Remotely provided Air Traffic Services for two low density aerodromes Appendix F: HP Assessment Report

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Abstract

This document contains the Human Performance (HP) assessment report for the P06.09.03 Remotely provided Air Traffic Services for two low density aerodromes (SDM-0205) and consists of the HP assessment plan; the results of the HP activities conducted according to the HP assessment process, newly identified issues and the HP recommendations & requirements. It corresponds to the completion of the four steps of the Human Performance assessment process, namely: Step 1 – Understand the concept: Baseline, Solution and Assumptions, Step 2 – Understand the Human Performance Implications, Step 3 – Improve and Validate the concept and Step4 – Collate findings & conclude on transition to next V-phase.

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Executive summary

This document describes the human performance assessment for P06.09.03 Remotely provided Air Traffic Services for two low density multiple aerodromes (SDM-0205) according to SESAR Human Performance Reference Materials. P06.09.03 Remote and Virtual Towers consists of three Operational Improvements:

a. Remote Provision of ATS to a Single Aerodrome (SDM-0201);

b. Remotely provided Air Traffic Services for two low density aerodromes (SDM-0205);

c. Remotely Provided Air Traffic Service for Contingency Situations at Small to Medium Aerodromes (with a Single Main Runway) (SDM-0204).

The Human Performance assessment for Remotely provided Air Traffic Services for two low density aerodromes develops on the results obtained from Human Performance assessments for Remote Provision of ATS to a Single Aerodrome and should be considered as complementary.

The SESAR HP assessment process provides a framework to help ensure that HP aspects related to SESAR technical and operational developments are systematically identified and managed in the concept design, development and validation process. The SESAR HP assessment process uses an 'argument' and 'evidence' approach. A HP argument is a 'HP claim that needs to be proven'. The aim of the HP assessment is to provide the necessary 'evidence' to show that the HP arguments impacted have been considered and satisfied by the HP assessment process. This includes the identification of HP requirements and recommendations to support the design and development of the concept.

Specific HP issues and benefits relating to the multiple remote tower concept for each of the relevant arguments were identified by performing a review of existing literature on the remote tower concept as well as conducting a series of HP issue and benefit brainstorming sessions / interviews with relevant stakeholders including ATCOs, pilots, engineers, safety and HF experts. Based on the HP arguments and issues / benefits identified, several HP activities were recommended. The HP related validation activities conducted to date include:

- Task analysis
- Stakeholder workshop
- Safety workshop
- Communication Survey
- Real Time Simulation Part 1 and Part 2 for multiple TWR (EXE-06.09.03-VP-060)
- Passive shadow mode for multiple TWR (EXE-06.09.03-VP-061)
- Passive Shadow Mode for multiple TWR AFIS (EXE-06.09.03-VP-063)

The output or 'evidence' collected from each of these activities that are relevant to the HP assessment are summarised in this report together with recommendations and / or requirements that have been proposed to help prevent or mitigate each of the potential HP issues identified. These recommendations and requirements relate to: the operational concept, and procedures; the technical system and HMI and the training of the end user.

Considering the evidence gathered during the HP validation activities, with the respect to HP maturity criteria it can be concluded that the "Remotely provided Air Traffic Services for two low density aerodromes" concept **has reached the V3 level of HP maturity, for both Tower and AFIS.** Although the broad evidence gathered during validation activities, the status of some issues and benefits is considered as on-going. The on-going status of the issue/benefit indicates that the complementary validation activities are recommended for the next validation phase.

It should be noted that the scope of SDM-0205 was narrowed during the project lifecycle. The focus was reduced to only two low density aerodromes. Previously SDM-0205 was intended to cover the entire concept of Multiple Remote Tower, yet as the concept matured via the planned exercises it became clear that the scope of the Multiple Remote Tower concept was far wider than could be

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considered within these exercises alone. Further applications such as three aerodromes, multiple controller positions, higher traffic and simultaneous movements to a greater extent may have different requirements. These expansions of the concept are not directly considered under the current scope of these exercises. However as the scope was reduced after VP-060, VP-061 and VP-063 had been already been conducted some of the exercises cover aspects which are beyond the current scope of SDM-0205. This change is in line with the logical development of this concept. Starting with a single remote air traffic service for one low density aerodrome, followed by simultaneously remote air traffic service to two low density aerodromes at the same time. Aerodromes with more dense traffic is likely to follow later in the development of the concept.

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1 Introduction

1.1 Purpose of the document

The purpose of this document is to describe the result of the activities conducted according to the Human Performance (HP) assessment process [2] in order to derive the HP assessment report for 06.09.03 including requirements and recommendations. It should be noted that the main focus of the assessment is **providing air traffic services to more than one aerodrome in parallel.** This assessment should be seen as complementary to the assessment that was performed for single remote tower concept [5].

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 “Remotely Operated Tower Technology Enablers” and P12.04.07 “Remotely Operated Tower Multiple Controlled Airports with Integrated Working Position”. Project P06.08.04 did not directly contribute to these validation activities, however the P06.08.04 project members are a key audience for this document due to the overlap in validation activities and the requirement to consolidate at OFA level.

At the level of the transversal areas and federating projects, WP16.06.05 and X.2 are also expected to have an interest in this document.

Other stakeholders that may be interested in this document are to be found among:

- Affected employee unions
- ANS providers
- Airport owners / providers
- Airspace users

1.3 Scope of the document

The human performance assessment for P06.09.03 concept was divided in three separate activities related to each of operational improvements:

a. Remote Provision of ATS to a Single Aerodrome (SDM-0201);

b. Remotely provided Air Traffic Services for two low density aerodromes (SDM-0205);

c. Remotely Provided Air Traffic Service for Contingency Situations at Small to Medium Aerodromes (with a Single Main Runway) (SDM-0204).

The Human performance assessment for to a Single Aerodrome (SDM-0201) was considered as a base for the HP assessment of Air Traffic Services for two low density aerodromes therefore the findings from HP assessment for Single Remote Tower apply equally to current assessment. The focus of the current activity was to assess the additional issues and benefits arriving from the multiplication of the aerodrome.

The main focus of assessment was ATCO’ and AFISO’ role as they are considered most impacted by the change. The other actors such as pilots and ground staff are considered in the assessment in limited extend. Some findings related to supervisory role/function are presented however; as supervisor role was seen as required considering the scope of validation, these findings should be addressed by further investigations.

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1.4 Human performance work schedule within the project

The Human Performance Assessment Remotely provided Air Traffic Services for two low density aerodromes (SDM-0205) *started* in Jan 2014 and finished in May 2015.

1.5 Structure of the document

- **Section 1** (this section) 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 SESAR Human Performance assessment process.
- **Section 3** describes the conduct of assessment: understanding the impact of the change expressed by issues and benefits, description of reference scenario, performed activities, gathered evidence and assessment of the maturity of the concept.
- **Section 4** lists the reference documents.
- **Appendix A** describes in the details of the task analysis.
- **Appendix B** describes in the detail the supervisory function.
- **Appendix C** presents the results of communication survey.
- **Appendix D** Summary of issues and benefits.
- **Appendix E** summaries the HP recommendations.
- **Appendix F** summarises the HP requirements.

1.6 Acronyms and Terminology

Term	*Definition*
a-CWP	Advanced - Controller Working Position. The advanced controller working position is a concept being developed within SESAR P06.09.02
AFIS	Aerodrome Flight Information Services
AFISO	Aerodrome Flight Information Services Officer
ANSP	Air Navigation Service Provider
APP	Approach Control Service
ART	Advanced Remote Tower Research Project
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Services
CAVOK	Ceiling and Visibility OK

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CWP	Controller Working Position
HMI	Human-Machine Interface
IFR	Instrument Flight Rules
LCD	Liquid Crystal Display
LFV	Swedish ANSP
Human Factors (HF)	HF is used to denote aspects that influence a human's capability to accomplish tasks and meet job requirements. These can be external to the human (e.g. light & noise conditions at the work place) or internal (e.g. fatigue). In this way, "Human Factors" can be considered as *focussing on the variables that determine Human Performance [2]*.
Human Performance (HP)	HP is used to denote the human capability to successfully accomplish tasks and meet job requirements. In this way, "Human Performance" can be considered *as focussing on the observable result of human activity in a work context*. Human Performance is a function of Human Factors (see above). It also depends on aspects related to Recruitment, Training, Competence, and Staffing (RTCS) as well as Social Factors and Change Management *[2]*.
HP activity	A HP activity is an evidence-gathering activity carried out as part of Step 3 of the HP assessment process. An HP activity can relate to, among others, task analyses, cognitive walkthroughs, and experimental studies *[2]*.
HP argument	A HP argument is a HP claim that needs to be proven by the HP assessment process *[2].*
HP assessment	A HP assessment is the documented result of applying the HP assessment process to the SESAR project-level (i.e. WP4-15 projects). HP assessments provide the input for the HP case *[2]*.
HP assessment process	The HP assessment process is the process by which HP aspects related to the proposed changes in SESAR are identified and addressed. The development of this process constitutes the scope of Project 16.04.01. It covers the conduct of HP assessments on the project-level as well as the HP case building over larger clusters of projects *[2]*.
HP benefit	An HP benefit relates to those aspects of the proposed ATM concept that are likely to have a positive impact on human performance *[2]*.
HP case	An HP case is the documented result of combining HP assessments from projects into larger clusters (e.g. Operational Focus Areas, deployment packages) in SESAR *[2]*.
HP issue	An HP issue relates to those aspects in the ATM concept that need to be resolved before the proposed change can deliver the intended positive effects on Human Performance*[2]*.
HP impact	An HP impact relates to the effect of the proposed solution on the human operator. Impacts can be positive (i.e. leading to an increase in Human Performance) or negative (leading to a decrease in Human Performance) *[2]*.

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HP recommendations	HP recommendations propose means for mitigating HP issues related to a specific operational or technical change. HF recommendations are proposals that require additional analysis (i.e. refinement and validation). Once this additional analysis is performed, HF recommendations may be transformed into HF requirements *[2]*.
HP requirements	HP requirements are statements that specify required characteristics of a solution from an HF point of view. HP requirements should be integrated into the DOD, OSED, SPR, or specifications. HF requirements can be seen as the stable result of the HF contribution to the project, leading to a redefinition of the operational concept or the specification of the technical solution *[2]*.
OTW	Out The Window
PTZ	Pan Tilt Zoom Camera
ROT	Remotely Operated Tower (proof of concept project)
R/T	Radio Telephone
RTC	Remote Tower Centre
RTM	Remote Tower Module
RTS	Real-Time Simulation
RVT	Remote and Virtual Tower Project
RWY	Runway
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SUP	Supervisor
TA	Transversal Assessment
TWR	Aerodrome Control Service (which is a subset of ATC Service)
VCS	Voice Communications System
VFR	Visual Flight Rules
V1, V2, V3, V4 and V5	Concept Lifecycle Model Phases V1, V2, V3, V4 and V5

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2 The Human Performance Assessment Process: Objective and Approach

The purpose of the HP assessment process described in detail in [2] is to ensure that HP aspects related to SESAR technical and operational developments are systematically identified and managed.

The SESAR HP assessment process uses an 'argument' and 'evidence' approach. A HP argument is a 'HP claim that needs to be proven'. The aim of the HP assessment is to provide the necessary 'evidence' to show that the HP arguments impacted have been considered and satisfied by the HP assessment process. This includes the identification of HP requirements and recommendations to support the design and development of the concept.

The HP assessment process is a four-step process. Figure 1 provides an overview of these four steps with the tasks to be carried out and the two main outputs (i.e. HP plan and HP assessment report In addition, a HP Log is maintained throughout the lifecycle of the project in which all the data/ information obtained from all HP activities conducted as part of the HP assessment is documented. This HP Log is a living document and is updated and / or added to as the project progresses.

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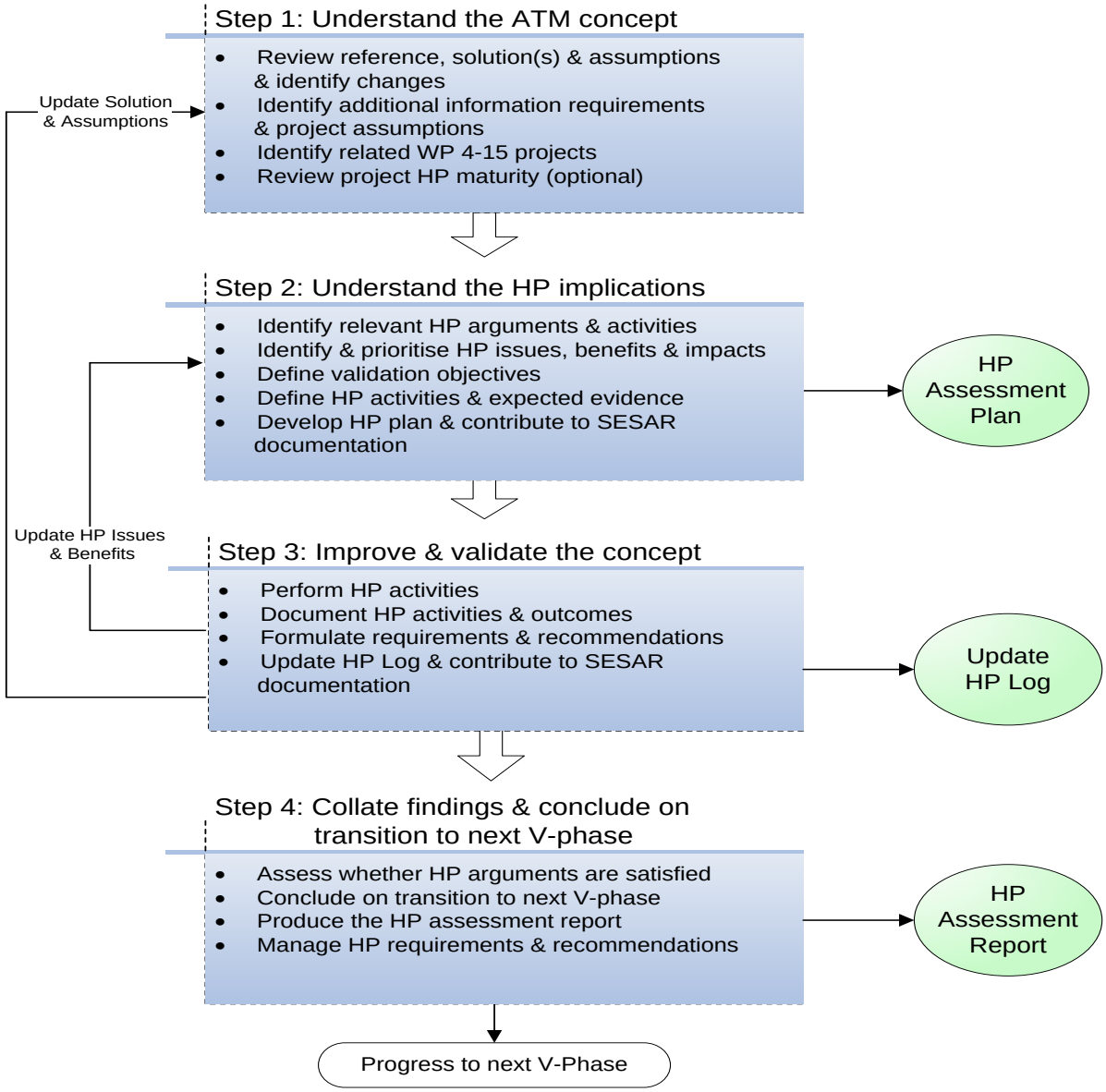

Figure 1: Steps of the HP assessment process

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3 Human Performance Assessment

3.1 Step 1 Understand the ATM concept

3.1.1 Description of reference scenario and solution scenario

Development of the OI step – SDM-0205

During the lifecycle of P06.09.03, the scope of SDM-0205 was narrowed to only two low density aerodromes. Previously SDM-0205 was intended to cover the entire concept of Multiple Remote Tower, yet as the concept matured via the planned exercises it became clear that the scope of the Multiple Remote Tower concept was far wider than could be considered within these exercises alone. The HP assessment was initiated with wider scope covering the Multiple Remote Tower concept and consequently part of the findings is in reference to the wider scope. The evidence/ recommendations related to these aspects are listed in the report for further considerations.

It is not possible to compare the services of the Remote Provision of ATS to two low density aerodromes to a reference scenario as there is no such service provided in current day operations. Comparisons may be drawn between exercises as the concept develops. The V2 validation activities conducted in relation to the Remote Provision of ATS to a Single Aerodrome (SDM-0201) were used as a reference scenario.

Table 1 Reference Scenario and solution scenario system comparison

REFERENCE SCENARIO AND SOLUTION SCENARIO SYSTEM COMPARISON		
ELEMENT	**SINGLE REMOTE TOWER**	**REMOTE TOWER MODULE**
General Operating Method	The ATCOs / AFISOs provide ATS to a single aerodrome.	The ATCOs / AFISOs provide ATS to more than one aerodrome in parallel.
Remote Tower Facility	The air traffic control unit for aerodrome control is a 'standard' building (i.e. not a tower building) not necessarily located within the aerodrome. The RTM will provide ATS for the aerodrome. A number of staff resources (ATS personnel) and a number of RTMs may be co-located in a RTC. An RTC may be a separate facility located far from any airport or it may be an additional facility co-located with a local facility at an aerodrome. Technical enablers, AVFs, communications, radar displays and other features/function to assist with the provision of ATS are related to only one aerodrome.	The RTM will provide ATS for a number of aerodromes in parallel. A number of staff resources (ATS personnel) and a number of RTMs may be co-located in a RTC. An RTC may be a separate facility located far from any airport or it may be an additional facility co-located with a local facility at an aerodrome. Technical enablers, AVFs, communications, radar displays and other features/function to assist with the provision of ATS shall have varying degrees of integration and sharing between aerodromes. It is thought that many features that cannot be used on more than one aerodrome at a time will be "switchable". This will enable the controller to switch that feature so that it operates which ever aerodrome the controller selects. Other features that are required continuously (such as the strip bay etc.) may require duplication for each aerodrome. Any duplication of equipment/features that occurs in the RTM may be accompanied by distinctive features to allow easy and instant recognition of the aerodrome the feature relates to.

