improved is the one mentioned in results for the Basic System: "Identification of an aircraft in the vicinity of the aerodrome (1)". 9 ATCOs of 12 reported a better capability (e.g. "Much better, mainly due to the tracking"), so less risk for inducing hazardous situations.

From the list of tasks also mentioned above, ATCOs reported an improvement on the capability to perform the following ones:

- Management of arriving aircraft landing (26) (9 ATCOs out of 12)
- Management of vehicle related operations on the runway (24) (8 ATCOs out of 12)

Enhanced features did not provide any significant improvement to perform some of the ATCO tasks, in particular for:

- Providing sufficient WT spacing between traffic (31) (9 out of 12)
- Managing departing aircraft take-off (25) (8 out of 12)

As mentioned before, additional hazardous situations induced by failure of the equipment / system enhanced features were not addressed in the safety questionnaire.

6.2.3.1.7.5 Task Allocation

Similar to what has been described in VP-056, it is not expected that the roles and responsibilities of the ATCO with the introduction of the RVT will change significantly. They will remain responsible for the provision of the required services. A higher reliance may be placed on technical equipment to perform tasks such as runway inspections and local agents may be used to perform tasks originally completed by the local ATCO.

ATCOs were asked to identify the main differences in task allocation between remote ATS and local operations. The feedback provided was as categorized below:

- **Weather**:
  - "*MetObs would not be possible from RTC, with respect to 'feeling wind' and noting type of precipitation*."
  - "*Harder and almost impossible to detect what kind of precipitation. Also, you get a good sense of when it actually starts blowing a lot since you hear and feel it in the tower*."
  - "*Lacking weather information*"
- **Visual Separation**:
  - "*ACFT will be visual for me later than I'm used to, harder to see gear*"
  - "*More restrictive when it comes to visual separations*"
  - "*Visual separation*"
- **Technical**:
  - "*More coordination with APP under 'abnormal' circumstances. The ATCO is troubleshooting the system as well as controlling*"
- **Geographical**:
  - "*Lacking local influence*"

Furthermore, one ATCO mentioned "*Situational Awareness night/day*" as the main difference in task allocation. Four ATCOs could not provide an answer to this question.

6.2.3.1.7.6 Working Methods (general)

A detailed assessment of the procedures took place and is reported elsewhere in this document. In the End of Trial questionnaire a more general question asked for ATCOs' inputs regarding working methods at a high level.

The working methods for this trial were answered by the ATCOs from their perception on how it *might* be, as this trial was in Shadow Mode and no working methods had to be applied. The ATCOs did not view the working methods to be differing from local tower operations. Figure 47 below shows an overview of their opinion of acceptability of the working methods. The results show that 93% of the ATCOs find the working methods under normal conditions acceptable. In abnormal situations 57% of the ATCOs found the working methods acceptable, which is the same percentage for degrade mode.

Some ATCOs also commented:

- "*I do not think the working methods will be different in ROT from a local tower*"
- "*It will take more validations mainly in advanced mode for me to begin to feel comfortable in a new role. Basic system in its present form is out of my world*."

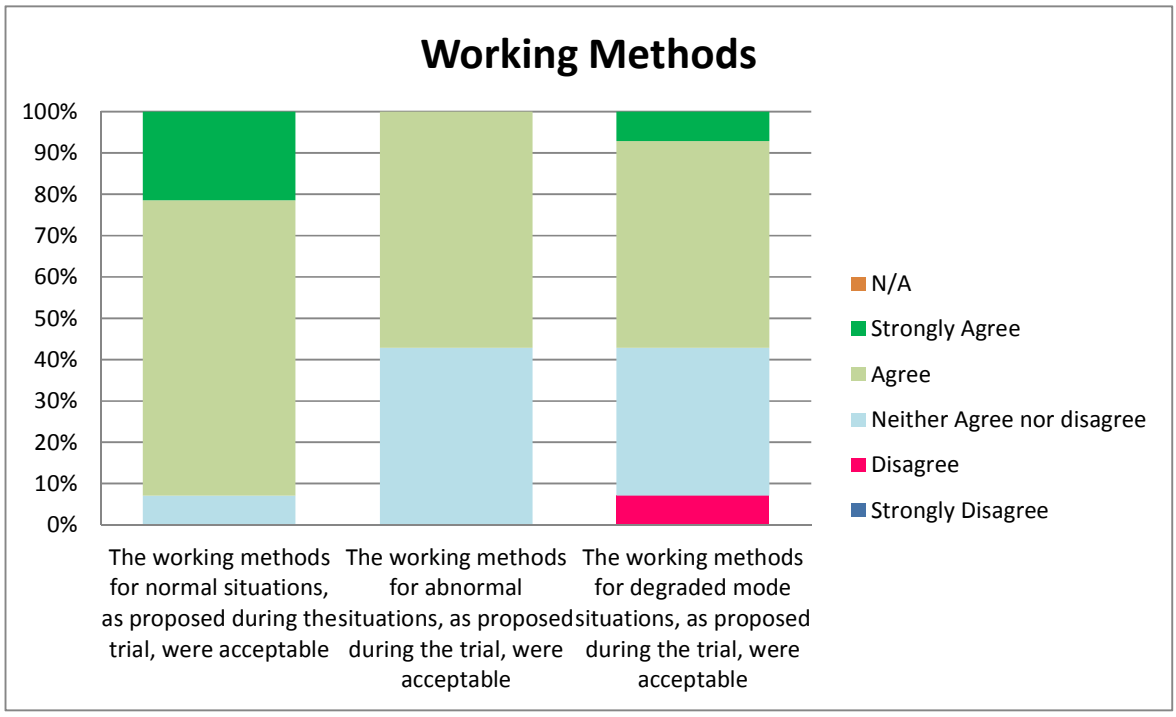


Figure 47 - ATCO Response to Working Methods

6.2.3.1.7.7 Utility of features and impact on Human Performance

The enhanced features available in the Advanced System are:

- Radar based surveillance information
- Radar tracking function directly in the OTW displays
- Video tracking function directly in the OTW displays
- Alternative Cameras providing hotspot views

Some results on the several enhanced features have already been presented in the previous validation objectives results. The conclusions provided here are complementary to those ones.

Figure 48 (overleaf) shows the use of each enhanced feature for the several ATC tasks addressed in the safety questionnaire.

The main enhanced features potentially supporting "air operations related tasks[2]" were first the radar tracking one (15% of the total use of enhanced features), closely followed by the radar-based surveillance display and the video tracking (11% each).

Concerning the "ground operations related tasks[3]", the two enhanced features potentially to be used were video tracking (25%) and the additional cameras (23%).

Based on those results, it seems that redundant features/information is being provided to the ATCO to perform the same type of task. This has to be assessed from a safety view point, in particular to be able to balance the safety benefit that can be provided by this redundancy, and the potential risk that all these features/information can induce (in case of malfunction or failure for example).

Apart from that, here is the main feedback that ATCOs provided for each of the enhanced features:

- Radar-based surveillance display
    - ATCOs reported that availability is not necessary when providing tower control service with only 1 movement at the same time. But for 2 or more simultaneous movements and in case the control service exceeds the aerodrome control area; radar information becomes essential to provide the service.
- Radar and video tracking
    - Both features were very well scored by the ATCOs, which reported that both radar and video tracking were really useful (even essential for some of them) to remotely provide ATC service from the remote tower.
    - Some improvements were suggested by some ATCOs with respect to the type of data presented in the radar label; for example, to include the type of aircraft and the speed in the label instead of the destination/arrival airport information.
    - Opinion was divided on the need to also have labels (with identity information) for ground vehicles.
- Additional Cameras
    - A part from some usability issues, overall ATCOs' opinion was really positive with respect to the availability of hotspots views directly in the OTW display.
    - It was clearly stated that the number of these cameras and their corresponding views need to be adapted to each specific aerodrome (to better support local operational tasks and needs).

[2] Air operations related tasks : from (1) to (12) in the tasks list of the safety questionnaire
[3] Ground operations related tasks: from (13) to (34) in the tasks list of the safety questionnaire

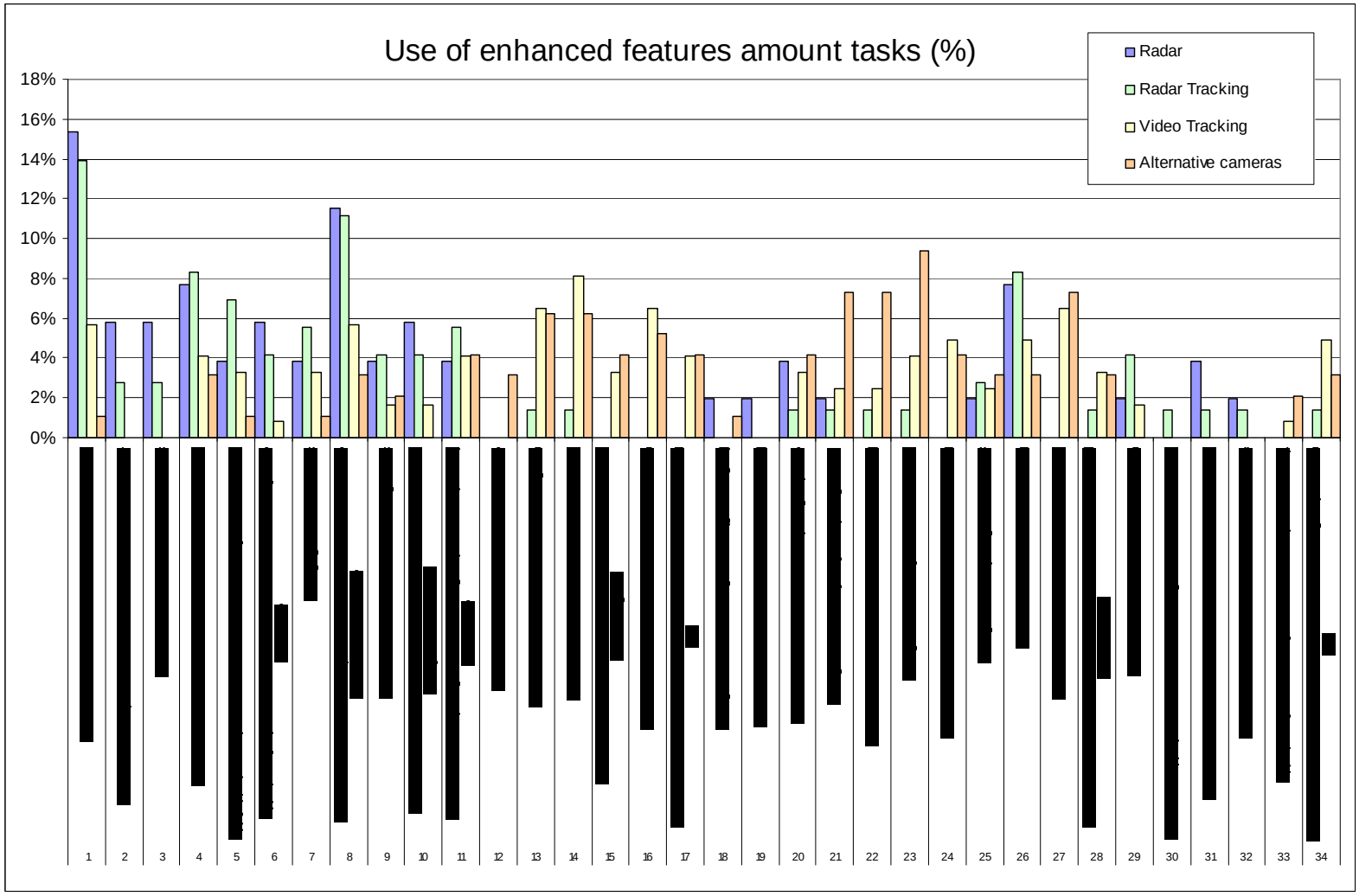


Figure 48 - Use of Enhanced Features per task

6.2.3.1.8 Procedure Development Support

The conclusions presented here are based on the results obtained during VP-057, in particular from the safety questionnaire, and from the individual debriefings done with the ATCOs.

The validity of these results is dependent to the conditions in which VP-057 was run, as explained in earlier sections of this report (type of scenarios encountered, PSM exercise, daylight, etc.).

6.2.3.1.8.1 Procedures for Normal Situations

6.2.3.1.8.1.1 Related to Reduced Separation in the vicinity of the airport

Reduced separation in the vicinity of the airport, to whatever is adequate to prevent a collision, can be applied in case of:

1. ATC can see both aircraft
2. Both aircraft report that they can see each other
3. Following aircraft reports that it can see the preceding one

The purpose of this validation objective was to assess the capability of applying reduced separation using the Visualisation Reproduction System. The trial was focused in particular in the first case, but as ATCO still have to monitor situation in the other 2 cases, all of them were finally addressed.

Results for the Basic System

ATCOs did not feel really capable of applying visual separation in the Basic System. Only 3 of them reported that they could perform it as in current operations (but in particular conditions as for example in daylight). 5 ATCOs out of 12 clearly stated that Remote Tower capability in this configuration was lower for applying visual separation, mainly due to the difficulty to judge depth and distance between aircraft.

Thus, vertical and procedural separations are to be remotely applied, but not reduced separation based on OTW displays.

Results for the Advanced System

ATCOs' opinion was divided with respect to the potential improvement in the Advanced System in the capability to apply visual separation. 6 ATCOs out of 12 mentioned a certain improvement, in particular thanks to the tracking functions and the availability of surveillance (radar) data. Nevertheless all ATCOs were aware, agreed, that these means were not to be used for reducing separation.

6.2.3.1.8.1.2 Related to the use of IR camera view

As per previous results from VP-056, it seems that IR camera is mainly to be used for ground movements. The objective for this VP-057 is to determine which parts of the manoeuvring area need more the use of IR.

Results for the both Basic and Advanced configuration (as this functionality is part of both)

For most of the ATCOs the IR camera functionality was not used, mainly because the scenarios experienced were in daylight. Only some recorded scenarios were presented to some of them, but no interaction with the system was possible.

As per the safety questionnaire and individual debriefings, and even if ATCOs did not really experienced the IR camera feature, 90% of the tasks for which IR camera was mentioned as feature supporting them were related to operations on the ground, manoeuvring area, in darkness or poor visibility conditions.

As shown in Figure 49 (overleaf) the main ground tasks that IR camera could support are:

- identification of aircraft and vehicles on the ground (13 and 14)
- detection and resolution of conflicts in the manoeuvring area (16 and 17)
- runway related operations (21 and 23)

6.2.3.1.8.1.3 Related to weather observations

Scenarios to be addressed:

Currently, visual information is used (among other types of information) to support the following operations:

- Assess weather conditions impacting traffic/operations, for example in order to determine when conditions are CAVOK again after a certain period of Low Visual Conditions (in order to stop LVP)
- Determine Runway Conditions (including FODs and presence of animals on the RWY): this is to be done in complement to information from Meteorological Aerodrome Report (METAR) and also information provided by airport personnel based on RWY inspections

These two items were addressed during the trial, in the safety questionnaire (tasks (32) and (33) respectively) and also during the individual debriefing.

Results for the Basic System

The results on these two tasks from the safety questionnaire are:

- 4 ATCOs out of 10 reported that the capability for assessing weather conditions was lower, and 4 reported that the capability was as good as in current operations
- 5 ATCOs reported a lower capability concerning the runway conditions assessment, but 2 out of 10 reported a better one.

The comments collected during the debriefing leads to conclude that improvement is still needed in order to remotely perform these two tasks as in current operations. Particular feedback was provided on the difficulty to judge “wind” and “rain” related information from the remote facilities. Here are some comments on weather assessment item:

- “*Wind is more difficult to be judged with the cameras than in local tower. The assessment of the clouds is ok*”
- “*Weather perception seems to be ok, at least in terms of visibility and type of clouds*”
- “*Type of precipitation is more difficult to be assessed from remote tower, as well as the wind strength and direction*”
- “*For weather observations often you need to go outside, but can’t do that in a remote tower, so more difficult to judge the weather*”

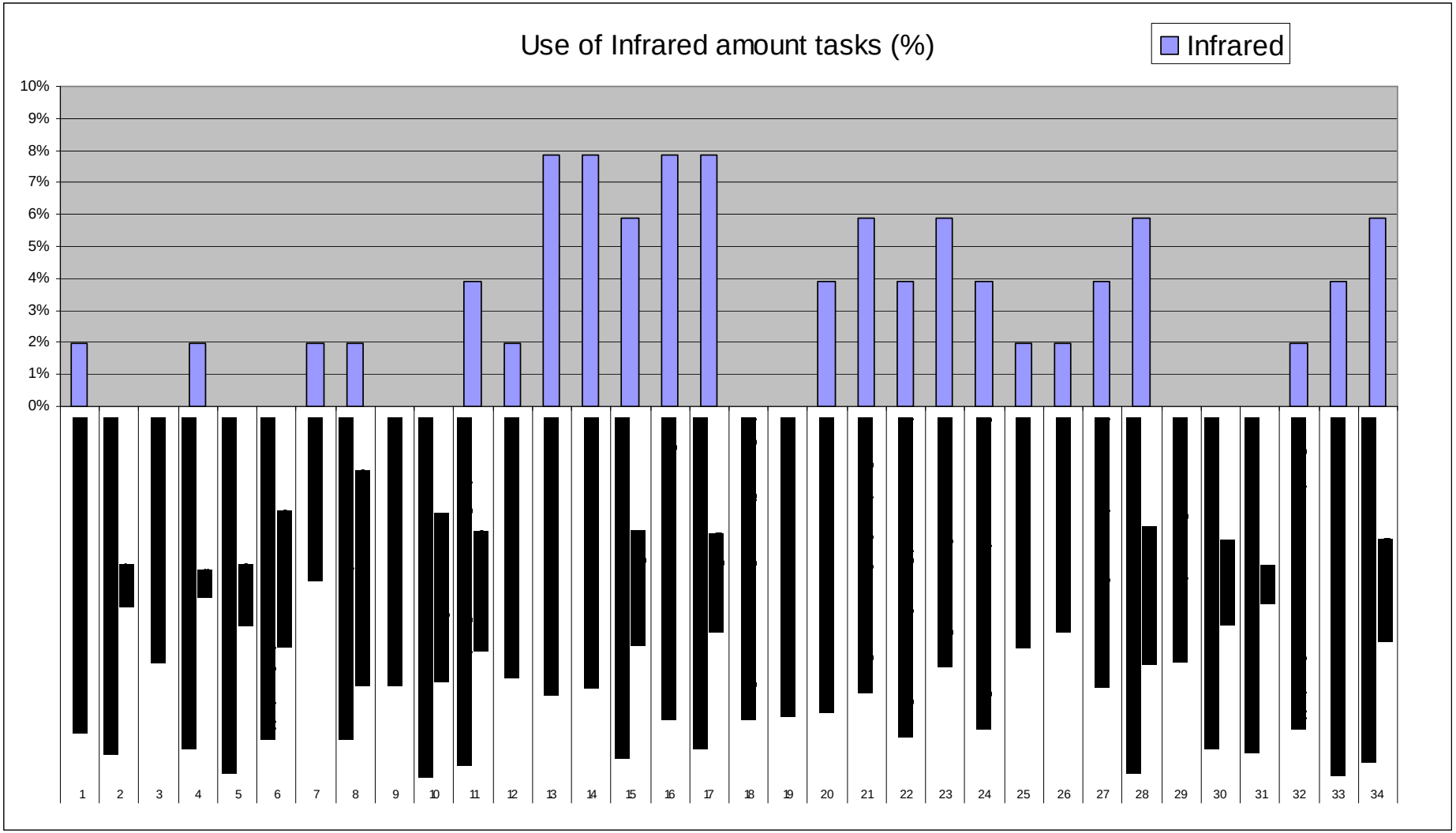


Figure 49 - Use of IR Camera per task

It was also mentioned the risk of losing local related knowledge, including the weather one: "*In aerodromes close to mountains, with snow, fog, changeable weather, this information could be critical as this extra information affects decisions and the overall situational awareness"*.

Two recommendations were suggested with respect to those issues:

- to include a pre-setting for the PTZ, or additional fixed cameras, in order to facilitate the ATCO in finding the windsocks;
- to allocate the MET observation task to the field officer, or to even increase the number of sensors at the aerodrome being controlled remotely.

ATCOs seemed to be less "worried" about the assessment of the runways condition, as for them it was clear that this is a task under the responsibility of the "Runway inspection service" located in the aerodrome.

Results for the Advanced System

No significant improvement was observed due to the introduction of enhanced features in the remote tower system. Only the IR camera and the additional cameras seemed to potentially be able to provide some improvement.

6.2.3.1.8.2 Procedures for Abnormal Situations

Abnormal conditions were not thoroughly investigated throughout the trial. Only a few results were gained during the trial (through the safety questionnaire) but no conclusion can be drawn from them. Results for the workshop held after the trials, as detailed in **Error! Reference source not found.**, revealed more detailed subjective qualitative results on the implications of abnormal events occurring. Overall conclusion revealed that the procedure for handling these events should not differ from standard procedures as long as technical enablers provide adequate functionality. The PTZ Camera, acting as binoculars, was viewed as a key enabler to allow for the handling of abnormal situations.

6.2.3.1.8.3 Procedures for Degraded Mode

During the trial briefing the ATCOs were given an introduction to some proposed Remote Provision of ATS "checklists". These checklists described the procedures ATCOs should apply under various degraded mode scenarios such as equipment failure or unreliable information.

The ATCOs were then asked to use their experiences in the facility to assess the suitability of the procedures in the checklist and made recommendations for change if necessary.

The main feedback was as follows:

- General Proposals:
  - A procedure for start-up and close down of the remote tower is needed;
  - A procedure for hand-over between ATCOs is needed;
- Results for One Movement mode:
  - The main proposed procedure was to revert to One Movement Mode in case of loss of visual reproduction. This mode is a replication of the commonly used Low visibility procedures (LVP) with regards to the ATCO tasks. This rather strict mode was widely accepted by the ATCOs as a good proposal. At least it should have to be applied in early introduction of Virtual and Remote towers. Some ATCOs said that by time when confidence in the system will grow maybe those rules could become less restrictive. Recommendation: To further detail One Movement Mode;
- Use of landing lights:
  - It was proposed that the ATCO should put on runway lights if visual reproduction failed. This proposal was not widely accepted by ATCOs. Recommendation: To delete this rule;
- Informing the flight crew:

- Almost all ATCOs said there was a need to inform flight crews that the control is remote and that the ATCO has lost visual contact. Recommendation: To produce phraseology to cover this need;

- Go-around or land:
  - Half of the ATCOs said that ordering a go-around at a late stage on final might introduce a greater risk than the risk to land even if the ATCO has lost visual contact. The proposal is to let the pilot take over visually and decide whether to land “at own discretion” or not. Recommendation: Let flight crew decide if it is possible to land and to do it on own discretion. Recommendation: Design dedicated procedure for determining “Runway free” if no visual contact from the tower. (Example by a delegated responsibility to airport operations staff to inspect the runway and the taxiways and report to remote tower);

- Other proposals:
  - Introduce a decision point for when an aircraft can line up before a landing, expressed as a minimum distance from the threshold for landing aircraft. It has to be determined if this distance has to be observed by the ATCO or if a pilot report is enough. The distance has to be determined as well;
  - Black screens might be safer than frozen screens or screens with corrupted data. Need to develop a procedure to close down screens when in malfunction;
  - In general the ATCOs would like to see a system that always is able to generate alerts when there is a malfunction of any kind. And a back-up system should always be available at a “click of a button”;
  - Need to carefully determine what are critical screens and non-critical screens;
  - Possibility to move VFR to an area where the screen is not corrupt;
  - Stop bars should always be active if the system is degraded.

6.2.3.2 Analysis of Exercise Results

Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results	Validation Objective Analysis Status per Exercise
OBJ-06.09.03-VALP-0060.0073	Assess the acceptability of single remote tower operations for ATCOs, in terms of: • The concept in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	The Remote Provision of ATS to a single aerodrome concept, is usable/acceptable to the ATCO in terms of: • The concept in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	The ATCOs were satisfied with the majority of technical aspects relating to the visual reproduction provided, including: contrasts, the screens, the screen distance, the resolution, the viewing angle, the screen layout, the general view, the screen size, the picture quality, and the camera positions: between 64% and 93% of the ATCOs agreed with their acceptability. The concept in general: o 9/14 agreed they would like to use the system to provide ATS HMI visual reproduction: Overall, ATCOs found the picture quality acceptable but also that it could still be improved. o Depth: **2/14** agree ability to judge o Night time: 3/14 agree it is as good as daytime o Distance: 5/14 agree ability to judge Advanced Visual Features: o **IR camera**: mainly positive from those who were able to use it during the trial. Some concerns about procedures and contribution to workload. o **PTZ**: generally negative feedback, mainly related to usability and quality of picture. o **ACV**: Mainly positive feedback, but number and location of cameras could be improved. o **Tracking labels**: Overwhelmingly positive feedback all round. **HMI CWP**: In general the ATCOs found the work environment acceptable in the current state. o 10/14 agree on acceptable layout **The Working Environment**: o 9/14 agree on pleasant place (3 disagree).	OK
OBJ-06.09.03-	To assess the utility and usability of enhanced visual	The ATCO can easily use the enhanced visual features and	Usefulness:	OK

