HP Assessment Report for Single Remote TWR

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Abstract

This document contains the Human Performance (HP) assessment report for the OFA 06.03.01 Remote Provision of ATS to a Single Aerodrome. It is an update of P06.09.03 D15 HP based on the P06.08.04 validations VP-639 and VP640 on Single Remote Tower. The HP assessment report describes the changes resulting from the introduction of the remote tower concept from a human performance perspective and identifies the potential human performance issues and benefits associated with those changes. A description of the HP related activities conducted to date to address the potential HP issues and benefits identified is provided. The results and HP recommendations & requirements generated from these activities are then presented. The HP recommendations and requirements resulting from the HP assessment will be used to help further the design and development of the remote tower concept for single aerodromes. In addition recommendations are made with regards to future activities that need to be performed in the next stages of concept development for singe remote towers

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This deliverable consists of SJU foreground.

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Executive summary

This report describes the results of the activities conducted according to the SESAR Human Performance (HP) assessment process applied on the single remote tower concept to date within OFA 06.03.01 comprising of results collected in P06.09.03 and P06.08.04.

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.

Level of maturity of the concept at the start of the HP assessment was considered to be V2. Therefore the argument structure for V2 was applied on the project. From the changes that would result from the introduction of the single remote tower concept, it was concluded that all twelve V2 second level HP arguments needed to be considered and satisfied in the HP assessment, namely:

- 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 The 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 analysed
- Argument 4.3 Changes in staffing requirements and levels are identified

Specific HP issues and benefits relating to the single 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. Over eighty potential HP issues / benefits were identified in total.

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
- Four tower passive shadow mode trials for ATCOs
  (EXE-VP-056, EXE-VP-057, EXE-VP639 and EXE-VP640)
- Shadow mode trials for AFIS in passive and 'advanced' mode (EXE-VP-058)

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. The HP recommendations and/ or requirements relate to each HP argument that had to be considered in the HP assessment for the single remote tower concept. These recommendations and requirements

relate to: the operational concept, and procedures; the technical system and HMI and the training of the end user.

From the completion of the HP maturity criteria checklist for transition from V3 to V4 which is based on the 'evidence' obtained from the HP related validation activities conducted within SESAR P06.09.03 it can be concluded that the single remote tower concept plus enhanced visual features tested in the shadow mode trials (i.e. the basic remote tower setup which consists of the visual reproduction screens, PTZ camera and infra-red (thermal imaging) plus radar, automatic video and radar a/c identification and tracking function and additional camera views) satisfies the V3 transition criteria, and has reached the V3 level of HP maturity, for both ATC and AFIS for low density aerodromes.

Basically the same Human Performance recommendations/requirements apply to single remote tower for low density (solution #71) and medium traffic volume aerodromes (solution #12).For this reason just one HP assessment document addressing both solutions is provided. This document is an update to 6.9.3 HP Assessment for low density aerodromes and provides the additional results from VP-640 which contribute to HP assessment. In chapter 3.4.3 (synthesis of arguments and recommendations) the main results of VP-640 were added (chapter 3.4.1 provides the results that were derived for small aerodromes). The description of the VP-640 exercise was added to Chapter 3.3.

The status of the recommendations was updated and most recommendations could be closed in co-ordination with LFV due to the validation results, some others mainly referring to visual separation still remain open that are of higher relevance for medium traffic density aerodromes. These recommendations will be addressed in the large scale demonstrations of the projects RTO and Remote Towers. Due to the remaining open HP recommendations, solution #12 has not yet reached V3 maturity.

It should be noted that for Contingency Tower (solution #13) a separate HP Assessment [17] has been provided which considers also some non-contingency aspects.

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 [1] in order to derive the HP assessment report for P06.09.03 including the HP requirements and recommendations to inform the design and development of the remote tower concept for single aerodromes.

1.2 Intended readership

The intended audience for this document are the other team members of the project P06.08.04.

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

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

1.3 Scope of the document

The aim of the OFA 06.03.01 Remote and Virtual Towers is to develop and assess an operational concept that enables the cost effective provision of Air Traffic Services (ATS) at one or more aerodromes from a control facility that is not located in the local ATS Tower.