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REFERENCE SCENARIO AND SOLUTION SCENARIO SYSTEM COMPARISON		
ELEMENT	**SINGLE REMOTE TOWER**	**REMOTE TOWER MODULE**
Visual reproductions & transition of ambient sound	The traffic situation will be viewed using a high resolution panoramic display located in the remote 'tower' control unit. State of the art video cameras located at various locations in the aerodrome vicinity will be used to project a real time image of the aerodrome and traffic situation onto the panoramic display together with selectable options to choose the ambient noise of the aerodrome.	The screen layout options available within the multiple RTM will enable the provision of ATS to multiple aerodromes simultaneously. The primary methods to achieve this will depend on the number of aerodromes being controlled. It is predicted that the continuous visual monitoring of aircraft shall be provided via a visual presentation set up to view aerodromes horizontally (side-by-side) or vertically (up-down). The distribution of screens may be switchable and hence fluid, allowing the RTM operator to change the number of screens each aerodrome is displayed on. This will allow the controller to select which aerodrome to have on the larger visual presentation (likely to be the aerodrome with active traffic) or to view all aerodromes on an equal screen split. There may also be the option to completely hide the visual display of an aerodrome.
Operating Methods and Roles	There will be up to three different primary roles in an RTC (not necessarily all at once, in the same RTC or to the same aerodrome): 1. ATCO; 2. AFISO; 3. RTC supervisor. The ATCO/AFISO to provide ATS to single e aerodrome. The scenario presented is: One ATCO/AFISO to a single aerodrome (one-to-one) The (optional) RTC supervisors main responsibilities will be with regard to staff/RTM/aerodrome allocation.	The ATCO/AFISO to provide ATS to multiple aerodromes in parallel in various ways, all allowing for the continuous visual watch of all of the aerodromes being provided with an ATS. Two main types of scenarios are presented: 1. ATS to two aerodromes (1-to-Two); 2. ATS to multiple aerodromes (1-to-Many). **The scope of current assessment focuses on Scenario 1 (one-to-two), the other possibility will be investigated in later stage of concept development outside of P06.09.03.** The (optional) RTC supervisors main responsibilities will be with regard to staff/RTM/aerodrome allocation. Within the scope of validation, narrowed to two low density airports the supervisor role was not seen as necessary.
Controller Tool Support	The concept assume the basic and advanced features: The visual presentation of aerodrome and PTZ camera. • Flight Progress Strips (electronic or paper); • Radio Telephony Communications (ground and air); • Aerodrome sound; • Functionality for manoeuvring	In addition to the controller tool support introduced for single remote tower, supplementary support tools may be introduced in the context of Multiple Remote Tower Operations (RTO): Integrated flight data processing systems FDPS The configuration of the ATCO/AFISO working desk could consist of consolidating the flight data information of all relevant aerodromes into one FDPS. Thus all flight

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REFERENCE SCENARIO AND SOLUTION SCENARIO SYSTEM COMPARISON		
ELEMENT	**SINGLE REMOTE TOWER**	**REMOTE TOWER MODULE**
	and controlling: • Airport lights; • Signal Light Gun; • Navigation aids; • ILS; • Alarms and; • Other airport systems. Advanced features • Overlay information (including geographic, meteorological, operations and service and visual reminder information). • Information from additional sensors such as hot spot cameras or infrared cameras etc. (information enhanced by input from infrared sensors. This could potentially further improve the visual reproduction in CAT II/III low visibility conditions or in darkness.	strips are merged into one system and for example distinguished through colour coding. Indication from which aerodrome a radio transmission is received On the CWP (e.g. visual reproduction screen) an indication could be made highlighting where a radio transmission is coming from. Thus the ATCO/AFISO may easily bring together a station calling and its origin – situational awareness may be increased.
Air Traffic Management	The aim of the Single remote tower concept is to provide the same set of services that are provided from conventional towers, albeit in a more efficient and improved way. The RTM are configurable to any of the aerodromes. At any given time the ATCO/AFISO can switch from one aerodrome to another. The ATCO/AFISO can therefore provide ATS service to more than one aerodrome but not in parallel. The use of collaborative planning and/or traffic coordination would increase the ability of a single ATCO/AFISO to provide ATS service to multiple aerodromes in sequence. Airspace and ATS at a specific aerodrome will normally be established in conjunction with an IFR departure or arrival, allowing the Remote ATCO/AFISO to then sequentially handle traffic from/to more than one airport.	To provide the most optimal balance between ATS staff required and daily traffic demand while providing ATS to multiple aerodromes, advanced traffic coordination and planning is necessary. Coordination may have to be done between aerodrome owners and the ANSP, to ensure that the traffic is sequenced in such a way that simultaneous aircraft movements at different aerodromes are rare/minimised; For scheduled flights this could be done when time tables are being approved. For non-scheduled IFR flights arrival/departure times could be granted or a slot time could be set on a daily "tactical" basis by the RTC supervisor in the RTC. The same procedures could take place in the case of revised arrival/departure times (most common cause of delays).

3.1.2 Consolidated list of assumptions

Assumptions taken from the OSED:

- Provision of ATS for a single aerodrome is available from October 2014 (i.e. this can be used to support the development of the multiple aerodrome solution)

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- The option for implementing remote reproduction of airport sound (e.g. engine noise, flocks of birds, wind, etc.) remains active
- Tasks external to the control facility (e.g. physical runway inspection), that whilst not part of the official remit of the ATCO, will still be able to be instigated by the ATCO remotely and executed by local personnel.
- The remote provision of ATS for multiple aerodromes is applicable to two low density aerodromes, where low density is determined as being mostly single operations, rarely exceeding two simultaneous (see OSED Section 3.3.1.)
- A unified Remote Tower Module (RTM) solution will be developed and implemented (rather than different or even bespoke solutions) within an RTC.
- If the RTM provides ATS to more than one aerodrome there shall be means to ensure that the ATCO/ AFISO is readily aware which aerodrome they are currently operating.
- There will be up to three primary roles in the RTC, comprising ATCO, AFISO and Supervisor.

Assumptions taken from the VALP:

- ASS-6.2-S1-022 - Airport (and TMA) and airspace demand and capacity forecasts are available and exchanged with other stakeholders (like Airspace Users)
- ASS-6.2-S1-025 - Airspace users should provide future traffic forecasts containing aircraft type, origin/destination and preferred time of operation to the airport operator
- ASS-6.2-S1-013 - Visual contact approaches are applied instead of IFR operations when appropriate visual conditions prevail.
- ASS-6.2-S1-018 - The optimization of the runway throughput and minimization of the holding time at the runway before take-off.
- ASS-6.2-S1-003 - Mixed mode of operations exists.
- ASS-6.2-S1-021 - Service Levels agreed between the airport operator and airspace users or set by regulatory bodies will be regularly updated
- ASS-6.2-S1-028 - The airport is coordinated All flights (during peak traffic periods) are subject to regulation to ensure that demand does not exceed capacity.

3.1.3 List of related WP 4-15 projects to be considered in the HP assessment

The intended audience for this document are the members of Project P06.09.03, and those in the corresponding technical projects:

- P12.04.07 provides prototypes and technical specification for single and multiple Remote Tower
- P12.04.-06 provides technical enablers supporting the single and multiple remote tower prototypes

Project P06.08.04 is also working within SESAR on the remote tower concept for single and multiple aerodromes and so will also have an interest in the HP assessment report. In addition P06.09.02 (a-iCWP) and P12.04.08 should also have an interest in this document.

At the level of the transversal areas and federating projects, WP16.06.05 and X.2 are also expected to have an interest in this document.

Other stakeholders that may be interested in this document are to be found among:

- Affected employee unions / professional organisations i.e. IFATCA / IFALPA; IFATSEA, ECA

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- ANS providers
- Airport owners / providers
- Airspace users

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3.1.4 Identification of the nature of the change

Table 2: Description of the change

HP ARGUMENT BRANCH	CHANGE & AFFECTED ACTORS
1. ROLES & RESPONSIBILITIES	
1.1 ROLES & RESPONSIBILITIES	ATCO/AFISOs will be responsible for providing ATS to one or more aerodromes in parallel. Supervisor may have to co-ordinate slots with the Aerodrome owners & ANS provider to ensure the planned scheduled IFR are not all scheduled at the same time. Supervisor will take responsibility of some of ground coordination (scheduled works, ground vehicle outside of manoeuvring areas) Any tasks that have to be performed at the aerodrome will be performed by personnel located on-site at the aerodrome.
1.2 OPERATING METHODS	The operating methods as such do not change for each airport, however an ATCO might work simultaneously on different airport with different operational modes (LVP at only one airport) The operational methods related to transition period (closing and opening the airport should be described in details).
1.3 TASKS	The ATCOs will be providing ATS for one or more aerodrome in parallel, so the individual tasks may not change significantly compared to single RTO. However, the number of tasks an ATCO will have to perform and the working methods will change, e.g. switching from one aerodrome detail display to another. The supervisor will be responsible for managing resources on tactical level on a daily basis. Hence resource management becomes less strategic and more tactical, i.e. on a shift basis rather than over a larger period of rotations. The supervisor may also have to co-ordinate slots to ensure that the planned IFR are not all scheduled at the same time, such co-ordination may have to be done between aerodrome owners & ANS provider.
2. HUMAN & SYSTEM	
2.1 ALLOCATION OF TASKS (HUMAN & SYSTEM)	Compared to single remote tower no current change in task allocation between the ATCOs and the system is currently foreseen. Although as for single RT automated a/c identification and tracking may be implemented to enhance ATCOs situation awareness. The new task of assignment of operators to RTMs/ aerodromes is envisaged to be allocated to the human [i.e. Supervisor], and the workload of the Supervisor is liable to increase.
2.2 PERFORMANCE OF TECHNICAL SYSTEM	Compared to single RTO no real changes in the performance of the technical system are foreseen. However, for R/T communication speakers may be replaced by headphones, just to help reduce ambient noise in the multiple tower control room. Also the R/T from all aerodromes being controlled will be integrated into the ATCO/AFISOs R/T communications, i.e. it is currently not

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	thought that there will be a separate R/T communication device for each aerodrome when at ATCO is responsible for providing ATS to two or more aerodromes – this will help to ensure that the incoming communications are streamed.
2.3 HUMAN – MACHINE INTERFACE	When providing ATS to more than one aerodrome the ATCOs HMI will be configured so that the two aerodromes can be monitored & controlled by one ATCO. The information displayed relating to an aerodrome should stay the same (compared to single remote towers) but the information for the two or, however many aerodromes are being controlled by an ATCO, will be displayed. So the amount of information displayed to the ATCO will increase depending on the number of aerodromes being provided by ATS by one ATCO. Furthermore, as for single remote tower operations, additional information/ support tools may be added to support the ATCOs work e.g. automatic a/c identification & tracking (see HP assessment for single [[5]). The CWP in multiple RT will display information & OTW via visual reproduction (as is done for the single RTO) for each of the aerodromes being controlled by an ATCO. The actual design / setup of the CWP has not been decided at this stage i.e. how to organise the HMIs / CWP to optimise ATCO performance and minimise the potential for error. The supervisors may require more information to support him/her with the additional tasks e.g. tactical resource management & slot co-ordination. There may be a requirement to reproduce the ambient sound environment of the aerodrome at the RTM.
3. TEAMS & COMMUNICATION	
3.1 TEAM COMPOSITION	Instead of providing ATS for one aerodrome ATCOs/AFISOs will be providing ATS to two low density aerodromes, therefore the total number of ATCOs/AFISOs providing service per aerodrome should be less than current operations. The supervisor role may take on more responsibility, s/he will be responsible for distributing the work and deciding which positions to open and what and how may aerodromes each ATCO will be responsible for providing ATS services. Therefore the supervisor role will become more prominent, and each shift may require a dedicated supervisor.
3.2 ALLOCATION OF TASKS	Instead of providing ATS to one aerodrome ATCO/AFISO will be expected to provide ATS to two aerodromes. However, the tasks the ATCOs will be required to do in order to provide ATS will be the same as with single RTO. The supervisor will take on additional tasks and his role will involve, as described in 3.1, deciding how many and what combination of aerodromes each ATCO can be responsible for providing ATS at a tactical level depending on traffic demands.
3.3 COMMUNICATION	The ATCO/AFISO will be communicating with more pilots than with a single RTO as they will be providing ATS to two low density aerodromes, ATCOs will require information relating to each of the

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	aerodromes they are managing, instead of just the one aerodrome. Some changes to phraseology are foreseen in order to reduce the potential for communication errors. R/T may be provided via a headset (to try and reduce noise in the RT control room) with the R/T comms for all aerodromes being provided & received from one device / headset (streaming of comms.). The aerodrome sound environment may need to be included. Supervisors will have to have more information relating to the ATCOs workload and may require more tactical information about the imminent traffic load as they will have to communicate tactical changes to resource management / allocation. Supervisors will be required to communicate with and co-ordinate more ATCOs on a shift than in current operations as they will have to tactically manage resources. The ATCO may need to instigate changes to ATS provision, e.g. in the event of an incident at one aerodrome necessitating additional attentional resources, so that the ATCO needs to relinquish control over other aerodromes.
4. HP RELATED TRANSITION FACTORS	
4.1 ACCEPTANCE & JOB SATISFACTION	There were concern about the acceptability of the multiple RT concept among ATCOs before the validation. Concerns specifically relating to safety – in particular concerns regarding whether or not ATCOs can provide a safe service if working multiple aerodromes concurrently, concerns regarding situation awareness and potential for error, particularly mode type errors. The supervisor will also be responsible for tactical resource management and slot co-ordination with local aerodromes and the ANS provider.
4.2 COMPETENCE REQUIREMENTS	ATCO/AFISO will hold ADI rating, endorsement for remote tower control & unit endorsement to a number of aerodromes. New unit endorsement types may be introduced e.g. separate ratings for traffic levels to multiple aerodromes could be defined. ATCOs will have to be trained to provide ATS to more than one aerodrome at a time and also any changes to working method, procedures and phraseology. Supervisors may need training in the effective assignment of multiple ATCOs to RTMs handling multiple aerodromes.
4.3 STAFFING REQUIREMENTS & STAFFING LEVELS	As one ATCO can provide ATS to more than one aerodrome the total number of ATCO/AFISOs required to provide ATS to all small aerodromes will be reduced. Many ATCO/AFISOs providing ATS to different aerodromes will be co-located in the same RTC. Like single RTs, centres can be located anywhere. There will remain a requirement for site-based personnel to carry out some tasks that may previously have been (at least partly) executed by ATCOs e.g. METAR, answering incoming telephone calls, etc.

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3.2 Step 2 Understand the HP implications

3.2.1 Identification of relevant arguments

The HP arguments are 'claims that need to 'proven' by the HP assessment'. Therefore, the aim of HP assessment is to provide 'evidence' to show the HP arguments impacted have been considered and satisfied by the HP assessment process. From the changes that would result from the introduction of multiple remote towers (as described in Table 1), it was identified that all twelve V2-level HP arguments need to be considered by the HP assessment. Hence the arguments to be considered by the HP assessment process were:

- Argument 1.1 The roles and responsibilities of the human are clear & exhaustive
- Argument 1.2 The operating methods are clear, exhaustive and support human performance
- Argument 1.3 Human actors can achieve their tasks in normal, abnormal and degraded modes of operation
- Argument 2.1 There is appropriate allocation of tasks between the human and the machine
- Argument 2.2 The performance of the technical system supports the human in carrying out their tasks
- Argument 2.3 The design of the HMI supports the human in carrying out their tasks
- Argument 3.1 Effects on team composition
- Argument 3.2 The allocation on tasks between human actors support human performance
- Argument 3.3 The communication between team members supports human performance
- Argument 4.1 The proposed solution is acceptable to the affected human actors
- Argument 4.2 Changes in competence requirements are identified
- Argument 4.3 Changes in staffing requirements and staffing levels are identified.

3.2.2 Identification of HP issues, benefits, impacts & activities

Potential issues and benefits on human and system performance that may arise from the changes to ATCOs and other actor's impacted work were identified through a series of interviews with air-space users, current ATCOs, operational experts and safety and HF specialists. Over 80 issues and benefits identified from the interviews are documented in Table 10, Section 3.3 together with evidence and recommendations and requirements. More information regarding the issues/benefits identified in terms of: 1) a description of the issue / benefit and the potential impact of the issue / benefit on human performance (and where appropriate the wider system;) the priority of the potential issue/benefit identified ; 3) a possible means for prevention or mitigation and/or a recommended action; 4) the HP / validation objective associated with the potential issue/benefit and; 5) recommended activity to further investigate the potential issue or the suggested mitigation, can be found in Appendix D in the Issue and Benefits register.

Please note the arguments, issues & benefits plus activities identified below are specific for multiple remote tower operations, and do not cover issues and benefits already identified for the single remote tower concept. The issues and benefits identified for the single remote tower concept can be found in [3][5].

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Step 3 Improve and validate the concept

3.2.3 Description of HP activities conducted

The activities required to develop and assess the remote tower concept for multiple aerodromes from a HP perspective have been identified as a result of the objectives listed in Table 3.

The HP activities that were conducted include:

1. Document Review
2. Hierarchical Task Analysis
3. Safety Workshop
4. Multiple TWR Simulation (EXE-06.09.03-VP-060)
5. Multiple ATS Passive Shadow Mode (EXE-06.09.03-VP-061)
6. Multiple AFIS Passive Shadow Mode (EXE-06.09.03-VP-063)
7. Communication survey

Some findings listed in current assessment were also supported by the results of Resilience Engineering Assessment that was performed as additional activity by WP16.06.01b. The output of the Resilience Assessments can be found in Appendix 2.
Parts of the activities were combined with Safety assessment activities task analysis and safety workshop).

Table 3: Description of Activity 1

ACTIVITY 1.	DOCUMENT REVIEW
DESCRIPTION	Review of concept documentation which describes the roles, responsibilities, tasks and operating methods of the end users impacted by the concept.
ARGUMENTS & RELATED ISSUES ADDRESSED	Arg. 1.1.2 – Roles & responsibilities cover all tasks Arg. 1.1.3 - Ensure roles and responsibilities are clear and consistent Arg. 1.2.1, Arg. 1.2.2, Arg. 1.2.3 - Ensure the operating methods cover all normal, abnormal conditions and all relevant degraded modes of operation Arg. 1.2.4 - Ensure operating methods are clear and consistent Arg. 2.3.1 - Ensure input devices (and HMI) adhere to HF principles Arg. 4.3.1 - Assess impact of change in roles and responsibilities on staffing levels
TOOLS / METHODS SELECTED OUT OF THE HP RESPOSITORY	*N/A*
SUMMARY OF THE HP ACTIVITY	Review of concept documentation: P06.09.03 OSED P06.09.03 HP Assessment for Single Remote tower P06.09.03 SAR for Single Remote Tower

Table 4 Description of Activity 2

ACTIVITY 2.	HIERARCHICAL TASK ANALYSIS
DESCRIPTION	A structured, objective approach to describing users' performance of tasks, hierarchical task analysis originated in human factors. In its most basic form, a hierarchical task analysis provides an understanding of the tasks users need to perform to achieve certain goals. Originally developed in response to the need for greater understanding of cognitive tasks, HTA involves describing the activity under analysis in terms of hierarchy of goals, sub – goals, operations, and plans. The end result is an exhaustive description of

	task activity.
RELATED ARGUMENTS	Arg. 1.1.1 - Ensure the roles and responsibilities cover all end users impacted by the concept Arg. 1.1.3 - Ensure description of roles & responsibilities covers all tasks to be performed by human actors Arg. 1.2.1 - Ensure the operating methods cover all normal conditions of operation Arg. 1.3.1 - The potential for human error is reduced to a tolerable level Ar. 1.3.3 - Ensure ATCO & Supervisor workload is acceptable (initial analysis) Arg. 2.3.1- Define information needs/requirements of ATCOs and Supervisor Identify changes in existing team roles and new roles Arg.3.1.1 & Ar. 3.1.2 – Changes to roles in team are identified (changes to existing roles and new roles) Arg. 3.2.1 Ensure changes to task allocation between human actors so not lead to adverse effects on human tasks Arg. 3.2.2 – Ensure task allocation is supported by technical systems / HMI Arg. 3.2.3 – Ensure the potential for error is reduced to a tolerable level Arg. 4.2.1 - Identify changes in competence requirements (initial assessment)
ISSUES ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	1.1.1a, 1.1.3a, 1.2.1a, 1.2.1b,1.2.1c, 1.3.1a, 1.3.1b, 1.3.1c, 1.3.1d, 1.3.1e,1.3.3a, 1.3.3b, 1.3.3c, 2.3.1a, 2.3.1b, 2.3.1c, 2.3.1d, 3.1.1a, 3.1.2a, 3.2.1a, 3.2.2a, 4.2.1a
TOOLS/METHODS SELECTED OUT OF THE HP RESPOSITORY	The task analysis
SUMMARY OF THE HP ACTIVITY	The task analysis of single remote tower operations was used as basis to identify changes to ATCO/ AFISOs/ Supervisors' work under remote tower operations providing service to multiple aerodromes. The changes to work under the proposed regime were be identified by reviewing the OSED and procedures developed for the remote tower concept for multiple aerodromes. Two-days' workshop with a controller and operational expert was organised to analyse using walk-throughs methods to analyse the activities in multiple remote tower. The information was confirmed during the observations performed during the validation exercises.

Table 5 Description of Activity 3

ACTIVITY 3.	**SAFETY WORKSHOP**
DESCRIPTION	The safety workshop was organised focusing on degraded modes scenarios. The failure modes and the mitigation strategy were reviewed.
RELATED ARGUMENTS & HP OBJECTIVES	Arg. 1.2.1, Arg. 1.2.2 Arg. 1.2.3 - Assess the operating methods to ensure they cover all normal, abnormal conditions and all relevant degraded modes of operation Arg. 1.3.1 - Investigate the potential for human error & investigate means to prevent / mitigate Arg. 1.3.3 - Investigate the potential impact of the concept on trust and investigate means to mitigate any potential impacts

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	Arg. 1.3.4, Arg. 3.3.5 - Identify factors that may impact end users individual and team situation awareness and investigate means to mitigate any potential negative impacts Arg. 2.3.1 – Identify potential information requirements of end users Arg. 3.1.1 & Arg. 3.1.2 - Identify changes to team roles Arg. 4.1.2, Arg. 4.3.1, Arg. 4.3.2, Arg. 4.3.3 - Investigation impact on transitional factors such as acceptability, job satisfaction, staff levels, shift system and workforce relocation
ISSUES ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	1.2.1a, 1.2.1b, 1.2.1c, 1.2.1d, 1.2.2a, 1.2.3a,1.3.1a, 1.3.1b, 1.3.1c, 1.3.1d, 1.3.1e, 1.3.3a, 1.3.3b,1.3.3c, 1.3.4a, 3.3.5a, 2.3.1a, 2.3.1b, 2.3.1c, 2.3.1d 3.1.1a, 3.1.2a, 4.1.2a, 4.3.1a, 4.3.2a, 4.3.3a
TOOLS/METHODS SELECTED OUT OF THE HP RESPOSITORY	N/A
SUMMARY OF THE HP ACTIVITY	One day workshop involving three controllers previously experienced with multiple remote tower concept, operational and safety experts from 06.09.03 project. Review of relevant, high priorities Human Performance issues that are interdepended with safety aspects. Contribution to scenarios used during the workshop.