VALP-0060.0102	features e.g. automatic a/c identification & tracking function, etc.	consider them to be useful for their tasks.	o **IR camera**: 11/14 useful o **ACV**: 13/14 agree useful o **Tracking Labels**: 13/14 useful Intuitiveness: o **IR camera**: **6/14** agree intuitive (3 disagree) o **ACV**: 10/14 agree intuitive o **Tracking labels**: 7 agree intuitive (2 disagree)	
OBJ-06.09.03-VALP-0060.0051	Assess the utility of enhanced visual features, by determining their impact on: • the human performance, in particular in terms of situational awareness • the working methods and procedures, in particular for visual separation and for the use of the IR camera	The enhanced visual features have a positive impact on human performance.	The main enhanced features potentially supporting "air operations related tasks " were first the radar tracking one (15% of the total use of enhanced features), closely followed by the radar-based surveillance display and the video tracking (11% each). Concerning the "ground operations related tasks", the two enhanced features potentially to be used were video tracking (25%) and the additional cameras (23%). For most of the ATCOs the IR camera functionality was not used, mainly because the scenarios experienced were in daylight. Only some recorded scenarios were presented to some of them, but no interaction with the system was possible. When asked, ATCOs reported the opinion that the main ground tasks that IR camera could support are: o identification of aircraft and vehicles on the ground; o detection and resolution of conflicts in the manoeuvring area; o runway related operations.	OK
OBJ-06.09.03-VALP-0060.0061	To assess the impact of the Remote Tower Concept on TWR ATCO Human Performance under **good and limited visibility** conditions and during the day and night, in terms of: I. Situation awareness II. Trust This objective differs from objective OBJ-06.09.03-VALP-0060.0051 and OBJ-06.09.03-VALP-0060.0033 in the nature of the viewpoint for Situational Awareness: The current objective looks at the Human Performance	The Remote ATCO is able to detect potential conflicts, hazardous situations and other scripted events that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas.	In general, ATCOs were experiencing high Situational Awareness. There was a statistically significant difference between Basic and Advanced System for Situational Awareness. **SASHA Basic System average**: 4.72 (out of 6) **SASHA Advanced System Average**: 5.21 (out of 6) Overall, ATCOs reported a good level of trust in the concept, and in particular when using the Advanced System. For the Basic System, ATCOs felt that they could understand the system but were less trusting of the reliability and robustness of the system and this had a negative impact on ATCOs' confidence when working with the system, with only 35% of participants saying that they often, or very often felt confident using the system. For the Advanced System the results are much more positive. 100% of	OK

	aspect rather than user experience.		the ATCOs gave a positive response to the ability to understand the system and also to finding the system useful (Often to Always). **Trust - Basic System**: reliable 8/14 'often' or higher **Trust - Advanced System**: reliable 13/14 'often' or higher	
OBJ-06.09.03-VALP-0060.0033	Assess, from a safety viewpoint, the impact of the ATCO Situations Awareness on: • detecting hazardous situations on the area of control • inducing more or additional hazardous situations This objective differs from objective OBJ-06.09.03-VALP-0060.0051 mentioned in the nature of the viewpoint for Situational Awareness: The current objective looks at a safety aspect rather than user experience.	The ATCO situational awareness is not decreased or has no negative impact on: • the ability to detect hazardous situations in the area of control • inducing more or additional hazardous situations	In general, ATCOs were experiencing high Situational Awareness. There was a statistically significant difference between Basic and Advanced System for Situational Awareness. **SASHA Basic System average**: 4.72 (out of 6) **SASHA Advanced System Average**: 5.21 (out of 6) Although specific hazards and conflicts were not scripted into the trial, ATCOs were asked to give their opinion on their ability to detect hazards and conflicts while providing remote ATS. o 12/14: able to detect hazards o 14/14 able to detect conflicts o 14/14 agree Enhanced Visual features will increase SA **43%** of ATCOs felt Remote Tower will induce more hazardous situations. **Results from the workshop are detailed in** Error! Reference source not found.**.** Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations.	OK
OBJ-06.09.03-VALP-0060.0012	To gather ATCO opinion on the level of service that can be supplied under a range of technical system options.	The requirement for the various technical enablers with respect to service levels provided is known for the scenarios experienced during the trial.	ATCOs feel that they can handle an increased traffic load in the Advanced System compared to Basic (thanks to the additional functionalities). When asked if Remote provision of ATS would increase the aerodrome capacity for GA traffic using the **Basic System**: o 11 out of 14 disagreed that it would increase capacity for GA; o 13 ATCOs disagreed with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR	OK

			traffic when provided ATS remotely (1 ATCO indecisive). When asked if Remote provision of ATS would increase the aerodrome capacity for GA traffic using the **Advanced System**: o 3 ATCOs agreed on the statement that capacity may be increased for GA traffic (6 disagree) o 3 ATCOs agreed with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (6 disagree). Most ATCOs only narrowly rated a local tower as being best for providing a service with Advanced system very close behind. For scenarios with only one aircraft the Advanced system rated higher compared to a local tower. The Basic system rated lowest when there was more than one simultaneous aircraft or vehicle movement. However ATCOs still felt they would be able to provide a service but it would place more demand on mental workload.	
OBJ-06.09.03-VALP-0060.0074	Obtain feedback relating to the remote provision on ATS on ATCO roles, responsibilities & task allocation	Trial feedback indicates that ATCO find the roles, responsibilities & task allocation acceptable.	Feedback from the trial indicated no major issues related to roles, responsibilities & task allocation. Some less critical feedback was obtained, mainly centred on issues such as direct MetObs collection, local influence and technical troubleshooting.	OK
OBJ-06.09.03-VALP-0060.0091	To assess the perceived capacity of the Remote Tower prototypes, relative to a local tower operation in terms of: • Time of day (daytime/CAVOK, night-time) Functionality of the prototype (Basic System, Advanced System)	The ATCO are able to provide feedback on what they perceive to be the relative capacity under various operating scenarios. The ATCO perceive that the remote provision of ATS does not have a significant impact on capacity.	ATCOs responded that they did not feel capacity would be *increased* when providing ATS remotely. However, an increase in capacity is not the aim; more that capacity is not negatively impacted. ATCOs felt that when using the Basic System, they would be able to conformably provide service to 1 movement at a time. Introducing a second or even third aircraft would be possible under some scenarios, but it would require much more mental workload and potentially degradation of quality of service to airspace users. They therefore perceive this system to have a lower capacity than a local tower. ATCOs felt that when using the Advanced System they would be able to comfortable provide service to the same number of aircraft as they would in a local tower. It was only for once specific scenario where ATCOs felt that capacity would be reduced (two aircraft closely following behind during darkness). This is countered by feedback from some scenarios suggesting slightly higher capacity when using the Advanced system along with its advanced functionalities but this was not statistically significant. The ATCOs therefore perceive the Advanced system to be at	OK

			least as good as the local system in both day time and night time hours.	
OBJ-06.09.03-VALP-0060.0022	Support the development of working methods & procedures for **normal situations** related to Visual Separation application, use of IR camera, and weather observations	The working methods & procedures for normal situations related to Visual Separation application, use of IR camera, and weather observations have been reviewed. The working methods & procedures for normal situations related to Visual Separation application are accepted or, where not, suitable suggestions for improvement have been identified.	ATCOs did not feel comfortable with applying visual separation in the Basic System. Thus, when using the Basic System vertical and procedural separations are to be remotely applied based on OTW displays, but reduced separation could not be applied. ATCOs felt more comfortable with the Advanced System but were still not comfortable with reduced separation. When asked, ATCOs reported the opinion that the main ground tasks that IR camera could support are: • identification of aircraft and vehicles on the ground; • detection and resolution of conflicts in the manoeuvring area; • runway related operations. The ATCOs commented that improvement is still needed in order to remotely perform the following weather related tasks: • Assessing weather conditions; • Assessing runway conditions	OK
OBJ-06.09.03-VALP-0060.0032	Support the development of working methods & procedures for **abnormal situations** potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft)	The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) have been reviewed. The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) are accepted or, where not, suitable suggestions for improvement have been identified.	**Results from the workshop are detailed in** Error! Reference source not found.**.** Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having accurate PTZ camera functionality and a 360˚ degree visual representation were included in ATCO feedback. PTZ camera functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars. The provision of a 360° degree visual representation was to enable the ATCO to maintain a continuous visual view of aircraft, and would be dependent on the traffic patterns at individual aerodromes.	NOK
OBJ-06.09.03-VALP-0060.0042	Support the development of working methods & procedures in **degraded mode situations** related to the failure of the visualisation system (black-out, frozen, corrupted information)	The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information) have been reviewed. The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted	Some degraded mode scenarios were simulated in the trial on an opportunistic basis, mainly related to screen failure or out of date MET information. The main proposed procedure was to revert to One Movement Mode in case of loss of visual reproduction. This mode is a replication of the commonly used Low visibility procedures (LVP) with regards to the ATCO tasks.	OK

		information) are accepted or, where not, suitable suggestions for improvement have been identified.	Other feedback included: • All ATCOs said there was a need to inform flight crews that the control is remote and that the ATCO has lost visual contact. • The ATCOs would like to see a system that always is able to generate alerts when there is a malfunction of any kind. And a back-up system should always be available at a "click of a button"; • A procedure for hand-over between ATCOs is needed.	
OBJ-06.09.03-VALP-0060.0080	To validate information and assumptions that will be used in any Business Case Transversal Assessments, relating to the Cost Effectiveness of Remote Provision of ATS to Single low to medium density airports	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.	The primary driver for Remote Provision of ATS is Cost Effectiveness. However, it was never the project's aim to prove this directly through validation trials. Rather, the trials were used to validate the assumption in the business case i.e. that it is operationally feasible to provide ATS from a remote location. Maintaining Operational Feasibility depends most on safety, human performance and capacity and so it is those areas that are further explored. Results show that the assumption was validated and information was provided to suggest that the concept was feasible.	OK

Table 22: Validation Objectives Analysis Status in this exercise

6.2.4 Conclusion and Recommendations

6.2.4.1 Conclusions

The main focus of VP-057 was on assessing the acceptability of the concept and HMI; Human Performance; Safety; and Capacity.

The trial indicated that the Remote Provision of ATS to a Single Aerodrome concept is viable and acceptable.

ATCOs rated the overall picture quality as very good. Feedback suggests a large improvement compared to VP-056 in terms of quality (definition) and frame rate. There are still some issues regarding the ability to judge depth, distance and separation using only the main visual reproduction. Procedural workarounds were suggested by the ATCOs for dealing with situations where depth and separation could not be accurately judged, primarily when using the Basic System. The Advanced system and the inclusion of radar surveillance and Advanced Visual Features overcame some of these issues. Feedback on the Advanced Visual Features (additional camera viewpoints and label overlays) was very positive from all ATCOs.

The feedback from the ATCOs suggested that the new PTZ camera requires further development. There were issues with the picture quality, particularly when zoomed in which impacted on the usefulness of the tool. In addition, the HMI for operating the PTZ was not considered successful by most ATCOs. These results were unexpected given the success and favourable reception of the PTZ camera in VP-056.

Not all ATCOs were able to test the IR camera during the trial due to a technical fault and/or lack of darkness. Feedback for this component was therefore limited. However, those who did use it or who were able to judge potential usefulness commented that it would be a very useful tool contributing to Situational Awareness.

Feedback on the CWP was generally positive and again, an improvement on VP-056. Likewise the feedback on the overall working environment was much improved compared to the previous trial with the majority of ATCOs finding it acceptable.

Situational Awareness was assessed throughout the trial and whilst no baseline measurements (local tower) were taken, scores corresponding to high SA were reported for all SASHA categories and as an average. The IR camera and Advanced Visual Features were noted specifically as contributors to good SA. There was a statistically significant difference between Basic system and Advanced System with ATCOs reporting significantly higher SA when using the Advanced System. Nearly all ATCOs stated that they would be able to detect hazards and conflicts using the systems.

ATCOs reported a good level of trust in the concept, and in particular when using the Advanced System. For the Basic System, ATCOs felt that they could understand the system but were less trusting of the reliability and robustness of the system and this had a negative impact on ATCOs' confidence when working with the system. For the Advanced System the results are much more positive. 100% of the ATCOs gave a positive response to the ability to understand the system and also to finding the system useful.

Further feedback was sought from the ATCOs regarding allocation of roles and responsibilities. No major concerns but mentioned but topics raised included: Weather (when in the remote facility it is not as easy to "feel" wind or identify type of precipitation); coordination with Approach under abnormal conditions (ATCO will, at the same time, be trying to technically trouble shoot as well as control); and geographic distance which might lead to changes in local influence.

Ability to provide a quality service to all airspace users was a concern raised following VP-056. In VP-057 the capacity of the system and ability of the ATCOs to provide a service to varying numbers and types of aircraft was assessed in more detail. Overall the feedback was much more positive with participants and observers seeing an obvious improvement due mainly to the increased picture quality and Advanced Visual Features. Of the range of scenarios assessed, most ATCOs only narrowly rated a local tower as being best for providing a service. The ability to provide service using Advanced System was very close behind mainly due to some slightly lower scores for one specific scenario (two aircraft following close behind during darkness). In fact, for scenarios with only one aircraft the Advanced System rated higher compared to a local tower. The Basic system rated lowest

when there was more than one simultaneous aircraft or vehicle movement. However ATCOs still felt they would be able to provide a service during all scenarios when using the Basic system – but it would be more mentally demanding and potentially more procedural intervention.

When considering the overall performance of the Basic system compared to the Advanced System the feedback suggested that the Basic system would be adequate for some aerodromes and/or scenarios if the additional mental workload that it involved was not a blocker. However, when aerodromes and/or scenarios became more complex, then the added value of the Advanced System became apparent due to traditional tools such as radar and newer enablers such as Advanced Visual Features.

When the results from VP-057 are compared to those from VP-056 it is obvious that progress has been made within the project and the concept and platform development. Even accounting for the differences in trial set up and participants it can be seen that many issues from VP-056 are no longer present and that the ATCOs have a concept and system that they think could be used to provide ATS.

In addition, the conduct of the trial was improved in VP-057 compared to VP-056, including:

- More rigorous and strict timetabling of trial sessions;
- More focus from participants when using the system (despite already known limitations of PSM);
- A more complex and informative trial design with different system configurations;
- The use of recorded scenarios to illustrate how the system would react in scenarios that were not otherwise observed by participants;
- More regular simulation of abnormal scenarios to generate discussion.

The stated aim of VP-057 was "*to build upon the technical and operational findings of EXE-06.09.03-VP-056 and address objectives and scenarios not already addressed or concluded upon in VP-056. The trial also looked at various technical configurations to gain an understanding of the different operational service levels possible using different technical enablers*". It can be concluded that the Trial achieved that aim.

6.2.4.2 Recommendations

The recommendations from VP-057 include the following:

- Recommendations for the Validation Planning:
  - Plan in a full shakedown to test trial timetable, scheduling and equipment;
  - Conduct the validation in a varied and representative set of conditions where possible e.g. include day time and darkness;
  - Maintain a structured timetable for the trial conduct in order to enforce rigour and promote quality of data collected;
  - Continue the use of recorded scenarios to present conditions and events that the ATCO may not otherwise encounter;
  - Potentially consider giving ATCOs more access over longer periods of time in order to negate (or at least understand) any learning effects;
  - Consider what validation techniques can add further value in future on top of the successes of this PSM Trial e.g. ASM;
- Recommendations for the Concept:
  - Continue development and support of the Advanced Visual Features (additional camera viewpoints and label overlays) given the strong positive feedback from this trial;
  - Consider elaborating on the notion of system variants in the OSED e.g. Basic System and Advanced System;

- Consider ways in which to overcome the on-going issues related to the ability of operators to judge distance, depth and separation, perhaps through the use of more technical enablers;

- Recommendations for the Trial Platform:
  - Resolve the issues with the PTZ camera – technical robustness, quality of image and HMI;
  - Get a better understanding of the overall system robustness given the stability issues with the PTZ and IR cameras operation (with the acceptance that this is a prototype trial platform).

6.3 Remote Provision of AFIS to a Single Aerodrome Trial 1 (EXE-06.09.03-VP-058) Report

6.3.1 Exercise Scope

The concept being addressed is the Remote Provision of ATS to a Single Aerodrome, as described in the OSED for Remote Provision of ATS, Section 3.1:

> *The full range of* Aerodrome Flight Information Services (AFIS) *defined by the EUROCONTROL Guidelines for AFIS will be provided. The airspace users will be provided with the appropriate level of services as if the AFIS were provided locally at Værøy. The AFISO will not be located at the aerodrome. They will be located at the RTC in Bodø.*
>
> *The Remote AFISO will perform AFIS tasks using the Remote Tower Module (RTM) in the Bodø Remote Tower Facility. The visual surveillance will be provided by a reproduction of the OTW view, by using visual information capture.*

The Remote Provision of AFIS to a Single Aerodrome was assessed firstly through PSM and secondly in ASM. The PSM part entailed the AFISO observing live traffic in a non-intrusive manner, not interacting with the aircraft or providing any service. The Advanced Mode required the AFISO to provide AFIS services to the aircraft as the AFISO-in-the-loop using the prototype system. The purpose of the first, PSM element of the exercise was to assess confidence and assurance among stakeholders that the system can be used for provision of ATS to live traffic during the second part of the trial. The ASM followed after the PSM, therefore there was an opportunity to familiarise the AFISO with the platform and indicate the confidence in providing AFIS from a Remote Tower to meet the regulator requirements in order to start providing AFIS in *partial* Advanced Mode (see section 6.3.2.1.2 for details).

This platform was built upon the validation platform used in EXE-06.09.03-VP-056 and of EXE-06.09.03-VP-057.

6.3.2 Conduct of Validation Exercise

6.3.2.1 Exercise Preparation

6.3.2.1.1 Passive Mode Exercises

Platform installation and configuration was a major task in preparing for the trial.

On top of a strategically placed mast at the Heliport (Værøy) 14 high definition cameras were placed, having a 360° visual view, which was presented on 55 inch LCD portrait monitors in the RTC at Bodø airport. View and sound from the Heliport was captured with digital video cameras and microphones. The actual airport systems, e.g. runway and taxi lights, were connected to the network with the relevant data displayed in the RTC. The CWP in the RTC included a presentation of all necessary systems e.g. flight plan, Met, airport lights, navigational aids, alarms, with interfaces to the airport.

Compared to VP-057 many technical features stayed the same while others changed slightly as follows:

- Technical features:
  - 14 high definition cameras, representing a 360^{o} view around the Heliport;
  - 14 55” screens, presented in portrait orientation;
  - Off-set rear screens showing view “behind” tower;
  - Picture processing and quality visual reproduction will be the same, with 30 frames per second;
  - Radar coverage to ground level, covering whole Traffic Information Zone (TIZ);
  - The same PTZ camera, with better operability;

- IR Camera;
- Visual Tracking, radar tracking plus combined tracking;
- Inclusion of an e-Strip system (manual activation of strips);
- Advanced Weather Observation System (AWOS).

- Technical Configuration – unlike VP-057, were there where different technical configurations – a single configuration was used. However, the AFISO chose to temporarily disable certain features from time to time (e.g. radar, advanced visual features) for the purposes of comparison. A mid-trial software upgrade was also performed during the PSM trials.

Figure 50: RTC Room

The RTC room was located at Bodø Airport and is pictured in Figure 50.

A separate visitor's room featured, relaying a live camera feed of the RTC in order to try and keep the trial environment "sterile" which was particularly important during ASM.

The CWP set-up for the AFIS trials is shown in Figure 51.

Figure 51: CWP Set-up

6.3.2.1.2 Advanced Mode Exercises

The technical setup remained static between PSM and ASM trials.

In order to proceed to the ASM trial, following the PSM, approval was granted through the Norwegian CAA (NCAA). Meetings and negotiations with the NCAA, Bodø ATCC and helicopter companies operating from Værøy Heliport enabled the trial to continue resulting in an “almost full AFIS” service being provided.

The full range of AFIS services could not be supplied by the Remote AFISO, the service provided was very close to the full complement of services but with a few differentiations. Bodø ATCC provided the FIS in Værøy TIZ but radar contact was made with the remote AFISO via “role-play” as agreed between the project and the airline, Lufttransport. Pilots had to work on two frequencies - the official frequency at Bodø and a remote frequency/Tabbisodden radio. The Remote AFISO provided MET and additional information to the aircraft on the remote frequency. At any point in the trial, Bodø ATCC or the pilot in command could stop the trial when necessary due to traffic. In this case, the radio communication between the RVT and the aircraft would be terminated.

6.3.2.2 Exercise Execution

6.3.2.2.1 Overall Execution

6.3.2.2.1.1 Airport Information (Værøy heliport/ENVR)

The remote services were provided to Værøy Heliport from Bodø Airport where Bodø ACC is also located. At Bodø the remote facility is housed in the terminal building in a former NCAA office.

Værøy heliport is in Røssnesvågen village, one mile south of the municipal centre of Sørland. Extremely strong and unpredictable winds on the island are common due to the steep mountains which led to the closure of the airport on the north of the island in 1992.

Locale:

- Værøy 748 inhabitants in 2011
- Bodø 47847 inhabitants in 2011

Airport Layout

- 67°39′16″N 012°43′37″E
- 85 km NW of Bodø
- 1 helipad FATO 03/21
- Runway 184 x 112ft
- Elevation 12ft/4m ASML
- 1388 movements at the Heliport and 10261 passengers in 2011

Airport Technologies

- FATO and TLOF 03/21 edge lights
- No NAVAIDs – closest is Roest VOR-DME

Airspace Characteristics

- Obstacles – 2ft retaining wall along NE edge of safety area
- TIZ Class G+
- Only serves one destination – Bodø

Procedures

- RNAV (GNSS) 027°

- RNAV (GNSS) 200°
- RNAV (GNSS) 267°

Air Traffic Services at Værøy (ENVR)

Except during testing, the following services were performed in Værøy TIZ:

- FIS/ Flight information service provided by Bodø ATCC sec N
- Alerting service
- METOBS service provided by dedicated MET observers at Værøy

The service is normally accomplished by one AFISO.

Figure 52 - Map showing Værøy (A) and Bodø (B)

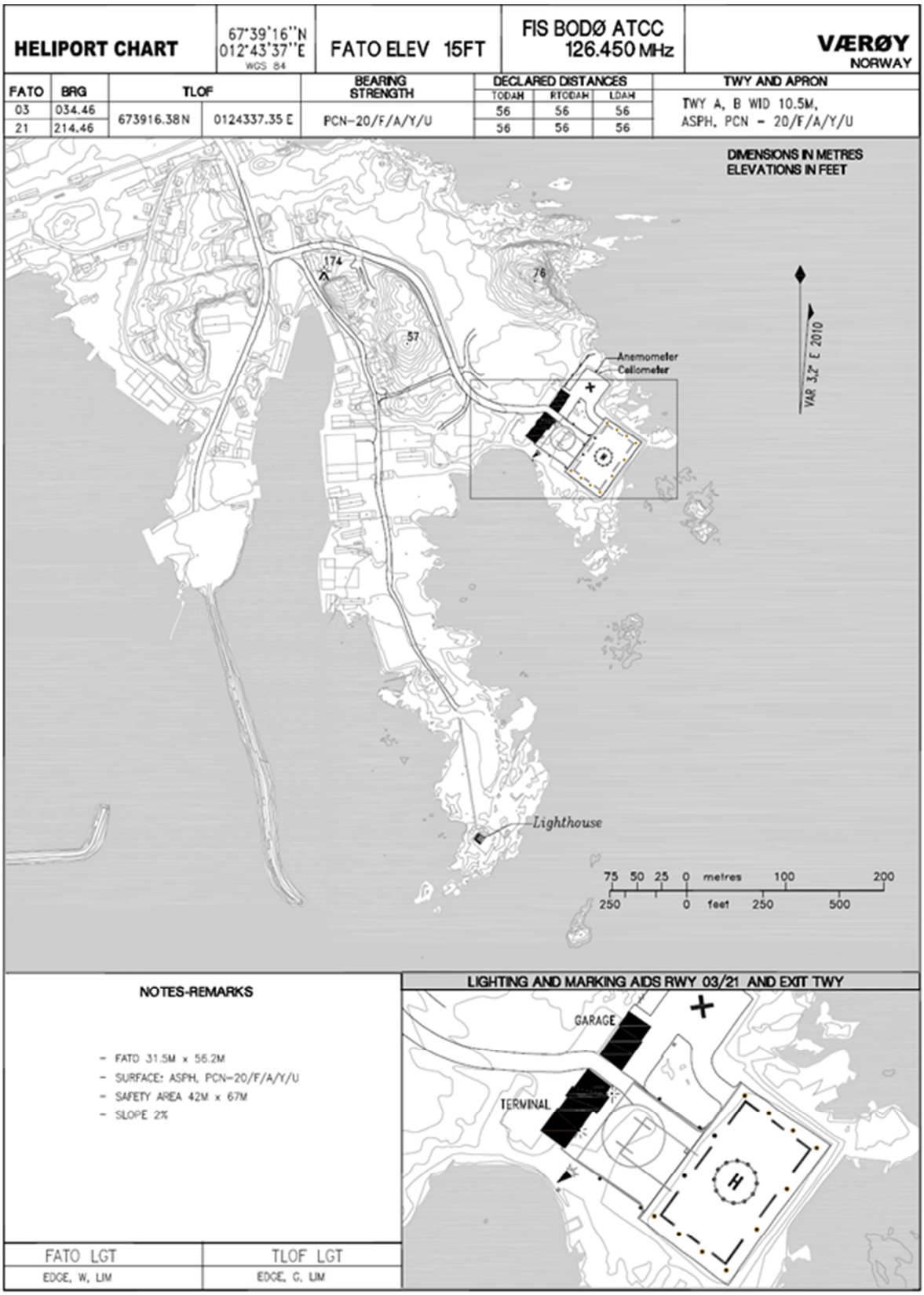


Figure 53 – Værøy Heliport Chart

6.3.2.2.1.2 Traffic Scenarios

Trial traffic operations:

- One local helicopter performed four daily flights in the CTR/below TMA and Værøy TIZ. During test hours, the Remote AFISO assumed responsibility of Værøy TIZ from Bodø ATCC;
- Only one aircraft allowed to operate with Værøy TIZ at one time, otherwise Bodø ATCC terminated exercise.

The Validation Scenario consisted of four scheduled helicopter flights a day (2 x return flights between Bodø and Værøy). AFIS service was provided by one person. Weather information was also provided to the aircraft.

6.3.2.2.1.3 Data collection

Data collected during the trial comprised of subjective feedback from “End of Session” and “End of Trial” AFISO questionnaires, observations made by experienced observers, AFISO comments, Pilot questionnaires and debrief material. Representatives from IVT were also present within this trial.

Subjective results are used in this report, where appropriate, to provide evidence supporting or contradicting the statistical conclusions from the quantitative data obtained in the questionnaires. Comments that are believed to be representative of the overall view or that are individually important are quoted.

6.3.2.2.2 Passive Shadow Mode Execution

6.3.2.2.2.1 Participants

The participants included a Tower AFISO who performed the majority of the runs, **and two retired ATCOs**.

6.3.2.2.2.2 Timetable

The timetable for the PSM trials is illustrated in Figure 54. The initial timetable comprised of morning shifts from 07:00 UTC to 11:00 UTC and afternoon shifts from 14:00 to 17:00. However, the participants were present at the sessions all day.

Week	Beginning	M	T	W	T	F	S	S
48	26-Nov	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*		
49	03-Dec	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*	*AM*		
50	10-Dec	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*	*AM*		
51	17-Dec	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*	*AM*		
52	24-Dec							
1	31-Dec							
2	07-Jan	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*	*AM*		
3	14-Jan	*AM/PM*	*AM/PM*	*AM/PM*	*AM/PM*	*AM*		

Dry Run
Passive
Closed

Figure 54: PSM Trial Timetable

6.3.2.2.3 Advanced Shadow Mode Execution

6.3.2.2.3.1 Participants

The same Tower AFISO that participated in the PSM Trial participated in the ASM Trial. This enabled results to be stable and kept training time and resources to a minimum. **No other participants were involved providing the live service** in ASM.

6.3.2.2.3.2 Timetable

Week	Beginning	M	T	W	T	F	S	S
4	21-Jan	AM/PM	AM/PM	AM/PM	AM/PM	AM		
5	28-Jan	AM/PM	AM/PM	AM/PM	AM/PM	AM		
6	04-Feb							
7	11-Feb				AM	AM		
8	18-Feb	AM/PM	AM/PM	AM/PM	AM/PM	AM		
9	25-Feb	AM/PM	AM/PM	AM/PM	AM/PM	AM		
10	04-Mar	AM/PM	AM/PM	AM/PM	AM/PM	AM		
11	11-Mar	AM/PM	AM/PM	AM/PM	AM/PM	AM		

Advanced
Closed

Figure 55: ASM Trial Timetable

6.3.2.3 Deviation from the planned activities

6.3.2.3.1 Operational

The timetable was revised to include two more weeks of PSM instead of ASM trials (Week 2 and 3).

Unfortunately the full range of services provided by the AFISO could not be fulfilled as initially stated for the ASM Trial, amendments which are stated in Section 6.3.2.1, above.

6.3.2.3.2 Technical

There were several technical issues throughout:

- **VCS**: There were problems with the VCS Setup. AFISOs complained that it was hard to hear on the telephone and the radio due to feedback, interference and the fact that no split function was available. In addition, the loudspeaker was malfunctioning
- **FDP:** The FDP was not tested as there was a late AFTN connection the FDP was not compatible with the flight plan system or the e-Strip. Weather information provided using online weather source.
- **Radar tracking:** The tracking labels were usable outside 10NM/DME but inside 10NM from Værøy the labels were “jumping” and unstable.
- **Lights:** The exposure time of the camera was too long when using the heli-light/aerodrome beacons. The lights were only visible intermittently. Regarding the signal light gun the red light appeared “blinking” when it should have been steady.
- **Emergency button:** This could not be tested as it was not linked up.
- **RDP:** Partially tested, as technically not fully ready. Vector function not working with pen, only with mouse.
- **Compressor** *(Powering the supply of air to the windblades):* The compressor stopped on numerous occasions without any indication due to power cuts at Værøy. The compressor could not be re-started from the RVT. The Remote AFISO had to call Værøy. In addition “exhaust from the compressor” blew onto the lens obscuring them. However, filters were added to the compressor air exhausts. The Compressor blades were also out of position resulting in the airflow over the cameras not being distributed properly in order to clear the camera lenses.
- **Windblades** *(Distributes air flow over the camera lens window aka windknives):* Windblades were out of position and hence were not distributing air optimally to clear obstructions (e.g. snow) from the camera windows.
- **PTZ and IR:** The PTZ and IR camera were not aligned with the horizon on the OTW.

- **Messages:** There were messages at the bottom on the screen about “corrupt windows”. These messages appeared on the OTW and informed the AFISO that certain data was corrupt.
- **Snow and sea salt**: Snow covered the OTW view on some screens. The windscreen compressor air managed to wipe off some of the snow but this had to be facilitated by aerodrome staff that had to help remove the remaining snow. Sea spray also contributed to impairing the view.
- **AWOS**: The sensor for visibility was out of service. The RVR sensor was too close to the sea and got blocked by the salt in the sea water. This blocked the sensor and made the readings unreliable.
- **Replay**: Replay of recorded scenarios was not functioning. The replay jumped and the picture and sound were operating sporadically.

6.3.2.3.3 Platform updates mid-trial

At the end of January some cameras were relocated to different positions, this was so that the helicopters could be clearly seen landing and so that a camera wouldn’t be obscured by a planned new building. In addition, there was a software update in December which updated the quality of the OTW as well as the addition of two new screens. The OTW view on screen 6 and 8 had different glass than the rest of the screens in the RTM (anti-reflect/optical glass). There was an update to change screen 3 and 4 to this new glass.

The video tracking was also masked below the horizon; an update was issued to resolve this.