The concept is divided into three main application areas (detailed description is provided in [2]):

- Single Remote Tower Concept
- Multiple Remote Tower Concept
- Contingency Tower

This document describes only the HP Assessment conducted to date for single aerodrome remote tower operations for small to medium sized aerodromes. Large aerodromes are not considered in the scope of the HP assessment.

As the multiple remote tower concept is built on the concept for single remote towers the HP assessment for the single remote tower concept will also be applicable to the multiple remote tower concept. However, there will be additional aspects that need to be considered and addressed in the HP assessment that are specific to the multiple remote tower concept. Hence, additional HP validation activities will be performed for the multiple remote tower concept and a separate Assessment Report for these additional aspects that must be considered specifically for multiple remote tower concept only will be developed.

It is currently not known what HP aspects will need to be considered for contingency tower operations, therefore it is currently expected that a separate HP assessment, and hence HP assessment report, will be developed for specifically for contingency tower operations.

The HP assessment process considers those personnel whose work is directly affected by the introduction of the proposed remote tower operations, for single aerodromes. However, the main focus will be the tower ATCO/AFISOs. Aircrew will be considered to a lesser extent. Data specialists, engineers and technicians are not currently included within the scope of the HP Assessment Process.

1.4 Human performance work schedule within the project

The Human Performance activities for the Remote Tower concept for single aerodromes was started by P06.09.03 and was complemented by P06.08.04.

1.5 Structure of the document

- §1 (this section) introduces the document
- §2 describes the objective and approach to the four stages of the SESAR Human Performance Assessment Process
- §3 describes the main findings and the HP recommendations and requirements from the activities performed as part of the HP assessment process;
- §4 lists the documents referenced in this document
- Appendix A provides the HP recommendations register which provides the list of HP recommendations gathered in the project.
- Appendix B provides the HP requirements register which provides the list of HP requirements gathered in the project.

1.6 Acronyms and Terminology

Term	*Definition*	*Source*
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	
CWP	Controller Working Position	
HMI	Human-Machine Interface	
IFR	Instrument Flight Rules	
LCD	Liquid Crystal Display	
LFV	Swedish ANSP	

LVP	Low Visibility Procedures	
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*.	HP Guidance Material
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.	HP Guidance Material
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.	HP Guidance Material
HP argument	A HP argument is a HP claim that needs to be proven by the HP assessment process	HP Guidance Material
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.	HP Guidance Material
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.	HP Guidance Material
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.	HP Guidance Material
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.	HP Guidance Material
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.	HP Guidance Material
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).	HP Guidance Material
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.	HP Guidance Material

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.	HP Guidance Material
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	
RTS	Real-Time Simulation	
RVT	Remote and Virtual Tower Project	
RWY	Runway	
SA	Situational Awareness	
SESAR	Single European Sky ATM Research Programme	
SJU	SESAR Joint Undertaking (Agency of the European Commission)	
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	

2 The Human Performance Assessment Process: Objective and Approach

The purpose of the HP assessment process described is to ensure that HP aspects related to SESAR technical and operational developments are systematically identified and managed within a project. 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 SESAR 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). For a detailed description of the SESAR HP assessment process, refer to [1].