Table 6: Description of Activity 4

ACTIVITY 4.	**MULTIPLE TWR SIMULATION (EXE-06.09.03-VP-060)**
DESCRIPTION	Remotely Provided ATS for Multiple Aerodromes was assessed during a RTS. This exercise was investigating the provision of ATS as defined in ICAO Document 4444 [8][7] with the ATS being provided remotely by an ATCO. The overall aim of the exercise was to assess the technical and operational capability of an initial prototype for multiple aerodromes in an operational environment. The first exercise was split into 2 parts; each activity was conducted as RTS. • **Part 1** was based on Ängelholm, Halmstad and Kristianstad. The CWP prototype was be selected by SAAB and included the basic system, Advanced Visual Features (AVF) but not an e-strip. Standard scenarios were used comprising of daytime and good visibility conditions. The screen set was varied to decide on preferred screen layout (either side by side or up/down). In addition, the communications options were experimented with in order to test the preferred communications set up. The overall goals were to exit and choose the preferred screen layout and communications panels. • **Part 2** was be based on Ängelholm, Halmstad and Kristianstad. The prototype which was developed in Part 1 was assessed and the trials comprise of a more complete system which was more integrated and representative. Updates to the system included a prototype multiple/combined e-Strip and Information-Data Processing (IDP) including features to allow for the control and supervision of Aerodrome Ground Lighting (AGL) and Instrument Landing System (ILS). Scenarios included IMC and VMC in daylight and darkness. Traffic density was increased and non-nominal scenarios were

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	introduced. The overall goals were to obtain a high fidelity assessment of the prototype, alongside investigation into more complex scenarios to include non-nominal events. Gaining a fuller understanding of operator acceptance and system operational feasibility.
RELATED ARGUMENTS & HP OBJECTIVES	Arg. 1.2.5 - Assess operating methods (procedures) for normal, abnormal and degraded modes to ensure they can be executed in an accurate, efficient and timely manner for all ATCO/AFISO and supervisor Arg. 1.3.1 – Assess potential for human error Arg. 1.3.2 – Assess tasks to ensure they can be achieved in a timely (& efficient) manner Arg. 1.3.3 – Assess level of workload to ensure it is acceptable Arg. 1.3.4 – Assess level of trust in the concept to ensure it is acceptable Arg. 1.3.5 & Arg. 3.3.5 – Assess situation awareness (individual and team) to ensure it is at a sufficient level Arg. 2.2.1 – Ensure the accuracy of the information provided by the system is adequate to perform the tasks Arg. 2.2.2 – Ensure the timeliness of the information provided by the system is adequate for carrying out the task Arg. 2.3.1 – Ensure the type of information provided satisfies the end users information requirements Arg. 2.3.2 & Arg. 2.3.3– Ensure input devices, visual displays and other output devices correspond to HF principles Arg. 2.3.6 – Ensure the usability of the interface design is acceptable Arg. 2.3.7 – Assess user interface design to ensure human error is reduced as far as possible Arg. 2.3.8 – Assess the user interface to ensure it supports a sufficient level of situation awareness Arg. 3.2.1 – Assess task allocation between human actors to ensure there are no adverse effects on human tasks Arg. 3.2.2 – Ensure task allocation between end users is supported by technical system / HMI Arg. 3.2.3 - Assess the potential for human error in individual & team tasks Arg. 3.2.4 – Assess team tasks to ensure tasks can be achieved in a timely and efficient manner Arg. 4.1.1. – Assess whether the changes to roles and responsibilities etc. are acceptable to the affected actors.
ISSUES ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	1.2.5a, 1.3.1a, 1.3.2a, 1.3.2.b, 1.3.3a, 1.3.3b, 1.3.3c, 1.3.4a, 1.3.5a, 1.3.5b, 1.3.5c, 1.3.5d, 1.3.5e, 1.3.5f, 1.3.5g 1.3.5h, 2.2.1a, 2.2.2a, 2.3.1a, 2.3.1c, 2.3.1d, 2.3.2a, 2.3.3a, 2.3.6a, 2.3.6b, 2.3.7a, 2.3.7b, 2.3.7c, 2.3.8a, 2.3.8b, 2.3.8c, 2.3.8d, 2.3.8e, 2.3.8f, 3.2.1a, 3.2.2a, 3.2.3a, 3.2.4a, 3.3.5a, 4.1.1a.
TOOLS/METHODS SELECTED OUT OF THE HP RESPOSITORY	• CARS The Controller Acceptance Rating Scale • SHAPE Automation Trust Index (SATI) • SHAPE Measurement technique for Situational Awareness in ATM

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	systems (SASHA) • NASA TLX workload measurement • Bedford workload questionnaire
SUMMARY OF THE HP ACTIVITY	For detail please refer to Section 6.1 in [7]

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Table 7 Description of Activity 5

ACTIVITY 5.	MULTIPLE ATS TWR PASSIVE SHADOW MODE (EXE-06.09.03-VP-061)
DESCRIPTION	EXE-06.09.03-VP-061 was a PSM trial assessing the Remote Provision of ATS for Multiple Aerodromes. The trial validated using Sundsvall (ESNN) and Örnsköldsvik (ESNO) aerodromes in Sweden, both candidate target environments for the Multiple Remote Tower concept as two low density aerodromes This exercise represented the first PSM trial to assess OI step SDM-0205 "*Remotely provided ATS for Multiple Aerodromes*". The trial aimed to build upon the prototype developed within earlier exercises of the Multiple Remote Tower Concept (VP-060 part one and VP-060 part two). As in VP-060 the trial focused on the provision of ATS in accordance with ICAO Document 4444 [8][7] with the ATS being provided remotely by an ATCO. The overall exercise aimed to assess the capability of the RTM in a live operational setting. This was primarily focused on the usability and capability of the visual reproduction and various technical configurations. Validation within this exercise was also focused on establishing and defining technical requirements for the prototype and attempt to gain an initial insight into working methods for degraded mode operations.
RELATED ARGUMENTS & HP OBJECTIVES	The following objectives are based on the assumption that the shadow mode trials will be passive mode trials. If however, the shadow mode trials are in active mode then additional HP objectives can be added to the list below. Arg. 2.2.1 – The accuracy of the information provided by the system is adequate for carrying out all tasks Arg. 2.2.2 – The timeliness of information provided by the system is adequate for carrying out the task Arg. 2.3.1 – Ensure the type of information provided satisfies the end users information requirements Arg, 2.3.6 – The usability of the user interface is acceptable Arg. 2.3.8 – The user interface design support a sufficient level of individual situation awareness Arg. 3.2.2 – Ensure task allocation between end users is supported by technical system / HMI
ISSUES ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	2.2.1a, 2.2.2a, 2.3.1a, 2.3.1b, 2.3.1c, 2.3.1d, 2.3.6a, 2.3.8a, 2.3.8b, 2.3.8c, 2.3.8d, 2.3.8e, 2.3.8f, 3.2.2a
TOOLS/METHODS SELECTED OUT OF THE HP RESPOSITORY	• CARS The Controller Acceptance Rating Scale • SHAPE Automation Trust Index (SATI) • SHAPE Measurement technique for Situational Awareness in ATM systems (SASHA) • NASA TLX workload measurement • Bedford workload questionnaire
SUMMARY OF THE HP ACTIVITY	For detail please refer to Section 6.2 in [7]

Table 8 Description of Activity 6

ACTIVITY 6.	MULTIPLE ATS AFIS PASSIVE SHADOW MODE (EXE-06.09.03-VP-063)
DESCRIPTION	The remote provision of ATS AFIS to a Multiple Aerodrome is assessed during a Live Passive Mode Trial. This entails the AFIS Officer (AFISO) observing live traffic in a non-intrusive manner and not interacting with the aircraft or providing any service. The purpose of the first, Passive Shadow Mode element of the exercise is to assess confidence and assurance among stakeholders that the system can be used for provision of AFIS in live traffic. The overall aim of this first live passive mode trial is to use the prototype developed in the Multiple TWR Simulation (VP-060) and Multiple TWR Trial (VP-061) to assess the effectiveness of the remote provision of AFIS to Multiple Aerodromes. The prototype will run in the background, in parallel with the live operational system at the local airport. The target airports which were used in the trial are Værøy and Røst. The Remote AFISO will perform AFIS tasks using the CWP in the RTC. The visual surveillance will be provided by a reproduction of the OTW view, by using visual information capture The RTM included 14 visual reproduction screens (each 55 inches). When viewing one aerodrome, 14 cameras were used covering 360° on 14 screens. The live data feed of Røst and Værøy were provided to the RTM screens after being captured on a series of High Definition (HD) cameras mounted on camera masts at each aerodrome. Each camera provided a 25.7° of the aerodrome (360°÷14=25.7°) totalling a 205.6° viewing angle. When two aerodromes were being viewed simultaneously, the screen split ratio between each aerodrome was 8:4 (using 12 screens with two spare/blank screens). View and sound from the local tower was captured with digital video cameras and microphones. The actual airport systems, e.g. runway and taxi lights, was connected to the network with relevant data displayed in the RTC. Data was transmitted over a communication network between the actual airport and the RTC. The CWP in the RTC included all presentation of all necessary systems e.g. radar, flight plan, Met, airport lights, navaids, alarms, with interfaces to the airport.
RELATED ARGUMENTS & HP OBJECTIVES	The following objectives are based on the assumption that the shadow mode trials will be passive mode trials. If however, the shadow mode trials are in active mode then additional HP objectives can be added to the list below. Arg. 2.2.1 – The accuracy of the information provided by the system is adequate for carrying out all tasks Arg. 2.2.2 – The timeliness of information provided by the system is adequate for carrying out the task Arg. 2.3.1 – Ensure the type of information provided satisfies the end users information requirements Arg, 2.3.6 – The usability of the user interface is acceptable Arg. 2.3.8 – The user interface design support a sufficient level of individual situation awareness Arg. 3.2.2 – Ensure task allocation between end users is supported by

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	technical system / HMI
ISSUES ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	2.2.1a, 2.2.2a, 2.3.1a, 2.3.1b, 2.3.1c, 2.3.1d, 2.3.6a, 2.3.8a, 2.3.8b, 2.3.8c, 2.3.8d, 2.3.8e, 2.3.8f, 3.2.2a
TOOLS/METHODS SELECTED OUT OF THE HP RESPOSITORY	• CARS The Controller Acceptance Rating Scale • SHAPE Automation Trust Index (SATI) • SHAPE Measurement technique for Situational Awareness in ATM systems (SASHA) • NASA TLX workload measurement • Bedford workload questionnaire
SUMMARY OF THE HP ACTIVITY	For detail please refer to Section 6.3 in [7]

Table 9 Description of Activity 7

ACTIVITY 7.	COMMUNICATION SURVEY
DESCRIPTION	The survey investigating the preference for the technical solution and the communication mode for pilots and controllers
ARGUMENTS & RELATED ISSUES ADDRESSED	Arg. 2.3.1 - Ensure input devices (and HMI) adhere to HF principles
TOOLS / METHODS SELECTED OUT OF THE HP RESPOSITORY	*N/A*
SUMMARY OF THE HP ACTIVITY	The survey was created by HP and SAF team in order to investigate the preference for communication means and related issues.

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3.3 Step 4 Collate findings & conclude on transition to next V-phase

3.3.1 Summary of HP activities results & recommendations / requirements

Table 10 provides a summary of the HP argument and related issues / benefits along with the HP activity(ies) conducted. For each argument and issue or benefit the results/evidence obtained from the activities conducted are briefly described along with the recommendations and / or requirements generated.

The status of each issue is also given. The status of an issue / benefit can either be '**closed**', '**ongoing', 'cancelled**': An issue is considered '**closed'** when the issue had been sufficiently answered or no additional activities relating to that issue are foreseen as necessary; An issue is considered as being **'open'** when the issue has been either: partially addressed and more studies are needed or; the issue had been addressed by certain activities but as a result other related issues had arisen or; when no activity has been performed to date to address a specific issue. An issue is considered as being **'cancelled'** when the activities conducted have shown the issue to be not relevant to the given concept under investigation.

Table 10: Summary of the HP results and recommendations/ requirements for each identified issue & related argument

ARG.	ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED	RESULTS / EVIDENCE	ISSUE STATUS & RECOMMENDATIONS / REQUIREMENTS
1.1.1	1.1.1a	Not all human actors impacted by Multiple remote Tower concepts are identified.	Review of roles & responsibilities -Task analysis	The main focus of the HP assessment was the ATCO/AFISO as they are considered the most impacted. The RTM Supervisor role may become more significant depending on traffic demand/density, traffic complexity and aerodrome complexity Others actors impacted by the change are ground staff located at aerodromes, pilots, engineers responsible of maintenance. The impact on the technical staffs and engineers has been considered in the assessment for Single remote tower). In specific configuration the APP controller could also be impacted however the APP function is out of scope of the current assessment.	Closed
1.1.2	1.1.2a	The description of the roles & responsibilities does not cover all task to be performed by a human actor	- Review roles, tasks & responsibilities - Stakeholder (end users/SMEs workshop,	The description of role and responsibilities of ATCO/AFIS and Supervisor (SUP) were seen to be completed. The tasks of ATCO/AFISO do not change as such, the Supervisor role and responsibilities might expand depending on traffic demand/density,	On- going Recommendations: The task sharing between ATCO/AFISO and SUP should be

			-Task analysis	traffic complexity and aerodrome complexity. The task analysis (Appendix A) and Supervisor Role description ((Appendix B) The task related to METOBs and runway inspections have been addressed by HP assessment to Single Remote tower.	defined.
1.1.3	1.1.3a	Roles & responsibilities are not clear & consistent	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The description of role and responsibilities of ATCO/AFISO and Supervisor (SUP) were seen to be completed. The task analysis (Appendix A) and Supervisor Role description (Appendix B). The results of all three validation exercises suggested that the ATCO/AFISO role were clear and consistent. In the scope of the OI step SDM-0205 (limited to two aerodromes with low traffic) the SUP role was not seen as required. For this reason the supervisor role as not investigated in the validation.	On-going Recommendations: Define the task sharing between ATCO/AFISO and SUP.
1.2.1	1.2.1a	Operating methods do not cover the normal operating conditions	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The operating methods related to normal operating conditions were reviewed during the Task Analysis and investigated during Val EXEs. The validation scenarios have included the range of normal conditions (day light, darkness, VMC, IMC and mixed visual conditions). ATCO/AFISO reported to be comfortable with working methods in all exercises. (Depending on the set up of cluster of the aerodromes the supervisor role may become more significant The Supervisor's tasks are described in the Appendix B. The operating methods of supervisor were not investigated during validation exercise.	On-going Recommendations Validate the procedures developed in (EXE-06.09.03-VP-060 in active mode Trials[1] Validate the operating methods of Supervisor in active mode trials.
1.2.1	1.2.1b	Procedures/operating methods for changing control of aerodromes are not clear or	Stakeholder (end users/SMEs workshop, -Task analysis	The procedure of Closure of aerodrome was investigated in (EXE-06.09.03-VP-060) and (EXE-06.09.03-VP-061). The ATCO claimed that the	On-going Recommendations : The ATCO AFISO procedures of closing

[1] The HP assessment process for V3 phase recommends as appropriated validation activities, allowing to gather the evidence relevant for V3 are: high fidelity real-time simulations and operational trials carried out as active shadow mode trials.

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		efficient. Clear procedures need to be defined for opening and closing the aerodromes.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	operational procedures for transferring an aerodrome into/out of the RTM were acceptable". The results of EXE-06.09.03-VP-061 claimed however that the opening of aerodrome is likely more demanding than closing. In addition considering the passive shadow mode of the exercise and lack of supervisor position; it should be revised in the active mode.	and opening the aerodrome shall be investigated in an active mode and with the involvement of SUP.
1.2.1	1.2.1c	Different aerodromes have different procedures and different characteristics. This may add confusion, increase the amount of information ATCOs have to remember, and as a consequence increase the potential for human error. This could have an impact at the system level on safety	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	Providing the ATS services to two aerodromes working in different operating method might significantly increase cognitive load of ATCO/AFISO. The situation awareness could be also impacted. The configuration of clustering the aerodromes with different visibility IMC/VMC other) was investigated during Part 2 (EXE-06.09.03-VP-060) however considering the Simulated video based feed the validation should be extended.	On-going Recommendations : Assess the impact of various MET conditions and related operating modes in different aerodromes on ATCO/AFISO performance.
1.2.2	1.2.2a	Operating methods do not cover all the required abnormal operating conditions	Safety Workshop EXE-06.09.03-VP-060 Part 2)	The operational methods for certain abnormal events were defined and prioritised during safety workshop. These procedures were tested in RTS to gather the feedback. The abnormal conditions tested during simulation were go-arounds, circling, diversions and runway incursions. The results coming from EXE-06.09.03-VP-060 Part 2 suggest that ATCO considered the operational procedures for the handling of non-nominal conditions acceptable. Due to validation limitation these conditions were tested during four runs only. Within the scope of the validation the supervisor position was not seen a necessary; however ATCOs feedback was that the presence of a supervisor would improve working	On – going Recommendations: The ATCO/AFISO working methods in the complex emergency situations should be further validated. The SUP working methods in complex emergency situations should be validated in active trial mode.