6.3.3 Exercise Results

6.3.3.1 Summary of Exercise Results

Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
OBJ-06.09.03-VALP-0060.0013	Gain feedback on the technical capability of the Remote AFIS Platform and its systems.	The trial has facilitated the gathering of technical capability feedback; The AFISO indicates satisfactory workings of the technical platform and its systems. The technical platform has been assessed and works optimally.	Failure of the compressor and incorrect positioning of compressor blades caused reduced/poor OTW visibility. Otherwise no issues with MET observations. Communications rated negatively. The AFISO answered "no" in response to if the system was safe and comfortable in the AFISO acceptance rating. Some parts of the technical system contributed to reducing workload. Technical problems with specific functions increased workload. The VCS received reduced technical capability scores due to poor functionality.
OBJ-06.09.03-VALP-0060.0014	All the participants (Bodø TWR, Bodø ATCC, Værøy – personnel, technicians, operators, pilots and the Royal Norwegian Air Force (RNoAF) in the trial are fully aware of all the relevant procedures and have been either trained or briefed prior to entering ASM.	The trial participants have shown full understanding of the relevant procedures prior to entering ASM.	Briefings and training sessions were completed. The AFISO answered "yes" to being prepared to use the (PSM) system in an ASM trial to provide service to aircraft. Experienced observers and members of the validation team were also monitoring the AFISO's ability and competence using the system tools. Letters of agreement were signed for approval of the trial conduct and associated techniques/methods used
OBJ-06.09.03-VALP-0060.0017 *(N.B. this objective was added during the trial itself)*	Gain feedback from the airspace users relating to: • Communication , quality, consistency, problems experienced; • Surveillance, clearances received," trust in the system", separation; • Flight Safety, conditions observed, but not reported by ATC (birds, objects in the FATO area etc.);	The airspace users interviewed during the trial find the concept acceptable and state a willingness to use such a service.	Positive feedback obtained from pilots indicated that the RVT *"strongly contributes to improving the level of service to and from Værøy".* In relation to level of service 90% of all responses indicated a positive opinion. 3 out of 5 pilots agreed and 2 out of 5 strongly agreed that the level of service received via the remote tower concept was at least the same as would be received from a local aerodrome tower. Communication, information provision, co-ordination and accuracy of MET were all rated by pilots a being acceptable.

	• General impression.		
OBJ-06.09.03-VALP-0060.0015	To assess, during **Passive Mode**, the range of AFIS functions that could be performed, including: • The visual surveillance of the aerodrome and vicinity of the aerodrome area, in any weather condition. • Providing information to aircraft based on the remote MET observation. • Assess the confidence the AFISO has in the accuracy of the MET observation.	The Remote AFISO indicates that they could perform a sufficient range of functions and tasks using the platform, to provide live service to the aircraft. Sufficient feedback has been gathered and the AFISO indicates that the MET observations are accurate	The AFISOs were able to maintain visual surveillance in any weather and provide MET to aircraft. 85% of AFISO responses within PSM trials indicated they could "very accurately" judge the MET conditions (78% during ASM trials). The IR camera was able to detect weather including showers in the vicinity, providing the AFISOs with more information than they were used to. With the help of the AWOS information and the OTW the AFISOs had confidence in the accuracy of the MET information. Overall the AFISO was neutral on the system's ability to provide accurate MET information giving it a rating of "neither agree nor disagree".
OBJ-06.09.03-VALP-0060.0016	To gather AFISO opinion, during **Passive Mode**, on the level of service that can be provided under the current technical configuration to a single aerodrome.	The requirement for the various technical enablers with respect to service levels provided is known for the scenarios experienced during the trial.	The AFISOs stated the level of service provision would be the same as in local operations. The IR and PTZ cameras were rated as **improving service.** The lack of physical judgement of weather **reducing service** the most, however if ever in doubt local personnel can be contacted to confirm conditions. The average acceptance for **all** functions was 78% "strongly agree" or "agree".
OBJ-06.09.03-VALP-0060.0022	Support the development of working methods & procedures for normal situations related to Visual Meteorological Conditions (VMC) conditions, use of IR camera, and weather observations.	The working methods & procedures for normal situations related to VMC conditions, use of IR camera, and weather observations have been tested. The working methods & procedures for normal situations related to VMC conditions are accepted or, where not, suitable suggestions for improvement have been identified.	The ASM AFISO was able to perform all AFIS tasks and functions necessary. The ASM AFISO "strongly agreed" that the working methods for normal situations relating to VMC, the use of IR camera and the observation of weather in normal conditions were **acceptable.** Suggestions to enhance the procedures and working practices included; **Basic training days locally to improve knowledge**.
OBJ-06.09.03-VALP-0060.0023	Obtain feedback on the safety, under normal conditions, of the Remote AFIS **Concept** during the **Advanced Mode.**	The trial has facilitated the gathering of safety feedback by the AFISO.	The safety feedback suggested the remote tower was the same as a local tower in terms of the **concept,** however currently the **technical system** does not provide adequate safety standards. Under normal conditions (*safety not tested for abnormal or degraded mode operations*), the ASM AFISO "strongly agreed" that **the Remote AFIS concept was safe**. The main operational risk was the OTW viewing angle and need to improve the VCS. Hazard detection was either not impacted or improved by advanced features for both aircraft in the air and on the ground in both limited and good

			visibilities. Pilots' feedback was positive, stating the RVT strongly contributed to improving information and safety.
OBJ-06.09.03-VALP-0060.0032	Support the development of working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft)	The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) have been tested. The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) are accepted or, where not, suitable suggestions for improvement have been identified.	**Results from the workshop are detailed in** Error! Reference source not found.**.** Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having an accurate PTZ camera functionality and a 360° visual representation were included in ATCO feedback. PTZ camera functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars. The provision of a 360° visual representation was to enable the ATCO to maintain a continuous visual view of aircraft, and would be dependent on the traffic patterns at individual aerodromes.
OBJ-06.09.03-VALP-0060.0042	Support the development of working methods & procedures in degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information)	The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information) have been tested. The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information) are accepted or, where not, suitable suggestions for improvement have been identified.	Working methods for degraded operations did not rate as highly, with the AFISO neither agreeing nor disagreeing with their acceptance when questioned. Various unusual/unexpected events occurred throughout the trials which were not "scripted" or structured. These included: Power cuts at Værøy; Problems with the VCS; Screen blackouts; Compressor blades (and therefore means to clean the lens via distribution of airflow over the lens) was out of position, resulting in snow blocking the OTW, which required local intervention; Bearing in mind the AFISO was faced with numerous technical problems, the AFISO was still able to perform almost all necessary AFIS tasks.
OBJ-06.09.03-VALP-0060.0052	Assess the utility of the Remote AFIS Concept, by determining its impact on: • the human performance, in particular in terms of situational awareness; • the working methods and procedures, in particular for visual assessment of the	The trial has facilitated the gathering of feedback; The concept does not have a negative impact on safety and human performance.	Situational awareness was at a high level throughout. **SASHA scores were 5.4 (average)** and did not drop below 4. The AFISO scored highest in "feeling ahead of the traffic" and "not having to search". The PTZ and IR camera most contributed to increasing situational awareness. The AFISOs also said that after software updates and when coupled with the PTZ and IR cameras, the OTW became very sharp allowing for a high degree of detail to be seen. There is potential for the visual representation, with the help of technical enablers to aid the real-life OTW. Some technical features decreased situational awareness for

	aerodrome area.		example the Tracking Overlay which was jumping and unstable within 10NM of Værøy.
OBJ-06.09.03-VALP-0060.0063	To assess the impact of the Remote AFIS Concept on AFISO Human Performance during **Passive Mode** in all weather and visibility (including daylight and darkness) conditions: I. Situation awareness II. Trust	AFIS situation awareness must be shown to be within acceptable limits (the value of the 'acceptable limits' will be defined with regard to the tool(s) employed to assess situation awareness). The Remote AFISO is able to detect potential conflicts, hazardous situations and other events that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas. AFISOs reported level of trust must be shown to be acceptable.	SASHA results were very positive. On average PSM situational awareness was 5 out of 6. Scoring highest "in feeling ahead of the traffic" and "not having to search". The lowest score given was 3 out of 6 on one occasion for "ability to plan". AFISOs mentioned you can obtain a more detailed focus on the surroundings with the advanced visual features. In daylight, the detail and focus was stated to be the same or **better than in a local tower**. The positive feedback regarding situational awareness was mentioned in both good visibility and limited visibility. All the ATCOs said the system is: • "very often" **understandable and accurat**e; • "always" or "very often" **confident, reliable and useful;** • two AFISOs said it is "often" **robus**t.
OBJ-06.09.03-VALP-0060.0064	To assess the impact of the Remote AFIS Concept on AFISO Human Performance during **Advanced Mode** in all weather and visibility (including daylight and darkness) conditions : I. Situation awareness II. Trust III. Workload	AFISO situation awareness is within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment). The Remote AFISO is able to detect potential conflicts, hazardous situations that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. AFISOs reported level of trust must be shown to be acceptable. AFISO Level of workload is within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).	Situational awareness scored highly in the SASHA results equating to "very often" being able to maintain situational awareness. The **trust for the ASM trial was acceptable, SATI average 5.2 out of 6.** Average SATI 5.5 out of 6 for; useful, reliable, accurate, understandable and confident. The most trusted technical systems mentioned were the IR, PTZ, OTW and the aerodrome sound (important for situational awareness). The VCS caused many problems for the AFISO and was highlighted as the least trusted operational system. Overall workload was shown to be acceptable in all weather conditions and visibility. The lowest workload was in how mentally demanding the task was, and how rushed the pace of the task was. The **average NASA TLX score was 0.8 out of 10**, indicating a very low workload.
OBJ-06.09.03-	Assess the acceptability of the Remote AFIS prototype for AFISO, in	The Remote Provision of ATS to a single aerodrome concept, is	**Visual Reproduction:** 88% of responses within the end of trial questionnaires indicating acceptance overall, with a need for more

VALP-0060.0075	terms of: • The prototype in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	usable/acceptable to the ATCO in terms of: • The prototype in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	filters and adjustments to OTW angle. **PTZ Camera HMI**: 75% acceptance. Easy to use although the HMI could be improved. **IR camera:** 85% acceptance. No negative feedback. **Tracking Labels:** 90% acceptance. Labels malfunctioning within 10NM of the aerodrome. **CWP HMI:** 73% acceptance in PSM trials and 25% in ASM trials. Rated least favourably throughout trials. The AFISOs felt the letters on the CWP systems were too small. **Working Environment:** 62% acceptance. Not always ideal conditions.
OBJ-06.09.03-VALP-0060.0076	Gain feedback into the impact of the Remote Provision of AFIS on AFISO roles tasks & responsibilities.	The trial has facilitated the gathering of feedback, relating to the impact of remote tower ops on AFISO roles, tasks & responsibilities'. The operators find the proposed their current roles tasks & responsibilities to be clear and acceptable to them. Feedback has been gathered where the roles and responsibilities could be improved if necessary.	The ASM AFISO said that the AFISO remote tower tasks, **roles and responsibilities were clear and acceptable**. The AFISO also commented that there was **no difference between the roles, tasks or responsibilities t**hat were provided when located remotely compared to when they were located locally.
OBJ-06.09.03-VALP-0060.0103	To gather feedback of the operability ,usability and utility of the various technical features for Remote Provision of ATS to a single aerodrome, including PTZ Camera, Radar, Advanced Visual Features etc.	The requirement for the various technical enablers with respect to service levels provided is known for the scenarios experienced during the trial. The usability and operability of the Remote Provision platform of AFIS to a single aerodrome is acceptable, i.e. the system is user friendly	**The operability, usability and utility of technical features scored highly, although improvement required.** **OTW** all displays and e-strip (manual use only) were used 100% of the time. **PTZ** camera was found to be easy and intuitive to use. **IR** camera gave AFISOs information regarding weather. Used to assess cloud base, consistency in the dark and to scan FATO for obstacles. **Radar** contributed the most to reducing workload in ASM trials. **Tracking** scored highly on usefulness, although not intuitive. Compensated for the "cone of silence." **FDP** was useful but over complicated (not fully tested as not currently fully compatible). **Filters** were deemed important for a usable OTW. **Sound** increased perceived situational awareness. **AWOS** useful; technical issues limited assessment.

OBJ-06.09.03-VALP-0060.0104	Gain feedback on Communication facility utility, usability and acceptability in the Remote Tower platform during **Passive Mode**, including: • Communication with Værøy personnel through radio • Communication with Værøy personnel through telephone • Internal and External communication in case of an emergency	The trial has facilitated the gathering of communication feedback, the AFIS indicates having confidence in the communication facilities and systems during normal and abnormal operations.	100% of the time the AFISOs rated that it was “Very easy” to communicate with Værøy personnel through radio. The PSM AFISO rated all forms of communication with Værøy (radio and telephone) and co-ordination with Bodø ACC a “very easy”.
OBJ-06.09.03-VALP-0060.0105	Assess the Communication facility utility, usability and acceptability in the Remote Tower platform during **Advanced Mode**, including: • Communication with Værøy personnel through radio • Communication with Værøy personnel through telephone • Internal and External communication in case of an emergency	The trial has facilitated the gathering of communication feedback, the AFIS indicates having confidence in the communication facilities and systems during normal and abnormal operations.	Below average (2.5) technical capability scores (2 out of 5 = disagreement) for communications with: Værøy personnel through radio and telephone and emergency communications. The VCS suffered from interference, feedback and there was an issue that there was no split function as the AFISOs are used to. The telephone absorbed and amplified any noise in the room which was a safety risk. Deficiencies with the VCS made it hard for the AFISO to perform their function which resulted in a move to co-ordination via mobile telephone, this being highlighted as a safety. Results from the workshop investigating abnormal situations are detailed in **Error! Reference source not found.**.

Table 23: Summary Exercise Results

6.3.3.1.1 Acceptability

6.3.3.1.1.1 Acceptance of Technical System and Component Parts

6.3.3.1.1.1.1 Functions

The AFISO was asked to state which functions were used during each exercise within both shadow mode trials. In total seven runs were included for PSM and 20 for ASM trials. The percentage of use for each function was calculated. The visual displays (both front and rear), PTZ camera and E-Strips were used 100% of the time in both trials. The use of other functions was distributed differently between the trials, although this is influenced primarily by the number of runs within each trial.

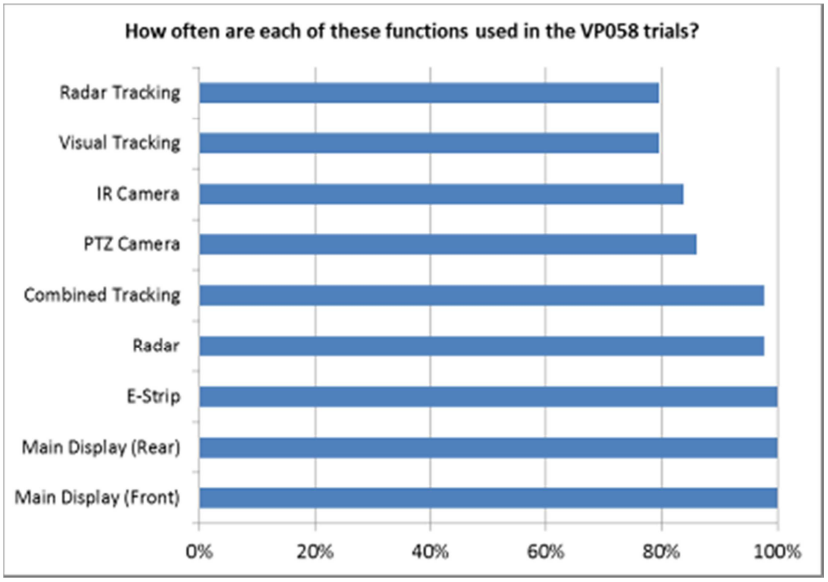


Figure 56: Advanced Visual Feature and Function use throughout trial

The acceptance of functions within the trials was generally very high as shown in Figure 57.

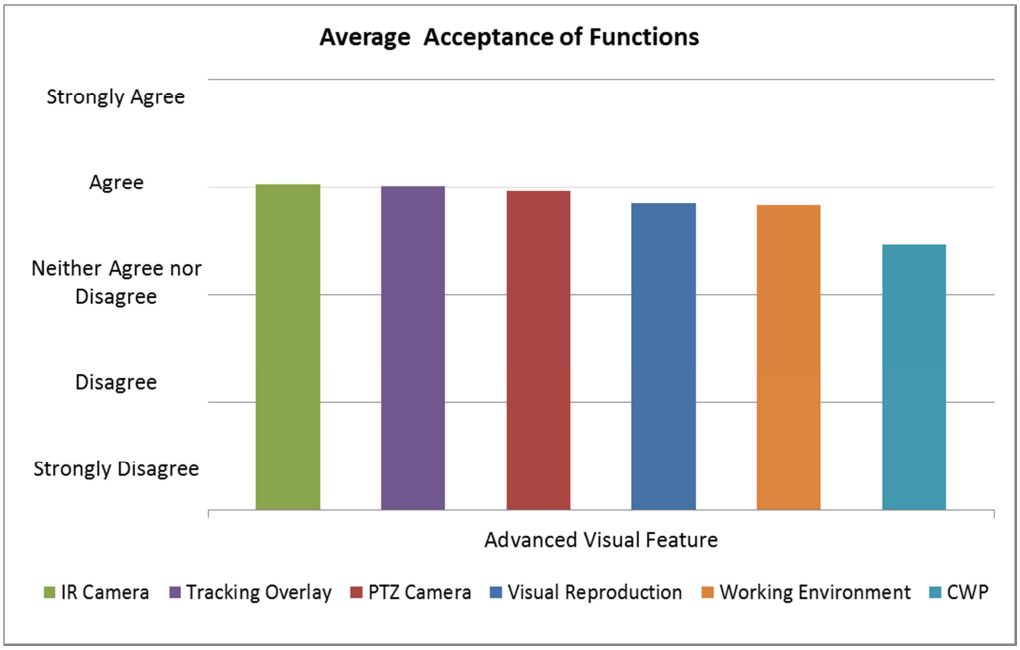


Figure 57: Average feature Acceptance

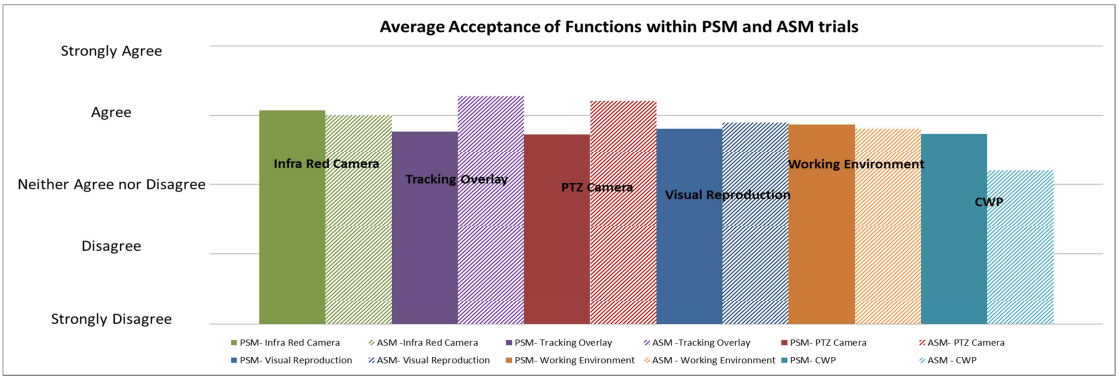


Figure 58: Acceptance of visual systems within PSM and ASM trials

All acceptance levels were scored from strongly disagree to strongly agree with analysis using a score of 5 to indicate the most positive response (strongly agree) and a score of 1 to indicate the most negative response (strongly disagree).

The IR camera and tracking overlays had the highest acceptability throughout EXE-06.09.03-VP-058, with acceptance levels of 4.03 and 4.02 (out of 5) respectively. The CWP had the lowest level of acceptance at 3.47. However the average score of all other functions (excluding CWP) was 3.94, which indicates an extremely high overall acceptability. This high level of acceptance for the IR camera was particularly impressive as the AFISO commented that the camera was not used to its full potential all the time; “The IR camera was mainly used to scan FATO, movement and safety areas, but it is useful when observing weather, showers, CB, except in visibility less than 1000-1500 meters with a vertical visibility of 500ft”. Both advanced visual feature cameras (PTZ and IR) also were not optimally aligned to the horizon in the AFISOs opinion, yet despite were scored as highly acceptable.

The AFISOs CWP slightly lower average score was heavily impacted by the low level of acceptance given with ASM trials.

Function	Variation between ASM and PSM (%)
Visual Reproduction	2%
PTZ Camera	13%
IR Camera	-2%
Tracking Overlay	13%
CWP	-14%
Working Environment	-2%

Table 24: Showing the difference in acceptability scores between ASM and PSM

Ideally between the PSM and ASM trials results should have no change or should improve, however this was not uniformly found with the acceptability scores for IR camera, CWP and working environment decreasing in their acceptability scores. Table 25 shows the total level of agreement/ disagreement for all functions:

- ***Agreement* =** responses of agree and strongly agree;
- ***Disagreement* =** responses of disagree and strongly disagree.

Acceptance of the…	Agreement	Neither	Disagreement
Visual Reproduction	88%	6%	6%
PTZ Camera	75%	23%	3%
IR Camera	86%	7%	7%
Tracking Overlay	90%	8%	2%
CWP	49%	32%	19%
Working Environment	62%	19%	19%

Table 25: Average overall acceptability scores for Advanced Visual Features showing level of agreement

The results throughout the trial, for both acceptability and human performance, may have been impacted by external factors within the working environment of the RTM (discussed in section 6.3.3.1.2.5). Result may have also been impacted by problems experienced with the voice communication system (VCS) the AFISO was impacted by this, commenting “it was hard to hear on the telephone and the radio due to feedback and interference and no split function available”. Deficiencies with the VCS made it hard for the AFISO to perform their function which resulted in a move to co-ordination via telephone; this being highlighted as a safety issue. This issue was commented upon multiple times through the end of session questionnaires and was highlighted as an area of improvement.

Also reductions in acceptance level between ASM and PSM trials may be related to the extended period of the ASM trial when compared to the PSM trial. With the ASM trial commencing after the PSM trial the AFISO was more familiar with the advanced features and RVT set-up and would have been more able to critically judge its performance. Decreases in acceptance between the PSM and ASM trial therefore do not raise a great concern.

6.3.3.1.1.1.2 System

The high overall acceptance of technical features should be considered in the context of the overall low technical capability score given for the ASM trial. To test the level of concept acceptance the AFISO was asked to fill in the following flow diagram as shown in Figure 59 below. The diagram allows the participant to answer questions that will lead to one, two or three statements of which then they choose which one they agree most with. These answers represent if the system needs improvement, and if it does, to what degree and how the AFISO will be affected if the system was to be put into operation as it is.

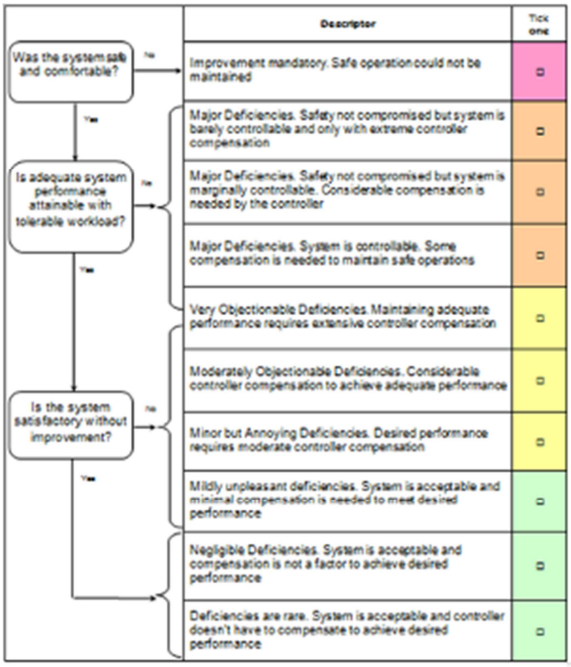


Figure 59: AFISO Acceptance Rating Scale Flow Diagram

For the ASM trial the AFISO rated the system with an acceptance score of 1, the lowest possible score. However, this score was coupled with the following comment:

> *“Reason for answer…is due to the problems with: the VCS-unable/hard to hear on the telephone and radio, feedback/interference, no split-function. We did not test the FDP and E-strip as planned. Late AFTN-connection, but FDP weren`t compatible with FPL2012... SESAR should have known about it. Aeronautical Information Management (AIM) track not tested. Helicopters climb to 70 or 100 feet before deciding if they will continue the flight, before the helicopters reach 70 FT they are outside the OTW angle, should the video tower be removed or will the AIM track be developed to take care of this. ATS shall see the flight during*

landing/departure, on the manoeuvring area, in the circuit/vicinity of the aerodrome, ref ICAO DOC 4444."

On average the technical capability was rated highly throughout the trial, with lower scores for communications and accuracy of MET observations during the ASM trial for technical reasons. The AFISO judged that MET could be very accurately judged in 78% of sessions within the ASM trial and 86% of sessions within the PSM trial. The remaining sessions all deemed that MET could be judged quite accurately. Despite this, the technical capability of the concept to provide accurate MET was marked down within ASM trials due to its inability to robustly function.

The overall system usability score was also high, however the need to learn more information before working with the system was rated as 3 (neither agree nor disagree). Positive results show the AFISO felt the system was quick to learn, consistent and easy to use.