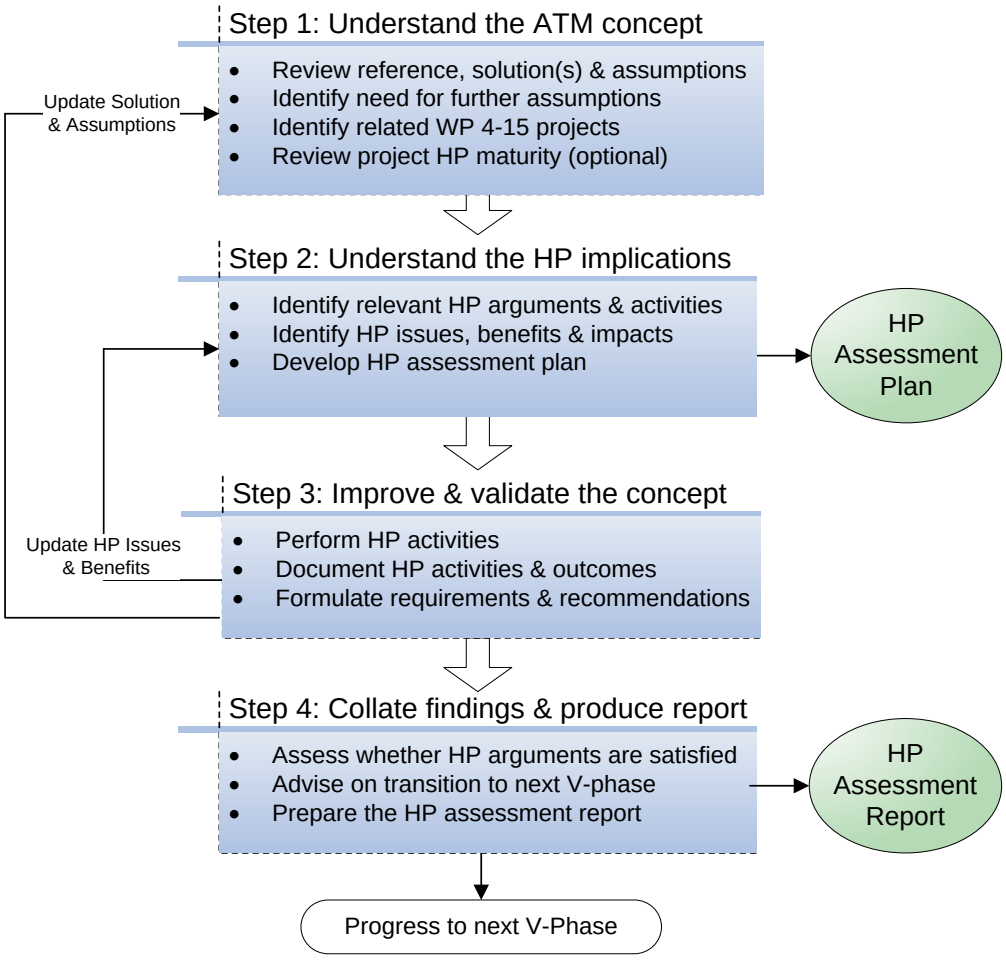

Figure 1: Steps of the HP assessment process

3 Human Performance Assessment

3.1 Step 1 Understand the ATM concept

3.1.1 Reference scenario and proposed solution comparison

Table 1 summarises the main changes currently foreseen due to the introduction of the remote tower operations for single aerodromes, as understood at the beginning of the HP assessment process in November 2011. It defines the system 'element' that will change and then describes at a high level the current system (reference scenario) and the system proposed in future remotely operated single aerodrome (solution scenario). The completed table can be found in [3].

Table 1: Comparison of reference scenario with proposed solution scenario under remote tower operations for single aerodromes

REFERENCE AND PROPOSED SYSTEM COMPARISON		
ELEMENT	**REFERENCE ATM SYSTEM**	**PROPOSED ATM SYSTEM**
Remote 'tower' centre (RTC)	The air traffic control unit for aerodrome control is located in a tower building on-site at the aerodrome	The air traffic control unit for aerodrome control is a 'standard' building (i.e. not a tower building) not necessarily located within the aerodrome.
Use of a panoramic display & transition of ambient sound	The traffic situation is viewed from the tower control room located on site at the aerodrome. ATCO/AFISOs have a 'real world' three dimensional view of aerodrome and traffic situation gained from looking out through the windows of the control tower. In small TWRs can often hear the ambient noise. Large TWR are often noise protected.	The traffic situation will be viewed using a high resolution panoramic display located in the remote 'tower' control centre (RTC). State of the art video cameras located at one or more locations in the aerodrome vicinity will be used to project a real time image of the aerodrome and traffic situation onto the panoramic display. As the case may be selectable options to choose the ambient noise of the aerodrome is also provided.
Use of pan tilt and zoom cameras	Binoculars are currently used when necessary to enable ATCO/AFISOs to get a close-up view of objects / elements in the aerodrome and in its vicinity	A separate video camera installed at the aerodromes will have pan, tilt and zoom functions to enable ATCO/AFISOs to get a close-up view of target objects / elements in the aerodrome vicinity.
Automatic identification and tracking of aircraft	Aircraft and vehicles are identified visually using the outside view from the tower, in combination with information derived from the radar, flight progress strips (made of paper or electronic flight strips at some places) and associated radio communication.	The system will automatically identify and track the aircraft in the aerodrome vicinity. The aircraft and perhaps vehicles displayed on the panoramic display will be accompanied by labels automatically generated by the system displaying the necessary relevant information.
Head-up display of information	Information required by the ATCO/AFISOs to perform their tasks is displayed on a number of different pieces of equipment and HMIs present on CWP.	Certain objects and information will be displayed on the panoramic display (exact objects and information to be displayed on the panoramic display to be defined).
Facility to highlight certain objects / information (augment reality)	In the current system ATCO/AFISOs use the 'real world' view from the remote tower – there is no facility to augment reality / highlight certain objects / information	Certain objects and/ or information displayed on the panoramic display will be highlighted in some way (to gain ATCO/AFISOs attention) (exact objects and information to be highlighted on the panoramic display to be defined).