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				methods in case of more extreme occurrence or severe emergencies.	
1.2.3	1.2.3a	Operating methods do not cover all relevant degraded modes.	Safety Workshop Stakeholder workshop	The degraded modes were addressed by specific Safety and Stakeholder workshop. The working methods related to major degraded modes were reviewed and tested during validation exercises via walk-through techniques. The procedures were updated based on the feedback from the ATCO/AFISO.	On-going Recommendations The ATCO/AFISO and SUP procedures for mitigation of degraded modes should be validated in active mode trial.
1.2.4	1.2.4a	The content of the operating methods is unclear & contradictory. If the operating methods are unclear and/or contradictory this will confuse ATCOs and will increase the potential for human error. This in term may have a negative impact on safety at the system level. It will also have a negative impact on user trust of the system with consequential impact on, for example, ability to make rapid decisions without the perceived need to re-verify information.	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	With the support of the HF and Safety team the operational procedures team developed procedures for specific abnormal and degraded mode operations identified as necessary for remote tower operations. These procedures were assessed by the ATCOs using walkthrough in EXE-06.09.03-VP-061 and EXE-06.09.03-VP-063. The procedures were updated based on the ATCO/AFISO feedback. For all other events / scenarios existing operating methods were used as in current day tower ops and seen to be clear , consistent and appropriate for remote tower operations.	On-going Recommendations The procedures developed and updated for abnormal and degraded modes in remote tower operations following EXE-VP 60 should be validated in active mode trials.
1.2.5	1.2.5a	The operating methods (procedures) for ATCOs & SUP the normal & abnormal conditions and degraded modes of operation are not easy to execute, and cannot be performed in an accurate, efficient for timely manner. This will impact the efficiency with which the ATCOs and supervisors	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	With the support of the HF and Safety team the operational procedures were developed for ATCO/AFISO and SUP for normal, abnormal and degraded mode operations. The operating procedures were reviewed during Tasks Analysis and safety workshop. During the EXE-06.09.03-VP-060, EXE-06.09.03-VP-061, EXE-06.09.03-VP-063, the certain operating methods of ATCO/AFISO were investigated and considered as accurate or sustainable. The	On-going Recommendations The procedures developed and updated for abnormal and degraded modes in remote tower operations following EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063 needs to be validated in active mode trials. The SUP working methods in complex

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		can perform their tasks. For certain situations, in particular degraded modes, this can have an impact on safety.		ATCO/AFISO claimed that in some abnormal conditions/ degraded modes the SUP role would improve the operations. The SUP role was not investigated in the current validation exercises.	emergency situations should be validated in active trial mode.
1.3.1	1.3.1a	The potential for human error is not reduced as far as possible. As some human errors have safety implications, this means system safety may be impacted.	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The risk of increasing the human error was analysed in Task Analysis and Safety workshop. During EXE-06.09.03-VP-060, EXE-06.09.03-VP-061, (EXE-06.09.03-VP-063 the human error was also investigated via the survey. The results did not reported that the concept itself would increase the risk of error as such. However ATCO/ AFISO were concerned about the number of potential errors could grow proportionally with the number of aerodromes controlled from one RTM. ATCOs found that most of the RTM tools assisted in improving or at least maintaining safety, including the tracking functionality. The passive shadow mode provided limited opportunity to test the planning of tasks thus the assessment of planning phase was not seen as systematic.	Ongoing Recommendations: Support function for aircraft identification should be implemented in visual presentation to support human performance, in particular SA and reduce the potential for error.
1.3.1	1.3.1b	Confusion of APTs (such confusion could arise in several ways e.g. when linking an a/c to APT, there could be a risk to mismatch the a/c to the APT or not identify the correct airport for the correct action e.g. monitoring, looking for info, seek confirmation etc..). Operations are often time-critical and a mismatch either in terms of incorrect identification of a/c to	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The impact on situational awareness was investigated in Safety Workshop, Tasks analysis and by post- exercise questionnaires in validation exercises. ATCO/AFISO reported that the level of situation awareness was acceptable. It was reported that visual cues for aircraft identifications would be helpful in OTW for maintain the correct SA. It was recommended to consider similarity of airport codes, runway numbers when clustering the aerodromes. The phraseology was also seen as key element that	Ongoing Recommendations: Assess the impact on SA after the recommendation from EXE-06.09.03-VP-060 in active trial mode. The aerodromes with similar airport callsigns should have distinctive designators if clustered together. The aerodromes with similar runway

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		APT or action to the correct a/c/or aerodromes or putting attention to the wrong airport can have a negative impact on safety as well as efficiency.		supports situational awareness The passive shadow mode provided limited opportunity to test the planning of tasks thus the assessment of planning phase was not seen as systematic. The Situation Awareness of SUP was not investigated.	number should have distinctive designators If similar call signs are recognised in clustered airports consider applying the Call Sign Similarity solution from EUROCONTROL Call sign similarity service. Provide visual cues supporting aircraft identification in visual presentation. Reinforce the training on aircrew increase the awareness and importance of complying with standard phraseology (using the airport code at each exchange, referring always to information provided by standard publications, avoiding referring to local features)
1.3.1	1.3.1c	Wrong procedures applied to wrong APT. If an ATCO confuses the aerodromes s/he may provide erroneous control actions. Safety implications.	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	During Task Analysis and Safety workshop the consistency of procedures between various aerodromes was considered. The EXE-06.09.03-VP-060 has investigated the impact of operating into two airports operating in different operating mode on ATCO/AFISO situational awareness. Within limited number of runs it was concluded that the SA was acceptable.	On-going Recommendations: The consistency of procedures between clustered aerodromes should be reviewed. In case of inconsistency of procedures, the common procedure for clustered airports should be designed. After any update on the procedure verify if the inconsistency was not introduce. Reinforce the training on aircrew

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					increase the awareness and importance of complying with standard phraseology (using the airport code at each exchange, referring always to information provided by standard publications, avoiding referring to local features) Reinforce the training on ground staff to increase the awareness and importance of complying with standard phraseology (using the airport code at each exchange, referring always to information provided by standard publications, avoiding referring to local features).
1.3.1	1.3.1d	Situation monitoring / controlling two landings at two different airports something requires the ATCO to give an urgent instruction (e.g. animal on RWY). What if ATCO gives instruction to the wrong a/c? How to ensure that the ATCO direct the instruction to the correct aircraft. This again could have a negative impact on safety	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	During Task analysis and Safety workshop the potential opportunities for human errors were investigated and appropriate mitigation were derived During the EXE-06.09.03-VP-060, EXE-06.09.03-VP-061 the simultaneous movements were investigated and although the level of situational awareness was high. The ATCO/AFIS claimed that simultaneous movements are contributing factor to worsening Situation Awareness.	On-going Recommendations : To enable ATCO AFISO dealing with aircraft in the sequence consider implementation: • Common approach service for clustered aerodromes • Traffics restrictions • Traffic planning by supporting tools Provide visual cues supporting aircraft identification.
1.3.1	1.3.1e	ATCOs confuse geographical local details of two airports. Pilots refer often to local geographic positions, therefore the ATCO needs to be aware of the local	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061)	During Task analysis and Safety workshop the potential opportunities for human errors were investigated and appropriate mitigation were derived. It was found that the visual overlay were helpful for	The aerodromes with similar airport callsigns should have distinctive designators if clustered together. The aerodromes with similar runway

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		geographical details for all aerodromes they are controlling. However, as they are controlling more than one aerodrome it means they have to remember more information and could confuse information relating to different aerodromes. The same could be said relating to other local information which may impact ATCO decision making, e.g. weather etc. This may increase the potential for human error and hence have a negative impact on system safety.	(EXE-06.09.03-VP-063)	airport identification in darkness.	number should have distinctive designators If similar call signs are recognised in clustered airports consider applying the Call Sign Similarity solution from EUROCONTROL Call sign similarity service. Reinforce the training for aircrews on aspects related to being controlled from multiple environments. Reinforce the ATFO AFISO training on local environment (visit to the local airports) Requirements Visual presentation shall allow the identification of each aerodrome.
1.3.2	1.3.2a	Tasks cannot be achieved in a timely manner. Resulting in operator stress (with tasks stacking up and requiring recall) leads to increased human error probabilities and consequences. At system level could impact efficiency and safety	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	During the Task analysis the potential of errors related to sequence and timing of movement has been analysed and the mitigation were generated. During the EXE-06.09.03-VP-060, the workload was investigated in terms of taskload, or as a peak and average workload. In both cases workload was considered as low. The factors contributing to increase of workload were: Simultaneous movements, VFR flight. The controller stress was investigated using Periodic Instantaneous Assessment (PITA), and was considered as acceptable. Workload was not systematically assessed as it was not seen to be feasible given it was a passive shadow mode trial. However, given the low traffic load plus the fact it	On-going Recommendation(s) ATCO/AFISO workload should be assessed in active mode trials under high taskload normal operating conditions as well as abnormal & degraded modes of operation. To enable ATCO AFISO dealing with aircraft in the sequence consider implementation: • common approach service for clustered aerodrome • Traffics restrictions • Traffic planning by supporting tools

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				was passive shadow mode WL was not considered an issue by ATCOs	
1.3.2	1.3.2b	What if two movements at two different airports coincide? Will the ATCO know which one to prioritise? Such a situation may stress an ATCO and could increase the potential for human error. Hence this could negatively impact system safety.	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	Pls refer to 1.3.2a	
1.3.3	1.3.3a	The level of workload (induced by cognitive &/or physical task demands) is not acceptable. Increasing the number of aerodromes that the ATCO is responsible for controlling simultaneously may negatively impact ATCO workload. This could increase the potential for human error and at the system level negatively impact safety.	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	Workload was not systematically assessed as it was not seen to be feasible given it was a passive shadow mode trial (EXE-06.09.03-VP-061and (EXE-06.09.03-VP-063. However, given the low traffic load plus the fact it was passive shadow mode WL was not considered an issue by ATCOs During the EXE-06.09.03-VP-060, workload was investigated in terms of task load, or as a peak and average workload. In both cases workload was considered as low. The factors contributing to increase of workload were: Simultaneous movements, VFR flight. The controller stress was investigated using Periodic Instantaneous Assessment (PITA), and was considered as acceptable.	Recommendation(s) ATCO/AFISO workload should be assessed in active mode trials under high taskload normal operating conditions as well as abnormal & degraded modes of operation. To enable ATCO AFISO dealing with aircraft in the sequence consider implementation: • Common approach service for clustered aerodrome • Traffics restrictions • Traffic planning by supporting tools
1.3.3	1.3.3b	Simultaneous activities at different aerodromes (especially if case of emergency) may make it difficult to focus on what is expected and cause more stress, as well as overload the ATCO.	Stakeholder (end users/SMEs workshop, -Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	During task analysis the sequence of activities was investigated and appropriate recommendations have been generated. The results of (EXE-06.09.03-VP-060) showed that the ATCOs had no difficulty prioritising for more than one aerodrome.	On – going Recommendations: Define the SUP tasks related to transfer to Rescue team To enable ATCO AFISO dealing with

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		This may increase the potential for human error and negatively impact system safety.		Considering that both EXE-06.09.03-VP-061 and EXE-06.09.03-VP-063 were passive shadow mode trials the assessment on planning and prediction task for ATCO/AFISO was limited.	aircraft in the sequence consider implementation: • Common approach service for clustered aerodrome • Traffics restrictions • Traffic planning by supporting tools
1.3.3	1.3.3c	Multiple airports can keep you busier and overcome boredom issues, as often in small aerodromes lack of activity and boredom is an issue as in some there are only two movements a day. Thus the workload may be more optimal, resulting in greater vigilance and situation awareness.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	Situation awareness level was compared between two and three aerodromes in EXE-06.09.03-VP-060. The level of SA has increased when three aerodromes were controlled, however there was less time for planning and organising. Workload was not systematically assessed as it was not seen to be feasible given it was a passive shadow mode trial (EXE-06.09.03-VP-061and (EXE-06.09.03-VP-063.	On –going Recommendation(s) ATCO/AFISO workload should be assessed in active mode trials under normal operating conditions as well as abnormal & degraded modes of operation.
1.3.4	1.3.4a	ATCOs are not confident in the multiple tower concept and associated CWP/HMI and procedures. This may lead to issues resulting from a perceived need by operators to re-verify data/ information prior to executing action.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The trust level investigated using the SATI survey was considered acceptable for the experimental conditions. It was reported that the PTZ Camera, Technical stability of system, e-strip, and The voice communications has the lowest scores. Considering the passive character of (EXE-06.09.03-VP-061) and (EXE-06.09.03-VP-063) It is recommended to repeat the measurement in active trials.	On going Recommendations ATCO/AFISO the trust level for remote tower concept should be validated in active mode trials.
1.3.5	1.3.5a	ATCOs cannot maintain a sufficient level of situation awareness. If ATCOs are responsible for controlling more than one aerodrome simultaneously, it may reduce their situation awareness on one or more of the aerodromes they are controlling. If ATCOs	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	Some of the element of situation awareness (planning) was not systematically assessed as it was not seen to be feasible given it was a passive shadow mode trial (EXE-06.09.03-VP-061and (EXE-06.09.03-VP-063. In the scope of validation average situational awareness remained high throughout all exercises. SASHA scores (EUROCONTROL SHAPE questionnaire)	On-going Recommendations: The ATCO/AFISO's situation awareness should be validated in active mode trials.

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		situation awareness is negatively impacted it may increase the potential for human error. This may then negatively impact safety at the system level.		for each exercise indicated that controllers were able to maintain situational awareness "more often" or "very often" in each SASHA category, independent of external conditions. Situational awareness was maintained at a high level independent of the configuration used in the RTM (basic or advanced). SASHA scores were unaffected by low visibility/darkness or IMC conditions, which is likely to be an improvement on current operations;	
1.3.5	1.3.5b	Supervisors cannot maintain a sufficient level of situation awareness of the traffic situation and as a result is unable to manage ATCO workload effectively i.e. fails to open up additional CWPs when necessary. This may have a safety impact		The issue was not investigated due to limited scope of validation.	On-going Recommendations: SUP situation awareness should be validated in normal, abnormal and degraded modes active mode trial.
1.3.5	1.3.5c	SUP believes ATCO is controlling two or three APTS but in fact ATCO is controlling one or two. This may have a safety impact.		The issue was not investigated due to limited scope	On-going Recommendations: SUP situation awareness should be validated in normal, abnormal and degraded modes active mode trial.
1.3.5	1.3.5d	If the ATCO is working on one APT and there is movement on a second s/he is controlling, ATCO may misinterpret movement as they had not been fully focussing on the second APT. This may lead to reduction in controlling efficiency as the ATCO will need to deploy further attentional resources to identifying what the nature of the movement had been, and determining any action		See 1.3.5a	

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		to take.			
1.3.5	1.3.5e	Risk that attention / mental focus is on the wrong airport or ATCO takes time to switch focus and recall the appropriate context for the respective airport. The various options on the airport induce a risk to mismatch signal/cue and relate that to the wrong airport. This may have safety implications.		See 1.3.1b	
1.3.5	1.3.5f	Darkness or not - actually there could be darkness on airport 1 and not on airport 2 as well as various weather conditions. Again this increases the consequences of ATCO mismatching the a/c to the aerodrome and providing the wrong information to the a/c. This may have safety implications.		See 1.2.1a	
1.3.5	1.3.5g	How to ensure that the aircraft understand that the message for him/her. If a/c acts on an instruction not intended for him/her this may have safety implications.	Stakeholder and Safety workshop Communication survey	The aircrew situational awareness was not systematically investigated during the validation activities. The aircraft preferred choice s for communication means was capture and recommendations were generated.	Ongoing Recommendations The aerodromes with similar airport callsigns should have distinctive designators if clustered together. The aerodromes with similar runway number should have distinctive designators If similar call sigss are recognised in clustered airports consider applying

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					the Call Sign Similarity solution from EUROCONTROL Call sign similarity service
1.3.5	1.3.5h	Compressed OTW presentation as curved RWYs, non-proportional relations between aircraft/ ground and between aircraft/ aircraft may impact ATCOs ability to judge distance / separation.	(EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The screen compression has been investigated in following configurations: 4 and 8 screens. The acceptance was slightly lower when using four screens than eight screens due to limitation in presentation and decreased judgement of distances and depth. It was reported that when working with 4 screens the constraints of single aircraft movement might need to be applied. The proposed mitigation was an efficient swap between airports and the appropriate clustering the aerodromes: one more busy aerodrome and one with very low traffic volume.	On-going Recommendations: The traffic level should be considered when clustering the airports. The impact of using a compressed image of the aerodrome to provide visual surveillance should be to further investigated to determine if traffic restrictions are required. Requirements : If expanded and compressed view solution is implemented, ATCO/AFISO shall be able to swap the visual presentation between expanded and compressed view at any time.
Arg 2 Technical systems support the human actors in performing their tasks					
2.2.1	2.2.1a	The performance of the technical system for both ATCO/AFISO and SUP in terms of accuracy of information provided by the systems is inadequate for carrying out the task. This will lead to rapid loss of trust/ confidence in the system, and low ATM performance. In the worst case it can impact decisions made and hence lead to error.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The accuracy of the following technical systems was investigated: Visual reproductions, Tracking functionality, E-strips, PTZ, radar, visual reproductions overlays and aerodrome sounds. In general, the controllers were satisfied with the quality of the visual presentation. Depth perception was deemed to be slightly reduced however one of the ATCOs commented that aerodrome overlays aided them in determining depth, especially during	On-going Recommendation(s) The automatic identification of aircraft should be implemented in visual presentation in order to optimise SA Support function for aircraft tracking should be implemented in visual presentation to support human

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		Depending on the type of error this could impact system safety.		night and reduced visibility. The majority also felt that tracking added operational value during darkness and IMC, providing heightened situational awareness beyond that of a local tower. Resolution was a slight concern with 38% of the ATCOs feeling it was not sufficient for smaller objects such as vehicle movements or for airborne movements. Some stated that smaller aircraft were harder to spot on the screens.	performance, in particular SA and reduce the potential for error. Requirement(s) -The a/c automatic identification & tracking function if implemented needs to be re-fined to ensure that only relevant objects e.g. a/c and aerodrome vehicles are identified and tracked.(RT_REQ_ DESIGN_006)
2.3.1	2.3.1a	The type of information provided does not satisfy the information requirements of the both the ATCOs and the SUP. This will lead to inefficient and possibly erroneous task execution and loss of trust in the system. Some errors may have an impact on system safety	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	During Task analysis the type of information needed were identified. The validations activities provided the operational feedback on: integrations, easiness of interpretation, HMI acceptability. The recommendation for further improvements regarding specific tools is listed below (after VALR: <u>Tracking functionality</u> - Add ID for visual tracks, regardless type of movement; Add the possibility to toggle tracking labels off and on very quickly <u>E-strips</u> Overall ATCO suggestions related to increasing the flexibility of the e-strip regarding the information they would input. The following ways in which the tool can be further enhanced were suggested: • The possibility to see all the traffic strips at the same time. The information required for SUP was not	On-going Recommendations The visual tracks should to be provided with identification tag Requirements: The ATCO/AFISO shall be able to toggle tracking labels in due time The ATCO/AFISO shall be able to see all relevant flight data information at any time.

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				investigated.	
2.3.1	2.3.1b	Different aerodromes may be operational at different times. How to ensure the ATCOs are aware of the operational modes (e.g. active, dormant, on hold, etc.) for each aerodrome? If ATCOs are not aware of the operational mode of each aerodrome this may cause confusion for the ATCOs and increase the potential for human error (e.g. not monitoring an aerodrome that is active). At the system level could have safety implications	(EXE-06.09.03-VP-060)	The "Airport Activator" function was investigated as a part of Interactive Display Panel (IDP).It was reported that the technical support in closing/opening airport is sufficient; however the working methods need to be revised.	Ongoing Recommendation The ATCO/AFISO working methods related to transferring the aerodromes should be validated in active mode trial.
2.3.1	2.3.1c	Data, e.g. flight strips, flight plan data from several airports need to be presented for the ATCO, what if ATCOs confuse the data for different a/c and aerodromes.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The combined E-strips and CWP has been reported as well integrated and its functionality was logical and easy to learn. Colour coding was applied to associate the e-strips with aerodromes overlay. The positioning of E-strips was matched with visual presentation. ATCOs commented that the placement of the strips relative to the location of the aerodromes on the visual presentation aided situational awareness and was more useful that matched colour coding.	Closed Requirements If colour coding applies it shall be matched between flight data information and other systems such as OTW, VCS. The location of flight data information shall be relative to location of the aerodromes on visual presentation.
2.3.1	2.3.1d	The level of workload for SUP is not acceptable. The SUP with the new task of allocating multiple APTs to ATCOs – possibly dynamically depending on the traffic and activity levels/ types at respective APTs- will need some sort of information / decision aid		The issue was not investigated	On-going Recommendations: Validate the SUP workload under normal, abnormal and degraded mode in active trials.

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		to help him make the correct allocation decisions			
2.3.2	2.3.2a	Wrong APT input device is used to control function in the different APT. Some errors would be readily identified and corrected, others not. If ATCOs are controlling more than one APT they may have different input devices for different APT, these may lead to the wrong input device being used to control a function in a different APT. This may affect the efficiency with end user can execute a task.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The combined E-strips with Interactive Display Panel (IDP) has been investigated. The interaction via pen was used. It was reported that ATCOs commented that the placement of the strips relative to the location of the aerodromes on the visual presentation aided situational awareness and was more useful that matched colour coding. The e-strip system was met with a high level of acceptance subject to some HMI improvements. (see 2.3.1a)	On-going Recommendations The way of interacting for control function should be the same for each aerodrome Requirements: As few device as possible shall be used to control the same functions for different aerodromes The way of interacting for control function shall be the same for each aerodrome.
2.3.3	2.3.3a	Visual displays and other output devices are not usable and /or picture quality is poor there is confusion with regards to which aerodrome is displayed on which visual display. This may impact ATCO / AFISO / supervisor situation awareness and increase the potential for human error. This may also affect the efficiency with end user can execute a task.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The visual presentation was were investigated in terms of: quality of image, number and positioning of screen and cameras, viewing angle, Overall the ATCOs declared themselves satisfied with the quality of the visual reproduction, the position and size of the screens and the 206 degree viewing angle. It was also identified that acceptance of viewing angle is dependent on traffic configuration and radar provision.	On going Recommendations: The acceptance of visual presentation depending on radar provision in different traffic configuration should be validated in active trial mode.
2.3.6	2.3.6a	If two a/c have to be controlled at the same time at two different APTs and ATCO only has main screen on one APT i.e. emergency a/c arrival. This could mean that the ATCOs have to change the	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061)	The transferring of the airport was investigated only in (EXE-06.09.03-VP-060), thus based on video feed mode. Also the procedures were recommended to be revised (See also 1.2.1b). It is recommended to validate the transferring of the aerodrome in active mode and with all involved actors to verify	On-going Recommendations The timeliness of opening and closing the aerodromes should be validated in active mode trial.