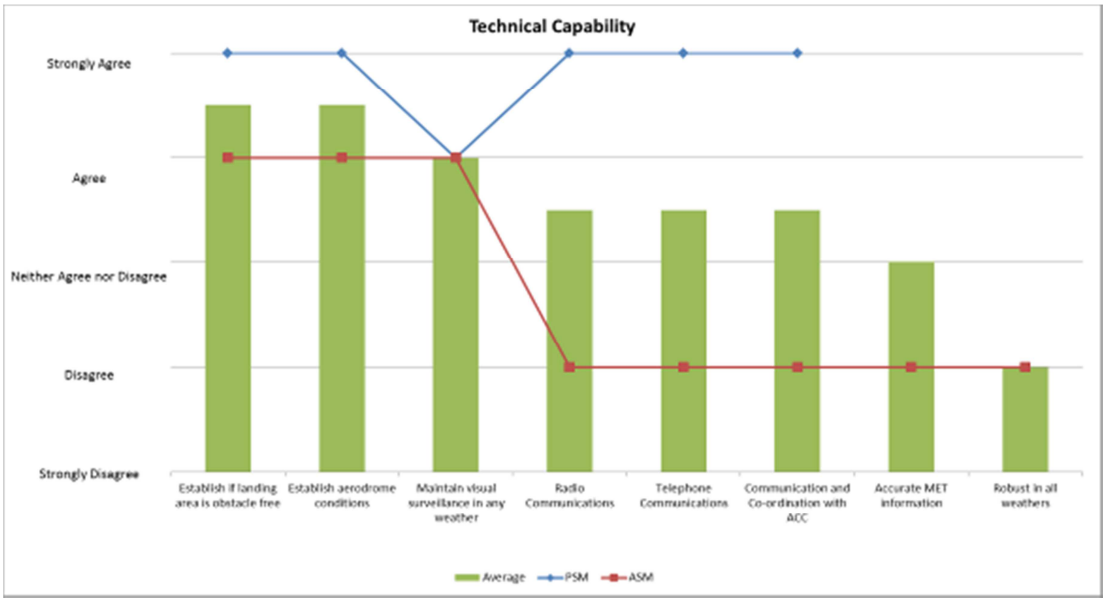


Figure 60: Technical Capability rating

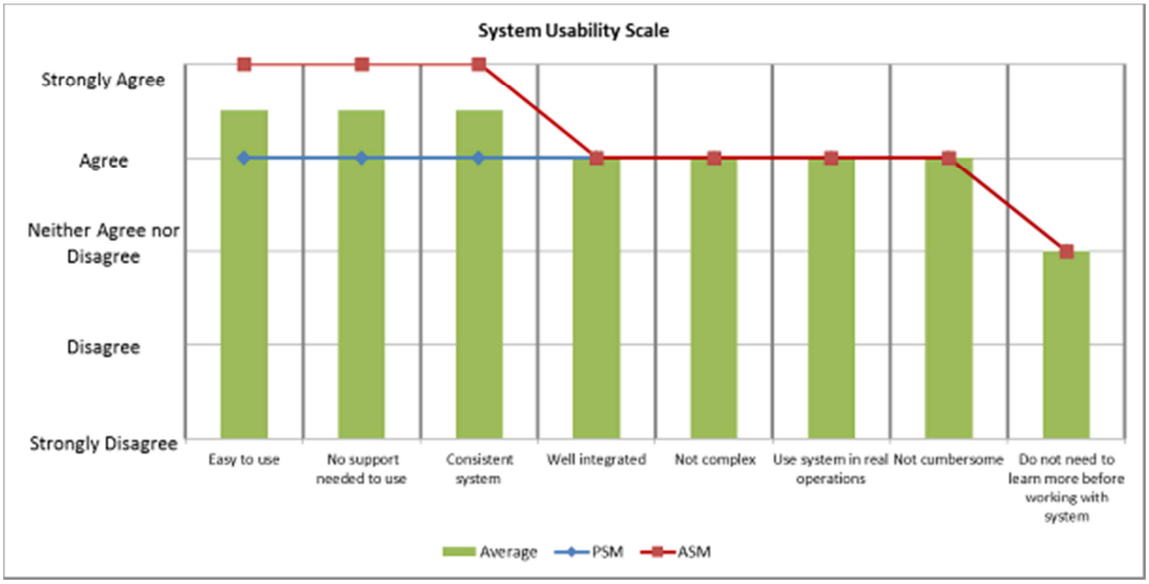


Figure 61: System Usability Scale

6.3.3.1.1.2 Visual Reproduction

6.3.3.1.1.2.1 Resolution

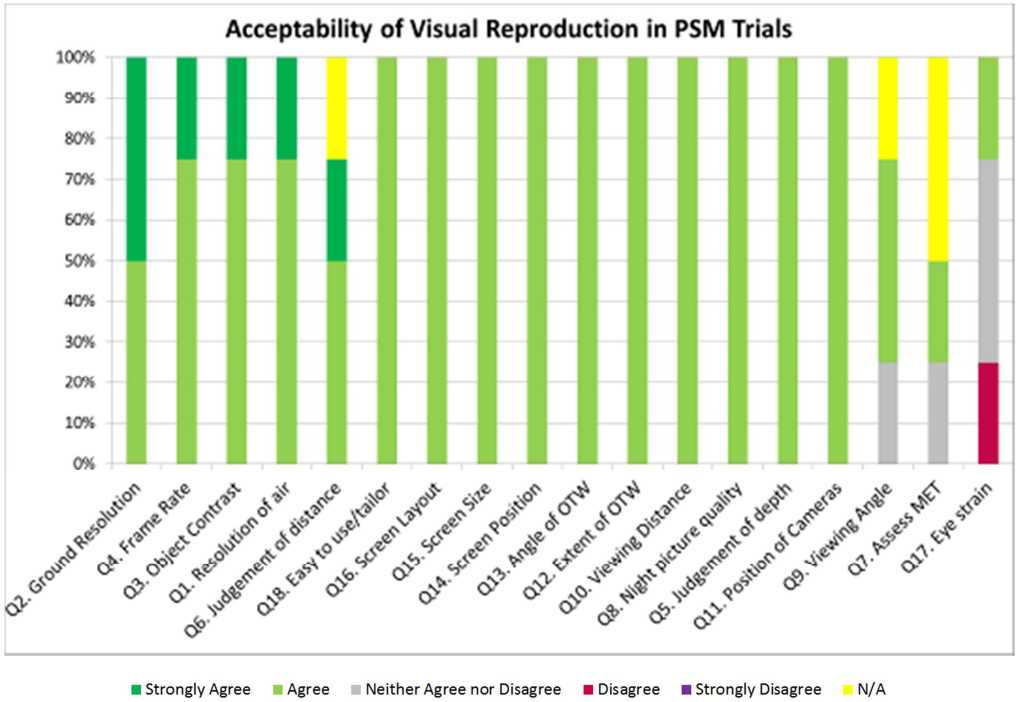


Figure 62: Visual Reproduction Acceptance for PSM Trials

Q7	I was able to assess weather and met conditions (including cloud ceiling) using the visual reproduction.	**Q8**	The picture quality during night time was as good as during daylight hours.
Q15	The screen size used in the trial was adequate.	**Q9**	The viewing angle between myself and the screens was acceptable.
Q16	The screen layout used in the trial (several screens, joined together, with frame seams) was acceptable.	**Q10**	The viewing distance between myself and the screens was acceptable.
Q1	The resolution of the visual reproduction was sufficient for airborne movements.	**Q12**	The range and extent of the aerodrome OTW view captured by the cameras was acceptable.
Q2	The resolution of the visual reproduction was sufficient for ground movements.	**Q18**	The configuration of the visual reproduction was easy to use and tailor to my own preferences.
Q3	The contrast between objects / areas was acceptable.	**Q14**	The position of the screens in the Remote Tower Trial was acceptable.
Q4	The frame rate used was sufficient to provide ATS.	**Q17**	Using the visual reproduction for an extended period of time did not cause eye strain and/or other physical strains.
Q5	I was able to judge depth sufficiently using the visual reproduction.	**Q11**	The position of the cameras at the aerodrome was acceptable and sufficient.
Q6	I was able to assess distance using the visual reproduction.	**Q13**	The angle of the aerodrome OTW view captured by the cameras was acceptable.

Strongly Agree Agree Neither agree nor Disagree Disagree Strongly Disagree

Table 26: Full Questions relating to visual representation, corresponding to colour coded ASM responses and questions posed relating to Figure 62 above

The AFISO scores corresponded to an 83% acceptance level within ASM trials (agree or strongly agree), with the only areas of low acceptance being related to camera position, the viewing angle of the OTW provided and potential health and safety issues relating to eye strain, with the AFISO commenting "*Eyes felt very dry in the RVT side, it is hard when using contact lenses, otherwise no problem"*, this comment being substantiated by various visitors.

Overall the acceptance scores relate well to the comments of the AFISO, however comments do highlight areas of criticism that were not reflected in the scores the AFISO gave in the quantitative questionnaire.

The comments relating to general safety issues were due to undetected or invisible areas with the visual representation, meaning the AFISO was unable to detect helicopters by sound or sight within a certain area. The AFISO stated *"The angle of the OTW is too narrow and the cone of silence is too wide. When helicopters depart they disappear into the cone of silence"*. Another safety issue arose as the flashing beacon could not be properly seen using the OTW possibly due to the exposure time rate. This led the AFISO to unintentionally pass false information to pilots regarding the beacons status. "*The aerodrome beacon can be seen by personnel at Værøy but only a few flashes are visual from the RVT. The OTW doesn't manage to update with the flash. It is confusing for me as RVT AFIS as I gave info to the pilots regarding the heli-light being out of service when it's not".* However the impact of these errors was not enough to degrade the rating for frame rate, as Q4, in Table 26 above, indicates the AFISO agreed that frame rate was sufficient for the provision of ATS.

There was a need for **more filters on aerodrome cameras to filter sunlight**, "*A few times two filters were too little against the sun. FATO and Apron also got too dark sometimes when it was sunny, and there was snow outside the movement area. I could hardly see helicopter/persons when only using the OTW in the mentioned conditions".* A further comment within the end of session questionnaires indicated this impact the AFISOs' ability to view the movement area.

The screens, although rated highly for resolution of air and ground movements (Q1 and Q2 agree) were given comments regarding the appearance of different resolutions. During one session the AFISO mentioned "*when monitoring the clouds in the OTW screens 1-4, they appeared animated/ pixelated being made up of multiple small squares but looking at the clouds in the OTW screens 5-9 they appear to look more realistic*".

The end of trial questionnaire also gave some insight with the comments below helping to more fully explain the result for Q11 and Q13, corresponding to a low acceptance for camera position and OTE view;

- "I could not see the whole departure of helicopters. The video tower needs to be relocated some meters N-NE";
- *"Helicopters climb to 70 or 100ft before they decide if they will continue with the flight. However, before they reach 70ft they are outside the OTW angle. Will the AIM track be developed to take care of this? ATS should be able to see the flight during landing and departure, on the manoeuvring area in the circuit/vicinity of the aerodrome. .*

AIM tracking is being developed therefore should be possible in the future and the horizontal angle of the video tower should be improved.

During the trial a range of weather conditions were experienced, enabling the trial to take in a range of useful information about the systems robustness and potential technical weaknesses. Many comments raised regarding the visual reproduction understandably involve some weather effect, some further issues highlighted by varying weather are noted below:

- *The windscreen blades didn't work as planned. The compressor stopped many times due to power cuts at Værøy. Sometimes there wasn't air from the blades of the compressor. The blades weren't adjusted and there were some problems with oil spill from the compressor in the air to the windblades";*
- *"Sea spray (salt) got on the windows, sometimes together with snow and it was impossible to see out of the window. In the last part of the ASM test we had heavy snow showers, then the windows at the video tower was covered with snow, some of our test sessions would have been cancelled as we couldn`t see, but the staff at Værøy helped us the cleaning/removing the snow from the windows at the video tower";*

- *"During a snow storm when the visibility decreased to less than 400ft the visual reproduction was excellent but the IR camera did not help. When the weather improved and the snow shower had passed, a helicopter made a straight in approach. The pilots were very happy about the weather report given and updated information".*

Pixel disturbance and visual abnormalities that occurred on screens were noted during the trial, these included shadow, lines, and pixel malfunction.

The above statements provide a detailed insight into the concerns the AFISO had, **however it must be put in the content of the 86% overall acceptance the AFISO gave the visual representation.** Although a few issues surfaced, overall the AFISO agreed that the visual representation was acceptable in terms of viewing movements, making judgements and ease of use amongst many other things. From the comments it can be concluded that areas that are negatively impacted relate to health and safety, technical robustness and general safety. The quality of the OTW improved after the mid trial update.

6.3.3.1.1.2.2 IR Camera

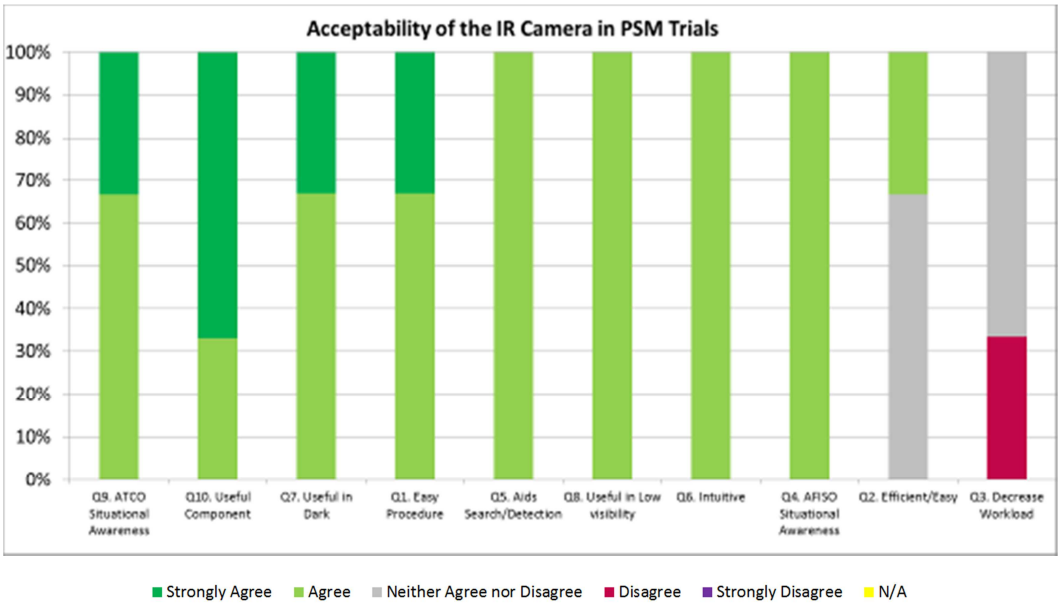


Figure 63: Acceptability of IR Camera in PSM trials

Q1	I found the procedure for using the IR camera easy.	**Q9**	Using the IR camera will improve the AFISO's situation awareness in good visibility.
Q4	Using the IR camera will increase my situational awareness.	**Q10**	Using the IR camera will improve the AFISO's situation awareness in limited visibility.
Q5	I found the IR camera useful for searching and detecting aircraft and vehicles.	**Q11**	Using the IR camera will aid my hazard/conflict detection ability of aircraft in the air in good visibility.
Q6	Operating the IR camera was intuitive.	**Q3**	Using the IR camera will not increase my workload.
Q7	The IR camera is useful during darkness with clear visibility.	**Q2**	While using the IR camera, my attention did not focus too much on this function or a particular area.
Q8	The IR camera is useful during daylight conditions with decreased visibility.	**Q13**	Using the IR camera will aid my hazard/conflict detection ability of aircraft on the ground in good visibility.

Q15	I found the IR camera to be a useful component to my system.	**Q12**	Using the IR camera will aid my hazard/conflict detection ability of aircraft in the air in limited visibility.
Q14	Using the IR camera will aid my hazard/conflict detection ability of aircraft on the ground in limited visibility.		

■ Strongly Agree ■ Agree ■ Neither agree nor Disagree ■ Disagree ■ Strongly Disagree

Table 27: Full Questions showing acceptability level of the IR camera in ASM Trials

The IR camera was rated very favourably, with an 87% acceptance level in ASM trials. The only elements that the AFISO did not agree with were that the function would aid conflict detection when aircraft are in the air in limited visibility and aircraft on the ground in good visibility. These elements gained neither agreement nor disagreement and contribute to highlighting the sort of situations the IR camera is likely to be used.

The AFISO comments related to additions that the IR camera could incorporate in order to improve its already high level of functionality. One addition mentioned would be "*active track/lock function, scanning the landing area with a pop up function in case it detects a sheep, elk/moose, deer or goose. During winter and in snow this can be a particular problem".*

The AFISO states that the IR camera allowed weather that would not normally be observable, to be observed. "*The IR is very useful for MET observations"* and another comment indicating that the IR camera would aid in pre-flight checks. Hence this advanced visual feature could potentially improve the safety standards an AFISO can provide.

Other comments concerning the IR camera included some additional ideas for extra functionality; "*Very useful for assessment of cloud altitude and their consistency in the dark. Useful for "runway inspection" as well, but we miss "automatic sweep" as we had at Ängelholm. It is also desirable to have an opinion about the pitch / angle of the camera when it is pointing into the "cone of silence". It is desirable to have an angular registration".*

A noteworthy difference between the ASM and PSM results is that after the PSM trial the AFISO did not agree that this feature would decrease workload, however after the ASM trial opinion changed to agreement. This highlights how the IR cameras perceived benefit depends on the range of situations it is being used under and may not truly be appreciated until a scenario is presented where without the IR camera the AFISO or ATCO would otherwise be unable to perform their function.

6.3.3.1.1.2.3 PTZ Camera

The results from both ASM and PSM trials give an overall positive outcome; with 89% agreement on statements posed within the ASM end of trial questionnaire and no disagreement, see Table 28 below. There was minimal difference in the perception of the PTZ Camera between the PSM and ASM trials. The two areas of negativity fall within the PTZ cameras ability to automatically track targets and its ability to aid hazard detection of aircraft in the air during limited visibility.

AFISO comments mentioned that on numerous occasions the IR and PTZ cameras were "*appearing and disappearing*"*".* This seemed to be linked with turning off the FATO light, it is hoped a technical fix will be developed for this in the future.

The way the PTZ camera was used and additional elements that may be necessary were also highlighted during the trial; the AFISO commented that when using the PTZ to perform *"visual sweeps"* there was not much zoom functionality and the PTZ proved more useful over a small area where it added improved image quality, clarity and light for a particular area. The AFISO commented "*It is used a bit like an IR camera in that sense".*

As with the IR camera, it was noted that the ability to track and *"lock on"* to a target is desirable and may negate some of the negative impact cause by a large "*cone of silence".*

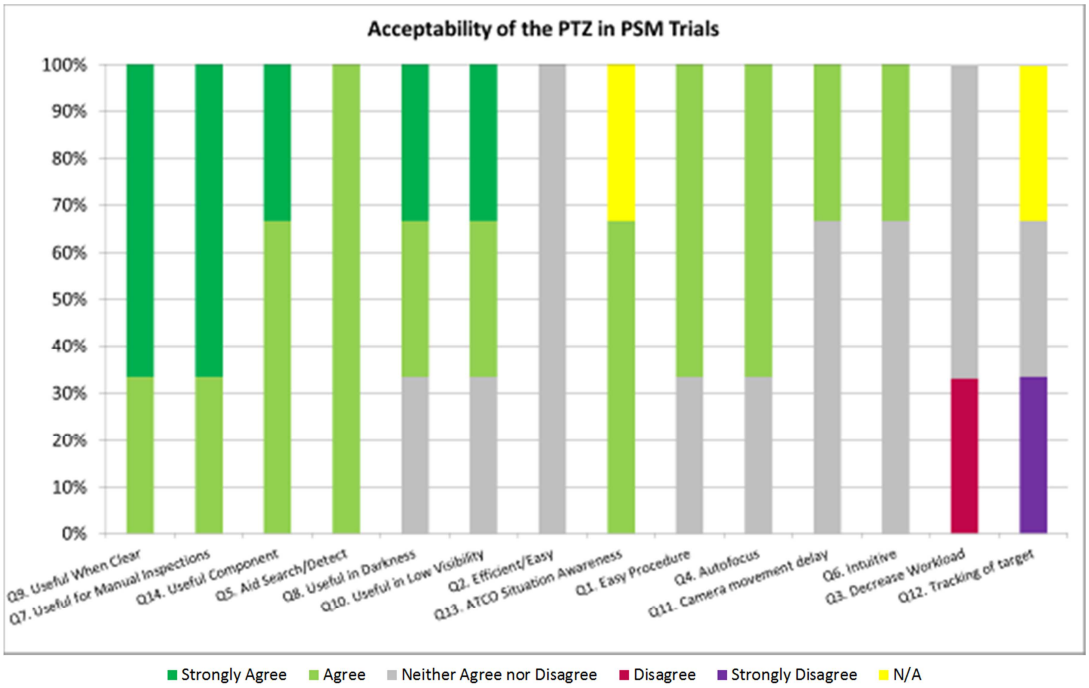


Figure 64 Acceptability of the PTZ Camera in PSM Trials

Q1	I found the procedure for using the PTZ camera easy.	**Q10**	The PTZ-view is useful in decreased visibility conditions during darkness and daylight.
Q6	Operating the PTZ camera was intuitive.	**Q11**	I found the time delay in manually moving the PTZ camera acceptable.
Q7	I found the PTZ camera useful for manual inspection of the runway.	**Q13**	Using the PTZ will improve the AFISO's situation awareness in good visibility
Q9	The PTZ-view is useful during daylight conditions with clear visibility	**Q5**	I found the PTZ camera useful for searching and detecting aircraft and vehicles.
Q17	Using the PTZ camera will aid my hazard/conflict detection ability of aircraft on the ground in good visibility	**Q14**	Using the PTZ will improve the AFISO's situation awareness in limited visibility
Q2	While using the PTZ camera, my attention did not focus too much on this function or a particular area.	**Q15**	Using the PTZ camera will aid my hazard/conflict detection ability of aircraft in the air in good visibility
Q3	Using the PTZ camera will not increase my workload	**Q18**	Using the PTZ camera will aid my hazard/conflict detection ability of aircraft on the ground in limited visibility
Q8	The PTZ-view is useful during darkness with clear visibility.	**Q12**	I found the ability of the PTZ camera to automatically track a selected target acceptable
Q4	The Autofocus on the PTZ camera was sufficient.	**Q16**	Using the PTZ camera will aid my hazard/conflict detection ability of aircraft in the air in limited visibility
Q19	I found the PTZ camera to be a useful component to my system		

Strongly Agree Agree Neither agree nor Disagree Disagree Strongly Disagree

Table 28: Full Questions showing acceptability levels of the PTZ Camera in ASM Trials

The PTZ Camera acted as a good substitute for binoculars, however at certain wind velocities it was seen to vibrate a little.

Other AFISO comments included:

- *"When using the PTZ, pointing it towards the dark wall of the terminal building allows you to see how heavy or light the precipitation is. I used weather radar on www.ippc.no as supplement for weather observations and providing MET info to the pilots. Sometimes when the sun is in the south, it becomes quite dark on the manoeuvring area, almost unable to see aircraft, cars and persons. (Seems to be darker when it is a lot of snow outside the manoeuvring area)";*
- *"PTZ and IR cameras need to show degrees/angle horizontally and vertically when using it OTW";*
- *"HMI bit difficult to manoeuvre the IR and the PTZ cameras on the screens behind the CWP".*

Overall it can be concluded that the **PTZ camera was easy and intuitive to use, although the HMI could still be improved**. The PTZ performs best in daylight during clear visibility and has the potential to **aid hazard detection of ground movements in both good and poor VMC**. However the PTZ camera is performing its main purpose adequately as highlighted clearly by the following AFISO comment; *"Using the PTZ with heavy snow showers where the visibility was less than 1000m and the vertical visibility was 800ft, it is just like using binoculars, and not different to a local ATS".*

6.3.3.1.1.2.4 Tracking Label Overlays

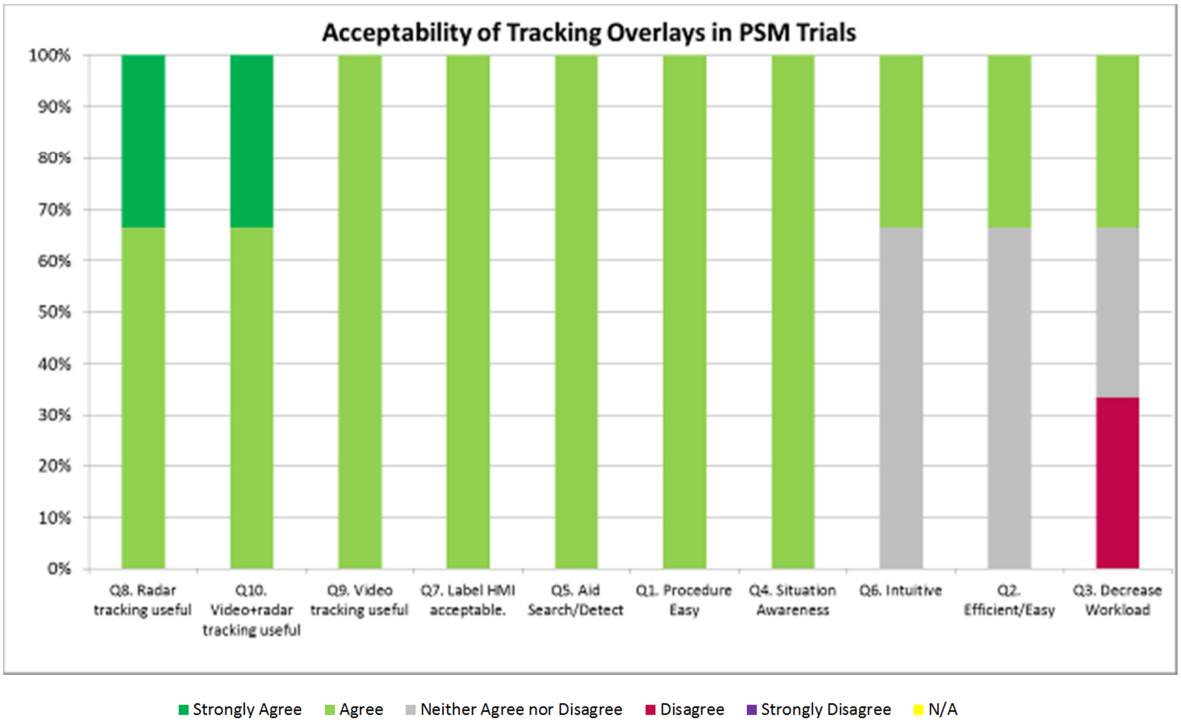


Figure 65: Acceptability of Tracking Overlay Labels in PSM Trials

Q3	Using the tracking labels will not increase my workload	**Q9**	Using the tracking labels will aid my hazard/conflict detection ability of aircraft on the ground in limited visibility
Q4	Using the tracking labels will increase my situational awareness in good visibility	**Q10**	I found the tracking labels useful for detecting aircraft and vehicles.
Q5	Using the tracking labels will increase my situational awareness in limited visibility	**Q11**	Operating the tracking labels was intuitive.

Q15	The tracking labels combining both video and radar information were a useful component in my system	**Q12**	The label HMI was acceptable (size, colour, clarity, symbology, font etc.)
Q2	While using the tracking labels, my attention did not focus too much on this function or a particular area.	**Q13**	The tracking labels using radar information only were a useful component in my system
Q6	Using the tracking labels will aid my hazard/conflict detection ability of aircraft in the air in good visibility	**Q14**	The tracking labels using video information only were a useful component in my system
Q7	Using the tracking labels will aid my hazard/conflict detection ability of aircraft in the air in limited visibility	**Q1**	I found the procedure for using the tracking labels easy.
Q8	Using the tracking labels will aid my hazard/conflict detection ability of aircraft on the ground in good visibility		

■ Strongly Agree ■ Agree ■ Neither agree nor Disagree ■ Disagree ■ Strongly Disagree

Table 29: Full Questions showing acceptability levels of the Tracking Overlay in ASM Trials.

The Tracking overlay was the most positively rated function within ASM trials and overall was rated second to the IR camera. In the PSM trial is was judged that the tracking overlays would not decrease AFISO workload, yet in the ASM trials there was strong agreement that workload would decrease.

The majority of the AFISO feedback given to the tracking overlays related directly to the functionality of the tracking labels and their poor performance within close proximity to the aerodrome (comments indicated issues arising within 10NM). It was also mentioned that labels should be moveable in the case they obscure other aircraft.

The AFISO comments relating to the tracking overlays and improving the performance of the tracking labels and were as follows:

- *"Radar Tracking jumping 6-12NM on the OTW";*
- *"Work needs to be done with the radar label inside approximately 10NM. It is jumping to and from";*
- *"At 12NM Radar label is unreliable, unstable and useless";*
- *"Radar label starts wondering at 8NM";*
- *"The tracking labels are useful outside 10DME/NM, inside 10NM Værøy the labels are jumping are jumping a lot, normal again at 2NM but back and forth inside 2NM";*
- *"Video track was deleted under the horizon. Tracking on birds must be adjusted. Video and radar track was not working optimally inside 10NM from Værøy. You should be able to move the label in case the flights are on the same track, same as in RDP";*
- Recommendations included *"a specific colour or some head up for fast moving aircraft";* this could take the form of these aircraft being assigned emergency transponder codes and/or the visual tracking labels on the OTW appearing in red.
- *"You should be able to move labels when two labels cover each other; it's possible on the RDP".*

The above comments are in contrast to the positive acceptability results gained via the end of trial questionnaires for both PSM and ASM trials. However the quantitative results indicate that despite the technical errors, the AFISO still concluded that the tracking feature would benefit workload, situational awareness and aid hazard detection. The tracking labels were also rated as aiding in good and limited visibility with and easy and intuitive HMI. The AFISO clearly rates the tracking labels as a beneficial additional advanced visual feature, despite work that needs to be done to improve the performance of the feature.

6.3.3.1.2 Human Performance

6.3.3.1.2.1 Situational Awareness SASHA Results

SASHA scores range from 0 – 6, with a score of 6 indicating a positive rating and hence high situational awareness.

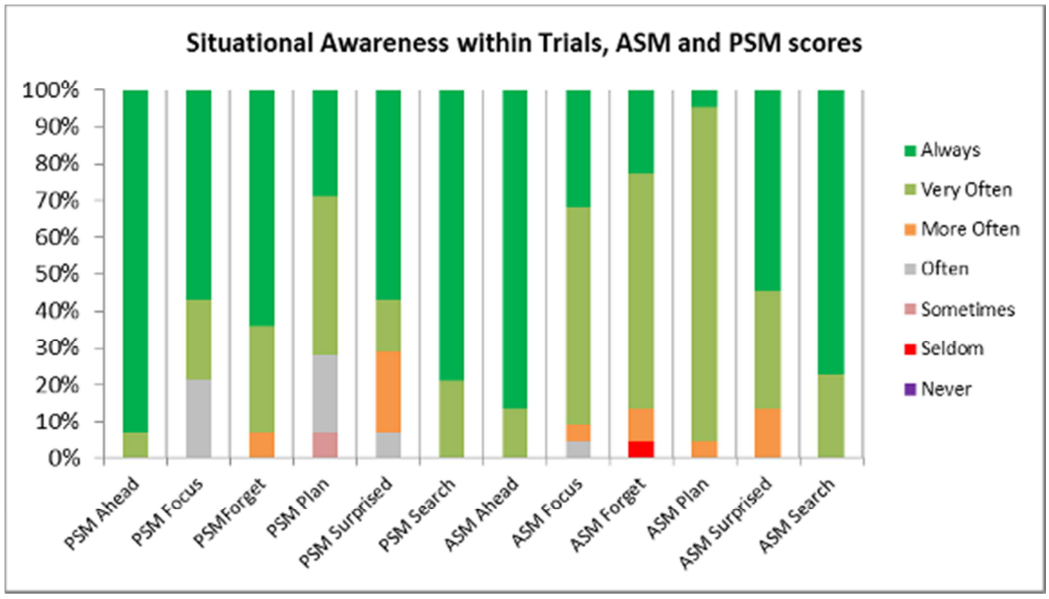


Figure 66 - SASHA scores for ASM and PSM trials

Situational awareness was at a high level throughout both trials, with the average SASHA score not dropping below 4 out of 6. The weakest categories were the ability to plan and organise work as desired and the pitfall of focusing too much on a single problem. The risk of forgetting was also rated lower than the average SASHA score yet this was impacted by one session when a score of 1 (seldom) was given, indicating during this run that there were seldom occasions when the AFISO did not struggle to remember important information. During this specific session the technical issues were still having an impact, coupled with sudden rain showers and low visibility. The workload for this session was also lower with a high level of frustration.