REFERENCE AND PROPOSED SYSTEM COMPARISON		
ELEMENT	**REFERENCE ATM SYSTEM**	**PROPOSED ATM SYSTEM**
Visual Enhancement Technology	In the current system no visual enhancement technology is used to increase visibility in poor visibility conditions and/or darkness.	Visual enhancement technology can be used to help enhance visibility in poor visibility conditions such as fog
Electronic Flight Strips (EFS)	Currently in most low density aerodromes paper strips are used where ATCO/AFISOs have to manually identify, organise and mark the status of the aircraft.	Electronic strips which will be automatically presented to the controller on the CWP might be introduced. Though ordinary paper strips is also possible.
Video recording and play back	Currently there is no feature to continuously record and replay the visual chain of events (e.g. aircraft movements) on the ground or in the airspace visible from the TWR cabin.	The video system provides the possibility to record and replay all traffic movements
Integrated controller working position	In most current tower environments many separate pieces of equipment exist each having its own particular interface and control input / output devices with a minimum of standardisation between the different elements.	The CWP in the RTC will be integrated, as far as possible, to minimise the number of displays / menus / manoeuvres and associated HMIs present to allow as smooth and seamless operations as possible.

3.1.2 Consolidated list of assumptions

The following assumptions relating to the remote provision of ATS are listed below:

- Some potential solutions in other research projects and applications remove the need for a visual reproduction, but the solutions provided here will include a visual reproduction;
- The concept assumes that the range of services provided to airspace users will not change from those described in ICAO Docs 4444 [4], 9426 [5] and EUROCONTROL's Manual for AFIS [6]. It will not take into account (initially at least) the provision of new services;
- The concept assumes that airspace users (pilots) will not require any changes to procedures or any additional training or on-board equipment;
- Where provided in one entity, TWR and APP (where required for single aerodromes) can still be managed by the same number of ATCO/AFISOs as today (usually one);
- Any other necessary adjustments to rules and regulations will be possible to implement;
- Additional tasks provided by the local ATS personnel that require being physically present at the local facilities, or tasks which are not direct ATS tasks, can be provided by another local resource when the ATS personnel are no longer based at the aerodrome;
- It is currently assumed that changes to ATCOs and AFISOs work that result from the introduction of remote tower operations will be similar and hence the HP issues for the ATCO /AFIS will also be similar. (This assumption will be assessed during each of the HP validation activities conducted. Any differences between impact on ATCO and AFISO work identified will be noted and the impact of these differences on HP assessed).

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

HP issues relating to both the technical and operational aspects of the single remote tower concept are included in this document, and will be considered and addressed in the verification and validation

activities being conducted in P12.04.07 & P06.09.03 respectively. The HF team working in 12.04.07 is responsible for developing Design Document and style guide within the technical specification for single remote operations. The HF team in P06.09.03 is responsible for contributing to the development of the OSED. The HF teams working in P12.04.07.and P06.09.03 work together to ensure all relevant HP issues and impacts are adequately addressed in the verification and validation process.

In addition, P06.08.04 conducting validation exercises on the single remote tower concept. However, the scope of the P06.08.04 remote tower concept for single operations is specifically for medium and large sized aerodromes. As the scope of P06.08.04 validation activities is different to that of P06.09.03, the findings from the P06.08.04 HP related validation activities will be reported in the appropriate validation report and HP assessment report.

HMI design guidelines for the effective presentation of information developed in SESAR P16.05.03 – together with the HF & safety requirements development in P06.09.02 for the advanced integrated controller working position will feed into and support the development of the HF requirements being developed P12.04.07 and P06.09.03.