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		main screen view; this may take time so task would not be able to be achieved in a timely manner. This may impact overall system efficiency and for certain scenarios have a potential negative impact on safety.		timeliness of the task.	
2.3.6	2.3.6b	Headset is uncomfortable – this may lead to intolerance and reduction in morale, and possible errors arising from user-specified interventions, e.g. cushion padding resulting in reduction in sound signal strength at the ear.		The Issue was not investigated.	
2.3.7	2.3.7a	Wrong information related to APT is used – this may lead to a 'latent' failure in which an incorrect understanding of the system (aerodrome) status may exist, with possible later consequential system failure/ safety impact.		Issue not investigated	
2.3.7	2.3.7b	Confusion of which information (e.g. strips, meteo etc) is linked to which APT. This could increase the potential for human error, as ATCOs may give the wrong information, instruction to wrong a/c at another aerodrome. Therefore this could have a potential negative impact on system safety.		See 1.3.1b	
2.3.7	2.3.7c	In multiple RTC as many CWPs and ATCOs is expected to be available there is a better back	Safety workshop Stakeholder workshop	It was reported that working in RTC module is expected to provide the opportunity for back up in case of system failure.	Closed

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		up in case of system failure of a problem with ATCO – there is more flexibility as there is a larger resource pool to manage sudden changes in team workload.			
2.3.8	2.3.8a	Ambient conditions (sound vibrations, sound of birds) from more than one airport. How to distinguish or allocate the signals to the right airport? Planning can be supported by the ability to detect sound (APU etc.), detection of warm up of piston engine aircraft	(EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	It was found that aerodrome sound was not found to be mandatory, however when directional sound was provided it was valued by controllers. It was highlighted as a tool which could aid the situational awareness	Closed Requirements If sound is applied it shall be linked in directional manner with adequate airports.
2.3.8	2.3.8b	If R/T for each APT in each ear may mean that if ATCO received simultaneous info. no R/T may be distinguishable, leading to task inefficiency, or possible deficient situation awareness and consequent error. Possible safety impact.	Task analysis Safety workshop Communication Survey (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	See 3.3.1a	
2.3.8	2.3.8c	ATCOs believe other ATCO is controlling an APT, but in fact APT is not being controlled by anyone i.e. no one assumes responsibility. Possible delays in resuming service, which may occur at a time when an urgent resumption is imperative – safety implication.	Task Analysis Stakeholder workshop	The description of Supervisor role (appendix B) revealed the need for common information sharing tool that would provide the information's on active aerodromes, and facilitate clustering process based on prediction of traffic demand.	On-going Recommendations: Design the information sharing tool for managements of remote tower modules.
2.3.8	2.3.8d	Confusion relating to which pilot at which APT, ATCO is communicating / How to ensure	Task analysis Safety workshop (EXE-06.09.03-VP-060)	See 1.3.1b	

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		that the ATCO understand which aircraft is calling. How to address similar call-signs and similar airports	(EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)		
2.3.8	2.3.8e	Low visibility & dark conditions may make it more difficult for ATCOs to distinguish between different APTs.	(EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The validation activities have investigated the impact of darkness and low visibility on operating methods. ATCOs had a split opinion regarding whether or not the quality of the image during darkness was adequate for the provision of ATS during darkness. The aerodrome overlays and visual tracking were considered as major contributor to SA in darkness.	On-going Recommendations Support function for aircraft identification should be implemented in visual presentation to support human performance, in particular SA and reduce the potential for error. Requirements The aerodrome overlays if implemented shall be able to switch off or diminish.
2.3.9	2.3.9b	Headset may reduce team SA because it reduces operators' awareness of other ATCOs activity. If a situation in the team is developing that may require support from another ATCO, the other ATCO may not be aware of this and hence the transition may take longer than would have been the case if the ATCO had been aware. Possible safety impact.		The issue has not been investigated	On – going Recommendations: The team situational awareness depending on technical choice for communications should be validated.
Arg.3 Effects on team composition are identified.					
3.1.1	3.1.1a	Changes to existing roles in the team are not identified (including roles that become obsolete). This may lead to ineffective system/	Stakeholder (end users/SMEs workshop, -Task analysis	It was found both in Task analysis and in Safety workshop that the role of SUP became prominent in multiple environments. Appendix B summarises the activity of the SUP. The SUP role was not in the	On-going Recommendations: The SUP tasks should be validated in

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		interface design and inadequate training specification.		scope of current validation activities; however the ATCO and AFISO reported that the role of SUP would be significant in case of dealing with more complex emergencies.	active mode trials.
3.1.2	3.1.2a	The introduction of new roles to a team is not identified. This may lead to ineffective system/ interface design and inadequate training specification.	Stakeholder (end users/SMEs workshop, -Task analysis	Remote tower operations will require technical engineers that have the skills & knowledge to maintain and, when necessary, repair any problem associated with the remote tower equipment e.g. cameras, visual reproduction screens plus associated software and hardware. The technical engineers must be available at all times in case of any technical failure	On-going Recommendation(s) -Define new responsibilities/task of technical engineers -Ensure technicians with the required skills and knowledge are trained and available prior to implementation -Technical engineers must be available in case technical failures or maintenance issues
3.2.1	3.2.1a	Changes to the task allocation between human actors lead to adverse effects on human tasks.	Stakeholder (end users/SMEs workshop,	Not explicitly investigated although feedback from ATCOs indicates this is not a major issue for the metrological observations as in some aerodromes the ground staff are already responsible for this task.	On-going Recommendation(s) -Assess impact of allocating certain tasks previously performed by ATCO/AFISO to aerodrome staff on human performance (i.e. efficiency and potential for error) in future validation activities i.e. TWR active mode trials
3.2.2	3.2.2a	The proposed task allocation between human actors is not supported by technical systems / the HMI	Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The appendix B describes the SUP tasks. The SUP role has not been explicitly investigated in the current activity due to limited scope. The results revealed that in some situation the SUP should be supported by the supervisor tool to facilitate the management of modules/ cluster of aerodromes. The information provided to SUP are: Technical status of RTM (Alerts related to degraded modes, alerts informing of triggering search and rescue brigade, means of coordination with	On-going Recommendation(s) The SUP should be provided with the information related to management of remote tower modules such as: active aerodromes, degraded modes alerts, emergency alerts)

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				upstream sectors)	
3.2.3	3.2.3a	There is a potential for human error in individual & team tasks, which is increased as a result of the proposed changes. Some errors may impact system safety	Task analysis (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	In task analysis and the post- exercises debriefings it was found that for ATCO/AFISO simultaneous movements are main contributor to human error. The SUP role was not explicitly investigated towards the information sharing between SUP and ATCO/AFISO.	On-going Recommendations: To enable ATCO AFISO dealing with aircraft in the sequence consider implementation: • Common approach service for clustered aerodrome • Traffics restrictions • Traffic planning by supporting tools The validity of information provided to SUP should be assessed in active mode trial.
3.2.4	3.2.4a	Individual & team tasks cannot be achieved in a timely & efficient manner –leading to increased human error probability, and decrease in trust in the system. This may impact safety and efficiency at the system level	Task analysis Safety workshop	Appendix B describes the SUP tasks. The team tasks were not explicitly investigated in the validation trials due to limited scope.	On going Recommendations: The task sharing between ATCO/AFISO and SUP depending on RTM configuration should be defined. Validate if SUP task can be performed in timely manner in active trial mode.
3.3.1	3.3.1a	Intra-team & inter-team communication does not support the information requirements of team members	Task analysis	Due to limited scope of validation the communication between SUP, Metobs services, APP was not explicitly investigated.	Recommendations: The inter-and intra-team communication should be validated in active trial mode.
3.3.2	3.3.2a	The phraseology does not support communication in all operating conditions, including vehicles, aircraft, and approach.	Task analysis Safety and Stakeholder workshop, Communication Survey (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The coordination with on-site staff might be more difficult due to lack of face-to face communication. Ground staff or aircrew might refer to local conditions (local features of or airport layout) that ATCO/AFISO might not be completely aware of. It was recognised that callsign similarity, airport	On-going Recommendations: Reinforce the training of ATCO/AFISO related to local features, aerodrome layout/ specific meteorological

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				codes similarity our runway numbers similarity could be the factor contributing to decreasing the safety levels.	occurrences. Reinforce the training for aircrews on aspects related to being controlled from multiple environments (complying to standard procedure, avoiding the referring to local features). Consider to implement "airport callsign for each pilot transmission" procedures for aerodromes provided with multiple ATS operations. Consider to implement "airport callsign for each ground vehicle transmission" procedures for aerodromes provided with multiple ATS operations.
3.3.3	3.3.3a	Changes in communication means & modalities are not identified &/or not acceptable, leading to potential workload issues or human error probability increase.	Task analysis Safety and Stakeholder (end users/SMEs workshop, (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The communication means focusing on ATCO/AFISO has been investigated during (EXE-06.09.03-VP-060). Two modes: "transmit to all" and "transmit to one" has been specifically analysed. The majority of the time ATCOs chose to communicate by transmitting to each aerodrome individually. However the results do not allow concluding which mode is the preferred one. After the trial recommendation regarding HMI has been gathered and improved. The impact of change of communication means on air crew was analysed in Communication survey and the result are in Appendix C	On-going Recommendations: The impact of communication modes: "transmit to all" and "transmit to one" should be validated for all involved actors.
3.3.4	3.3.4a	The communication load of team members is not acceptable in	Task analysis Safety and Stakeholder	The final communication solution has not been identified yet. During Part 2 of (EXE-06.09.03-VP-	On going Recommendations:

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		normal & abnormal conditions & degraded modes of operations, leading to reduced system performance and potential increase in human error probability.	(end users/SMEs workshop, (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	060) it was observed the two aircraft calling the RTM frequency simultaneously. However during discussion with ATCOs this was not raised as an issue and none of the ATCOs felt that the occurrence of simultaneous transmissions was elevated compared to current operations. The results reported that the abnormal situation, such as emergency occurrences could increase the communication load, with SUP and ground services. Therefore the issue of Communication load should be further investigated.	The communication load of all team should be validated in active trial.
3.3.4	3.3.4b	Collapsing frequencies to "one" for more than one airport reduces efficiency of comms. as streaming of comms. may reduce the accessibility of communication with ATCOs.		See 3.3.4.a	
3.3.5	3.3.5a	Team members are unable to maintain a sufficient level of shared situation awareness, leading to reduced system performance and possible increased human error probability.		The issue has not been explicitly investigated	On-going Recommendations: The SUP should be provided with the information related to management of remote tower modules such as: active aerodromes, degraded modes alerts, emergency alerts).
Arg 4					
4.1.1	4.1.1a	The concept and resulting changes in roles & responsibilities are not acceptable to the affected actors	Task analysis Safety and Stakeholder (end users/SMEs workshop, (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	Considering the scope of the validation (the provision of ATS to two low density aerodromes) the overall acceptance of the RTM and technical features was high. Technical features included in the prototype RTM enhanced concept acceptance and provided controllers with support, especially in more operationally challenging conditions. The visual features were deemed to be well suited to their	On going Recommendations The acceptability of the multiple remote tower concept by aircrew and ground staff should be investigated.

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				function in aiding situational awareness and visual detection. The acceptability of the concept within pilots and ground staff has not been investigated.	
4.1.2	4.1.2a	Working in a team rather than in isolation may have a positive impact on job satisfaction	Safety workshop.	It was reported that in current operations in certain conditions ATCO/AFISO lacked a support in case of emergency situations. It was perceived as a benefit to work in RTM where the support could be provided in appropriate time.	Closed
4.2.1	4.2.1a	Knowledge, skills & experience requirements for human actors have not been fully identified. Thus the system may not adequately support the users and system performance will be reduced. Users in effect may not be suitable competent and experienced to operate the new system effectively.	Task analysis	The tasks in multiple remote towers were compared to providing ATS service to an aerodrome with multiple runways. The tasks for each airport remained the same, however some of the task were judged to be more difficult, e.g. visual separation, judgement of depth, local conditions on the aerodrome. It is necessary to ensure the adequate training for these tasks.	On going Recommendations A complete training programme for ATCO/AFISO should be developed with pre-specified performance criteria that need to be achieved before they can 'go operational'
4.2.1	4.2.1b	ATCOS operating several APTs will not be able to reach the same levels of knowledge when operating multiple aerodromes compared to just one. When operating just one aerodrome, ATCOs becomes highly skilled in normal local procedures, local anomalies in terrain, weather in local traffic behaviours. If ATCOs operating more than one aerodrome are not able to achieve the same level of skill and knowledge as for when operating a single aerodromes his may impact safety as ATCOs may	Task analysis Safety and Stakeholder (end users/SMEs workshop, (EXE-06.09.03-VP-060) (EXE-06.09.03-VP-061) (EXE-06.09.03-VP-063)	The concerns about losing local knowledge were revealed during the stake holder workshop. The experience about local conditions should be captured and implemented into the training program.	On-going *Recommendation(s)* -Ensure ATCO/AFISOs are able to visit the aerodromes they are controlling to ensure their local knowledge and awareness are somewhat maintained

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		not be able same service especially in demanding situations that require more than a general knowledge.			
4.2.2	4.2.2a	The changes introduced by multiple remote tower impacts operating licensing	Stakeholders workshop	Update on RIA towards licensing in multiple remote tower. The unit endorsement needs to be considered. Considering the significance of supervisor role, the licensing of SUP need also to be considered.	Closed. Recommendations The licensing of ATCO/AFISO should adhere to regulation set by NPA2015-04, Technical and operational requirements for remote tower operations [9].
4.3.1	4.3.1a	Impact on staff levels are not identified, leading to possible over- or under-staffing at the respective locations, and a delay in the organisation's ability to rectify the situation e.g. due to recruitment and training lead times, etc.		The acceptable shift pattern for ATCO/AFISO has not been established yet (see 4.3.2a) thus the impact on staff level has not been identified yet. The technical staff levels (locally based engineers and technical staff for met obs as well as the engineers based at RMT) have not been investigated.	On going Recommendation(s) -Cost of local staff and engineers e.g. training to ensure they have the skills required or recruitment of personnel if necessary, to be included in business case for remote tower (to be dealt with by P16.6.6.)
4.3.1	4.3.1b	Easier to recruit if RTC located near a big city / more interesting location		The issue has not been investigated.	On going Perform stakeholder workshop to investigate the issue.
4.3.1	4.3.1c	Overall staffing levels relating to operational staff should be reduced. This will provide cost benefits		The primary driver for Remote Provision of ATS to multiple aerodromes is cost effectiveness, understood as changes the ATCO - Aerodrome ratio and this change will induce an increase in the efficient use of staff. The shift length and scope of the SUP tasks have not been identified yet, (see 4.3.2a) thus it is it was impossible to assess what would be actual benefit with operational staff levels.	On - going
4.3.2	4.3.2a	How to ensure impact on shift	(EXE-06.09.03-VP-061)	It was reported that the currently existing shift	On going

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		organisation is acceptable	(EXE-06.09.03-VP-063)	length could apply but with introducing breaks. It was reported that the extended shift time would not be acceptable. Considering the limited scope of exercise, the shift length should be further investigated to standardise the procedures before implementation.	Recommendations: The shift length should be investigated in active trail mode in various visibility conditions. -The design of shift pattern shall adhere to appropriate regulation
4.3.3	4.3.3a	No-one wants to re-locate		The issue has not been investigated	On-going Recommendations: -If there is a problem findings ATCO/AFISOs that want to relocate offer incentives e.g. a relocation package for ATCO/AFISOs that have to relocate

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3.3.2 Maturity of the project

Checklist for finalising the V3 assessment		
ID	**Question**	**Comments**
1	Have all relevant arguments been addressed and appropriately supported?	Yes, all the argument has been addressed and the evidence has been gathered. In some cases the evidence (impact on other actors, such as aircrew, technical staff, and engineers) is coming mainly from stakeholder workshop only and has not been validated in trials.
2	Are the benefits and issues in terms of human performance and operability related to the proposed solution sufficiently assessed (i.e. on the level required for V3)?	Yes, the benefits and issues related to ATCO and AFISO role have been investigated which are the main actors impacted by the concept. Potential issues identified that impact on other actors (such as the Supervisor, (outside the scope of SDM-0205), ground staff, pilots, technical engineers) have been discussed to some degree and where possible mitigation identified. The safety issues relating in particular to technical system failures identified have been investigated by in the Safety Assessment. In addition technical improvements need to be made to enhance the performance and reliability of the technical components especially visual tracking and the validation activities need to include active shadow mode trials for TWR. More systematic assessment of abnormal events and degraded modes for both TWR and AFIS is also recommended. Future validation activities such as stakeholder workshops and trials should also include actors other than the ATCO / AFISO, namely, ground staff and technicians / technical engineers.
3	Have all the parts of the solution/concept been considered?	Yes, all the possible part of the concept been considered.
4	Have potential interactions with related projects/concepts been considered and addressed?	Yes. P12.04.07 provides the prototypes that are used in the validation exercises and findings from the validation exercise conducted by P06.08.04 for the single remote tower concept have been incorporated into the HP assessment report, where appropriate.
5	Is the level of human performance needed to achieve the desired system performance for the proposed solution consistent with human capabilities?	Yes, it was demonstrated that the proposed solution is consistent with human capabilities in passive shadow mode. It is recommended to demonstrate the level is achieved in active trials when all aspect of human performance could be investigated (especially Human Error)
6	Has the proposed solution been tested with end-users and under sufficiently realistic conditions, including abnormal and degraded conditions?	Yes, the combination of real – time simulations and passive shadow mode trials have been used to test the proposed solution which was considered as optimal solution for V3 phase. The advanced active mode trials real environment was not feasible due to validation limitation constrained by national authorities thus the active shadow mode trail are recommended in V4. Abnormal and degraded mode has been invested to the extent possible and relevance for V3 on a generic level for any aerodrome(s), however, due to limitation of the validation more systematic testing of abnormal and degraded modes are recommended to be performed in future trials.
7	Have all relevant SESAR documentation been updated according to the HP activities outcomes (OSED, SPR)?	Yes, the OSED incorporated the requirements and recommendations derived from both single and multiple assessments.

8	Do the outcomes satisfy the HP issues/benefits in order to reach the expected KPA?	Yes, The evidence of performance gathered during real-time simulations and passive shadow mode trials indicated that the KPA should be reached. The further study with involvement of active shadow mode trial should be conducted to confirm the expected level of performance.
9	Have HP recommendations and HP requirements correctly been considered in HMI design, procedures/documentation and training?	Yes. Recommendations relating to the design / functional requirements of the multiple remote tower, i.e. the enhanced visual features, have been made based on the HP benefits observed during trials. The initial investigation on communication means was performed, however the proposed solution is recommended to be further investigated.
10	Have the major factors that can influence the transition feasibility (e.g. changes in competence requirements, recruitment and selection, training needs, staffing requirements, and relocation of the workforce) been addressed? Are there any ideas on how to overcome any issues?	Yes, The transitions factors related to relocation and staffing levels has been investigated and appropriate recommendation has been proposed. The recommendation for training has been described in Appendix D. The shifts pattern was initially investigated however it is expected to be further explored by more representative trials, in longer periods of time.
11	Have any impacts been identified that may require changes to regulation in the area of HP/ATM? This includes changes in roles & responsibilities, competence requirements, or the task allocation between human & machine.	Yes. The impact on regulation has been investigated and the recommendations are documented in [7]. The impact on licencing is aligned with appropriate regulations.
12	Has the next V-phase sufficiently been prepared (additional testing conditions, open HP issues to be addressed)?	Yes, the recommendation for further validation activity are listed in Appendix E.

Considering the evidence gathered during the HP and Safety related validation activities, with the respect to HP maturity criteria it can be concluded that the Multiple Remote tower concept **satisfies the V3 level of HP maturity, for both Tower and AFIS.** Although the broad evidence gathered during V2 phase, the status of some issues and benefits is considered as on-going. The on-going status of the issue/benefit indicates that the complementary validation activities are recommended for the next validation phase.

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Appendix A Hierarchical Task Analysis

The task analysis for multiple remote towers is based on the task analysis on single. The two scenarios were considered with streams of activities for two aerodromes. The sequence of activities was built, the information sources were identified as well as potential issues, and mitigations. The performance shaping factors (PSF) according to {ref} for potential issues were reviewed to understand the impact on performance.

Performance Shaping Factors {ref}

1. Task familiarity Familiarity with the task being carried out will reduce human error rates at least down to the point where boredom may take over. Methods of improving performance may then have to be adopted.

2. **Available Time**Complex tasks may require more time to carry out than simple off-the-cuff tasks and if the time is not available, due to perhaps external constraints, than human rate will increase.