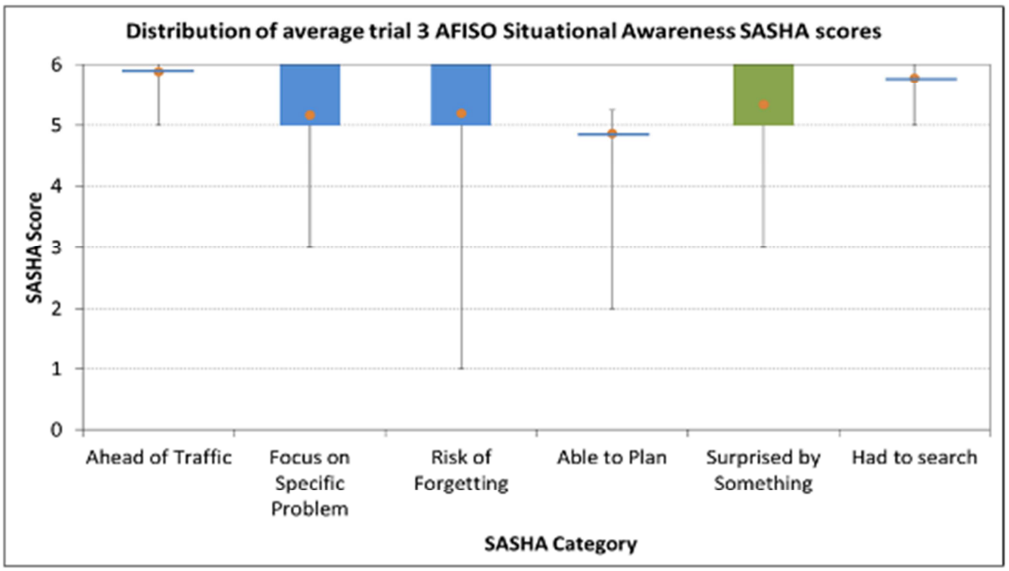


Figure 67: Average Situational Awareness SASHA score boxplot

On average the risk of forgetting was judged to be higher within the ASM trials. The ability to plan and the AFISO being surprised by an event were judged lower within PSM trials; however this could be due to nature of pseudo planning.

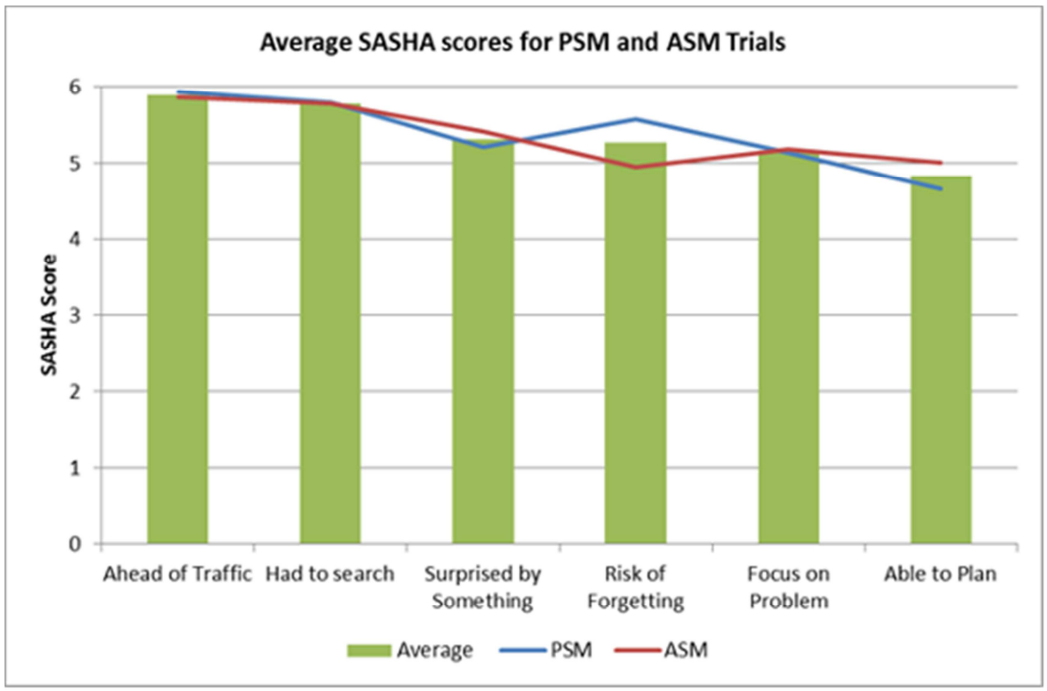


Figure 68: Average SASHA Score for PSM and ASM trials

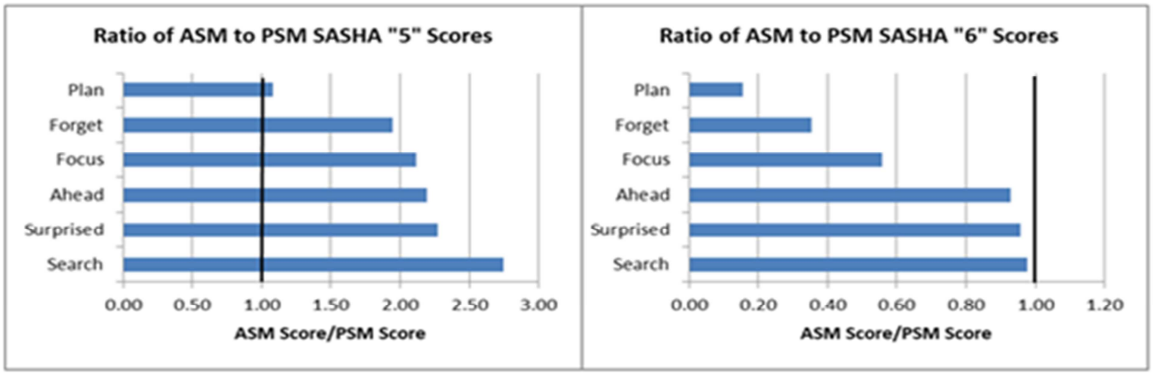


Figure 69: Ratio of ASM to PSM SASHA score "5" and "6"

Overall fewer SASHA Situational awareness scores of 6 (maximum) where given in all categories in the ASM trials compared to the PSM trials. However, more SASHA scores of 5 were given within the ASM trials than in PSM trials. It can be concluded that the situational awareness seen within all trials is at a high level. Scores within the advanced mode trial are more conservative, with the AFISO being less inclined to give a top score of 6. The lowest SASHA score of the trial was also given with ASM, on a single occasional which indicated that there was "very often a risk of forgetting".

It seems logical that the AFISO would be more critical of their situational awareness within an advanced mode trial, as they are interacting with traffic fully and hence have a greater appreciation of the situation within an advanced mode trial. Early conclusions from this could indicate that under a passive mode trial the AFISO may think they have a higher situational awareness than they would have indicated if they were fully interacting with traffic. However, any differences between PSM and ASM trials do balance out overall and are statistically non-significant (*two-tail paired two sample t-test*).

Other feedback from the AFISO included:

- When describing the overall perceptions about the Situational Awareness whist in the Remote AFIS facility one AFISO said *"It was an excellent real simulation"* you can obtain a *"more detailed focus on the surroundings".*
- *"My situational awareness was worst when I get a lot of messages e.g. failure/malfunctions and trying to tick these away. A lot of messages require "script-edition" in AWOS covering AWOS, MET-info company's doing".*
- When asked about how the situational differed between day and night operations, one AFISO said *"It was normal as in real tower's relation to day and night light.*
- When asked if AFISOs were able to pick up on all the visual and audible clues normally picked up in a local tower, one AFISO said *"Honestly, I am unable to tell any difference". Another AFISO said "For me it is sharper in the PSM. The detail is more focussed."*
- When asked which parts of the technical system contributed the most to situational awareness, the PTZ and IR camera were highlighted by two AFISOs.
- Positive feedback regarding the situational awareness in both good visibility and limited visibility.
- *"The less time I have to look down, the more vital info can be presented with on the OTW screen, the better! The IR camera is super. Electronic strips (used only manually), weather on the OTW and RVR is making my day easier".*
- *"It was strange not being able to go out and check the clouds but AWOS and the IR were helpful. Also asking staff for supplementary information regarding precipitation due to sensor visibility didn't work during the PSM and ASM. The sensor is located too close to the sea; it gets sea spray on the lenses all the time".*
- Regarding the RDP the AFISO felt a requirement for the RDP vector to indicate aircraft time to a fix (or target for example a waypoint, aircraft or destination), stating this would aid planning.

6.3.3.1.2.2 Workload

Workload for EXE-06.09.03-VP-058 could only be usefully measured during the ASM trial as this was the only element where results were realistic and the AFISO was in the loop. Workload was measured using the NASA TLX method. Figure 70 below shows the distribution of workload score NASA TLX workload category. NASA TLX scores range from 0 – 10, with a score of 10 indicating a negative rating and hence high workload.

The spread of NASA TLX scores was very narrow, with the mean workload score being 0.84 (out of 10) with the interquartile range being no greater than 1. The highest workload score was 1.9 for frustration, with a score of 7 being given on two occasions. Comments for these occasions detailed:

- *"Mainly the remote tower is working, it is possible to use it but AVINOR has not delivered AFTN and RVR sensor. Still some work with radar and video tracking. Clock is not working correctly. Frequentis VCS is just sad to work with. All these things together make it demotivating to work with at the moment."*
- *"PTZ/IR cameras jumping, blurry sometimes, when I switched off FATO lights suddenly the IR* camera *showed up down in OTW 5. This happens now and then. AFTEN in/out again and again. …Filters were out this morning. RVR sensor not good, sensor is located to near to the sea and gets sea spray on the lenses."*

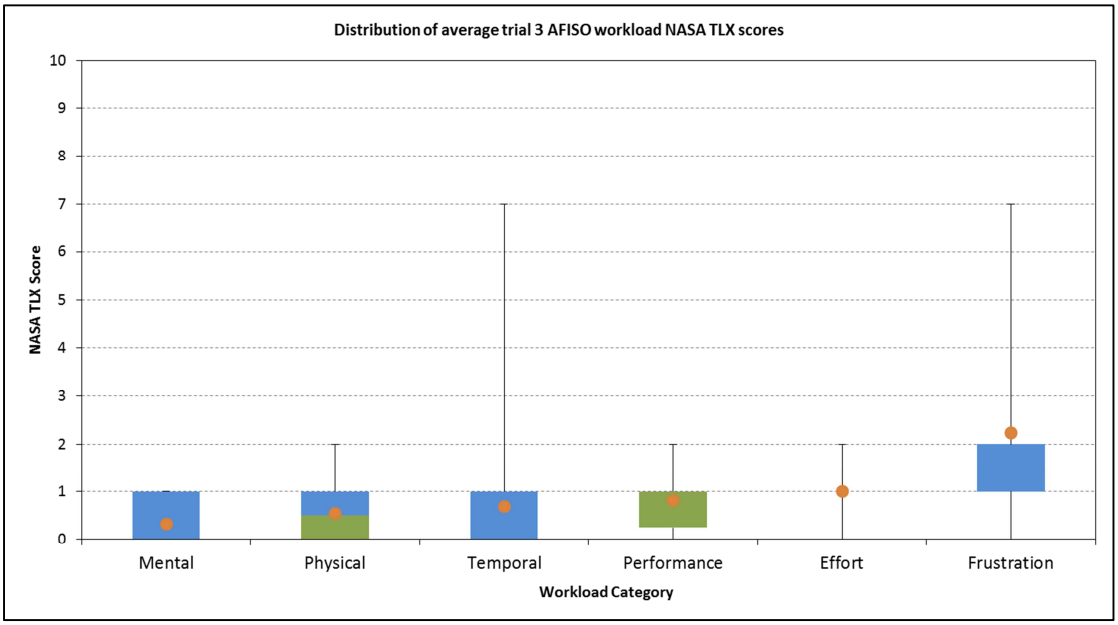


Figure 70: Distribution of NASA TLX workload scores

Other comments gathered from the End of Trial questionnaire give an insight into what factors contributed to increased workload in the RVT. The heavy snow shower experienced within the ASM trial brought about the highest level of perceived workload, when combined with reduced visibility. However, on these days NASA TLX scores indicated low workload and the comments that followed indicate that even in these conditions workload was "*never too high, it depends on planning and preparation, and of course it is easier when all devices are running as planned".*

Reduced workload	**Increased** workload
PSM	
IR camera, PTZ camera	MET
OTW	Video and Radar track (two aircraft inside 10NM)
Radar display	E-strips (lack of reporting boxes)

Table 30 Features impacting workload as commented by the AFISO

The AFISO stated that due to the video and radar tracking not working as planned, they contributed to increasing workload. This was particularly true when two aircraft where inside 10NM from Værøy. Glare from snow covered ground increased workload due to the reduced visibility of the manoeuvring area, as mentioned earlier the need for increase filters was commented on multiple times. Implementing letters of agreement for co-ordination would also help to reduce workload. During the ASM trials the IR camera, PTZ and Tracking Overlays all scored highly for "not increasing workload", within these results the Tracking Overlay scored the highest for "not increasing workload" with a score of 5 (strongly agree) this being despite comments on its reduced functionality.

6.3.3.1.2.3 Working Methods & Task Allocation

6.3.3.1.2.3.1 Working Methods

The results highlight that working methods proposed for normal situations are more acceptable than the working methods proposed for non-nominal/degraded situations such as during an emergency or technical failing. This is unsurprising for a V3 trial as operational procedures have been developed and should be stable to move onto V3; hence no responses indicated disagreement with the working methods currently in place.

Emergency situations were not tested within this trial; however there are plans and procedures in case of emergency situations. Due to the pseudo nature of the ASM trial a full FIS and alerting service were not provided during this trial, however telephone communications were set-up to external emergency services.

In relation to the working methods of abnormal situations the procedure for the automatic removal of anything obscuring the aerodrome cameras failed; the AFISO reported "*due to windblades/compressor being out of service".* Procedures for winter operations and a strong dialogue between the RVT and staff at Værøy are of high importance to establishing redundancy working methods. One comment indicated that having information regarding the status of the compressor, wind screen wipers and any power cuts on the IDP would be beneficial.

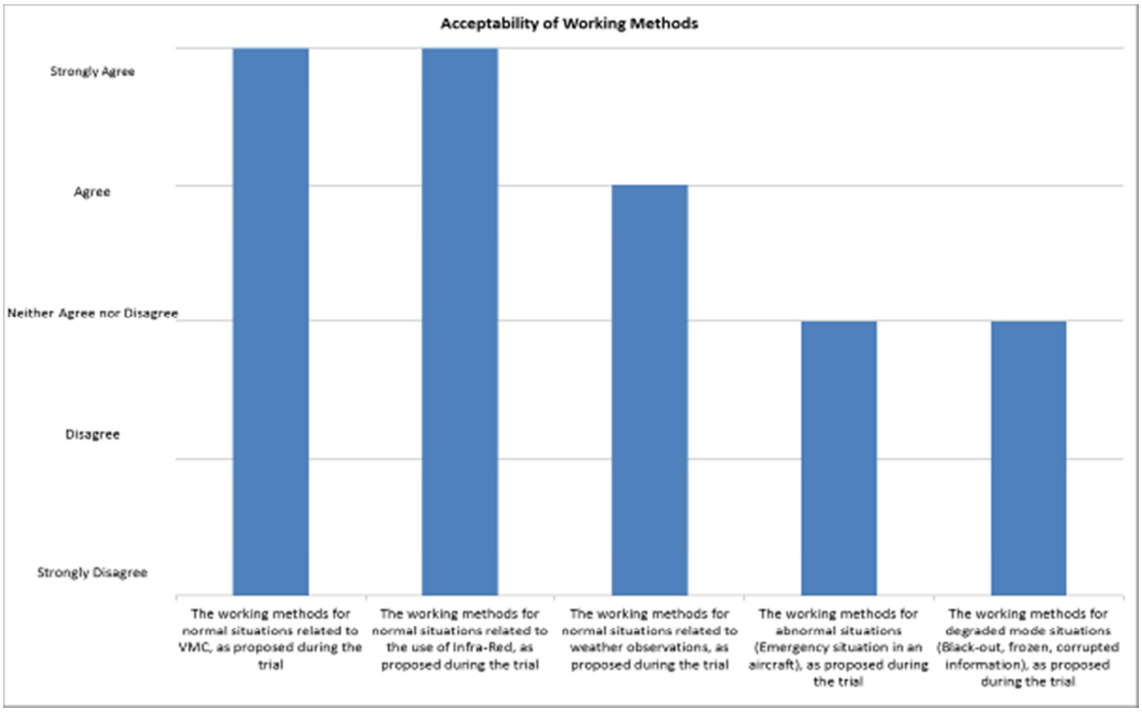


Figure 71: AFISO working methods

Suggestions for working methods included:

- *"Supply RTC with weather radar information. Have a dialogue with the personnel at Værøy to confirm wind and barometric pressure adjusted to mean sea level (QNH)."*
- *"AFIS/ATS personnel working in a RTC need a good theoretical education like todays, but also during education one needs to spend basic training days at the airport you`re going to be authorized at. Talk to the staff at the airport, AFIS who have worked there, use MET info from existing procedures, but MET info needs to be more specific in an RTC environment. ATS personnel also need to know about terrain, turbulence and other local knowledge etc., this we also learn today. In the future ATS-personnel need at least once a year go visit the units they are authorized for."*
- *"Establish video meetings with staff at airport and management, a short meeting once a week or more often if it is construction work, upgrades on the electrical system on the airport and a lot of external workers; we have routines for this today. But we need them in the future. Important to have a good dialogue between personnel ATS, handling, Fire and rescue, security, airport manager"*
- *"There should be two frequencies: one frequency for ground and another one for aircraft"*
- *"It seems to be OK to work in an RVT environment, but some modifications/changes need to be done, and we need good procedures. I'm unable to go out to check type of precipitation, but local staff can help ~~you~~, it is a back-up, also today in a local tower maintenance staff can support with info regarding precipitation. Cone of silence is big. If we have good procedures, operational and technical, between ATCC, AFIS, RVT and RVT, also between RVT and local staff/airport manager, between RVT/RTC and operators, emergency units, tech support, then it shouldn`t be any limitations to provide AFIS from an RVT."*

Many features were not fully tested including the E-strips, AIM Track and FDP. Also some technical failings impacted on the perception of working methods, for example the lack of space in the CWP to place approach map and logs and the inability to adjust the lighting level of the IDP were all mentioned as potential issues. These elements may impact on the working methods results.

6.3.3.1.2.3.2 Roles and Responsibilities

Roles and responsibilities were clear and acceptable to the AFISO, with comments indicating that there were clear procedures and agreements in place with ATCC and the aerodromes staff, coupled with briefings prior to the start of the ASM trial.

Having clearly defined roles was also a feature that surfaced within comments regarding working methods:

- *"AFISO remote tower tasks, roles and responsibilities were clear and acceptable. For the test procedures and agreements with ATCC staff, Værøy staff and operators were made and a brief was given out before the start of the ASM test. It is important to clear out roles"*
- *"**There is no difference between any of the roles, tasks or responsibilities that were provided when located remotely compared to when they were located locally**. I'm used to one frequency for aircraft and one for fire and rescue/fuel service/ground service/maintenance. At AFIS airports mentioned roles are covered by 2 or 3 persons. In the future in an RTC, we need to create good ways to exchange information about estimates, especially during winter operations. Today the runway is clear when traffic arrives, if the weather permits, it is due to good communication with neighbour units and staff on ground. How will we keep this good cooperation in the future?"*

The AFISO did feel there may be a slight difference to task allocation, mainly to do with supplementing the AWOS information with locally provided weather information from aerodrome staff. There would also need to be good routines for exchanging status information with neighbouring units. During winter operations these perceived changes to task allocations would become most obvious; this was highlighted during the trial with the AFISO having experienced a reliance on aerodrome staff to clear camera lens window to provide a clear OTW during server snow.

Overall there is an indication that the RVT may improve roles and responsibilities for the AFISO, "*Maybe, in an RTC it will be a greater professional working environment. But we shall not forget it is important to have meetings, dialogue with the local staff".*

6.3.3.1.2.4 Trust

SATI scores range from 0 – 6, with a score of 6 indicating a positive rating and hence high trust.

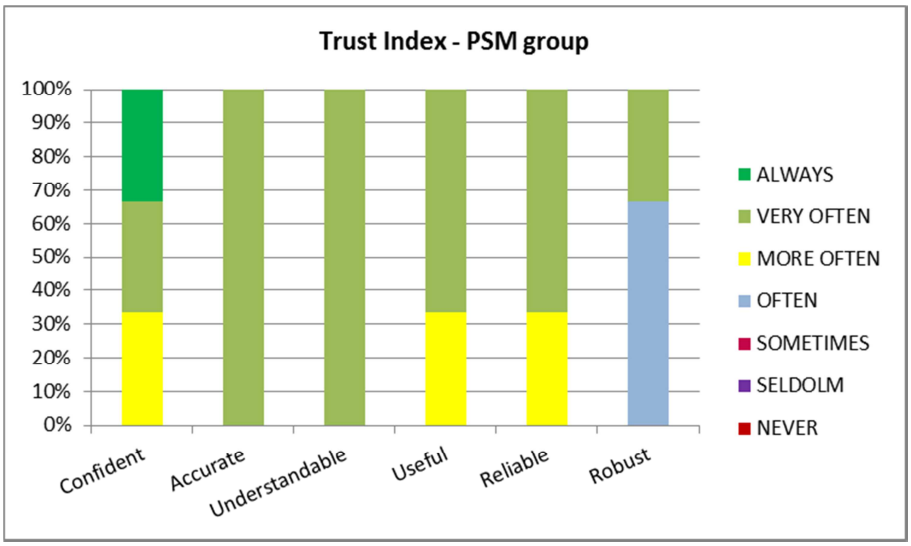


Figure 72: SATI results for PSM Trials

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 31: SATI Questions

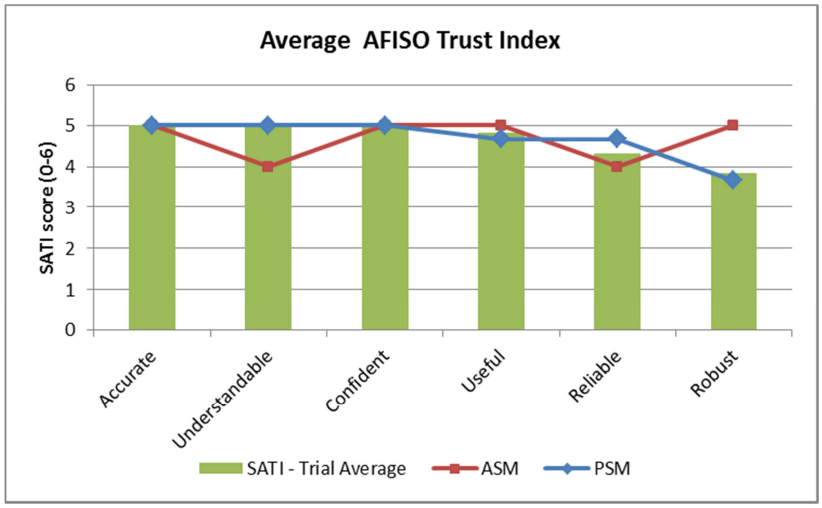


Figure 73: Average SATI scores for trials

Responses were overall very positive. With AFISOs rating that the system was **very often understandable, highlighting the ease of use**. The least positive responses were relating to the perceived reliability of the system and the robustness of the system. This must be taken in the context that the lowered trust in the systems robustness and reliability is primarily due to technical issues. Comments indicated the systems the AFISOs has least trust in all suffered from technical issues, these included the transfer of MET information via the AWOS and screen blackouts. However, the most trusted system was highlighted as being the alarm system as this increased the trust in the overall systems functionality. Comments also indicate that trust in technical systems improved after the mid-trial software update.

Most Trusted Operational/Technical Systems	**Least** Trusted Operational/Technical systems
PSM	
IR, PTZ, OTW, RDP	MET information provided, AWOS
Alarms improving overall system trust.	Screens: low frame rate, suddenly black screens
Camera, Procedures	Radar Labels: jumping a lot inside 10NM
ASM	
Cameras, Aerodrome sound	Video and radar track inside 10NM
OTW	Voice communication system (VCS)
PTZ and IR Camera	MET information provision process

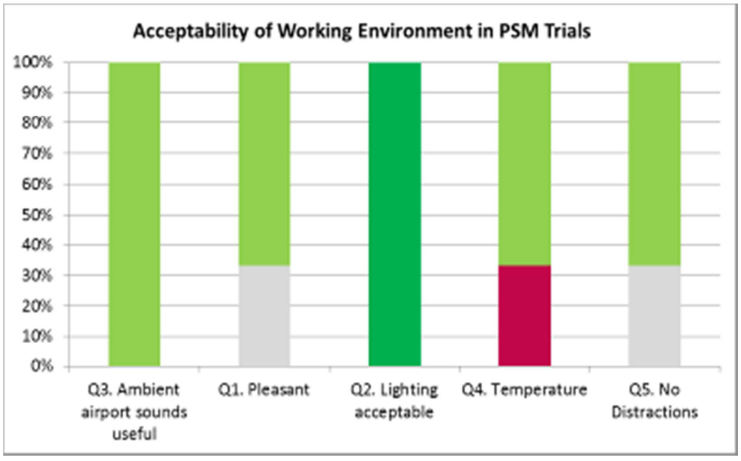
Table 32: Most and Least Trusted systems in PSM and ASM trials

When asked the parts of the technical and operational system did you have **least trust in**, the AFISO commented:

- *"The **VCS**! Delivered communications with headset only. In the start of ASM-test, it was a lot of feedback, interference, unable to adjust side tone, no split function. Using the telephone I hear all people in the RVT-room, the person I talked to staff at Værøy or the ATCO/ATC at Bodø was unable to hear, this is a big risk during coordination of information clearance or in an emergency. The VCS today is a hazard! Also when talking on the phone I couldn`t touch the microphone, if I did it felt like someone was inside my head, stressful. Why is the VCS delivered with headset only, it is the operator who determines whether to use headset or split microphone and telephone. It is normal to have the ability to choose depending on traffic, time of day/week/year- Monday morning or late Saturday evening-totally different traffic on mentioned times, also depending if there are external companies in the working room- like electricians, technicians, construction work and so on, VCS should be delivered with possibility to choose between microphone/telephone and headset." ;*
- *"**FDP not tested**. Late AFTN connection, but it didn`t help, the FDP is not Flightplan 2012 compatible. Since the FDP is not tested, then the e-Strip is tested manually only."*
- *"To **request weather**-METAR, TAF, AIRMET, NOTAM and SNOWTAM there seemed to be to be too many operations to get the information if a pilot request it comparing with NAIS/Norwegian Aeronautical Information System, see also www.ippc.no" ;*
- ***Video and radartrack** OK outside 10 NM from Værøy, not possible to use inside 10 NM, due to the label was 30 cm left/right of target, information on label was correct. Useful if it`s working as planned inside 10 NM. EME: Not tested. RDP: Not fully tested, due to almost ASM-test. AIM track: Not tested."*

6.3.3.1.2.5 Work Environment

Working environment within the trial was scored negatively under certain areas due to specific events and issues. Improved organisation of future trials should result in a pronounced improvement in the acceptability of the working environment. The AFISO commented that the presence of windows in the RTC was positive as it was possible to follow daylight levels. The RTC was located 85km from Værøy and hence daylight levels would have been proportional in both locations.