3.1.4 HP maturity of the concept

According to the Validation Strategy & Plan Plus Validation Report developed for P06.09.03 ([1], [6] respectively) the concept maturity level for the Single Remote Tower in October 2010 was considered to be V2-V3 for the basic concept (i.e. remote tower operations reproducing the Out The Window (OTW) view, by using visual information capture and/or other sensors) and; V1-V2 for the other more advanced technology options that are less mature elements of the concept, e.g. advanced visual enhancement features, automatic a/c identification and tracking. In addition the P06.09.03 Validation Report [7] states that the aim of the VP-EXE-057 (the second planned trial to assess the remote tower concept for single aerodromes) was to bring the remote tower concept for single aerodromes to V3. In addition to this VP640 in P06.08.04 also aimed mature remote tower concept for medium size aerodromes to V3 maturity.

At the start of the HP assessment based on our understanding of the concept, the HP maturity of the remote tower concept for single towers was the same as described above. As a result the HP assessment is based on the HP argument structure for V2 [1]. V2 assesses the feasibility of different concept options, taking the concept up to V3 i.e. pre-industrial development and integration. Therefore, the aim of the HP assessment being conducted for the single remote tower concept is to help ensure that the remote tower concept explored in the validation activities (i.e. the basic format plus certain advanced technology options) reach the V3 level of maturity.

While solution #71 (for low density aerodromes) has reached V3 maturity after VP-058, solution #12 (or medium traffic volume aerodromes) has not yet reached V3 maturity after VP-640. While some of the recommendations could be closed due to the validation results, some others mainly referring to visual separation still remain open that are of higher relevance for medium traffic density aerodromes. These recommendations will be addressed in the large scale demonstrations of the projects RTO and Remote Towers. Other recommendations that are still open are related pre-industrial implementation phase.

3.1.5 Identification of the nature of the change

Table 2: Description of the change

ARGUMENT BRANCH/ HF AREA	CHANGE & AFFECTED ACTORS
1.ROLES & RESPONSIBILITIES	
1.1 ROLES & RESPONSIBILITIES	Overall the ATCO/AFISO responsibilities with regards to providing Air traffic services (ATS) will not change. However, ATCO/AFISOs will no longer be able to perform any additional tasks that require physical proximity to the aerodrome; such tasks will be allocated to other aerodrome personnel e.g. fire-fighters that are located on-site.
1.2 OPERATING METHODS	The criteria under which low visibility procedures (LVP) are applied for a specific aerodrome may be changed due to the visibility improvements expected as a result of the introduction of the visual enhancement technology e.g. Infra-Red (thermal imaging), automatic a/c identification & tracking. In addition the LVP themselves may have to be updated / amended. The use of the visual reproduction display may result in ATCO/AFISOs finding it more difficult to judge aircraft separation, and distance & depth in general, therefore methods of (and hence procedures for) separating VFR traffic and IFR traffic may have to be amended. Other procedures may have to be developed or amended to ensure performance is optimised under remote tower operations (both nominal and non-nominal), but if and what such changes are necessary will be determined as the concept matures.
1.3 TASKS	ATCO/AFISOs will no longer be able to perform any additional tasks that require physical proximity to the aerodrome; such tasks will be allocated to other aerodrome personnel e.g. fire-fighters that are located on-site.
2. HUMAN & SYSTEM	
2.1 ALLOCATION OF TASKS (HUMAN & SYSTEM)	Potential functions for automatic aircraft and vehicle identification, labelling and tracking at the aerodrome and in its vicinity should facilitate those tasks for the ATCO/AFISOs and help to enhance ATCO / AFISO situation awareness.
2.2 PERFORMANCE OF TECHNICAL SYSTEM	Picture quality of the visual reproduction display is a very important factor that will impact ATCO/AFSO situation awareness and acceptance of the remote tower operations
2.3 HUMAN – MACHINE INTERFACE	Consideration must be given to the design and layout of the work environment in RTC to ensure that ATCO/AFISO have all necessary information and equipment to support their tasks to ensure operations are optimised in terms of safety and efficiency. Additional information may be provided e.g. additional camera views at hotspots, additional weather information may be necessary. How and where best to display this information needs to be considered
3. TEAMS & COMMUNICATION	