3. **Ergonomics**it is important that the design of the equipment adequately supports the need of the operator and if it does not, than this will cause human error rate to increase.

4. **Fatigue and stress**Depending on the level of stress, the effect can vary from merely distracting to the totally incapacitation. At the same time there is an optimal level of arousal and stimulation necessary to maintain vigilance also s(see task familiarity above). Fatigue affects the ability to perform the tasks accurately and also increase the influence of other PSFs mentioned in the table,

5. **Attentional demands**human error rates for single task carried if other tasks or distractions compete for attention. Human beings are not particularly good at multitasking.

6. **Availability of plans/ procedures combined with a level of training** Complex tasks require both experience and information to be completed successfully. Information should be presented in the form of easily understood procedure and plans which in some cases must be memorized depending on the task complexity

7. **Operator experience**Human error rates will depend upon whether the person carrying out the task is novice or an expert. And this must always be taken into account in assessing Human performance. to same degree this swill depend upon tasks complexity.


task analysis scenario1.docx


TAsk Analysis Scenario 2.docx

Appendix B Supervisor Role Description

Task type	Phase	Task	Description	Information needed	Comments
DCB Task	Strategic (4-6 weeks before D)	Roasting	To be done for all the positions in the center, including RTM and APP modules	- opening hours for each aerodrome (this can change depending on the season and other requests, constraints) - controllers unit ratting	The TMA is constantly opened, so the 'roasting' for the centralised APP is different from the one for RTMs.
	Pre-Tactical (D-1)	Staff allocation	Based on flight plan information for schedules flights, and taking into account the controllers available that day (roasting), the allocation of staff to the several 'clusters' of aerodromes is done. Weather forecast is also taken into account for the allocation. This is done in parallel with next task: "Management of modules/clusters in the RTC"	Information required: - Flight plans - roasting - weather forecast (METARs, weather radar data, etc.)	Two types of clusters: - for RTM - for centralised APP Clusters of aerodromes: to be defined taking into account - type of aerodromes, - their location (for example being fed by a common APP) - airspace structure and their layout (closer enough) - type of traffic (IFR, VFR) Clusters of TMA to be defined taking into account: - geographical location (in order to ensure homogeneous conditions in those airspace volumes) -traffic volumes

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Task type	Phase	Task	Description	Information needed	Comments
					For each Aerodrome cluster a "maximum capacity" is to be defined based on: - number of movements per time unit (including air movements and ground movements - AC and vehicles) - number of simultaneous movements - foreseen weather and visibility conditions For each APP cluster the capacity is to be defined taking into account: -Traffic volumes - weather conditions - APP working methods - Capacity of Airport clusters being feed by the centralised APP (arrival rates, separation between aircraft)
		Planning of modules/clusters in the RTC	Done at the same time of the allocation of staff, the supervisor defines which modules are needed to be opened and which clusters 'activated'. As for the staff allocation, this takes into account foreseen traffic and any planned event occurring in the concerned aerodromes and TMAs.	Activities occurring in the aerodromes Activities occurring in the TMA	At tactical level no supervisor action is in principle required. ATCo applies corresponding checklists for opening/closing modules and clusters/aerodromes. Handover of a cluster in normal conditions is done following the corresponding checklist too.

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Task type	Phase	Task	Description	Information needed	Comments
	Tactical (D)	Dynamic DCB'	To dynamically monitor the flow in order to anticipate any potential overload (or underload) with respect to 'cluster' capacity and - to reallocate staff by opening/closing modules as necessary. See dedicated task below: 'Management of modules/clusters...'.- to potentially change the flow (e.g. requesting some delays to specific flights, TTAs, etc.) in order to avoid the overload. See related 'Coordination' task.	Specific tool - to monitor the flow: flight plans and surveillance data- to decide on the action to be taken	
		Management of modules/clusters in the RTC with respect to unexpected events	In case an expected event occurs in the area of responsibility of a controller, the supervisor is informed by the corresponding ATCO. Supervisor decides then the action to be taken depending on the situation (as he has the overall view of the situation in the RTC).		Some examples of unexpected situations: - an event happening at the aerodrome that may impact the provision of ATS service - overload for a controller in a RTM - 'abnormal' situation happening in one to the aerodromes requiring a specific attention from the ATCO

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Task type	Phase	Task	Description	Information needed	Comments
					Some actions that may be taken with respect to that: - supervisor to coordinate with the airport authorities in order to decide on the need to close the aerodrome and then to provide support to do so - to change the clusters in the concerned RTM (in case of ATCo overload or in case of a situation in one aerodrome requiring a significant attention from the ATCO): the supervisor to decide how to 'split' the clusters and which other clusters need to be activated and allocated to which RTM
					There is a need for defining a 'contingency' plan for the Clusters taking into account potential unexpected events that may happen.
					In case of closure of the airport: A way to inform AU whether ATS are being provided in a specific aerodrome or not is to install a 'airport beacon' on the top of the tower (switch on if ATS is provided, switch off is not).

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Task type	Phase	Task	Description	Information needed	Comments
Coordination Task	Strategic Pre-Tactical	Aerodrome activities Coordination	To plan with the airport authorities and airport services the 'best schedule' (taking into account the foreseen traffic) for any intervention affecting the manoeuvring area in the aerodrome (maintenance, works, specific aerodrome activities as fire guard exercises, etc.).	From the aerodrome relevant service: - Type of intervention / activity - Duration	The objective is to schedule these aerodromes activities in a way that the impact on the traffic and on the controllers is a minimum.
				Flight plans for the concerned days	Coordination with the APP should be necessary for getting them informed.
			Even if any activity affecting the manoeuvring area is already notify by NOTAM (and this is the responsibility of the aerodrome), the supervisor could make sure that this information is available to all relevant actors potentially affected by that by 'redistributing' it as necessary. A specific sharing tool would be needed for that.	NOTAMs Scheduled aerodrome activities	

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Task type	Phase	Task	Description	Information needed	Comments
	Pre-Tactical	Coordination on TMA activities	To coordinate with APP and military with respect to specific events occurring in the TMA or the CTR, for example on the activation/deactivation of restricted areas, parachuting activities, etc.		
	Tactical	Coordination for DDCB measures	Coordination with upstream sectors/units in order to (agree?) and apply specific measures (as per DDCB task above) on individual/a set of flights in order to avoid overloads in the concerned APP / aerodromes. A specific tool is needed for performing this task.		
Statistics Task	Post-operations	Statistical support on aerodrome activities	To gather information on number of movements, type of traffic, etc., relevant to a specific aerodrome.A dedicated tool should support the supervisor on that.	Automatic data from the MRT system	This is a task that currently is done by controllers and that should be transferred to the supervisor.

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Task type	Phase	Task	Description	Information needed	Comments
Service provision	Tactical	SAR service	In case a flight is lost in the APP controlled from the same center: the APP controller contact the Supervisor who will trigger the SAR service by contacting the corresponding SAR center.		
			In case the event happens in one aerodrome for which ATS service is provided from the RTC: the corresponding ATCo triggers the SAR service. Supervisor is informed about that and can then support/ensure the provision of this service as per the corresponding checklist.		The SAR check list may contain the following tasks: - coordinating with the SAR related services in the aerodrome - supporting the closure of the aerodrome and coordinating withe the APP with respect to the other flights expected in the aerodrome - replace the controller in charge of the aerodrome and start a debriefing with him on the situation (to take him in charge) - reallocate the other aerodromes from the 'affected' module to another one

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Task type	Phase	Task	Description	Information needed	Comments
Degraded Modes management	Tactical	Management of 'operational' alerts on degraded modes	Watch supervisor is provided with ops alerts from the several RT modules (alerts related to those degraded modes having a potential impact on the operations). For each alert a fall back procedure is to be applied.		The fall-back procedures to be applied following an ops alerts are to be defined for each implementation as mitigation means are very depending on the technical system used. In some of these procedures the supervisor would have a role: - coordinating with adjacent sectors (see dedicated task 'Coordination') - reallocation of clusters (see dedicated task 'Management of clusters/modules ...') - closing an aeroport (see dedicated task 'Management of clusters/modules ...')
		Management of 'technical' alerts on degraded modes	Technical supervisor is provided with the ops alerts and also the technical alerts (related to degraded modes related to the technical infrastructure in the RTC). The Technical supervisor is in charge of coordinating with the technical team for solving the problem triggering the alert.		

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Appendix C Communication Survey Results

Survey on RTcomms multiple-Final.docx

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Appendix D HP Issues and Benefits Register

Argument 1.1 The roles and responsibilities of the human are clear & exhaustive					
Arg. 1.1.1 The description of the roles & responsibilities cover all affected human actors					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY[2]**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
1.1.1a	The description of the roles and responsibilities does not include / cover all affected human actors. If roles and tasks of certain affected human actors are not described this could cause confusion, as human actors impacted by a new concept may not be aware of new/additional roles and responsibilities. Depending on the roles and responsibilities not covered this can lead to error and impact *safety* at the system level and also reduced *efficiency*	High	Assess the description of the roles and responsibilities to ensure it covers all human actors	- Support the definition of human roles & responsibilities: Identify human actors affected by the change & check against the description of roles and responsibilities	-Review of roles & responsibilities -Task analysis
Argument 1.1.2 The description of the roles & responsibilities cover all task to be performed by a human actor					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
1.1.2a	The description of the roles & responsibilities does not cover all tasks to be performed by human actors. If the description of roles and responsibilities	High	Assess the description of the roles and responsibilities to ensure it include all tasks to be performed by human actors	Project Manager to ensure that HP resource is effectively integrated early into the multidisciplinary design team.	-Stakeholder (end users/operational experts) review roles, tasks & responsibilities

[2] Issues and benefits are prioritised according to their impact on human performance and KPA, as follows:
High priority: An issue has a negative and significant impact on safety, a safety concern, or a serious degradation of safety performance.
Medium priority: An issue has a negative and significant impact on KPA other than safety, for instance, degradation in efficiency or capacity, a negative impact on environment.
Low priority: An issue has a no significant impact on HP and/or KPAs.

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	is incomplete then this may result in a mismatch between the designed system and the task requirements. It may also lead to no-one performing the tasks or confusion with regards to whom is responsible. Depending on the tasks that are not allocated this can lead to reduced safety (due to errors of task omission) & reduced efficiency.			Support the allocation of tasks and identify those that are assigned to human actors: Identify tasks to be performed by the affected human actors to identify role changes in the solution scenario(s) compared to roles in the reference scenario & check against the description of roles and responsibilities.	-Task analysis

Argument 1.1.3 Roles & responsibilities are clear & consistent

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.1.3a	Roles & responsibilities are not clear & consistent. If roles and responsibility are not clear and consistent then this could lead to certain actors not performing their duties as required or performing them incorrectly or training needs being identified wrongly. Depending on the roles and responsibilities that are not clear and/or consistent this can lead to reduced efficiency and even perhaps safety at the system level.	High	Assess the description of the roles and responsibilities to ensure they are clear and consistent	Review Roles & Responsibilities as described in CONOPS/OSED to ensure they are clear and consistent.	-Stakeholder (end users/operational experts) review roles, tasks & responsibilities

Arg. 1.2 The procedures / operating methods are exhaustive and support human performance

Argument 1.2.1 Operating methods cover normal operating conditions

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.2.1a	Operating methods do not cover normal operating conditions. If operating methods do not cover all normal	High	-Assess operating methods for normal operating conditions to ensure all normal operating conditions are covered.	-	-Stakeholder (end user & safety) workshop / interviews

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	operating conditions, this may lead to ATCOs not knowing or being uncertain of exactly how to deal with certain normal operating conditions. It may also result in the system or interface being designed inadequately and not supporting the actual system requirements. This may reduce efficiency at the system level and under certain conditions could have safety implications.				-Task analysis
1.2.1b	Procedures/operating methods for changing control of aerodromes are not clear or efficient. Clear procedures need to be defined for opening and closing the aerodromes. If such procedures are not clear and efficient then, at the system level, efficiency and perhaps even capacity as well as safety could impacted.	High	-Assess procedures for opening closing, and changing control of aerodromes between RTMs/ ATCOs to ensure they are clear and efficient (usable)		-Task analysis -Stakeholder (end user) interview to review procedures/operating methods -RTS
1.2.1c	Different aerodromes have different procedures and different characteristics. This may add confusion, increase the amount of information ATCOs have to remember, and as a consequence increase the potential for human error. This could have an impact at the system level on safety	High	Assess impact of controlling different combinations of aerodromes on ATCO situation awareness, workload and potential for error (note: the impact of different aerodrome combinations on situation awareness, workload and potential for error should be done on an case by case basis during later stages of validation V4, i.e. aerodrome by aerodrome as to develop generic rules may not feasible)	-Standardise procedures and equipment in different aerodromes as far as is possible -Ensure aerodromes being controlled by the same ATCO use the same equipment and procedures (as far as is possible) -Consider competency aspects such as certification for operating specific aerodromes based on a level of knowledge, familiarity and experience of working with that facility.	-RTS or trials (V4 activity - as this should be done an aerodrome by aerodrome basis, as it would be difficult to generate generic rules)

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Argument 1.2.2 Operating methods cover abnormal operating conditions					
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.2.2a	Operating methods do not cover all the required abnormal operating conditions. If operating methods do not cover all required abnormal operating conditions, this may lead to ATCOs not knowing or being uncertain of exactly how to deal with certain abnormal operating conditions. This may reduce efficiency at the system level (as a result of increased human error or delays in action execution) and under certain conditions have safety implications.	High	-Assess operating methods for abnormal operating conditions to ensure all abnormal operating conditions are covered.	-Ensure operating methods for all identified and relevant abnormal operating conditions are developed.	- Stakeholder workshop /interviews (HAZID - liaise with safety).to identify abnormal operating conditions. -End user review of draft operating methods for abnormal conditions.

Argument 1.2.3 Operating methods cover degraded modes					
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.2.3a	Operating methods do not cover all relevant degraded modes. Impact as per 1.2.2a, except that the consequences of human error resulting from this issue are often greater when operating in degraded mode because some functionality is not enabled and this may be safety related.	High	-Assess operating methods for relevant degraded modes of operation to ensure all relevant degraded conditions are covered (liaise with safety).	Develop operating methods for all relevant degraded-mode operating conditions (safety should support definition of relevant degraded modes of operation)	- Stakeholder workshop / interview (HAZID - liaise with safety). -End user review of draft operating methods for degraded modes of operation.

Argument 1.2.4 The content of the operating methods is clear & consistent					
ISSUE	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES

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ID					
1.2.4a	The content of the operating methods is unclear & contradictory. If the operating methods are unclear and/or contradictory this will confuse ATCOs and will increase the potential for human error. This in term may have a negative impact on safety at the system level. It will also have a negative impact on user trust of the system with consequential impact on, for example, ability to make rapid decisions without the perceived need to re-verify information.	High	Assess operating methods for normal, abnormal conditions and degraded modes of operation to ensure they are clear and consistent. (The review should be carried out with operational experts / end users, if necessary supported by native speakers/ linguistic experts.	Review the suite of operating methods for clarity and consistency and revise as necessary.	-Review of procedures with end-user / operational expert input.

Argument 1.2.5 The Operating methods (procedures) can be followed in an accurate, efficient and timely manner.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.2.5a	The operating methods (procedures) for ATCOs & SUP the normal & abnormal conditions and degraded modes of operation are not easy to execute, and cannot be performed in an accurate, efficient nor timely manner. This will impact the efficiency with which the ATCOs and supervisors can perform their tasks. For certain situations, in particular degraded modes, this can have an impact on **safety**.	High	Assess ATCO and SUP operating methods for normal, abnormal conditions and degraded modes of operation to ensure they can be performed in an accurate, efficient and timely manner.		-RTS

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Arg. 1.3 Human actors can achieve their tasks (in normal conditions of the operational environment).					
Argument 1.3.1 The potential for human error is reduced to a tolerable level					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
1.3.1a	The potential for human error is not reduced as far as possible. As some human errors have safety implications, this means system safety may be impacted.	High	Assess the impact of concept/task changes (roles, responsibilities, tasks & procedures / working methods) for ATCO and SUP on potential for human error.	Identify changes in potential for errors and their causes and develop appropriate mitigation / recovery means.	-Task analysis -Stakeholder workshop (focus groups, low fidelity mock-up review HAZID (liaise with safety) -RTS
1.3.1b	Confusion of APTs (such confusion could arise in several ways e.g. when linking an a/c to APT, there could be a risk to mismatch the a/c to the APT or not identify the correct airport for the correct action e.g. monitoring, looking for info, seek confirmation etc..). Operations are often time-critical and a mismatch either in terms of incorrect identification of a/c to APT or action to the correct a/c/or aerodromes or putting attention to the wrong airport can have a negative impact on safety as well as efficiency.	High	Assess impact of concept /task changes (roles, responsibilities, tasks & procedures / working methods) for ATCO and SUP on situation awareness and error. (Types of error identified so far: risk to mismatch the a/c to the APT or not identify the correct airport for the correct action e.g. monitoring, looking for info, seek confirmation)	-Mark the actual display surface with the airport designator / name -Ensure differences between APT are highlighted to reduce potential for confusion; -Associate R/T with APT(s) being controlled; - Ensure consistency in positioning of APTs to ATCOs; -APTs should all have different runway names. -Sequencing system, e.g. AMAN / DMAN	- Task analysis -Stakeholder workshop (focus groups, low fidelity mock-up review HAZID (liaise with safety) -Prototyping -RTS
1.3.1c	Wrong procedures applied to wrong APT. If an ATCO confuses the aerodromes s/he may provide erroneous control actions. Safety implications.	High	Assess impact of concept /task changes (roles, responsibilities, tasks & procedures / working methods) for ATCO and SUP on situation awareness and error. (Types of error identified so far: Wrong procedures applied to wrong APT)	-Make procedures for different APTs being controlled together as similar possible e.g. VFR traffic should be treated the same as IFR -Align behaviours in APTs so that all APT cultures are the same, local aerodrome staff & local flight crew (VFR clubs) in particular -Information campaigns to inform aircrew of aerodrome procedures	-Human reliability assessment of procedure selection error (liaise with safety). -RTS

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1.3.1d	Situation monitoring / controlling two landings at two different airports something requires the ATCO to give an urgent instruction (e.g. animal on RWY). What if ATCO gives instruction to the wrong a/c? How to ensure that the ATCO direct the instruction to the correct aircraft. This again could have a negative impact on safety	High	Assess impact of concept /task changes (roles, responsibilities, tasks & procedures / working methods) for ATCO on situation awareness and error. (Types of error identified so far: ATCO gives instruction to the wrong a/c)	-Highlight a/c to which communication is being transmitted	- Stakeholder workshop (HAZOP/HAZID) liaise with safety -HRA of selection of communication with incorrect aircraft in urgent situations. - RTS
1.3.1e	ATCOs confuse geographical local details of two airports. Pilots refer often to local geographic positions, therefore the ATCO needs to be aware of the local geographical details for all aerodromes they are controlling. However, as they are controlling more than one aerodrome it means they have to remember more information and could confuse information relating to different aerodromes. The same could be said relating to other local information which may impact ATCO decision making, e.g. weather etc. This may increase the potential for human error and hence have a negative impact on system safety.	**High**	Identify and assess changes to the potential for human error (together with causes of such error) and identify potential mitigation (liaise with safety). Assess proposed mitigation in the solution ATM system (liaise with safety) with focus on performance/ situation awareness decrements resulting from increase in the number of remote aerodromes under control.	-Tools/ features to increase situation awareness to be implemented according to the outcome of the recommended activities.	- Stakeholder workshop (HAZOP/HAZID) liaise with safety -HRA -RTS

Argument 1.3.2 Tasks can be achieved in a timely manner

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.3.2a	Tasks cannot be achieved in a timely	High	Assess timeliness of executing specific task.	-Consider options for deferring,	-Low fidelity mock-up

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	manner. Resulting in operator stress (with tasks stacking up and requiring recall) leads to increased human error probabilities and consequences. At system level could impact efficiency and safety		Assess ATCO workload under high task load conditions	shelving, omitting non-safety critical activities within a task. Also for delegating or dynamically reallocating functions from human to machine, or to other controllers or the supervisor. -Ensure supervisory procedures effectively protect against severe levels of workload, -Ensure task design is such that activities can be dynamically reallocated if workload reached levels at which human error probability is negatively impacted.	with end users -RTS
1.3.2b	What if two movements at two different airports coincide? Will the ATCO know which one to prioritise? Such a situation may stress an ATCO and could increase the potential for human error. Hence this could negatively impact system safety.		Assess events/ scenarios described in 1.3.2 in terms of ATCO situation awareness and human error	-ATCOs need to have capacity to delay one or both movements -Develop procedures for such events & ensure ATCOs are well trained on these procedures prior to implementation -Develop/ agree/ establish clear and simple protocols for enabling ATCO to rapidly determine priority in this situation.	-Mock-ups / prototyping sessions - RTS

Argument 1.3.3 The level of workload (induced by cognitive &/or physical task demands) is acceptable

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.3.3a	The level of workload (induced by cognitive &/or physical task demands) is not acceptable. Increasing the number of aerodromes that the ATCO is responsible for controlling	High	Assess ATCO and SUP workload in RTS under a variety of normal & abnormal conditions and degraded modes of operation, in different visibility and weather conditions.	-Ensure supervisory procedures effectively protect ATCOs against severe levels of workload, -Ensure task design is such that activities can be dynamically	-Task Analysis -RTS

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	simultaneously may negatively impact ATCO workload. This could increase the potential for human error and at the system level negatively impact safety.			reallocated if workload reached levels at which human error probability is negatively impacted. -Establish safe maxima for APTs that can be managed through a single ATCO taking consideration of APT type and level of traffic.	
1.3.3b	Simultaneous activities at different aerodromes (especially if one an emergency) may make it difficult to focus on what is expected and cause more stress, as well as overload the ATCO. This may increase the potential for human error and negatively impact system safety.	High	-Assess ATCO workload under such events/scenarios as described in 1.3.3b	-Network manager to consider clusters of APT in multiple RTC being one APT; -Supervisor / traffic manager to ensure workload in multiple tower centre is evenly distributed amongst ATCOs so they don't become over-loaded (e.g. supervisor can open a new position, or ask for traffic to be redirected to another sector / aerodrome) -Sequencing system, e.g. AMAN / DMAN -Develop procedures for SUP/Traffic Manager and ATCOs for such situations so they know how to deal with such situations -Ensure SUP/Traffic Manager and ATCOs are trained on such procedures before concept implementation	-Task analysis -RTS
1.3.3c	Multiple airports can keep you busier and overcome boredom issues, as often in small aerodromes lack of activity and boredom is an issue as in some there are only two movements a day. Thus the workload may be more optimal, resulting in greater vigilance and		Assess potential benefits of increased ATCO task load such as increased situation awareness, vigilance and motivation variety of normal & abnormal conditions and degraded modes of operation, in different visibility and weather conditions.. Also assess task load / workload.		-RTS

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	situation awareness.				