■ Strongly Agree ■ Agree ■ Neither Agree nor Disagree ■ Disagree ■ Strongly Disagree ■ N/A

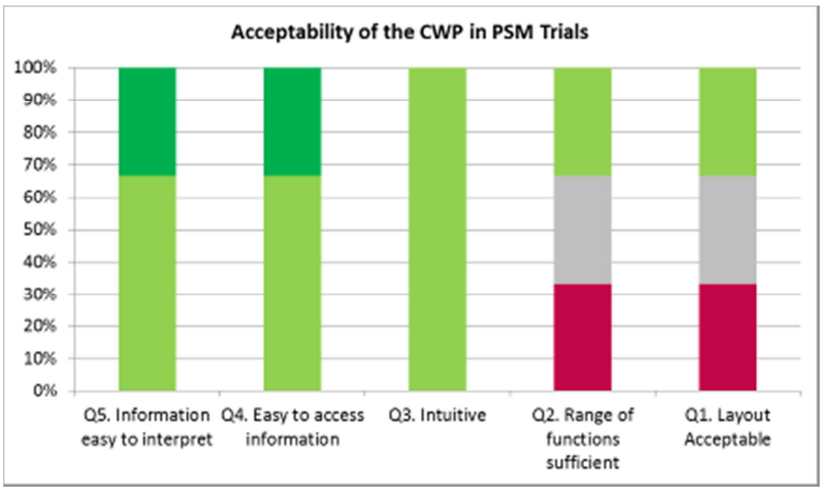
Figure 74: Acceptability of the Working Environment in PSM Trials

Q1	The remote AFIS facility is a pleasant working environment.
Q2	The lighting in the room is acceptable.
Q3	The use of ambient (outdoor) sounds from the airport was useful.
Q4	The temperature in the room was acceptable.
Q5	There were not too many distractions in the working environment (visitors, technicians, other staff etc.).

■ Strongly Agree ■ Agree ■ Neither agree nor Disagree ■ Disagree ■ Strongly Disagree

Table 33: Full Questions relating to working environment, corresponding to colour coded ASM responses and questions posed relating to Figure 74.

The size and configuration of the CWP was not accepted by the AFISO in the ASM trial. Suggestions for improvement included; the provision of space for additional items such as a notebook or laptop and additional activities such as writing and reading charts.



■ Strongly Agree ■ Agree ■ Neither Agree nor Disagree ■ Disagree ■ Strongly Disagree ■ N/A

Figure 75: Acceptability of the AFISO Working Position in PSM Trials

Q3	The input and output control devices were intuitive and easy to use
Q2	The range of systems and functions available to me via the CWP was sufficient
Q4	The information presented via the CWP systems was easy to access
Q5	The information presented via the CWP systems was intuitive and easy to interpret
Q1	The CWP layout (size, configuration) was acceptable

■ Strongly Agree ■ Agree ■ Neither agree nor Disagree ■ Disagree ■ Strongly Disagree

Table 34: Full Questions relating to CWP, corresponding to colour coded ASM responses and questions posed relating to Figure 75.

Other CWP feedback from the AFISO included:

- *"CWP was too small. Letters on the FDP must be bigger/bold letters. It is possible to move the screens closer to the operator but still the letters are tiny";*
- *"In AWOS, QNH, temp and dew point should be adjusted bigger"*
- On the FDP briefing, *"you should be able to choose the airport easier, not from a long list"*

- *"The video tower was robust regarding wind. It was no problem to work in different weather conditions, but we had some heavy snow showers, sometimes combined with sea spray. This covered the video tower and we couldn`t see anything. In these weather conditions we should have terminated the test, but Værøy staff were close by and could clean the windows on the video tower quickly. Due to a power cut at Værøy a few times, the compressor stopped, resulting in no air to the windblades, it seemed like they weren`t adjusted on the last part of the test. In the future we can`t expect staff at the airport to be ready a few minutes before landing to clean the windows as the video tower is located further away from the airport than at Værøy, it may be outside fences, higher than at Værøy, staff might have increased readiness on fire and rescue service due to slippery runway, combined with reduced visibility and crosswind..."*

- The CWP set up in relation to telecommunication systems was also not ideal, microphones and telephones should be positioned in front of the desk and not behind, as is the current set up. This CWP set up may have contributed to the negative comments regarding the VCS.

6.3.3.1.3 Service Provision

6.3.3.1.3.1 AFISO Perception

When asked "What do you think would be the level of service you could provide to airspace users using the Remote AFIS system compared to the current operations?" the AFISO responded that it would be **slightly better.**

Despite the technical difficulties faced with some of the advanced visual features and the low acceptability of the CWP and working environment, the AFISO and two retired ATCOs stated, after the PSM trials, that they were prepared to use the system in an ASM trial to provide service to the aircraft. This indicating their trust in the system (and corresponding to the above average trust levels discussed in section 6.3.3.1.2.3).

With regards to the weather, the AFISO said that that the service provision was "much better" than in a local tower. However comments indicated technical improvements are required with areas of concern including the CWP layout and improvements to HMIs.

Two AFISOs mentioned the *"window cleaner at Værøy needs to be adjusted/optimised"*. This is a problem at coastal aerodromes such as Værøy where there are *"quite often Easterly/South-Easterly strong winds"* causing *"salt from the sea to rapidly build up on the glass windows".*

During the ASM trial the AFISO seemed to supplement the OTW view with information obtained from other sources of information such as AWOS and local knowledge. At times, the AFISO also had help from the personnel at Værøy to judge the percentage of rain and snow.

- *"There seems to be no problem to do the weather observations from the OTW, supported with information from weather radar and AWOS"*

- *"I observed the weather OTW due to local knowledge about altitude of surrounding peaks".*

In response to being able to perform all the AFIS tasks and functions, the ASM AFISO responded "*yes*" after all sessions, however, the AFISO noted technical issues after nearly every session. "*Some technical parts of the system were missing such as the AIM track and the radar tracking not being optimal inside 10NM of Værøy. Furthermore, there was no connection between the e-strip and the FDP, and the same for the IDP, sensor visibility*". In addition, the AFISO was not happy with the VCS: *"It is difficult to hear on the telephone when using the microphone and the telephone at the same time. This is no good"*

The AFISO stated that the service improved the most due to the "*MET observations with IR Camera. It is very good in almost all conditions; no good in poor visibility and low cloud base and precipitation. The RVT is a greater professional working environment*". This correlates with the findings that the IR camera had the highest acceptance of all the advanced visual features. This is shows a link between acceptance of a feature and the perceived benefit the feature gives the operator.

The service would deteriorate the most with "lack of contact with local staff and local knowledge. Eurocontrol's AFIS manual needs a revision to include RVT service and training requirements for RVT personnel. It is important to write down requirements. AFIS should spend at least training days at the

airport to learn the airport, facility, staff, local weather, geography/terrain and local info". This comment, regarding training, gives an insight into the possible benefits in the reduction of training times for new AFISOs under the single remote tower concept, with any possible benefits being further economised under OI step SDM-0205 for multiple aerodromes.

"MET observations, scan landing area with IR and PTZ cameras during night time also during day time" AFIS tasks are made easier when providing AFIS remotely. The service being provided is therefore made easier under the remote tower concept compared to a local tower, with result linking this easy to the addition of intuitive and easy to use advanced features.

6.3.3.1.3.2 Pilot Perception

As recipients of the service provided from the RVT, the opinion of pilot on service provision is valuable. Figure 76 and Figure 77 giving an indication of the level of service perceived by pilots.

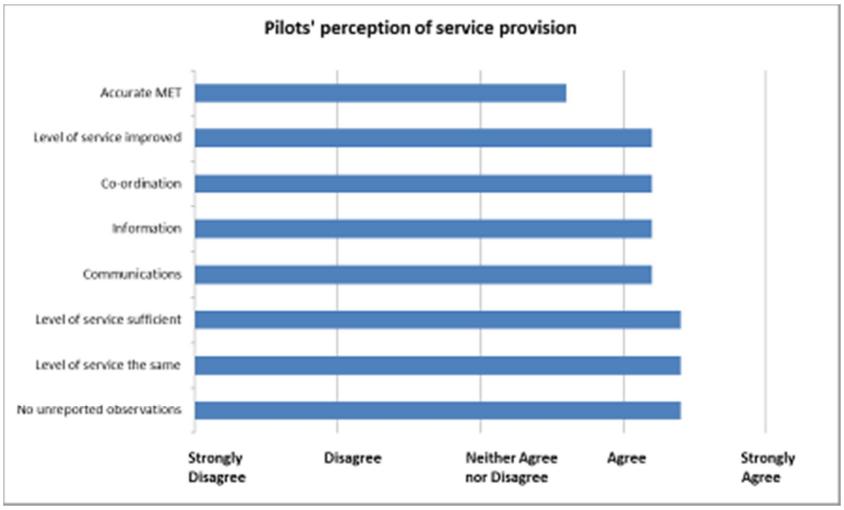


Figure 76: Pilots perceived service provision

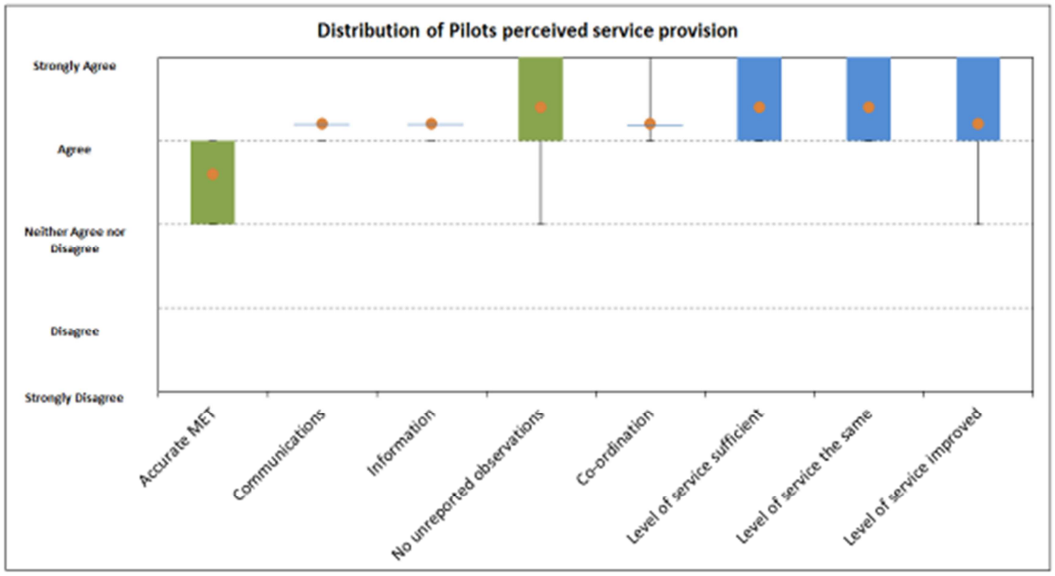


Figure 77: Distribution of Pilots perceived service provision

The distribution of pilots perception of the level of service received has a very narrow distribution, with no score below a 3. Over all questions 90% of pilot responses indicated a positive opinion/ and only 10% of responses gave a neutral response.

Three out of five pilots agreed and two out of five strongly agreed that the level of service received via the remote tower concept was at least the same as would be received from a local aerodrome tower. The pilot's score remain the same when asked if the level of service provided via the remote tower was sufficient. When asked if the level of service was an improvement on the current situation, 40% (two pilots) decreased their level of service rating by one level, 40% (two pilots) maintain their rating and 20% (one pilot) improved their rating.

Importantly, for safety, the pilots reported no occurrences of viewing a hazard that was un-reported by the AFISO. It is also worth noting that the technical issues that impacted the AFISOs communications and co-ordination did not seem to impact the pilots' perception of their communications as this was rated as being at an acceptable level. The worst performing measure of service provision was that of the accuracy of MET reports received, which is particularly important in the case of providing AFIS. The pilots rating the accuracy of MET as lower than other services however the pilots were being provided with MET information via Værøy and the AFISO was providing supplementary and/or repeating information in order to complete the trial. This gave pilots and direct comparison from which to judge MET accuracy, which may not have always been accurate due to the AFIS not having fully functioning AWOS.

6.3.3.1.4 Safety

6.3.3.1.4.1 General Perception

Within the PSM End of Trial questionnaire the AFISO stated, *"The working environment in the RVT is excellent; my confidence in the system is satisfactory. When the redundancy is established, I'm ready to go"*, this was followed in the ASM End of Trial questionnaire by "I **strongly agree" that under normal conditions the Remote AFIS concept is safe**". There was a slight degradation in the perception of safety between PSM and ASM, with the AFISO stating that within ASM safety was sufficient with some adjustments. This reflects the longer trial period for ASM compared to PSM and the technical failures during the ASM trials as discusses previously.

The pilots who contributed to the ASM trial were able to provide feedback, the comments and results of which are overall very positive. The operational service gained a lower score in relation to the level of trust the pilots had in the technical system. This is to be expected as the pilots were less able to judge the technical system and any degradation in operational service caused by technical failings may have been attributed purely to operational service errors. Overall, the pilots had positive feedback regarding their initial perceptions of the concept:

- *"Very good impressions. It seems that it has contributed strongly to improve information and safety"*
- *"Very good. It will initially take some time to get used to and to break in the procedures but so far I'm impressed"*
- *The RVT provided a very good professional service, contributing strongly to improve the level of service to and from Værøy".*

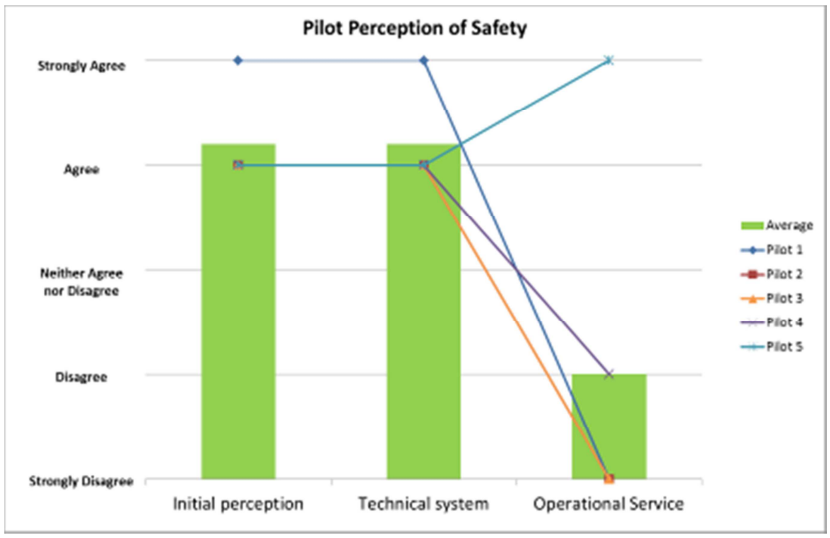


Figure 78: Pilot perception of safety

6.3.3.1.4.2 Risks

The main risk contributors mentioned after the PSM tests, from a technical point of view, were the *"bugs and unstable equipment with the 100MB line capacity"*. It was also mentioned *"the biggest risk was long "black outs" and being unable to find the cause of it". "Radar labels and video tracking must be improved, at present they are jumping all over the place".*

From an operational point of view, the AFISO said the main risk contributor from an operational point of view was the risk of being able to *"see too well compared to the pilots with the help of the IR camera"*. It was also mentioned the biggest operational risk was the *"lack of technical support and trust from our flying customers".*

Usual events occurring during the ASM sessions seemed to be abundant however this did not appear to affect AFISO performance. On all sessions, the AFISO said that they were able to perform all AFIS tasks and functions (not accounting for functions not fully tested such as the FDP). During one session snow resulted in the screens being obstructed. The AFISO said *"due to snow I could not see out of the OTW view on screens 2-4. The windscreen compressor knives managed to clean screen 4 but on screen 2 and 3 the Avinor Staff had to wipe off the snow."*

The AFISO seemed to be constantly faced with issues but managed to get around technical issues by using alternative methods/tools. *"The vector function of the RDP locked when using pen but it was normal when using the pen and keyboard. The filter was out-of service; the e-strip only allowed manual use, the IDP filter was unserviceable. There was no FDP information due to a late AFTN connection hence unable to provide MET information, had to use Norwegian Aeronautical Information System (NAIS) instead. The PTZ and IR cameras were jumping and slow/blurry at times, appearing and disappearing".* Although the results for human performance were not greatly reduced due to these issues there was the potential for this to be seen, with the workload scores for frustration dropping to low levels and the AFISO's ability to plan impacting overall situational awareness.

Other comments highlighting areas of risk and possible mitigations include;

- *"Problems with the VCS made it difficult to hear what was said on the telephone and this was not sufficient for me as an operator. Aircraft, AFIS and Værøy staff use the same radio frequency; I coordinated with Værøy staff via telephone/mobiles". "The telephone cannot be used in providing ATS live. Unable to hear what was said, this is a major safety/security issue"*
- *"Sea spray got on the windows, sometimes together with snow and it was impossible to see out of the window.*
- *A risk contributor from a technical point of view is a backup. Having a panel in the IDP to see the status of the compressor and windblades. From an operational point of view, the main*

risk contributors are the angle of the OTW; it is too small with a large cone of silence. The OTW can get covered in snow. The VSC must be improved, more stable. How to exchange information about estimates, interface between today's systems and FDP/other systems"

- *"Good communication devices to communicate with personnel at Værøy and exchange information with good procedures and routines will mitigate risks"*

6.3.3.1.4.3 Detecting Hazards

The advanced visual features PTZ camera, IR camera and tracking overlay all gained ratings indicating overall neutrality towards AFISO hazard detection capabilities. When asked if "Using the function will aid my hazard/conflict detection ability of aircraft in the air in limited visibility/aircraft in the air in good visibility/aircraft on the ground in limited visibility/aircraft on the ground in good visibility" the AFISO rated as follows:

		PTZ	IR	Tracking Overlay
Aircraft in Air	Good visibility	4	5	4
	Limited visibility	3	3	4
Aircraft on Ground	Good visibility	5	3	4
	Limited visibility	4	5	4

■ Strongly Agree ■ Agree ■ Neither agree nor Disagree ■ Disagree ■ Strongly Disagree

Figure 79: Hazard detection of advanced visual features during the ASM trial

6.3.3.2 Analysis of Exercise Results

Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results	Validation Objective Analysis Status per Exercise
OBJ-06.09.03-VALP-0060.0013	Gain feedback on the technical capability of the Remote AFIS Platform and its systems.	The trial has facilitated the gathering of technical capability feedback; The AFISO indicates satisfactory workings of the technical platform and its systems. The technical platform has been assessed and works optimally.	Failure of the compressor and incorrect positioning of compressor blades caused reduced/poor OTW visibility. Otherwise no issues with MET observations. Communications rated negatively. The AFISO answered "no" in response to if the system was safe and comfortable in the AFISO acceptance rating. Some parts of the technical system contributed to reducing workload. Technical problems with specific functions increased workload. The VCS received reduced technical capability scores due to poor functionality.	NOK
OBJ-06.09.03-VALP-0060.0014	All the participants (Bodø TWR, Bodø ATCC, Værøy – personnel, technicians, operators, pilots and RNoAF) in the trial are fully aware of all the relevant procedures and have been either trained or briefed prior to entering ASM.	The trial participants have shown full understanding of the relevant procedures prior to entering ASM.	Briefings and training sessions were completed. The AFISO answered "yes" to being prepared to use the (PSM) system in an ASM trial to provide service to aircraft. Experienced observers and members of the validation team were also monitoring the AFISO's ability and competence using the system tools. Letters of agreement were signed for approval of the trial conduct and associated techniques/methods used	OK
OBJ-06.09.03-VALP-0060.0017 *(N.B. this objective was added during the trial itself)*	Gain feedback from the airspace users relating to: • Communication , quality, consistency, problems experienced; • Surveillance, clearances received," trust in the system", separation; • Flight Safety, conditions observed, but not reported by ATC (birds, objects in the FATO area etc.); • General impression.	The airspace users interviewed during the trial find the concept acceptable and state a willingness to use such a service.	Positive feedback obtained from pilots indicated that the RVT *"strongly contributes to improving the level of service to and from Værøy".* In relation to level of service 90% of responses indicated a positive opinion. 3 out of 5 pilots agreed and 2 out of 5 strongly agreed that the level of service received via the remote tower concept was at least the same as would be received from a local aerodrome tower. Communication, information provision, co-ordination and accuracy of MET were all rated by pilots a being acceptable.	OK

OBJ-06.09.03-VALP-0060.0015	To assess, during **Passive Mode**, the range of AFIS functions that could be performed, including: • The visual surveillance of the aerodrome and vicinity of the aerodrome area, in any weather condition. • Providing information to aircraft based on the remote MET observation. Assess the confidence the AFISO has in the accuracy of the MET observation.	The Remote AFISO indicates that they could perform a sufficient range of functions and tasks using the platform, to provide live service to the aircraft. Sufficient feedback has been gathered and the AFISO indicates that the MET observations are accurate	The AFISOs were able to maintain visual surveillance in any weather and provide MET to aircraft. 85% of AFISO responses within PSM trials indicated they could "very accurately" judge the MET conditions (78% during ASM trials). The IR camera was able to detect weather including showers in the vicinity, providing the AFISOs with more information than they were used to. With the help of the AWOS information and the OTW the AFISOs had confidence in the accuracy of the MET information. Overall the AFISO was neutral on the system's ability to provide accurate MET information giving it a rating of "neither agree nor disagree".	OK
OBJ-06.09.03-VALP-0060.0016	To gather AFISO opinion, during **Passive Mode**, on the level of service that can be provided under the current technical configuration to a single aerodrome.	The requirement for the various technical enablers with respect to service levels provided is known for the scenarios experienced during the trial.	The AFISOs stated the level of service provision would be the same as in local operations. The IR and PTZ cameras were rated as **improving service.** The lack of physical judgement of weather **reducing service** the most, however if ever in doubt local personnel can be contacted to confirm conditions. The average acceptance for **all** functions was 78% "strongly agree" or "agree".	OK
OBJ-06.09.03-VALP-0060.0022	Support the development of working methods & procedures for normal situations related to VMC conditions, use of IR camera, and weather observations.	The working methods & procedures for normal situations related to VMC conditions, use of IR camera, and weather observations have been tested. The working methods & procedures for normal situations related to VMC conditions are accepted or, where not, suitable suggestions for improvement have been identified.	The ASM AFISO was able to perform all AFIS tasks and functions necessary. The ASM AFISO "strongly agreed" that the working methods for normal situations relating to VMC, the use of IR camera and the observation of weather in normal conditions were **acceptable.** Suggestions to enhance the procedures and working practices included; **Basic training days locally to improve knowledge**.	OK
OBJ-06.09.03-VALP-0060.0023	Obtain feedback on the safety, under normal conditions, of the Remote AFIS **Concept** during the **Advanced Mode.**	The trial has facilitated the gathering of safety feedback by the AFISO.	The safety of the remote tower was just like a local tower in terms of the **concept, however currently the system** does not provide adequate safety standards. Under normal conditions (*safety not tested for abnormal or degraded mode operations*), the ASM AFISO "strongly agreed" that **the Remote AFIS concept was safe**. The main operational risk was the OTW viewing angle and need to improve the VCS. Hazard detection was either not impacted or improved by advanced features for both aircraft in the air and on the ground in both limited	OK

			and good visibilities. Pilots' feedback was positive, stating the RVT strongly contributed to improving information and safety.	
OBJ-06.09.03-VALP-0060.0032	Support the development of working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft)	The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) have been tested. The working methods & procedures for abnormal situations potentially experienced during the trial (e.g. emergency situations in an aircraft, communication failure with one aircraft) are accepted or, where not, suitable suggestions for improvement have been identified.	**Results from the workshop are detailed in** Error! Reference source not found**..** Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having an accurate PTZ camera functionality and a 360^{o} visual representation were included in ATCO feedback. PTZ camera functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars. The provision of a 360^{o} visual representation was to enable the ATCO to maintain a continuous visual view of aircraft, and would be dependent on the traffic patterns at individual aerodromes.	OK
OBJ-06.09.03-VALP-0060.0042	Support the development of working methods & procedures in degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information)	The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information) have been tested. The working methods & procedures for degraded mode situations related to the failure of the visualisation system (black-out, frozen, corrupted information) are accepted or, where not, suitable suggestions for improvement have been identified.	Working methods for degraded operations did not rate as highly, with the AFISO neither agreeing nor disagreeing with their acceptance when questioned. Various unusual/unexpected events occurred throughout the trials which were not "scripted" or structured. These included: Power cuts at Værøy; Problems with the VCS; Screen blackouts; Compressor blades (and therefore means to clean the lens) stopped working, resulting in snow blocking the OTW, which required local intervention; Bearing in mind the AFISO was faced with numerous technical problems, the AFISO was still able to perform all the necessary AFIS tasks.	NOK
OBJ-06.09.03-VALP-0060.0052	Assess the utility of the Remote AFIS Concept, by determining its impact on: • the human performance, in particular in terms of situational awareness The working methods and procedures, in particular for visual assessment of the aerodrome area.	The trial has facilitated the gathering of feedback; The concept does not have a negative impact on safety and human performance.	Situational awareness was at a high level throughout. **SASHA scores were 5.4 (average)** and did not drop below 4. The AFISO scored highest in "feeling ahead of the traffic" and "not having to search". The PTZ and IR camera most contributed to increasing situational awareness. The AFISOs also said that the OTW is sharper in the trial compared to a local tower. Some technical features decreased situational awareness for example the Tracking Overlay which was jumping and unstable within 10NM of Værøy.	OK

OBJ-06.09.03-VALP-0060.0063	To assess the impact of the Remote AFIS Concept on AFISO Human Performance during **Passive Mode** in all weather and visibility (including daylight and darkness) conditions: I. Situation awareness II. Trust	AFIS situation awareness must be shown to be within acceptable limits (the value of the 'acceptable limits' will be defined with regard to the tool(s) employed to assess situation awareness). The Remote AFISO is able to detect potential conflicts, hazardous situations and other events that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas. AFISOs reported level of trust must be shown to be acceptable.	SASHA results were very positive. On average PSM situational awareness was 5 indicating "very often". Scoring highest "in feeling ahead of the traffic" and "not having to search". The lowest score given was 3 on one occasion for "ability to plan". AFISOs mentioned you can obtain a more detailed focus on the surroundings with the advanced visual features. In daylight, the detail and focus was stated to be **even better than in a local tower**. The positive feedback regarding situational awareness was mentioned in both good visibility and limited visibility. All the ATCOs said the system is: • "very often" **understandable and accurat**e; • "always" or "very often" **confident, reliable and useful;** • Two AFISOs said it is "often" **robus**t.	OK
OBJ-06.09.03-VALP-0060.0064	To assess the impact of the Remote AFIS Concept on AFISO Human Performance during **Advanced Mode** in all weather and visibility (including daylight and darkness) conditions : I. Situation awareness II. Trust III. Workload	AFISO situation awareness is within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment). The Remote AFISO is able to detect potential conflicts, hazardous situations that may impact their work, on the airport surface and in the vicinity of the airport under good and limited visibility conditions. AFISOs reported level of trust must be shown to be acceptable. AFISO Level of workload is within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).	Situational awareness scored highly in the SASHA results equating to "very often" being able to maintain situational awareness. The **trust for the ASM trial was acceptable, SATI average 5.2.** Average SATI 5.5 for; useful, reliable, accurate, understandable and confident. The most trusted technical systems mentioned were the IR camera, PTZ camera, OTW and the aerodrome sound (important for situational awareness). The VCS caused many problems for the AFISO and was highlighted as the least trusted operational system. Overall workload was shown to be acceptable in all weather conditions and visibility. The lowest workload was in how mentally demanding the task was, and how rushed the pace of the task was. The **average NASA TLX score was 0.8**, indicating a very low workload.	OK
OBJ-06.09.03-VALP-0060.0075	Assess the acceptability of the Remote AFIS prototype for AFISO, in terms of:	The Remote Provision of ATS to a single aerodrome concept, is usable/acceptable to the ATCO in terms of:	**Visual Reproduction:** 88% acceptance level overall. , with a need for more filters and adjustments to OTW angle. **PTZ Camera HMI**: 75% acceptance. Easy to use although the HMI could be improved.	OK

	• The prototype in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	• The prototype in general • HMI (visual reproduction) • HMI (Advanced Visual Features) • HMI (CWP) • The Working Environment	**IR camera:** 85% acceptance. No negative feedback. **Tracking Labels:** 90% acceptance. Labels malfunctioning within 10NM of the aerodrome. **CWP HMI:** 73% acceptance in PSM trials and 25% in ASM trials. Rated least favourably throughout trials. The AFISOs felt the letters on the CWP systems were too small. **Working Environment:** 62% acceptance. Not always ideal.	
OBJ-06.09.03-VALP-0060.0076	Gain feedback into the impact of the Remote Provision of AFIS on AFISO roles tasks & responsibilities.	The trial has facilitated the gathering of feedback, relating to the impact of remote tower ops on AFISO roles, tasks & responsibilities'. The operators find the proposed their current roles tasks & responsibilities to be clear and acceptable to them. Feedback has been gathered where the roles and responsibilities could be improved if necessary.	The ASM AFISO said that the AFISO remote tower tasks, **roles and responsibilities were clear and acceptable**. The AFISO also commented that there was **no difference between the roles, tasks or responsibilities t**hat were provided when located remotely compared to when they were located locally.	OK
OBJ-06.09.03-VALP-0060.0103	To gather feedback of the operability ,usability and utility of the various technical features for Remote Provision of ATS to a single aerodrome, including PTZ Camera, Radar, Advanced Visual Features etc.	The requirement for the various technical enablers with respect to service levels provided is known for the scenarios experienced during the trial. The usability and operability of the Remote Provision platform of AFIS to a single aerodrome is acceptable, i.e. the system is user friendly	**The operability, usability and utility of technical features scored highly, although improvement required.** **OTW** all displays and e-strip (manual use only) were used 100% of the time. **PTZ** camera was found to be easy and intuitive to use. **IR** camera gave AFISOs information regarding weather. Used to assess cloud base, consistency in the dark and to scan FATO for obstacles. **Radar** contributed the most to reducing workload in ASM trials. **Tracking** scored highly on usefulness, although not intuitive. Compensated for the "cone of silence." **FDP** was useful but over complicated (not fully tested as not currently fully compatible). **Filters** were deemed important for a usable OTW. **Sound** increased perceived situational awareness. **AWOS** useful; technical issues limited assessment.	OK
OBJ-06.09.03-VALP-0060.0104	Gain feedback on Communication facility utility, usability and acceptability in the Remote Tower platform during **Passive Mode**, including: • Communication with	The trial has facilitated the gathering of communication feedback, the AFIS indicates having confidence in the communication facilities and systems during normal and abnormal operations.	100% of the time the AFISOs rated that it was "Very easy" to communicate with Værøy personnel through radio. The PSM AFISO rated all forms of communication with Værøy (radio and telephone) and co-ordination with Bodø ACC a "very easy".	OK

	Værøy personnel through radio • Communication with Værøy personnel through telephone • Internal and External communication in case of an emergency			
OBJ-06.09.03-VALP-0060.0105	Assess the Communication facility utility, usability and acceptability in the Remote Tower platform during **Advanced Mode**, including: • Communication with Værøy personnel through radio • Communication with Værøy personnel through telephone • Internal and External communication in case of an emergency	The trial has facilitated the gathering of communication feedback, the AFIS indicates having confidence in the communication facilities and systems during normal and abnormal operations.	Below average technical capability scores (2 or disagree) for communications with: Værøy personnel through radio and telephone and emergency communications. The VCS suffered from interference, feedback and there was an issue that there was no split function as the AFISOs are used to. The telephone absorbed and amplified any noise in the room which was a safety risk. Deficiencies with the VCS made it hard for the AFISO to perform their function which resulted in a move to co-ordination via mobile telephone, this being highlighted as a safety and security issue. **Results from the workshop, focusing on abnormal operations, are detailed in** Error! Reference source not found.**.**	NOK
OBJ-06.09.03-VALP-0060.0080	To validate information and assumptions that will be used in any Business Case Transversal Assessments, relating to the Cost Effectiveness of Remote Provision of ATS to Single low to medium density airports.	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.	The primary driver for Remote Provision of ATS is Cost Effectiveness. However, it was never the project's aim to prove this directly through validation trials. Rather, the trials were used to validate the assumption in the business case i.e. that it is operationally feasible to provide ATS from a remote location. Maintaining Operational Feasibility depends most on safety, human performance and capacity and so it is those areas that are further explored. Results show that the assumption was validated and information was provided to suggest that the concept was feasible.	OK

6.3.3.2.1 Unexpected Behaviours/Results

The following unexpected results and/or behaviours as noted within exercises VP-058 are:

1. Certain ASM trial results were negatively impacted by the working environment (the presence of visitors, temporary failure of air ventilation systems) but these factors were only considered to impact results directly related to the working environment in the trial, have since been rectified and are not considered critical to the feasibility of the overall concept. This issue is only mentioned here to give some context to a few unusually low scores.