3.1 TEAM COMPOSITION	Where provided in one entity, TWR and APP (where required for single aerodromes) can still be managed by the same number of ATCO / AFISOs as today (usually one). So no change in team composition is foreseen for the single remote tower regarding ATCO/AFISOs. However, a new role may emerge in relation to supporting and maintaining the new technology implemented plus the associated hardware & software.
3.2 ALLOCATION OF TASKS	ATCO/AFISOs will no longer be able to perform any additional tasks that require physical proximity to the aerodrome; such tasks will be allocated to other aerodrome personnel e.g. fire-fighters that are located on-site.
3.3 COMMUNICATION	In the remote tower, ATCO/AFISOs will not be able to have direct (face to face) interaction and communication with aerodrome personnel if necessary for whatever reason on an ad hoc basis. Hence, communication with aerodrome personnel will be via telephone, and this may reduce communication efficiency and may lead to an increase in communication related errors.
4. HP RELATED TRANSITION FACTORS	
4.1 ACCEPTANCE & JOB SATISFACTION	Being local to operations may give ATCO/AFISO / AFISO a sense of reassurance, for example, in terms of the knowledge they can take direct action if necessary. Hence the ATCO/AFISO / AFISO's perceived level of safety may be affected by the remote location of the aerodrome control centre, and this in turn, may affect controller acceptance of the remote tower concept.
4.2 COMPETENCE REQUIREMENTS	All ATCO/AFISOs working in remote towers must be licensed (appropriate rating) and have the appropriate endorsement . Before ATCO/AFISOs are allowed to work in a remote tower they must be fully familiar with the system and its performance capabilities and limitations. Therefore a training programme must be designed and developed to ensure that they are fully trained and rated to provide ATS from the remote tower centres. All ATCO/AFISOs working in the remote tower must be fully familiar and trained with the new equipment and working procedures for remote operations prior to implementation.
4.3 STAFFING REQUIREMENTS & STAFFING LEVELS	Low density aerodromes are often located in rural areas. ATCO/AFISOs are trained and licensed locally for one tower / aerodrome environment. Thus one of the potential benefits of the remote tower is that there will be a larger centralised resource pool of ATCO/AFISOs available who are all trained and rated to use the same standardised equipment / CWP and working procedure. This will create flexibility and increase efficiency as ATS services will be able to be provided at any time of the day ("24/7" = 24hours a day / 7days a week) if required, and it will be easier for ATCO/AFISOs to relocate to other RTC as well if necessary even though aerodrome specific training/endorsement is of course required. Furthermore, low density aerodromes are often located in rural areas therefore a potential benefit of the remote tower is that the remote tower centre can be located in more denser populated areas hence making it easier to attract potential new recruits

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 single remote towers (as described in Table 2), it was identified that all twelve V2 level two 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 and HP activities

To identify potential HP issues, benefits & impacts relating to the remote tower concept for single aerodromes, two activities were performed:

- A literature review
- A HP issue analysis

3.2.2.1 Literature review

A literature review was conducted in October and November 2010 to identify potential issues relating to the introduction of remote tower operations in single aerodromes. The literature reviewed included documents produced from previous work conducted by NORACON (LFV) and NATMIG (SAAB) for the Remotely Operated Tower (ROT) project.Other research considered relevant to the project was also identified and reviewed, for example the Remote Aerodrome Tower Operations' Research conducted by DLR and the FAA in NEXT GEN [12][14][15].

3.2.2.2 HP Issue, benefit & impact analysis

During December 2010 and January 2011 several interviews / small focus groups were conducted with various subject matter experts to help identify potential issues and impacts that may result from the introduction of remote tower operations. The subject matter experts participating in these interviews consisted of two current LFV tower ATCOs, two former LFV Tower ATCO / ATM experts, one safety expert / engineer, one HP / safety expert and one engineer.

In order to facilitate the brainstorming session, participants were required to review the concept of operations prior to the issue & benefit analysis interview. The issue & benefit analysis consisted of a structured brainstorm lead by an HP expert, the aim being to identify as many potential issues & benefits for each HP work area relating to remote tower operations for single aerodromes as possible. The impact of each issue identified on human and system performance was defined and each issue identified was prioritised. Where possible mitigation to prevent or minimise the potential impact of an issue was also identified.