Argument 1.3.4 The level of trust in the new concept / procedures is appropriate

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.3.4a	ATCOs are not confident in the multiple tower concept and associated CWP/HMI and procedures. This may lead to issues resulting from a perceived need by operators to re-verify data/ information prior to executing action.	Med	Assess ATCO trust in concept and associated CWP/HMI and procedures.	Ensure end-user engagement with design development is effective. Ensure migration plan is well developed and agreed with the operator stakeholder. Ensure training needs are addressed effectively.	-Workshop / interviews with end users -RTS

Argument 1.3.5 Human actors can maintain a sufficient level of situation awareness

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
1.3.5a	ATCOs cannot maintain a sufficient level of situation awareness. If ATCOs are responsible for controlling more than one aerodrome simultaneously, it may reduce their situation awareness on one or more of the aerodromes they are controlling. If ATCOs situation awareness is negatively impacted it may increase the potential for human error. This may then negatively impact safety at the system level.	High	Assess ATCO situation awareness under a variety of normal & abnormal conditions and degraded modes of operation, in different visibility and weather conditions.	-Traffic planning / synchronisation between APT being controlled by one ATCO/AFISO in multiple set-up??? -Alerts	-RTS (compare multiple set-ups with single)
1.3.5b	Supervisors cannot maintain a sufficient level of situation awareness of the traffic situation and as a result is unable to manage ATCO workload effectively	High	Assess supervisor situation awareness as well as SUP ability to manage ATCO workload (task load) under a variety of normal & abnormal conditions and		-RTS

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	i.e. fails to open up additional CWPs when necessary. This may have a safety impact		degraded modes of operation, in different visibility and weather conditions.		
1.3.5c	SUP believes ATCO is controlling two or three APTS but in fact ATCO is controlling one or two. This may have a safety impact.	High	Assess Supervisor situation awareness under a variety of normal & abnormal conditions and degraded modes of operation, in different visibility and weather conditions (can such a scenario be simulated in a RTS)	-Ensure Sup CWP/HMI presents up-to-date and accurate information on what APTs are open and being controlled by which ATCOs them, i.e. an overview screen for SUP: -Assume a/c and use of colour coding for the assume function	-Prototyping sessions -RTS
1.3.5d	If the ATCO is working on one APT and there is movement on a second s/he is controlling, ATCO may misinterpret movement as they had not been fully focussing on the second APT. This may lead to reduction in controlling efficiency as the ATCO will need to deploy further attentional resources to identifying what the nature of the movement had been, and determining any action to take. Furthermore it could have	Med	Assess likelihood and consequence of such an event happening.	-Consideration to which APT can be managed simultaneously -Procedures -Alerts / alarms Careful specification of training to include how to ensure adequate situation awareness is maintained (training of required scanning patterns). -Possibly including interface feature to alert operator of movement, or the recommended need to make a check on other APT under control.	-Stakeholder (ATCO) workshop/interview - RTS
1.3.5e	Risk that attention / mental focus is on the wrong airport or ATCO takes time to switch focus and recall the appropriate context for the respective airport. The various options on the airport induce a risk to mismatch signal/cue and relate that to the wrong airport. This may have safety implications.	High	Assess ATCOs situation awareness of all APT under his/her responsibility under a variety of scenarios (using events to assess such a situation, i.e. assess likelihood and consequence of such an event happening)	-Training, Alert for RWY incursion, Prompt, text, flash, sound indicating the expected focus.	- RTS
1.3.5f	Darkness or not - actually there could be darkness on airport 1 and not on airport 2 as well as various weather conditions. Again this increases the consequences	Medium	Assess ATCO situation awareness in such a scenario as described in 13.5.i.	-Consideration to which APT can be managed simultaneously -Procedures	- RTS

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	of ATCO mismatching the a/c to the aerodrome and providing the wrong information to the a/c. This may have safety implications.			-Alerts / alarms -Careful specification of training to include how to ensure adequate situation awareness is maintained - Possibly including interface feature to alert operator of movement, or the recommended need to make a check on other APT under control.	
1.3.5g	How to ensure that the aircraft understand that the message for him/her. If a/c acts on an instruction not intended for him/her this may have safety implications.	High	Assess adequacy of existing protocols/procedures for ensuring the potential for such an error is mitigated.	-Modified phraseology. -Use of standard interaction protocols.	-Stakeholder (aircrew)workshop / interviews (HAZID liaise with safety) - RTS (aircrew debrief)
1.3.5h	Compressed OTW presentation as curved RWYs, non proportional relations between aircraft/ ground and between aircraft/ aircraft may impact ATCOs ability to judge distance / separation (this is especially relevant for the SAAB solution)	High	Assess acceptability of display presentation with partially/ wholly compressed areas.	Consider carefully any use of displays that are not to scale – ensure the impact of any such displays cannot lead to misjudgements that have a safety impact.	-Prototyping sessions -RTS.

Arg 2 Technical systems support the human actors in performing their tasks

Arg 2.2 The performance of the technical system supports the human in carrying out their tasks

Argument 2.2.1 The accuracy of information provided by the system is adequate for carrying out the task

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
2.2.1a	The performance of the technical system for both ATCOs and SUP in terms of accuracy of information provided by the systems is inadequate for carrying out the task	High	Assess the technical system to ensure accuracy of information provided is adequate		-Prototyping sessions -RTS &/or trials

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	This will lead to rapid loss of trust/ confidence in the system, and low ATM performance. In the worst case it can impact decisions made and hence lead to error. Depending on the type of error this could impact system safety.				

Argument 2.2.2 The timeliness of information provided by the system is adequate for carrying out the task

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
2.2.2a	The performance of the technical system for both ATCOs and SUP in terms of timeliness of information provided by the systems is inadequate for carrying out the task This will lead to rapid loss of trust/ confidence in the system, and low ATM performance. In the worst case it can impact decisions made and hence lead to error. Depending on the type of error this could impact system safety.	High	Assess the technical system to ensure timeliness of information provided is adequate		-Prototyping sessions -RTS &/or trials

Arg. 2.3: The design of the human-machine interface supports the human in carrying out their tasks.

Argument 2.3.1: The type of information provided satisfies the information requirements of the human.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
2.3.1a	The type of information provided does not satisfy the information requirements of the both the ATCOs and the SUP. This will lead to inefficient and possibly erroneous task execution and loss of trust in the system. Some errors may have an impact on system safety		Identify information needs/ requirements of the ATCOs and SUP Assess usefulness and requirement of the information displayed on HMI for both ATCOs and SUP		-Task Analysis -Focus groups with end users,(review of low fidelity mock-up) -Prototyping sessions - RTS
2.3.1b	Different aerodromes may be operational at different times. How to	High	Assess HMI to ensure different modes of operation are clearly distinguishable, (i.e.	-If different modes are applied the mode in use must be clearly known	-Task analysis -Review of best practice

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	ensure the ATCOs are aware of the operational modes (e.g. active, dormant, on hold, etc.) for each aerodrome? If ATCOs are not aware of the operational mode of each aerodrome this may cause confusion for the ATCOs and increase the potential for human error (e.g. not monitoring an aerodrome that is active). At the system level could have safety implications		easily interpreted & intuitive with regards to mode of operation)	by the users of the services (HMI design). Identify and specify appropriate design features that ensure situation/ mode awareness of aerodrome control status is maintained at an acceptable level.	HF guidelines to identify appropriate design features -Prototyping sessions -RTS
2.3.1c	Data, e.g. flight strips, flight plan data from several airports need to be presented for the ATCO, what if ATCOs confuse the data for different a/c and aerodromes.		Assess HMI/CWP layout / design to ensure it is usable and the potential for such errors of confusion are minimised	Supportive/smart automation of flight strips	-Prototyping session -RTS
2.3.1d	The level of workload for SUP is not acceptable. The SUP with the new task of allocating multiple APTs to ATCOs – possibly dynamically depending on the traffic and activity levels/ types at respective APTs- will need some sort of information / decision aid to help him make the correct allocation decisions	**Med**	Ensure the SUP information requirements / support tool requirements are achieved Validate the usability of the SUP HMI Ensure workload is acceptable		-Task analysis -Prototyping -RTS.

Arg. 2.3.2: Input devices (e.g. keyboard, mouse, touch screen) correspond to HF principles

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
2.3.2a	Wrong APT input device is used to control function in the different APT. Some errors would be readily identified and corrected, others not. If ATCOs are controlling more than one APT they may have different input devices for different APT, these may lead to the wrong input device being used to control a function in a different APT. This may affect the	Medium	Assess usability of input devices and potential for such an error	Where possible use the same input device for same input to different APT, i.e. minimise the number of input devices as far as is possible	-Check Input devices are consistent with design standards or regulations -Prototyping sessions -RTS

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	efficiency with end user can execute a task.				
Arg. 2.3.3: Visual displays and other types of output devices adhere to HF principles					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
2.3.3a	Visual displays and other output devices are not usable and /or picture quality is poor there is confusion with regards to which aerodrome is displayed on which visual display. This may impact ATCO / AFISO / supervisor situation awareness and increase the potential for human error. This may also affect the efficiency with end user can execute a task.	High	Assess usability of visual displays and other output devices and potential for such an error		-Check output devices are consistent with design standards or regulations -Prototyping sessions -RTS
Arg. 2.3.6: The usability of the user interface (input devices, visual displays/output devices, alarm& alerts) is acceptable.					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
2.3.6a	If two a/c have to be controlled at the same time at two different APTs and ATCO only has main screen on one APT (specific to SAAB solution) i.e. emergency a/c arrival. For the SAAB solution this could mean that the ATCOs have to change the main screen view, this may take time so task would not be able to be achieved in a timely manner. This may impact overall system efficiency and for certain scenarios have a potential negative impact on safety.	High	Assess impact of the visual reproductive screen layout alternatives on efficiency of aerodrome / task switching, situation awareness and human error with event/scenario described in 2.3.3a.	-Need to be able to visualise at least 2 APTs at the same -Use of augmented reality to alert ATCO to look at alternative screen (Thales solution) -SUP opening another position (this may have timing limitations)	-Prototyping session -RTS
2.3.6b	Headset is uncomfortable – this may lead to intolerance and reduction in	Low	Demonstrate headset acceptability as part of implementation trials.	-Light headset / blue tooth connectivity.	-Trials (V4)

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	morale, and possible errors arising from user-specified interventions, e.g. cushion padding resulting in reduction in sound signal strength at the ear.			-Alternative options available to be utilised by ATCOs on a per-shift basis	

Arg. 2.3.7: The user interface design reduces human error as far as possible.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
2.3.7a	Wrong information related to APT is used – this may lead to a 'latent' failure in which an incorrect understanding of the system (aerodrome) status may exist, with possible later consequential system failure/ safety impact.	High	Assess usability of the CWP/HMI and potential for error	-Link information to APT, how? Layout colour coding? -Location of windows etc. information on screen	-Prototyping sessions - RTS
2.3.7b	Confusion of which information (e.g. strips, meteo etc.) is linked to which APT. This could increase the potential for human error, as ATCOs may give the wrong information, instruction to wrong a/c at another aerodrome. Therefore this could have a potential negative impact on system safety.	High	Assess impact of concept (HMI/information presented) for ATCO and SUP on situation awareness and error. (Types of error identified so far: Confusion of which information (e.g. strips, meteo etc.) is linked to which APT; ATCOs may give the wrong information, instruction to wrong a/c at another aerodrome)		-Prototyping sessions(operator review of proposed solutions) - RTS
2.3.7c	In multiple RTC as have CWPs and ATCOs there is a better back up in case of system failure of a problem with ATCO – there is more flexibility as there is a larger resource pool to manage sudden changes in team workload.	Low			

Arg. 2.3.8: The user interface design supports a sufficient level of individual situation awareness.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES

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2.3.8a	Ambient conditions (sound vibrations, sound of birds) from more than one airport. How to distinguish or allocate the signals to the right airport? Planning can be supported by the ability to detect sound (APU etc.), detection of warm up of piston engine aircraft	Medium	Assess impact of providing auditory ambient conditions on ATCO situation awareness under the events described in 1.3.5, (in particular assess options of APT sound per channel (e.g. left/ right ear) or single-APT selectable for both channels)		-Prototyping session -RTS
2.3.8b	If R/T for each APT in each ear may mean that if ATCO received simultaneous info. no R/T may be distinguishable, leading to task inefficiency, or possible deficient situation awareness and consequent error. Possible safety impact.	Medium	Assess alternative R/T transition options to identify the best in terms of impact on ATCO situation awareness	-Merge frequencies -Change pitch / voice distortion -Phraseology – aircrew always include APT of arrival / departure in the first contact	-RTS or trials
2.3.8c	ATCOs believe other ATCO is controlling an APT, but in fact APT is not being controlled by anyone i.e. no one assumes responsibility. Possible delays in resuming service, which may occur at a time when an urgent resumption is imperative – safety implication.	High	Assess HMI to ensure the supervisor interface design adequately supports supervisors' awareness of the respective ATCOs' status.	-SUP must be responsible for allocating APT responsibility to ATCOs Overview screen for SUP of what APTs are open and being controlled by which ATCOs ATCO have to assume control of APT and use of colour coding for the assume function	-Prototyping sessions -RTS
2.3.8d	Confusion relating to which pilot at which APT, ATCO is communicating / How to ensure that the ATCO understand which aircraft is calling. How to address similar call-signs and similar airports	High	Assess ATCO situation awareness with regards to which pilot at which APT is communication	-Visual information / cue accompanies R/T -Prompt, or modified phraseology	-Prototyping - RTS
2.3.8e	Low visibility & dark conditions may make it more difficult for ATCOs to distinguish between different APTs.	High	Assess ATCO SA & ATCO ability to distinguish between different APTs under low visibility & dark conditions (i.e. night,	-Consider use of enhanced visual information, i.e. denoting objects/ positions that may not have been visible to ATCO with (only) OTW, to	-RTS

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			day, fog, snow, etc.).	enhance situation awareness. -Ensure displays are clearly marked with status information such as APT ID.	
2.3.8f	Ambient conditions (sound vibrations, sound of birds) from more than one airport. How to distinguish or allocate the signals to the right airport? Planning can be supported by the ability to detect sound (APU etc.), Detection of warm up of piston engine aircraft.	Medium	Assess impact of providing auditory ambient conditions on ATCO situation awareness under the events described in 1.3.5, (in particular assess options of APT sound per channel (e.g. left/ right ear) or single-APT selectable for both channels)		-Prototyping session -RTS

Arg. 2.3.9: The user interface design supports a sufficient level of team situation awareness.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
2.3.9b	Headset may reduce team SA because it reduces operators' awareness of other ATCOs activity. If a situation in the team is developing that may require support from another ATCO, the other ATCO may not be aware of this and hence the transition may take longer than would have been the case if the ATCO had been aware. Possible safety impact.	Medium	Assess impact of using headsets on SA with such a scenario as described compared to no head sets		-RTS or trials

Arg. 3.1: Effects on team composition are identified.

Argument 3.1.1 Changes to existing roles in the team are identified (including roles that become obsolete)

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.1.1a	Changes to existing roles in the team are not identified (including roles that become obsolete). This may lead to		Identify human actors that are likely to be affected by the change and identify role changes in the solution scenario(s)		-Task Analysis -Stakeholder workshop / interviews

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	ineffective system/ interface design and inadequate training specification.		compared to the reference scenario.		

Argument 3.1.2 The introduction of new roles to a team is identified

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.1.2a	The introduction of new roles to a team is not identified. This may lead to ineffective system/ interface design and inadequate training specification.		Identify changes to tasks and responsibilities in the solution compared to the baseline to see if new roles are introduced to a team		-Task Analysis -Stakeholder workshop / interviews

Arg. 3.2: The allocation of tasks between human actors supports human performance.

Argument 3.2.1: Changes to the task allocation between human actors do not lead to adverse effects on human tasks.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.2.1a	Changes to the task allocation between human actors lead to adverse effects on human tasks.	High	Identify changes to task allocation between human actors and any potential adverse effects on task demands and potential for error. See also HP activities for Argument 1.3.		-Task Analysis - RTS

Argument 3.2.2 The proposed task allocation between human actors is supported by technical systems / the HMI

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.2.2a	The proposed task allocation between human actors is not supported by technical systems / the HMI	High	Identify information & HMI needs/ requirements of each human actor impacted by the concept, and review proposed technical systems to ensure that		-Task analysis -Prototyping sessions -RTS -Trials

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			the technical system covers the task requirements identified.		