6.3.3.3 Confidence in Results of Validation Exercise

6.3.3.3.1 Quality of Validation Exercise Results

Two primary influences over the exercise VP-058 should be noted:

1. One participant AFISO directly took part in the trials. Responses from multiple retired ATCOs were also included and considered within results for the PSM trial yet all feedback for the advanced mode is from one participant. The potential biased this introduces to results, due to results being based around just one participants opinions, should also be noted;
2. The trial was performed at a heliport and hence the long distance visual issues that may be faced when operating at an airport may not have been fully realised. The updated OTW should also be tested within an airport setting.

6.3.3.3.2 Significance of Validation Exercise Results

EXE-06.09.03-VP-058 was undertaken by one AFISO. However, during the passive shadow mode trials the safety co-ordinator and project managers were also able to participate enough within the trial to be able to add value to the validation. Hence these members of the project team, together with the trial AFISO completed the end of PSM questionnaire, with results for all participants being considered.

Feature	Percentage difference between AFISO score and average score
Visual Reproduction	-3%
PTZ Camera	5%
Infra-Red Camera	-6%
Tracking Overlay	0%
CWP	-5%
Working Environment	-17%

Figure 80: Percentage difference between AFISO score and the average score given by other participants completing the End of PSM questionnaires.

The table above shows how much the AFISO's average score for each feature, given within the End of trial questionnaire, varied when compared to the average score for the three other participants filling out the same questionnaire. **Any variation seen above has been revealed to not be statistically different**, indicating that any variations within scores are due to natural variation and not due to a fundamental difference in the average scoring given. Although the sample size is small it does indicate that the AFISO's scores can be used to represent the other 3 participating members (on average) and vice versa.

All statistical analysis is quoted to a significance level of 95% (alpha =0.05) and are primarily two tailed T-tests, indicating that the directionality of results has not been assumed and decreasing the chances of a false significance being found within results.

6.3.4 Conclusions and recommendations

6.3.4.1 Conclusions

The main focus of VP-058 in the first PSM element was to assess the confidence and assurance among stakeholders that the system that could be used for the provision of ATS in live traffic during the second part of the trial. The second part of the trial, the ASM element, used the prototype system in order to assess the acceptability of the concept, HMI , Human Performance, Safety and Capacity.

The trial indicated that the Remote Provision of AFIS to a Single Aerodrome concept is viable and acceptable. AFISOs rated the average acceptance for the functions used very highly. Feedback suggests that there still is room for improvement. Features need to be optimised bearing in mind the typically moderately constrained environments which may be constrained geographically or by the weather. The trial took place in the middle of winter; conditions of heavy snow, wind and darkness were experienced frequently. Snow obstructed the camera lens window which resulted in the OTW becoming obscured, as the compressor air did not fully clear this obstruction, Værøy staff had to facilitate the removal of the remaining snow to clear the cameras view. In addition, the sea salt managed to obstruct the AWOS sensor, to decrease this phenomena it should be relocated or additional technical support added to reduce the issue. The video tower design worked well, remaining stable in the high and challenging winds which were experienced (up to 50kts).

Overall the OTW view received positive feedback especially concerning the resolution, screen size and contrast. Observes from IVT indicated that the visual reproduction was of a high quality and provided improved accuracy compared to the previous platform versions tested. This was optimized by the filters which the AFISOs found beneficial in blocking out the direct sunlight which at times shone directly into the cameras. The frame rate also scored highly although long exposure time was possibly the cause of the AFISOs not being able to see flashing lights such as the helix-lights which were in fact functioning properly. The position of the cameras and the angle of the OTW view scored the lowest due to the fact that there was a cone of silence and AFISOs could not see the entire helicopter departure. A potential solution for this could be to utilise a wider angled lens or move the video tower a short distance.

Feedback on the advanced visual features was positive from the AFISO (including the two retired AFISOs participating in the questionnaires), the IVT indicated that the Advanced Features aided the AFISO in performing a more safe and efficient provision of ATS. The IR and the PTZ cameras were particularly favoured. They were found to be useful, intuitive, and improved the AFISOs' situational awareness in good and limited visibility. Issues from VP-057 were resolved relating to the technical robustness, quality of the image and HMI of the PTZ. The tracking overlay throughout the trial scored highly on usefulness but slower on it being intuitive, efficient and easy to use. This could be because throughout the trial it was unstable with radar labels jumping inside 10NM from Værøy.

Feedback concerning the CWP, RTM and working environment was rated moderately positive. The ambient sound was found to be useful and improved situational awareness, the lighting was acceptable within the RVT room and the AFISO's agreed that it was a pleasant working environment. Results for the working environment were heavily impacted by room temperature rising to uncomfortable levels (due to failure of the ventilation system). In addition, the VCS caused multiple problems for the ASM AFISO. There was a lot of feedback interference and there was no split function. The noise within the RVT room was absorbed and amplified through the radio.

Situational Awareness was assessed throughout the trials and on average had high results in both good and limited visibility. The AFISOs mentioned that the OTW was even sharper than in a local tower with the help of the IR and PTZ camera which contributed to the clarity of the image.

AFISOs reported a good level of trust in the concept and systems. The lowest trust was found in the reliability and robustness of the system which was due to the technical issues experienced throughout the trial however this did not seem to impact their thoughts on how useful, accurate, understandable and confident the system was which all scored highly.

The acceptability of the working methods for normal situations related to VMC and the IR camera as well as weather observations was high. The working methods relating to abnormal and degraded mode situations received scored less highly. However, no responses indicate any disagreement with the currently working methods in place. Feedback regarding the allocation of roles and

responsibilities indicated that they were clear and acceptable. The AFISOs felt that there was no difference between the roles or responsibilities when provided remotely compared to when they were located locally. Supplying the weather did differ slightly when compared too local operations. The AFISO could not step outside like in a local tower so used the OTW together with AWOS, the IR camera, the PTZ, online weather radar and confirmed with local staff at Værøy when necessary.

The AFISOs believed that the level of service provided using the Remote AFIS system compared to current operations was slightly better. Positive feedback was also obtained from pilots with regards to the professional levels of service they received. They mentioned it strongly contributed to improving information and safety. The IVT indicate that although the proposed solution is not yet completely mature it is feasible enough for the intended AFIS service to be provided.

The initial aim of the Advanced Mode trial was for the AFISO to provide the full AFIS service to the aircraft as the ATCO-in-the-loop using the prototype system, the full AFIS service could not be provided due to the trial environment and agreement with airspace users. However, evidence suggests that this service could be provided and improvements to technical enablers and systems would only increasingly improve the quality of service the AFISO could provide.

6.3.4.2 Recommendations

The recommendations from VP-058 include the following:

- **Recommendations for the Validation Planning:**
  - Include simulated emergency situations with aircraft in a shadow mode trial environment in order to fully test procedures;
  - Improve the organisation of RTC, reducing secondary distractions.
- **Recommendations for the Concept:**
  - Continue development and support of the Advanced Visual Features (additional camera viewpoints and label overlays) given the strong positive feedback from this trial;
  - Consider elaborating information in the OSED for example further explanation of the advanced visual features;
  - When in implementation, the AFISO should complete a period of basic training at the airport they are providing service to which will improve the MET background knowledge such as local terrain/turbulence and also improve working relationship with local aerodrome staff.
- **Recommendations for the Trial Platform:**
  - Improve trial organisation so that it does not reduce the acceptability of the working environment;
  - Improve the video towers angle horizontally to give a wider viewing angle.
  - Include a **compressor status function** to clearly indicate if the compressor is malfunctioning.
  - Improve the stability of the **radar tracking** function within 10NM of Værøy. Make the radar tracking labels moveable so they do not block critical parts of the OTW;
  - Ensure the **FDP, e-strip, tracking, RDP, EME in IDP and the emergency button** are functioning and are tested for future trials;
  - Change or improve the current **VCS** in order to reduce the interference and feedback issues. Include a split function;
  - Sort out the issues concerning **snow accumulation on camera lens window, blocking the OTW** so that the Remote tower is not dependent on local Værøy staff;
  - Change the **layout of the CWP** so that there is space to accommodate items ;
  - **Relocate the AWOS sensor** so that it does not get blocked with sea salt.

7 References

7.1 Applicable Documents

[1] V&V Plan Latest version

[2] SESAR V&V Strategy Latest version

[3] Template Toolbox 02.00.00

[4] Requirements and V&V Guidelines 02.00.00

[5] Toolbox User Manual 02.00.00

[6] European Operational Concept Validation Methodology (E-OCVM) - 2.0 [March 2007]

7.2 Reference Documents

The following documents provide input/guidance/further information/other:

[7] **P06.09.03 Operational Services and Environment Description (OSED) for Remote Provision of Air Traffic Services to Aerodromes, including Functional Specification,** D04, Edition 00.04.02, NORACON, March 2013.

[8] **P06.09.03 Validation Plan (VALP) for Single Remote Tower,** D05.1, Edition 00.03.01, NORACON, March 2014.

[9] **ROT Project Final Report v1.00,** D-LFV2009-053075, LFV, 23/11/2010.

[10] **ART Project Validation Report Revision 1,** ART WP3.4 D3.4.1, 17/03/2010.

[11] **P06.02 Detailed Operational Description (DOD) Step 1,** D07, Edition 01.00.01, 20th February 2012.

[12] **P06.09.03 Validation Strategy (VALS),** D05, Edition 00.01.01, March 2011.

[13] **ICAO Document 4444 "Procedures For Air Navigation Services** - Air Traffic Management", 14th Edition, November 2005.

[14] **ICAO Document 9426 "Air Traffic Services Planning Manual",** 1st Edition, December 1992.

[15] **EUROCONTROL "Manual for AFIS",** 1st Edition, October 2010.

[16] **P06.09.03 Remote and Virtual Tower Safety Plan,** Edition 00.01.00, 28/03/2011

[17] **OFA06.03.01 Remote Tower - Safety Assessment Report for Single Remote Tower,** D14, Edition 00.01.01, NORACON, March 2014.

[18] **P06.09.03 HP Assessment Report for Single Remote Tower,** D15, Edition 00.01.01, December 2013

[19] **P06.09.03 Project Management Plan (PMP),** Edition 00.03.00, NORACON, 9th June 2011.

[20] **P06.09.03 Validation Report (VALR) for Remotely provided ATS for Contingency Situations at Aerodromes,** D09, NORACON.

[21] **P06.09.03 Remote Provision of ATS to a single aerodrome VALR Annex**, D08-02, Edition 00.05.02, April 2014.

Appendix A Additional assessment of SDM-0201 via a structure Stakeholder Workshop

A.1 Assessment of SDM-0201 "Remotely Provided Air Traffic Services for a Single Aerodrome" and Justification of Workshop

OI Step SDM-0201 "Remotely Provided Air Traffic Services for a Single Aerodrome" included three primary exercises assessed by ten project level validation objectives as shown in Table 4. During the course of the project exercises nine out of ten objectives were assessed. Of these nine objectives, all achieved SESAR validation objective status "OK" and were hence successfully met as detailed in Table 9 Section 4. Due to the constraints of the exercise assessment methods used and other validation constraints, one objective was not assessed throughout. The justification for this appendix is to detail the results gained during an assessment of the objective that was not covered during the planned exercises (VP-056, VP-057 and VP-058).

Table 35 below provides details of OBJ-06.09.03-VALP-0060.0030, the objective assessed outside of the planned exercises. The assessment was conducted during a workshop held on 8th October 2013, Göteborg/Landvetter (ESGG) airport, Sweden (herein referred to as "the workshop").

Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion
OBJ-06.09.03-VALP-0060.0030	Safety in Abnormal Conditions.	CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as defined in section 2.2 of the Safety Plan satisfied

Table 35: Validation objective under assessment during the workshop

A.2 Experimental design

A.2.1 Participants

Due to the time period between the Single Remote Tower exercises and the workshop being held, along with other constraints it was not possible to involve the Air Traffic Control Officers (ATCOs) who had previously participated within the Single Remote Tower trials in the workshop.

Instead the workshop combined with work being done in relation to the OI step SDM-0204 "Remotely Provided Air Traffic Service for Contingency Situations at Aerodromes" exercise EXE-06.09.03-VP-059 (Contingency Tower trial).

Hence the workshop utilised ATCOs who were participating in the exercise under the Contingency Tower trial and who had not been in direct involvement with the Single Remote Tower exercises.

Results gained via the workshop are therefore not directly based upon the conditions as seen under Single Remote Tower exercises VP-056, VP-057 or VP-058. This should be taken into consideration when assessing the findings documented within this appendix and assessing them against the results from the SDM-0201 validation exercises.

Two ATCOs participated in the workshop who had also participated in the contingency trial VP-059. Both of these ATCOs were familiar with the concept assessed under Single Remote Tower (SDM-0201) and one of these ATCOs had previously viewed the set-up as used within single remote tower ATCO trial 2 (VP-057). Alongside these ATCOs two further managerial level/Chief of Operations personnel at ESGG (also valid ATCOs), took part in the workshop, although they were not also participants of the Contingency Tower trial. Two senior experienced ex-ATCOs who were also on the P06.09.03 project team also were able to participate in the workshop and adding the value of operational experience and an experience with all parts of the P06.09.03 project.

The workshop also included other stakeholders in addition to ATCOs. All stakeholders were able to participate in discussions and contribute to results in full and equivalently.

Stakeholders present at the workshop included:

7. Four ATCOs from ESGG;
8. Representatives from Swedavia (*Swedish airports, government owned agency responsible for Sweden's commercial airport operation*);
9. Airspace users in the form of pilot representatives from International Council of Aircraft Owner and Pilot Associations (IAOPA) and Novair;
10. SAAB technical experts;
11. P06.09.03 LFV project management and team members *(whereof two members were senior experienced ATCOs and a further two contributed operational knowledge of ATC and validation)*
12. LFV (*Swedish Air Navigation Service Provider (ANSP))* human factors experts.

In summary a total 14 stakeholders were present at the workshop. This included four operational ATCOs and two experienced ex-ATCOs and two airspace users.

A.2.2 Variances in Validation Platform Setup

As detailed in A.2.1 above the workshop utilised ATCOs who were not directly involved in the trials under Single Remote Tower and instead these ATCOs were participants in/involved with the Contingency Remote Tower trial. This section discusses the impact of this and expands on the variances in the technical setup that the ATCOs were familiar with (i.e. the contingency remote tower) and that used within the single remote tower trials.

The variables that differed between single remote tower and contingency remote tower were primarily ATCO participants, the specific prototype and the operational environment of the concept.

The operational environment of the contingency remote tower is aimed at larger aerodromes with a higher number of movements; the concept does not aim to become a replacement for the existing local tower but too act as a contingency facility to be used during periods of time when the local tower is not operational. This is in contrast to the operational environment of the single remote tower where a lower traffic level is experienced and the operational concept is aimed at being a permanent and full time replacement to the local tower. Hence the workshop ATCOs were more familiar with using the concept together with a larger traffic sample size.

In relation to the prototype the ATCOs in the workshop had not used a 360° visual representation of the aerodrome. However within single aerodrome exercises VP-056 and VP-058 the ATCO/Aerodrome Flight Information Service Officer (AFISO) did have a 360° visual representation of the aerodrome. The ATCOs who partook in the workshop were familiar with the contingency trial which used a 240° visual representation of the aerodrome. For further information on the operational concepts assessed under each OI step, refer to the P06.09.03 OSED [7]

These conditional changes were considered to have a low impact on the overall quality of results that could be gained in relation to OBJ-06.09.03-VALP-0060.0030. This was deemed to be the case because the prototype the ATCOs used to assess the contingency remote tower was very similar to the system used in the single remote tower exercises, both relate to the same OSED requirements and technical specification [7]. Also the rationale behind the remote tower concept and specifically the single remote tower concept was known to ATCO participants.

It should be highlighted that technical configurations and ATCO participants were changed both between and within the single remote tower exercises (VP-056, VP-057 and VP-058) and hence none of the exercises under the single remote tower were directly comparable when considering these variables. It was therefore deemed acceptable to include conclusions from this workshop together with results from the Single Remote Tower Trials to form conclusions against OI step SDM-0201 "Remotely Provided Air Traffic Services for a Single Aerodrome".

A.2.3 Assessment Methods

As detailed above the validation technique for the assessment of safety in abnormal conditions was a workshop and hence results detailed within this appendix are qualitative, consisting of purely subjective feedback.

The workshop took the form of structured group based questioning, using pre-formatted questions, together with general discussions.

Discussions were held as part of one large group but also within small sub groups, in order to allow for more detailed questioning and to facilitate a contribution from all stakeholders.

A.3 Safety Criteria

The unassessed objective (OBJ-06.09.03-VALP-0060.0030) relates to safety under abnormal conditions. This objective is to be assessed alongside the full assessment of safety detailed within the Remote Tower safety plan and report [16]and [17].

The safety objectives, including objective OBJ-06.09.03-VALP-0060.0030 were derived from the safety plan [16]**Error! Reference source not found.** and influence the success criteria. The success criteria for OBJ-06.09.03-VALP-0060.0030 states "*The Safety Acceptance Criteria (as defined in section 2.2 of the Safety Plan within the appendix of the P06.09.03 VALP [16]) are satisfied*". Details of the safety acceptance criteria and safety plan are outlined below so that an understanding of the objective success criterion can be gained:

- The aim of the safety assessment is to show that "providing ATC/AFIS services remotely for one airport is as safe as current locally provided ATS services in low density airports". Hence **the workshop was designed to explore if cases of safety reduction exist** and hence provide evidence to be used in relation to the projects safety assessment report;
- The safety assessment criteria also states that "in relation to abnormal conditions, **evidence should be provided ensuring that the Single Remote Tower functional system can safely continue to operate under any external abnormal condition that it may exceptionally encounter**". The operational conditions that these occurrences shall be considered in should be equivalent to current operations in terms of traffic (capacity and movements) and operational environment;
- The hazardous situations and risks currently mitigated in current operations are to also be considered for Remote Tower operations.

The above criteria were considered in the planning of the workshop and hence discussions focussed on the fulfilment of these safety criteria by setting pre-planned discussion topics.

The safety plan [16] does indicate quantification of risk, however with this subjective assessment method risk was unable to be quantified in line with the safety plan.

A.4 Workshop Results

In general the opinion expressed during the workshop was that ATCOs would be able to use the Remote Tower Module (RTM) to provide ATS to a single aerodrome from a remote location. However note that this judgement was based on the platform used within the contingency tower trial - EXE-06.09.03-VP-059. This aligns with the findings from the Single Remote Tower validation exercises VP-056, VP-057 and VP-059. ATCOs did not identify any abnormal situations, unusual events or emergency occurrences where they felt safety would be degraded when using the concept to provide ATS compared to current operations.

A.4.1 Evaluation of Validation Platform Requirements

ATCOs felt that, of the Advanced Visual Features (AVFs) found within the RTM, the Pan Tilt Zoom (PTZ) camera was the most important in aiding them during an abnormal event.

The addition of a 360° visual representation was thought to positively impact ATCO tasks during abnormal conditions however was not seen necessary for safety to be maintained.. This was due to the possibility of using procedural separation to maintain safe minimum separation standards.

It should be noted (as detailed in section A.2.1 above) that the ATCOs participating within this trial did not use a 360°visual representation with VP-059 and instead partook in exercises involving a 240° visual representation. These ATCOs also experienced higher traffic levels within the VP-059 exercise than would be expected in the operational environments of single remote tower aerodromes. ATCOs expressed that with reduced traffic levels the benefit a 360° visual representation during abnormal conditions may be reduced.

Despite acknowledging that the single remote tower concept had potential, some concerns were raised over current functionality of technical enablers. One ATCO stated "*Most unusual events involve following a moving object and this is harder with the PTZ camera [than with binoculars], also is harder to use the PTZ camera to track a moving object at the same time as doing other tasks such as using the phone*." The ATCOs expressed concern over the current PTZ functionality, which they indicated would impose limitations on their response to emergency events. The main issues with the PTZ cameras current functionality were related to usability and manoeuvrability.

The ATCOs who participated in the VP-059 exercise did not have the opportunity to test the visual tracking tool, since it was not included in the validation platform. However the opinion was that for tracking to be beneficial during abnormal events it would need to be capable of tracking objects which move in an erratic manner, and ensuring smooth and accurate presentation.

The remote tower concept allows ATCOs to communicate via an aircraft "light-gun" or similar light emitting source, this in line with current operations and in compliance with regulation. This ability was mentioned by a pilot stakeholder as being particularly important in handling certain abnormal events safely from a remote tower location.

Based on the validation platform used in the VP-059 Contingency Tower trial exercise, as well as the conditions of VP-059 including the aerodrome under validation (Göteborg/Landvetter Airport), its traffic levels and traffic patterns, conclusions relating to the validation platform and functionality during abnormal conditions have been drawn. It was suggested that the combination of the PTZ camera and a 360° visual representation of the aerodrome were thought to facilitate the ATCO's response to events, allowing safety to remain unchanged in a remote tower compared to a local tower during abnormal conditions. Some improvement regarding the functionality of the PTZ camera (as listed in section 4) would be required to ensure reliable and responsive operation, something that was considered to be of upmost important during quickly developing abnormal situations.

A.4.2 Scenarios

During the workshop, discussions were held with a focus on revealing any abnormal event scenarios where safety may be reduced when providing ATS from a remote location. All stakeholders contributed to the discussions. Below are summaries detailing abnormal scenarios that were identified as being **positively impacted by the remote tower concept**.

- In the case of a "lost VFR aircraft" with a transponder the ATCO in the remote tower would be able to place a tracking label on OTW to locate the aircraft and aid in informing the aircraft of its position. In this situation the remote tower ATCO may have an advantage, hence increasing the safety of the situation;
- If an aircraft is required to fly past the tower to enable ATCOs to check the undercarriage then it was thought that the presence of the PTZ camera would enable the ATCO/AFISO to adequately track and visually checking the aircraft in order to determine its status;
- If an aircraft was forced to make a landing during darkness without functional aircraft lights it was suggested that the remote tower ATCO may have an advantage compared to when operating from a standardly equipped local tower. This was stated as being due to the potential to use the Infra-Red (IR) camera. This would hence increase the safety of the situation when providing ATS from the remote tower, if equipped with an IR camera.

However certain scenarios were highlighted as areas of concern, summarise of the discussions regarding **situations that may result in safety reduction included**:

- Stakeholders were uncertain as to whether or not the PTZ camera could be used to detect a non-functioning jet engine in scenarios where no fire or smoke was apparent. Technical systems experts from SAAB confirmed that the IR Camera can be used to detect temperature but the ability of the PTZ camera to detect turbine movement requires further verification;
- Discussions resulted in an overall agreement that in order to maintain safety during abnormal situations a 360°visual representation of the aerodrome may be a requirement. Discussions surrounding this identified the following situations as examples of where a 360° view would be required to maintain safety:
    - Small airports without a 24 hour Control Zone (CTZ) may risk experiencing aircraft taking off without the ATCO's knowledge. Although it was acknowledged that this type of event is unusual.
    - During the monitoring of VFR calibration flights a continuously visual watch may not be possible to maintain unless other traffic is limited;
    - Having full visual surveillance may enable the ATCO to provide a fuller service to aircraft and ultimately maintain a more flexible approach to the handling of abnormal events;
- Events that require the ATCO to "see" or inspect may be difficult to validate within the remote tower, this may result in a reduced ATCO trust in the visual reproductions ability to provide a robust visual view in abnormal conditions (which may involve a reliance on more detailed visual inspection).

In relation to the potential requirement for a 360° visual representation it should be noted that this requirement would only apply to certain aerodromes. Hence the requirements on the view provided by the visual representation should relate to ensuring coverage of the traffic patterns applicable to each aerodrome. Hence for some aerodromes, a 360° visual representation would be required and at others, where risk is reduced or the traffic pattern has a reduced coverage, a reduced view may be applicable.

It was suggested that a simulation could be used to further validate usual/abnormal events. However concerns were raised over whether simulations would provide the ATCOs with a "real enough" version of operations. It was expressed that realism is important in the behaviour of people during an emergency (i.e. pilot response to ATCO instructions) and also the provision of realistic communications with other agencies, including the realism of communication duration, understanding and content.

Further discussion regarding the realism of potential simulations mentioned that certain forms of ATCO emergency training is undertaken via a simulation and this form of simulation testing is accepted by the regulator as a means to keep an ATCO license valid. Therefore this may provide evidence that "visual realism" is not the defining feature in emergency training, as long as the realism of the visual reproduction of the single remote tower RTM has been sufficiently proven within other trials.