Over 80 HP issues and benefits were identified from the literature review and HP issue and benefits interviews conducted. The HP issues/benefits identified are listed in Table 8 under the HP arguments to which the issue/ benefit corresponds. 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; 2) 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 Annex A in the Issue and Benefits register.

Several of the issues identified were related to safety. These issues have been captured and are presented in Appendix A. All the safety-related issues are dealt with in more detail by the Safety team as part of the Safety Assessment process in V2 or V3 as appropriate.

It should be noted that the identified issues/ benefits listed in table 8 and described in more detail in Appendix A are not exhaustive or complete.

3.3 Step 3 Improve and validate the concept

3.3.1 Description of HP activities conducted

The validation activities that contribute to the HP assessment for the single remote tower concept have been conducted within SESAR P06.09.03 and P06.08.04. The HP validation activities conducted to date include:

- Task analysis (Annex C)
- Passive shadow mode trial EXE-VP-056 [7]
- Passive shadow mode trial EXE-VP-057 [7]
- AFIS shadow mode trial EXE-VP058 [7]
- Passive shadow mode trial EXE-VP639 [18]
- Passive shadow mode trial EXE-VP640 [17]

Findings of EXE-VP639 and EXE-VP640 were included in version 00.01.02 in chapter 3.4.3 and appendices B and C.

In addition an Early Regulatory Impact Assessment for P06.09.03.has been conducted by SESAR C03 in collaboration with P16.06.05 [9].

Each of the activities conducted is briefly described in the following tables. However, more detailed descriptions of each of the activities conducted can be found in the documents referenced next to each activity above.

Table 3: Task Analysis

TASK ANALYSIS (TA)	
DESCRIPTION	Task analysis is the systematic breakdown of ATCO/AFISOs work into its various tasks, subtasks and activities. An initial generic task analysis of the current day ATCO operations at small aerodromes was developed. This baseline task analysis of current day operations was then used to systematically identify the changes to ATCOs work that result from the introduction of the single remote tower concept. Information sources and control devices use / would use to support ATCO/AFISOs perform their tasks, both in the current tower and with the single remote tower were identified. Only nominal situations were included in the task analysis. (Abnormal conditions and degraded modes of operation are dealt with in the safety assessment process). The task analysis can also be used later on in the validation process as an input into a training needs analysis and to identify skill changes. In addition, the output of the task analysis will also be used as an input for error analyses being conducted by the safety team.
OBJECTIVE	The aim of task analysis was threefold: • to under ATCOs working methods under current tower operations in small to medium aerodromes. • to identify in a systematic way what information sources and control devices ATCO/AFISOs currently use and need to perform their tasks in order to understand & better define ATCO requirements for the remote tower CWP. • to identify in a systematic way the changes to the ATCO tasks under remote tower operations. This enabled a better understanding of the human performance related issues and their impact on human performance to be obtained.
RELATED VALIDATION OBJECTIVE ID	OBJ-06.09.03-VALP-0060-0062 OBJ-06.09.03-VALP-0060-0073
INPUTS/TOOLS/METHOD	An initial generic tabular task analysis for current day operations was developed using an existing EUROCONTROL task analysis of generic aerodrome operations. This task analysis was modified and updated following observations made during a visit to a small aerodrome (Ängelholm in Sweden) plus interviews with operational experts. Changes to ATCOs tasks and activities that would result from the introduction of the single remote tower concept were identified by reviewing the OSED developed for remote tower operations for single aerodromes, observations from the trials as well as in-depth interviews with ATCOs currently working at a small aerodromes and participating in the single remote tower trials. The task analysis of current day operations with the changes that would occur as a result of the introduction of the single remote tower concept was then reviewed by two operational experts that were current controllers that had taken part in the single remote tower trials.
ISSUES ADDRESSED / INVESTIGATED	1.1.2.1, 1.1.2.3, 1.1.2.3, 1.1.3.1, 3.1.2.1, 4.2.1.2
RESULTS	For the findings obtained relating to each issue addressed see table 8 in section 3.4.1. The Task Analysis conducted for single remote tower operations can be found in Annex C