Argument 3.2.3 The potential for human error in individual & team tasks is reduced as far as possible

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.2.3a	There is a potential for human error in individual & team tasks, which is increased as a result of the proposed changes. Some errors may impact system safety	High	Identify changes to the potential for human error and where appropriate identify potential mitigation		-Task analysis -HRA - RTS

Argument 3.2.4: Team tasks can be achieved in a timely and efficient manner.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.2.4a	Individual & team tasks cannot be achieved in a timely & efficient manner –leading to increased human error probability, and decrease in trust in the system. This may impact safety and efficiency at the system level	High	Assess the timeliness and efficiency with which SUP and ATCOs can perform both individual and team task (set of tasks to be identified, e.g. opening and closing different aerodromes)		-RTS

Arg.3.3 The communication between team members supports human performance

Argument 3.3.1: Intra-team and inter-team communication supports the information requirements of team members.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.3.1a	Intra-team & inter-team communication does not support the information requirements of team members		Identify information needs / requirements within the team/between teams. Assess intra and inter team communication		-Task Analysis. and/or review the main tasks through the use of low fidelity mock-up with

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					end users - RTS

Argument 3.3.2: The phraseology supports communication in all operating conditions.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.3.2a	The phraseology does not support communication in all operating conditions, including vehicles, aircraft, approach	High	Identify preliminary phraseology needs / requirements within the team/between teams to support the development of appropriate phraseology	Allow for post-implementation review to enable addition of further phraseology – to be included as part of the migration plan.	-Stakeholder (ATCO / aircrew) workshop -RTS

Argument 3.3.3 Changes in communication means & modalities are identified & acceptable

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.3.3a	Changes in communication means & modalities are not identified &/or not acceptable, leading to potential workload issues or human error probability increase.		Identify potential changes in communication means and modalities, and their possible impact on workload / task demand, potential for error, situation awareness and where possible identify preliminary mitigation. Assess impact of changes in communication in terms of workload and human error		-Task Analysis -Stakeholder workshop/interviews - RTS

Argument 3.3.4 The communication load of team members is acceptable in normal & abnormal conditions & degraded modes of operations

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.3.4a	The communication load of team members is not acceptable in normal & abnormal conditions & degraded modes of operations, leading to reduced system performance and potential increase in human error probability.		Assess communication load for all team members in normal & abnormal conditions & degraded modes of operation in terms of acceptability, system performance (efficiency in achieving tasks) and potential for human error		- RTS

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	Collapsing frequencies to "one" for more than one airport reduces efficiency of comms. as streaming of comms. may reduce the accessibility of communication with ATCOs.	Medium	Assess different potential options for R/T comms as well as other potential solutions e.g. data link in terms of efficiency	Data-link	

Argument 3.3.5 Team members can maintain a sufficient level of shared situation awareness

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
3.3.5a	Team members are unable to maintain a sufficient level of shared situation awareness, leading to reduced system performance and possible increased human error probability.		Identify factors that will impact upon team situational awareness, what is the potential impact of this and where possible identify preliminary mitigation Assess team situation awareness in multiple remote tower set up. Assess the impact of reduced team situation awareness on efficiency and potential for error. If necessary Identify factors that will impact upon team situational awareness, what is the potential impact of this and where possible identify preliminary mitigation		Stakeholder workshop - RTS

Arg. 4.1 The proposed solution is acceptable to the affected human actors & do not compromise job satisfaction

Argument 4.1.1 Changes in roles & responsibilities are acceptable to the affected actors

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
4.1.1a	The concept and resulting changes in roles & responsibilities are not acceptable to the affected actors		Obtain feedback on acceptability of the proposed changes, and feed mitigations in to the design (following review with affected stakeholders).		-Stakeholder interviews / workshops -RTS

Argument 4.1.2 The impact of changes on job satisfaction of affected human actors has been considered

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES

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4.1.2a	Working in a team rather than in isolation may have a positive impact on job satisfaction		Obtain feedback on potential impact on job satisfaction.		-Stakeholder interviews / workshops.
Arg. 4.2: Changes in competence requirements are analysed.					
Argument 4.2.1: Knowledge, skill and experience requirements for human actors have been identified.					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
4.2.1a	Knowledge, skills & experience requirements for human actors have not been fully identified. Thus the system may not adequately support the users and system performance will be reduced. Users in effect may not be suitable competent and experienced to operate the new system effectively.		Review new operating methods (if available) and tasks to identify changes in knowledge, skill and experience needs / requirements. Assess training needs and ensure effective training plan is implemented.	Ensure effective training plan is implemented prior to implementation	-Task analysis -TNA and specification.
4.2.1b	ATCOS operating several APTs will not be able to reach the same levels of knowledge when operating multiple aerodromes compared to just one. When operating just one aerodrome, ATCOs becomes highly skilled in normal local procedures, local anomalies in terrain, weather in local traffic behaviours. If ATCOs operating more than one aerodrome are not able to achieve the same level of skill and knowledge as for when operating a single aerodromes his may impact safety as ATCOs may not be able same service especially in demanding situations that require more than a general knowledge.		Identify knowledge and experience required for working at specific aerodromes Assess training needs and ensure effective training plan is implemented.	'Sign off' of ATCOs for respective a aerodrome which is based on detailed knowledge and experience of working at that specific aerodrome.	.
Arg. 4.2.2: The impact on operating licensing (as defined by the regulatory bodies) have been identified.					

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ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	HP VALIDATION OBJECTIVE	POTENTIAL MITIGATION	RECOMMENDED ACTIVITY/IES
4.2.2a	The changes introduced by multiple remote tower impacts operating licensing		Assess impact of multiple remote tower concept on operating licensing (		-(Preliminary) analysis of (in)consistencies between current licensing regulation and future licensing needs.
Arg. 4.3: Changes in staffing requirements and staffing levels are identified.					
Argument 4.3.1: The impact on staff levels is identified.					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
4.3.1a	Impact on staff levels are not identified, leading to possible over- or under-staffing at the respective locations, and a delay in the organisation's ability to rectify the situation e.g. due to recruitment and training lead times, etc.		Identification of future required staff levels. Produce migration strategy to include recruitment, reassignment and training required.		-Review roles & responsibilities and compare them with current roles & responsibilities/task analysis -Stakeholder workshop
4.3.1b	Easier to recruit if RTC located near a big city / more interesting location		Consider impact and modify timescales and scope of migration strategy (see 4.3.1a) accordingly.		
4.3.1c	Overall staffing levels relating to operational staff should be reduced. This will provide cost benefits	High	Assess cost benefit of introducing multiple remote tower centres		-Cost benefit analysis
Argument 4.3.2: The impact on shift organisation is identified					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**
4.3.2a	How to ensure impact on shift organisation is acceptable	Med			-Stakeholder workshop
Argument 4.3.3: The impact on workforce relocation is considered					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**HP VALIDATION OBJECTIVE**	**POTENTIAL MITIGATION**	**RECOMMENDED ACTIVITY/IES**

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4.3.3a	No-one wants to re-locate			-Offer incentives	-Stakeholder workshop

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Appendix E HP Recommendations Register

The following register presents the recommendations related to **multiple** aspect of remote tower concept. The scope of human performance assessment in P06.09.03 is set with the assumption that it is complementing the issues that has been already investigated in Human Performance assessment for single remote tower. For this reason all the recommendations derived from single remote tower assessment apply to multiple remote tower. For consolidated list of recommendations please refer to Appendix B of P06.09.03 D15 Intermediate HP assessment report.

The recommendations presented here are the one specifically related to multiple environments.

The scope of the validation activities was limited explicitly to AFISO and ATCO position, not complete Remote Tower Module/ Centre where the Supervisor role could be more significant Despite that he Supervisor position was not specifically investigated, some recommendations concerns the Supervisor role are provided below.

HP Recommendations Register						
his table presents the list of HP recommendations gathered in the project. If a recommendation has been transformed into a requirement, this will be indicated in the last column. In this case, the recommendation can be closed and a reference to the SESAR document in which the requirement has been integrated has to be made. If additional columns are needed to document additional information identified as necessary please add.						
ID	**Source** *Reference of HP activity*	**Recommendation** *Describe the recommendation.*	**Rationale** *Describe the rationale of the recommendation.*	**Type** *Specify the type of the recommendation: Design, Procedure, Training, or Test*	**Status** *Specify the status of the recommendation: Open, Cancelled or Closed*	**Justification of Status** *If the status is cancelled or closed, a justification has to be provided. In case a recommendation is closed because it was transformed into an HF requirement, a reference to the document in which the requirement has been integrated has to be made.*
Recommendations related to Procedures						
MRT_REC_PR1	1.3.1b 1.3.1d 1.3.5e	The aerodromes with similar airport callsigns should have distinctive	To support situation awareness in multiple environment any similarity in airport callsign should be avoided.	Procedure	Open	

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	1.3.5g	designators if clustered together.				
MRT_REC_PR2	1.3.1b 1.3.1d 1.3.5e 1.3.5g	The aerodromes with similar runway number should have distinctive designators	To support situation awareness in multiple environment any similarity in airport runway should be avoided.	Procedure	Open	
MRT_REC_PR3	1.3.1b 1.3.1d 1.3.5e 1.3.5g	If similar call signs are recognised in clustered airports consider applying the Call Sign Similarity solution from EUROCONTROL Call sign similarity service.	To support situation awareness in multiple environment any similarity in aircraft callsigns should be avoided.	Procedure	Open	
MRT_REC_PR4	1.3.1b 1.3.1d 1.3.5e 1.3.5g	The consistency of procedures between clustered aerodromes should be reviewed. In case of inconsistency of procedures, the common procedure for clustered airports should be designed. After any update on the procedure verify if the inconsistency was not introduce.	The aerodromes that are in one cluster should operate in similar way , e.g. similar way of processing VFR flight in order to create the common culture	Procedure	Open	
MRT_REC_PR5	1.3.1d, 1.3.3 a	To enable ATCO AFISO dealing with aircraft in the sequence consider implementation: • Common approach service for clustered aerodromes • Traffics restrictions • Traffic planning by supporting tools	Simultaneous movement were considered as factor for worsening situational awareness and workload thus having the negative impact on safety.	Procedure	Open	
MRT_REC_PR6	1.3.5h	Traffic levels should be considered when clustering the aerodromes	Simultaneous movement were considered as factor for worsening situational awareness and workload thus having the negative impact on safety.	Procedure	Open	
MRT_REC_PR7	4.3.2a	The design of shift pattern should	To ensure the shift pattern designed	Procedure		

founding members
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		adhere to appropriate regulation.	optimise human performance and reduces fatigue regulations on shift design should be adhered to. Failure to adhere to such regulation may have legal implications.			
MRT_REC_PR9	4.3.3a	An incentive package for relocation should be designed	To ensure the shift pattern designed optimise human performance and reduces fatigue regulations on shift design should be adhered to. Failure to adhere to such regulation may have legal implications.	Procedure		
MRT_REC_PR10	3.3.2a	Consider to implement "airport callsign for each pilot transmission" procedures for aerodromes provided with multiple ATS operations.	To support team efficiency of communication and situational awareness	Procedure	Open	
MRT_REC_PR11	3.3.2a	Consider to implement "airport callsign for each ground vehicle transmission" procedures for aerodromes provided with multiple ATS operations.	To support team efficiency of communication and situational awareness	Procedure	Open	
Recommendations related to Training						
MRT_REC_TR1	1.1.1a 1.3.5g 1.3.1b 1.3.5e 1.3.5g 3.3.2a	Design the information campaign for airspace users to increase the awareness and importance of complying with standard phraseology (using the airport callsing at each exchange, referring always to information provided by standard publications, avoiding referring to local features)	Complying with standard phraseology by pilots was found beneficial for ATCO/AFISO situational awareness in multiple environments	Training	Open	
MRT_REC_TR2	1.3.1b 1.3.5e 1.3.5g	Design the information campaign for ground staff to increase the awareness and importance of complying with standard phraseology (using the airport callsign at each exchange,	Complying with standard phraseology by ground staff was found beneficial for ATCO/AFISO situational awareness in multiple environments	Training		

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		referring always to information provided by standard publications, avoiding referring to local features).				
MRT_REC_TR3	1.3.2a 3.3.2a 4.2.2a	Reinforce the ATCO AFISO training on local environment and specific meteorological occurrences (regular visit to the local airports).	To ensure the transfer of local knowledge on specific meteorological phenomena	Training		
MRT_REC_TR4	4.2.1a	A complete training programme for ATCO/AFISO should be developed with pre-specified performance criteria that need to be achieved before they can 'go operational'	The specific skills need to be acquired before being operational in multiple remote tower environment, especially related to depth and distance judgement.	Training		
Recommendations related to Test						
MRT_REC_TS1	1.2.3a 2.3.1a 2.3.3a	The ATCO/AFISO procedures related to: • closing and opening the aerodrome • to transferring the aerodromes • dealing with complex emergency situations • for mitigation of degraded modes should be validated in active mode trials.	The listed actions haven't been validated in active mode.	Test		
MRT_REC_TS2	1.2.1c	Assess the impact of various MET conditions and related operating modes in different aerodrome on ATCO/AFICO performance	Providing the ATS services to two aerodromes working in different operating method might increase cognitive load of ATCO/AFISO.	Test		
MRT_REC_TS3	1.3.3a	ATCO/AFISO workload should be	Workload was not systematically	Test		

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	2.3.1d 3.1.1a	assessed under normal abnormal & degraded modes of operation in active mode trials[3]	assessed as it was not seen to be feasible given it was a passive shadow mode trial (EXE-06.09.03-VP-061and (EXE-06.09.03-VP-063.			
MRT_REC_TS4	1.3.5a	The ATCO/AFISO trust levels for remote tower concept should be assessed in active mode trials.	Considering the passive character of (EXE-06.09.03-VP-061) and (EXE-06.09.03-VP-063) It is recommended to repeat teh measurement in active trials.	Test		
MRT_REC_TS5	1.3.1b 1.3.5a	The ATCO/AFISO situation awareness should be assessed in active mode trial	Considering the passive character of (EXE-06.09.03-VP-061) and (EXE-06.09.03-VP-063) It is recommended to repeat the measurement in active trials.	Test		
MRT_REC_TS6	2.3.3a	The acceptance of visual presentation in different traffic patterns depending on radar provision should be validated in active trial mode.	The acceptance of the visual presentation was affected by radar provision.	Test		
MRT_REC_TS7	2.3.6	The timeliness of opening and closing the aerodromes should be validated in active mode trial.	The timeless of opening aerodrome was not tested in active mode.	Test		
MRT_REC_TS8	3.2.1a	Assess impact of allocating certain tasks previously performed by ATCO/AFISO to aerodrome staff on human performance (i.e. efficiency and potential for error) in future validation activities i.e. TWR active mode trials	The validation didn't explicitly investigate efficiency of performing the task such met obs and their process of transferring the information. Some procedure, checklist may need to be defined.	Test		
MRT_REC_TS9	3.3.4a	The impact of communication modes: "transmit to all" and "transmit to one for all involved actors should be validated in active mode trials.	Due to the limitation of PSM the all transitions modes could not be investigated.	Test		

[3]The HP assessment process for V3 phase recommends as appropriated validation activities, allowing to gather the evidence relevant for V3 are: high fidelity Real-Time Simulations and operational trials carried out as active shadow mode trials.

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MRT_REC_TS10	3.3.4a	The communication load of ATCO/AFISO should be validated in active mode trial.	Due to limitation of passive shadow mode the communication load could not be investigated.	Test		
MRT_REC_TS11	4.1.1a	The acceptability of the multiple remote tower concepts by ground staff should be investigated.	The acceptance of the concept by ground staff was not investigated	Test		
MRT_REC_TS12	4.2.2a	The shift length should be investigated in active mode trial in various visibility conditions.	Further investigation need to be performed including the eye strain, and fatigue.	Test		
Recommendations related to Design						
MRT_REC_DS 1	1.3.1b 2.2.1a	The automatic identification of aircraft should be implemented in visual presentation in order to optimise SA	The automatic identification was found as a contributor to situation awareness.	Design		
MRT_REC_DS2	2.3.1a	The user should be able to toggle tracking labels on and off in due time	To ensure the efficiency of performing the tasks by the end user.	Design		
MRT_REC_DS3	1.3.1a 1.3.1.d 2.3.8e 2.3.1a 2.2.1a	Support function for aircraft tracking should be implemented in visual presentation to support human performance, in particular SA and reduce the potential for error.	Tracking functionality was found as helpful for maintaining situation awareness during darkness and IMC. The importance of tracking functionality is dependent on traffic/work load and will be more significant in high density environments.	Design	Open	
MRT_REC_DS5	2.3.2a	The way of interacting for control function should be the same for each aerodrome.	To ensure the efficiency of end use to perform the tasks	Design	Open	
Recommendations related to specific technical solutions						
MRT_REC_PR12	1.3.5h	The impact of using a compressed image of the aerodrome to provide visual surveillance should be to further investigated to determine if traffic restrictions are required.	Technical The ATCO acceptance was lower while working with compressed image due to limitation in presentation linking to decreased judgement of distances and depth.	Procedure		
MRT_REC_DS3	2.3.8e	The aerodrome overlays should be	The aerodrome overlays were found	Design		

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		implemented in visual presentation to support situational awareness	as contributing to situational awareness during darkness.			
Recommendation for further work (Outside of scope of 06.09.03						
	1.2.1a 3.1.1a	Define the task sharing between ATCO/AFISO and SUP.	Supervisor tasks should be defined. The task sharing between ATCO/AFISO in emergency situation was found crucial.	Procedure		
	1.1.2a 3.2.4a 4.2.2a 1.3..3b	The operating methods of Supervisor under normal, abnormal and degraded modes should be validated in active mode.	The supervisor working methods should be defined.	Procedure		
	1.3.5b 1.3.5c	Assess situation awareness of SUP in normal, abnormal and degraded modes active mode trial.	THE SA of SUP should be investigated	Test		
	2.3.8c	Design the information sharing tool for managements of remote tower modules.	There was a need expressed about eth information sharing tool for team situational awareness.	Design		
	2.3.1a 2.3.3a	The validity of information provided to SUP should be assessed in active mode trial.	The information/ tool provided to sup should be tested.	Test		
	2.3.1a	The SUP should be provided with the information related to management of remote tower modules such as: active aerodromes, degraded modes alerts, emergency alerts)	The information needs of SUP are listed in Appendix B.	Design		
	3.2.4a	Validate if SUP task can be performed in timely manner in active trial mode.	The timeliness of performing SUP task has not been investigated	Test		
	2.3.9b	The team situational awareness depending on technical choice for communications should be validated.	The team situational awareness has not been investigated	Test		
	3.2.4a	The inter-and intra-team communication between ATCO - ATCO/AFISO-AFISO and SUP should be validated in active trial mode.	The team communication has not been investigated.	Test		

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Appendix F HP Requirements Register

The following register presents the requirements related to **multiple** aspect of remote tower concept. The scope of human performance assessment in 06.09.03 was set with the assumption that assessment for two low density aerodromes is complementary to human performance assessment for single remote tower. For this reason the all requirements derived from single remote tower assessment apply equally to current assessment and has been implemented to OSED[4]. For consolidated list of requirements please refer to Appendix C of 06.09.03 D15 Intermediate HP assessment report [5].The requirements presented here are the one specifically related to multiple environments.

HP Requirements Register						
This table presents the list of HP requirements gathered in the project. If additional columns are needed to document additional information identified as necessary please add.						
ID	**Source** *Reference of HP activity*	**Requirement** *Describe the requirement.*	**Rationale** *Describe the rationale of the requirement*	**Type** *Specify the type of the requirement: Design, Procedure, Training, or Test*	**Status** *Specify the status of the requirement: Open, Cancelled or Closed*	**Justification of Status** *If the status is cancelled or closed, a justification has to be provided. For each HF requirement, a reference to the document in which the requirement has been integrated has to be made.*
MRT_REQ_DS1	1.3.1e	Visual presentation shall allow the identification of each aerodrome.	It was found that the visual overlay marking/identifying the airports were helpful for airport identification in darkness.	Design	Closed	This HP requirement is covered by the following OSED requirements: REQ-06.09.03-OSED-MH04.1002 REQ-06.09.03-OSED-MH04.1003
MRT_REQ_DS2	2.3.1a	The ATCO/AFISO shall be able to see all relevant flight data	The flight data information were considered as main tool for de-	Design	Closed	This HP requirement is covered by the following OSED requirements:

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		information at any time.	conflicting tasks.			REQ-06.09.03-OSED-FN02.5003 REQ-06.09.03-OSED-MH04.1007
MRT_REQ_DS3	2.3.2a	As few device as possible shall be used to control the same functions for different aerodromes	To ensure the efficiency of end use to perform the tasks	Design	Closed	This HP requirement is covered by the following OSED requirement: REQ-06.09.03-OSED-MW04.5001
MRT_REQ_DS4	2.3.8a	If sound is applied it shall be linked in directional manner with adequate airports.	The sound implemented in directional manner to visual presentation was found as a contributor to optimal situational awareness.	Design	Closed	This HP requirement is covered by the following OSED requirement: REQ-06.09.03-OSED-MS04.3203
MRT_REQ_DS5	2.3.8e	If implemented the aerodrome overlays shall be able to switch off or diminish.	The aerodrome overlays function should be adjusted to user preferences.	Design	Closed	This HP requirement is covered by the following OSED requirement: REQ-06.09.03-OSED-MA04.3104
Requirements related to specific technical solution						
MRT_REQ_DS6	2.3.2a	If colour coding applies it shall be matched between flight data information and other systems such as OTW, VCS.	Colour coding was reported as beneficial for situational awareness	Design	Open	
MRT_REQ_DS7	1.3.5h	If aerodromes are not presented in a fixed view ATCO/AFISO shall be able to swap the visual presentation between expanded and compressed view at any time.	To ensure the efficiency of end user to perform the tasks unless a fixed view of both aerodromes is used	Design	Open	
MRT_REQ_DS8	2.3.2a	The location of flight data information shall be relative to location of the aerodromes on visual presentation.	The location of the e-strip relative to visual presentation was found as a contributor to optimal situational awareness.	Design	Open	

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