In summary many of the abnormal scenarios were safety was identified as a concern are mitigated by the technical improvements as suggested in section A.4.1. Hence with improved PTZ functionality and the provision of a 360° visual representation the potential for risk in these situations would be reduced. The exact platform configurations required may vary from aerodrome to aerodrome, dependant on the traffic pattern and traffic types. Discussions also revealed the potential for the single remote tower concept to lead to increased safety during abnormal situations (compared to current operations). This aligns with results from the SDM-0201 trials which indicate the addition of remote tower AVFs into traditional towers may provide operational benefit. Overall workshop participants did not identify any abnormal scenarios were they felt safety would be reduced without any potential for mitigations to be applied.

A.5 Workshop Conclusions

- Based upon the functionality of the PTZ as seen within VP-059, the PTZ functionality needs to be improved as a prerequisite for easy operation during abnormal situations. This stresses the importance of the OSED service requirement on a binocular functionality, stating: *"..a*

functionality corresponding to – and being (at least) equally easy and quick to use as – the binoculars in a local Tower..". For the ATCO to feel sufficiently able to handle abnormal situations the following improvements to the PTZ Camera as used in VP-059 were suggested:

- The PTZ camera movement should to be more fluid and smooth;
- Improvement to the manoeuvrability of the PTZ Camera HMI;
- Improve the technical robustness of the PTZ.

- ATCOs felt that a 360° visual representation/aerodrome view would improve their ability to respond in an abnormal situation. However this would be more beneficial at certain aerodrome than other, dependant on the extent of the traffic pattern and traffic types. Hence requirements for the view provided by the visual representation should focus on a requirement to cover the traffic pattern of the specific aerodrome.

In conclusion it can be said that ATCOs are not unduly concerned about the handling of unusual events in the single remote tower. However, it is evident that stakeholders felt validation through further activities was required in order to full establish the robustness of the concept in a range of abnormal conditions and to determine if there are any limitations on what can be safety handled under the concept. It is hence suggested that further trials under P06.09.03 look to assess abnormal conditions, testing the technical ability of the platform to facilitate the continued provision of ATS during abnormal events. The opinion of controllers within this workshop should be assessed in a simulation or shadow mode trial in order to test their initial opinions under a variety of conditions and provide a means for quantification.

Results gained through the qualitative assessment of workshop discussions have been deemed to satisfactorily met success criterion CRT-06.09.03-VALP-0060.0030. Hence objective OBJ-06.09.03-VALP-0060.0030 has been accepted by the project as gaining validation objective status "OK".

Appendix B Summary of Exercise Results

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0010	Technical and Operational Capability	CRT-06.09.03-VALP-0060.0010	The ATCO/AFISO is able to use the remote facility to perform a sufficient range of tasks to provide ATS under various operational conditions.	**24 of the 31 applicable Functional Requirements were approved without modification.** The ATCOs asked that **2 requirements be changed from *should*** to ***shall***. "The visual reproduction ***shall*** provide a non-flickering impression to the human eye" "The visual reproduction ***shall*** provide a smooth and regular impresssion of moving objects to the human eye." The remaining **5 requirements were not able to be tested in the trial.** **1 additional requirement** regarding ambient lighting in the RTC was proposed.	OK
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0010	Technical and Operational Capability	CRT-06.09.03-VALP-0060.0010	The ATCO/AFISO is able to use the remote facility to perform a sufficient range of tasks to provide ATS under various operational conditions.	ATCOs feel that they can handle an increased traffic load in the Advanced System compared to Basic (thanks to the additional functionalities). When asked if Remote provision of ATS would increase the aerodrome capacity for GA traffic using the **Basic System**: o 11 out of 14 disagreed that it would increase capacity for GA; o 13 ATCOs disagreed with the statement saying GA/VFR aircraft does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (1 ATCO indecisive). When asked if Remote provision of ATS would increase the aerodrome capacity for GA traffic using the **Advanced System**: o 3 ATCOs agreed on the statement that capacity may be increased for GA traffic (6 disagree) o 3 ATCOs agreed with the statement saying GA/VFR aircraft	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					does not have to be put on hold to wait for landing or arriving IFR traffic when provided ATS remotely (6 disagree). Most ATCOs only narrowly rated a local tower as being best for providing a service with Advanced system very close behind. For scenarios with only one aircraft the Advanced system rated higher compared to a local tower. The Basic system rated lowest when there was more than one simultaneous aircraft or vehicle movement. However ATCOs still felt they would be able to provide a service but it would place more demand on mental workload.	
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0010	Technical and Operational Capability	CRT-06.09.03-VALP-0060.0010	The ATCO/AFISO is able to use the remote facility to perform a sufficient range of tasks to provide ATS under various operational conditions.	Failure of the compressor and incorrect positioning of compressor blades caused reduced/poor OTW visibility. Otherwise no issues with MET observations. Communications rated negatively. The AFISO answered "no" in response to if the system was safe and comfortable in the AFISO acceptance rating. Some parts of the technical system contributed to reducing workload. Technical problems with specific functions increased workload. The VCS received reduced technical capability scores due to poor functionality. Briefings and training sessions were completed. The AFISO answered "yes" to being prepared to use the (PSM) system in an ASM trial to provide service to aircraft. Experienced observers and members of the validation team were also monitoring the AFISO's ability and competence using the system tools. Letters of agreement were signed for approval of the trial conduct and associated techniques/methods used. Positive feedback obtained from pilots indicated that the RVT *"strongly contributes to improving the level of service to and from Værøy".* In relation to level of service 90% of all responses indicated a positive opinion. 3 out of 5 pilots agreed and 2 out of 5 strongly	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					agreed that the level of service received via the remote tower concept was at least the same as would be received from a local aerodrome tower. Communication, information provision, co-ordination and accuracy of MET were all rated by pilots a being acceptable. The AFISOs were able to maintain visual surveillance in any weather and provide MET to aircraft. 85% of AFISO responses within PSM trials indicated they could "very accurately" judge the MET conditions (78% during ASM trials). The IR camera was able to detect weather including showers in the vicinity, providing the AFISOs with more information than they were used to. With the help of the AWOS information and the OTW the AFISOs had confidence in the accuracy of the MET information. Overall the AFISO was neutral on the system's ability to provide accurate MET information giving it a rating of "neither agree nor disagree". The AFISOs stated the level of service provision would be the same as in local operations. The IR and PTZ cameras were rated as **improving service.** The lack of physical judgement of weather **reducing service** the most, however if ever in doubt local personnel can be contacted to confirm conditions. The average acceptance for **all** functions was 78% "strongly agree" or "agree".	
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0020	Safety in Normal Conditions	CRT-06.09.03-VALP-0060.0020	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Under normal conditions, the ATCOs felt that **a safe service could be provided remotely**. Participant opinion was that, using the current technical set-up, **some restrictions may have to be applied** to that service, in terms of number of simultaneous a/c and VFR traffic.	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0020	Safety in Normal Conditions	CRT-06.09.03-VALP-0060.0020	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	ATCOs did not feel comfortable with applying visual separation in the Basic System. Thus, when using the Basic System vertical and procedural separations are to be remotely applied based on OTW displays, but reduced separation could not be applied. ATCOs felt more comfortable with the Advanced System but were still not comfortable with reduced separation. When asked, ATCOs reported the opinion that the main ground tasks that IR camera could support are: • identification of aircraft and vehicles on the ground; • detection and resolution of conflicts in the manoeuvring area; • runway related operations. The ATCOs commented that improvement is still needed in order to remotely perform the following weather related tasks: • Assessing weather conditions; • Assessing runway conditions	OK
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0020	Safety in Normal Conditions	CRT-06.09.03-VALP-0060.0020	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	The ASM AFISO was able to perform all AFIS tasks and functions necessary. The ASM AFISO “strongly agreed” that the working methods for normal situations relating to VMC, the use of IR camera and the observation of weather in normal conditions were **acceptable.** Suggestions to enhance the procedures and working practices included; **Basic training days locally to improve knowledge**. The safety feedback suggested the remote tower was the same as a local tower in terms of the **concept,** however currently the **technical system** does not provide adequate safety standards. Under normal conditions (*safety not tested for abnormal or degraded mode operations*), the ASM AFISO “strongly agreed” that **the Remote AFIS concept was safe**. The main operational risk was the OTW viewing angle and need to improve the VCS. Hazard	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					detection was either not impacted or improved by advanced features for both aircraft in the air and on the ground in both limited and good visibilities. Pilots' feedback was positive, stating the RVT strongly contributed to improving information and safety.	
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0030	Safety in Abnormal Conditions	CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Picture quality was occasionally affected when birds were sitting on the camera house. Their tail feathers covered parts of the upper image; however, they were easily scared away by rotating the PTZ. Not enough abnormal conditions were experienced during the trials to draw any firm conclusion. **Results from the workshop are detailed in** Error! Reference source not found**..** Within this workshop abnormal conditions were discussed in relation to the safety criteria. No significant concerns were raised in relation to the performance of the Remote Tower during abnormal situations. However the proviso of having a robust and accurate PTZ camera functionality and a potential requirement for a 360^{o} visual representation were included in ATCO feedback. PTZ camera functionality should allow for quick, accurate and easy manoeuvrability, equivalent to using standard binoculars. The provision of a 360^{o} visual representation view was to enable the ATCO to maintain a continuous visual view of aircraft where the traffic pattern negates a 360◦ view. This safety objective has been deemed to have been fulfilled due to the outcomes of the workshop, with further safety investigations to be performed to strength safety case.	OK
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0030	Safety in Abnormal Conditions	CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	In general, ATCOs were experiencing high Situational Awareness. There was a statistically significant difference between Basic and Advanced System for Situational Awareness. **SASHA Basic System average**: 4.72 (out of 6)	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					SASHA Advanced System Average: 5.21 (out of 6) Although specific hazards and conflicts were not scripted into the trial, ATCOs were asked to give their opinion on their ability to detect hazards and conflicts while providing remote ATS. o 12/14 able to detect hazards o 14/14 able to detect conflicts o 14/14 agree Enhanced Visual features will increase SA **43%** of ATCOs felt Remote Tower will induce more hazardous situations. Not enough abnormal situations were experience during the trial. Only a few results were during the trial (through the safety questionnaire mainly), but no conclusion can be provided from them. **Results from the workshop are detailed in** Error! Reference source not found.**. See results summarised in OBJ-06.09.03-VALP-0060.0030 VP-056 above**.	
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0030	Safety in Abnormal Conditions	CRT-06.09.03-VALP-0060.0030	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	**Results from the workshop are detailed in** Error! Reference source not found.**. See results summarised in OBJ-06.09.03-VALP-0060.0030 VP-056 above.**	OK
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0040	Safety in Degraded Conditions	CRT-06.09.03-VALP-0060.0040	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Some degraded (visual) conditions were naturally experienced and also simulated during the trial. The ATCOs that experienced the degraded conditions were **not unduly concerned, and related the scenarios to Low Visibility in today's operations**. The general feedback was that **operational and procedural solutions** (e.g. Low visibility Procedures) **could mitigate against degraded visual conditions**.	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0040	Safety in Degraded Conditions	CRT-06.09.03-VALP-0060.0040	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Some degraded mode scenarios were simulated in the trial on an opportunistic basis, mainly related to screen failure or out of date MET information. The main proposed procedure was to revert to One Movement Mode in case of loss of visual reproduction. This mode is a replication of the commonly used Low visibility procedures (LVP) with regards to the ATCO tasks. Other feedback included: • All ATCOs said there was a need to inform flight crews that the control is remote and that the ATCO has lost visual contact. • The ATCOs would like to see a system that always is able to generate alerts when there is a malfunction of any kind. And a back-up system should always be available at a “click of a button”; • A procedure for hand-over between ATCOs is needed.	OK
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0040	Safety in Degraded Conditions	CRT-06.09.03-VALP-0060.0040	The Safety Acceptance Criteria (as per Preliminary Safety Assessment, section 2.4) are satisfied	Working methods for degraded operations did not rate as highly, with the AFISO neither agreeing nor disagreeing with their acceptance when questioned. Various unusual/unexpected events occurred throughout the trials which were not “scripted” or structured. These included: Power cuts at Værøy; Problems with the VCS; Screen blackouts; Compressor blades (and therefore means to clean the lens via distribution of airflow over the lens) was out of position, resulting in snow blocking the OTW, which required local intervention; Bearing in mind the AFISO was faced with numerous technical problems, the AFISO was still able to perform almost all necessary AFIS tasks.	NOK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0050	Safety completeness and implementation	CRT-06.09.03-VALP-0060.0050	The set of safety requirements specifying the Remote Tower system for a single airport is complete and they can be implemented in a typical physical architecture	N/A	-
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0050	Safety completeness and implementation	CRT-06.09.03-VALP-0060.0050	The set of safety requirements specifying the Remote Tower system for a single airport is complete and they can be implemented in a typical physical architecture	The main enhanced features potentially supporting “air operations related tasks ” were first the radar tracking one (15% of the total use of enhanced features), closely followed by the radar-based surveillance display and the video tracking (11% each). Concerning the “ground operations related tasks”, the two enhanced features potentially to be used were video tracking (25%) and the additional cameras (23%). For most of the ATCOs the IR camera functionality was not used, mainly because the scenarios experienced were in daylight. Only some recorded scenarios were presented to some of them, but no interaction with the system was possible. When asked, ATCOs reported the opinion that the main ground tasks that IR camera could support are: o identification of aircraft and vehicles on the ground; o detection and resolution of conflicts in the manoeuvring area; o runway related operations.	OK
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0050	Safety completeness and implementation	CRT-06.09.03-VALP-0060.0050	The set of safety requirements specifying the Remote Tower system for a single airport is complete	Situational awareness was at a high level throughout. **SASHA scores were 5.4 (average)** and did not drop below 4. The AFISO scored highest in “feeling ahead of the traffic” and “not having to search”. The PTZ and IR camera most contributed to increasing situational awareness. The AFISOs also said that after software updates and when coupled with the PTZ and IR cameras,	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				and they can be implemented in a typical physical architecture	the OTW became very sharp allowing for a high degree of detail to be seen. There is potential for the visual representation, with the help of technical enablers to aid the real-life OTW. Some technical features decreased situational awareness for example the Tracking Overlay which was jumping and unstable within 10NM of Værøy.	
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0060	Human Performance	CRT-06.09.03-VALP-0060.0060	Human performance must be shown to be at an acceptable level, in terms of: Situation awareness; Human performance (efficiency) / potential for human error; Acceptability; Trust; Workload. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas.	**Technical issues including the quality of the picture caused situational awareness to be lower than a local tower**. However, the use of **the IR cameras had positive feedback**, especially in darkness where it could give a clearer view of the aerodrome Situational Awareness scores were acceptable overall but some individual scores bordered on unacceptable. The **best** situational awareness scores were recorded against ATCO **ability to keep ahead of the traffic** and be **able to plan and organise their work as they wanted**. The main **issues** relating to situational awareness were recorded against the areas of **focusing on a specific problem** and **searching for specific information**. ATCOs found it hard to identify and track aircraft using the visual reproduction. With regards **trust**, the ATCO feedback indicates **a general trust in the concept**, with most saying they found it **understandable and robust**. New tools such as the **IR camera**, as well as traditional systems such as **radar**, helped the majority of **ATCOs feel confident using the system**. The functions and tasks were **limited to those related to building a visual picture**. The ATCOs were **able to build the basic visual picture**, supported by the visual reproduction, PTZ camera and IR camera.	NOK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					Most ATCOs experienced **difficulties in accurately judging depth and separation for airborne aircraft.** The ATCOs were **able to monitor ground movements sufficiently**. Feedback on the **ability to judge MET conditions** (including cloud celling) was **mixed and inconclusive**. Opinion was divided among ATCOs. ATCOs found building an accurate visual picture **easier during day time, compared to night time**, although some of this is due to technical problems early in the trial (later resolved). **Low visibility did not cause any additional problems** due to the IR camera and also the way in which a darker sky / cloud allowed for greater contrast between the aircraft and the sky.	
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0060	Human Performance	CRT-06.09.03-VALP-0060.0060	Human performance must be shown to be at an acceptable level, in terms of: Situation awareness; Human performance (efficiency) / potential for human error; Acceptability; Trust; Workload. Any instances of Human Performance degradation are either mitigated or	In general, ATCOs were experiencing high Situational Awareness. There was a statistically significant difference between Basic and Advanced System for Situational Awareness. **SASHA Basic System average**: 4.72 (out of 6) **SASHA Advanced System Average**: 5.21 (out of 6) Overall, ATCOs reported a good level of trust in the concept, and in particular when using the Advanced System. For the Basic System, ATCOs felt that they could understand the system but were less trusting of the reliability and robustness of the system and this had a negative impact on ATCOs' confidence when working with the system, with only 35% of participants saying that they often, or very often felt confident using the system. For the Advanced System the results are much more positive. 100% of the ATCOs gave a positive response to the ability to understand the system and also to finding the system useful (Often to Always).	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				acceptably offset by improvements in other areas.	**Trust - Basic System**: reliable 8/14 'often' or higher **Trust - Advanced System**: reliable 13/14 'often' or higher	
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0060	Human Performance	CRT-06.09.03-VALP-0060.0060	Human performance must be shown to be at an acceptable level, in terms of: Situation awareness; Human performance (efficiency) / potential for human error; Acceptability; Trust; Workload. Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas.	SASHA results were very positive. On average PSM situational awareness was 5 out of 6. Scoring highest "in feeling ahead of the traffic" and "not having to search". The lowest score given was 3 out of 6 on one occasion for "ability to plan". AFISOs mentioned you can obtain a more detailed focus on the surroundings with the advanced visual features. In daylight, the detail and focus was stated to be the same or **better than in a local tower**. The positive feedback regarding situational awareness was mentioned in both good visibility and limited visibility. All the ATCOs said the system is: • "very often" **understandable and accurat**e; • "always" or "very often" **confident, reliable and useful;** • two AFISOs said it is "often" **robus**t. Situational awareness scored highly in the SASHA results equating to "very often" being able to maintain situational awareness. The **trust for the ASM trial was acceptable, SATI average 5.2 out of 6.** Average SATI 5.5 out of 6 for; useful, reliable, accurate, understandable and confident. The most trusted technical systems mentioned were the IR, PTZ, OTW and the aerodrome sound (important for situational awareness). The VCS caused many problems for the AFISO and was highlighted as the least trusted operational system. Overall workload was shown to be acceptable in all weather conditions and visibility. The lowest workload was in how mentally demanding the task was, and how rushed the pace of the task was. The **average NASA TLX score was 0.8 out of 10**, indicating a very low workload.	OK
EXE-	OBJ-	Acceptability	CRT-	The Remote	**8 out of 12** ATCOs stated that the overall **quality of the visual**	NOK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
06.09.03-VP-056	06.09.03-VALP-0060.0070		06.09.03-VALP-0060.0070	Provision of ATS to a single aerodrome is acceptable to ATCO/AFISO, airport operators and pilots, in terms of: The concept in general; The system; Roles, responsibilities & task allocation; Working methods; Procedures; HMI.	**reproduction was insufficien**t to provide similar levels of service compared to a local Tower. However, several **improvements** (many of which are currently under development) **were suggested** to mitigate this result. The ATCOs stated that the **picture of the ground segment** was generally **clearer and easier to interpret** than the air segment. ATCO opinion was that the **picture during day time** was generally **clearer and easier to interpret** than night time. **Frame rates were too low**, and at night time issues with the **video compression caused "artefacts" and "ghosting"** on the visual reproduction. The **PTZ camera was deemed to be a useful tool**, but there were **usability issues** and issue with the picture quality. The **IR camera** was **well received** by the ATCOs with the vast majority finding it a **useful component**. The majority of ATCOs found the **CWP size, layout and range of functions to be acceptable** although some useful feedback was given on how it could be improved. The working environment used in the trial was not representative of an implemented system, but even so, ATCOs suggested that some basic changes could be made to vastly improve the Working Environment. With regards the location of the remote facility, ATCO opinion was split with some strong feelings either side – some having potential objections, others having no problem. ATCOs felt that with the trial prototype **their tasks would change**, potentially becoming more "inefficient", with **increased separation** in the vicinity of the airport for visual separation. On a more positive note, **the IR camera might allow increased opportunities** and **flexibility in working methods**. Overall, ATCOs **do not expect the roles and responsibilities of**	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					the ATCO to change with the introduction of Remote ATS. The ATCOs felt that the **division of roles and responsibilities** when operating from the remote facility **was clear**. ATCO feedback suggested that their **procedures under Remote ATS would have a negative impact on VFR/GA capacity**. All ATCOs stated that **GA/VFR aircraft** will have to be **put on hold to wait for landing or arriving IFR traffic.** They felt that capacity for **IFR traffic would be maintained**. ATCOs were **cautious of the** conceivable **benefits regarding flexibility**. They responded **positively** to the suggestion that there is **flexibility of procedures** and potential to **lighten up restrictions in Low Visibility Procedures (LVP) with the use of the IR camera**.	
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0070	Acceptability	CRT-06.09.03-VALP-0060.0070	The Remote Provision of ATS to a single aerodrome is acceptable to ATCO/AFISO, airport operators and pilots, in terms of: The concept in general; The system; Roles, responsibilities & task allocation; Working methods; Procedures;	The ATCOs were satisfied with the majority of technical aspects relating to the visual reproduction provided, including: contrasts, the screens, the screen distance, the resolution, the viewing angle, the screen layout, the general view, the screen size, the picture quality, and the camera positions: between 64% and 93% of the ATCOs agreed with their acceptability. The concept in general: o 9/14 agreed they would like to use the system to provide ATS HMI visual reproduction: Overall, ATCOs found the picture quality acceptable but also that it could still be improved. o Depth: **2/14** agree ability to judge o Night time: 3/14 agree it is as good as daytime o Distance: 5/14 agree ability to judge Advanced Visual Features: o **IR camera**: mainly positive from those who were able to use it during the trial. Some concerns about procedures	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				HMI.	and contribution to workload. o **PTZ**: generally negative feedback, mainly related to usability and quality of picture. o **Additional Camera Viewpoints (ACV)**: Mainly positive feedback, but number and location of cameras could be improved. o **Tracking labels**: Overwhelmingly positive feedback all round. **HMI CWP**: In general the ATCOs found the work environment acceptable in the current state. o 10/14 agree on acceptable layout **The Working Environment**: o 9/14 agree on pleasant place (3 disagree) Feedback from the trial indicated no major issues related to roles, responsibilities & task allocation. Some less critical feedback was obtained, mainly centred on issues such as direct MetObs collection, local influence and technical troubleshooting.	
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0070	Acceptability	CRT-06.09.03-VALP-0060.0070	The Remote Provision of ATS to a single aerodrome is acceptable to ATCO/AFISO, airport operators and pilots, in terms of: The concept in general; The system; Roles,	**Visual Reproduction:** 88% of responses within the end of trial questionnaires indicating acceptance overall, with a need for more filters and adjustments to OTW angle. **PTZ Camera HMI**: 75% acceptance. Easy to use although the HMI could be improved. **IR camera:** 85% acceptance. No negative feedback. **Tracking Labels:** 90% acceptance. Labels malfunctioning within 10NM of the aerodrome. **CWP HMI:** 73% acceptance in PSM trials and 25% in ASM trials. Rated least favourably throughout trials. The AFISOs felt the letters on the CWP systems were too small. **Working Environment:** 62% acceptance. Not always ideal conditions.	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				responsibilities & task allocation; Working methods; Procedures; HMI.	The ASM AFISO said that the AFISO remote tower tasks, **roles and responsibilities were clear and acceptable**. The AFISO also commented that there was **no difference between the roles, tasks or responsibilities t**hat were provided when located remotely compared to when they were located locally.	
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0080	Cost Effectiveness	CRT-06.09.03-VALP-0060.0080	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.	N/A	-
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0080	Cost Effectiveness	CRT-06.09.03-VALP-0060.0080	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.	The primary driver for Remote Provision of ATS is Cost Effectiveness. However, it was never the project's aim to prove this directly through validation trials. Rather, the trials were used to validate the assumption in the business case i.e. that it is operationally feasible to provide ATS from a remote location. Maintaining Operational Feasibility depends most on safety, human performance and capacity and so it is those areas that are further explored. Results show that the assumption was validated and information was provided to suggest that the concept was feasible.	OK
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0080	Cost Effectiveness	CRT-06.09.03-VALP-0060.0080	Information relating to the Cost Effectiveness of the Remote Tower Concept at low to medium density airports can be derived from the validation results.	The primary driver for Remote Provision of ATS is Cost Effectiveness. However, it was never the project's aim to prove this directly through validation trials. Rather, the trials were used to validate the assumption in the business case i.e. that it is operationally feasible to provide ATS from a remote location. Maintaining Operational Feasibility depends most on safety, human performance and capacity and so it is those areas that are further explored. Results show that the assumption was validated and	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					information was provided to suggest that the concept was feasible.	
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0090	Capacity	CRT-06.09.03-VALP-0060.0090	The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.	N/A	-
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0090	Capacity	CRT-06.09.03-VALP-0060.0090	The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.	ATCOs responded that they did not feel capacity would be *increased* when providing ATS remotely. However, an increase in capacity is not the aim; more that capacity is not negatively impacted. ATCOs felt that when using the Basic System, they would be able to conformably provide service to 1 movement at a time. Introducing a second or even third aircraft would be possible under some scenarios, but it would require much more mental workload and potentially degradation of quality of service to airspace users. They therefore perceive this system to have a lower capacity than a local tower. ATCOs felt that when using the Advanced System they would be able to comfortable provide service to the same number of aircraft as they would in a local tower. It was only for once specific scenario where ATCOs felt that capacity would be reduced (two aircraft closely following behind during darkness). This is countered by feedback from some scenarios suggesting slightly higher capacity when using the Advanced system along with its advanced functionalities but this was not statistically significant. The ATCOs therefore perceive the Advanced system to be at least as good as	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					the local system in both day time and night time hours.	
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0090	Capacity	CRT-06.09.03-VALP-0060.0090	The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.	N/A	-
EXE-06.09.03-VP-056	OBJ-06.09.03-VALP-0060.0100	Usefulness	CRT-06.09.03-VALP-0060.0100	The utility of proposed/prototype features, functions and technologies is known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	The IR camera was the newest component in the trial and it was very well received. **ATCOs felt strongly that the IR camera should feature in future trials.** **Other suggestions for improvements to existing functions and technologies were suggested** including: • Better HMI for PTZ • Reduced seams between screens • Target symbols/labels on the main display Inlaid PTZ/IR camera images on the main display.	OK
EXE-06.09.03-VP-057	OBJ-06.09.03-VALP-0060.0100	Usefulness	CRT-06.09.03-VALP-0060.0100	The utility of proposed/prototype features, functions and technologies is known. Information	Usefulness: o **IR camera**: 11/14 useful o **ACV**: 13/14 agree useful o **Tracking Labels**: 13/14 useful Intuitiveness:	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	o **IR camera**: **6/14** agree intuitive (3 disagree) o **ACV**: 10/14 agree intuitive **Tracking labels**: 7 agree intuitive (2 disagree)	
EXE-06.09.03-VP-058	OBJ-06.09.03-VALP-0060.0100	Usefulness	CRT-06.09.03-VALP-0060.0100	The utility of proposed/prototype features, functions and technologies is known. Information collected on proposed/prototype features, functions and technologies can enable a decision on integration of these into a future trial platform.	**The operability, usability and utility of technical features scored highly, although improvement required.** **OTW** all displays and e-strip (manual use only) were used 100% of the time. **PTZ** camera was found to be easy and intuitive to use. **IR** camera gave AFISOs information regarding weather. Used to assess cloud base, consistency in the dark and to scan FATO for obstacles. **Radar** contributed the most to reducing workload in ASM trials. **Tracking** scored highly on usefulness, although not intuitive. Compensated for the "cone of silence." **FDP** was useful but over complicated (not fully tested as not currently fully compatible). **Filters** were deemed important for a usable OTW. **Sound** increased perceived situational awareness. **AWOS** useful; technical issues limited assessment. 100% of the time the AFISOs rated that it was "Very easy" to communicate with Værøy personnel through radio. The PSM AFISO rated all forms of communication with Værøy (radio and telephone) and co-ordination with Bodø ACC a "very easy". Below average (2.5) technical capability scores (2 out of 5 = disagreement) for communications with: Værøy personnel through	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					radio and telephone and emergency communications. The VCS suffered from interference, feedback and there was an issue that there was no split function as the AFISOs are used to. The telephone absorbed and amplified any noise in the room which was a safety risk. Deficiencies with the VCS made it hard for the AFISO to perform their function which resulted in a move to co-ordination via mobile telephone, this being highlighted as a safety.	

Table 36: Summary of Exercise Results

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