Table 4: EXE-VP-056 – ATCO PASSIVE SHADOW MODE TRIAL 1

EXE-VP-056 – ATCO PASSIVE SHADOW MODE TRIAL 1	
DESCRIPTION	
OBJECTIVE	The overall aim of the first trial conducted by NORACON was to assess the technical and operational capability of an initial prototype in an operational environment. The aim of the trial from a HP perspective was to gain feedback from ATCOs on the impact of the Remote Tower Concept on human performance aspects in terms of: situation awareness; human performance (efficiency) / potential for human error; trust; acceptability; usability; and utility of specific functions such as the Pan Tilt and Zoom (PTZ) camera, Infra-Red (thermal imaging). In addition the aim was to ensure that ATCO had all the information and support tools they required to perform their work using a remote tower CWP. The trials were also used to collect information relating to ATCO tasks under remote tower operations in order to further develop and validate the task analysis developed to identify changes to ATCOs work under remote tower operations. As well as feedback on the impact of the concept on ATCOs roles, tasks and procedures.
RELATED VALIDATION OBJECTIVE ID	OBJ-06.09.03-VALP-0060-0061 OBJ-06.09.03-VALP-0060-0062 OBJ-06.09.03-VALP-0060-0071 OBJ-06.09.03-VALP-0060-0072 OBJ-06.09.03-VALP-0060-0101
INPUTS/TOOLS/METHOD	Observations, questionnaire and debriefs were used to obtain feedback from the ATCOs on the single remote tower concept. Feedback relating to situation awareness was obtained using SASHA which was administered at the end of each exercise. A detailed post-trial questionnaire was developed specifically to assess acceptability of the concept in general as well in relation to specific elements, usability and utility of the various component of the remote tower set up and ATCO in the concept trust using questions from the SHAP SATI questionnaire. The feedback obtained from questionnaire was complemented by observations as well as semi-structured debriefs conducted during the trial.
ISSUES ADDRESSED / INVESTIGATED	1.1.2.1, 1.1.2.3, 1.2.3.2, 1.1.3.1, 1.2.3.7, 1.2.5.1, 2.2.1.1, 2.2.1.2, 2.3.1.1, 2.3.2.1, 2.3.3.2, 2.3.5.1, 2.3.5.2, 2.3.5.3, 2.3.5.4,.2.3.5.5, 2.3.6.1, 2.3.7.1, 2.3.7.3, 2.3.7.4, 2.3.7.6, 2.3.7.7, 2.3.7.8, 2.3.7.10, 2.3.7.11, 2.3.7.12, 2.3.7.13, 2.3.7.14, 2.3.7.15, 2.3.9.1, 2.3.9.2, 2.3.9.3, 3.1.2.1, 4.1.1.5, 4.1.1.7,
RESULTS	For the findings obtained relating to each issue addressed see table 8 in section 3.4.1 Detailed description of the results for EXE-VP-056 can be found in [7]

Table 5: EXE-VP-057 – ATCO PASSIVE SHADOW MODE TRIAL 2

EXE-VP-057 – ATCO PASSIVE SHADOW MODE TRIAL 2	
DESCRIPTION	The three week passive shadow mode trial was performed at the Remote Tower test installation at LFV's Malmö Sturup site using the CWP-remote tower prototype developed by SAAB. The trial assessed live traffic from Ängelholm Aerodrome under a variety of scenarios. Target Aerodromes are low density aerodromes. Ängelholm controllers as well as controllers from other ATS units participated. As the trials were passive shadow mode any ATS tasks requiring direct interaction with the aircraft were not possible. Other tasks such as strip management, aircraft tracking, separation assessment etc. were still possible. Nine cameras were placed on top of the local tower (Ängelholm), with each having a 40° visual view, which was presented on LCD monitors in the RTC. Two remote tower set-ups were assessed and compared: a basic setup and an advanced setup. The basic set up consisted of Panoramic view (visual reproduction), radio (passive only), Flight strip system, Pan-Tilt and Zoom (PTZ) camera to replace binoculars and Infra-Red (Thermal imaging). The advanced set-up included in addition to the basic set-up radar, video and radar automatic a/c identification and tracking function as well as additional cameras view-points.
OBJECTIVE	The overall aim of this passive shadow mode trial is to progress the technical and operational capability of the single remote tower concept and achieve V3 maturity. From a HP perspective the main aim of the trial is to assess the two different single remote tower concept set-ups in terms of: • Acceptability of the concept in general, HMI, CWP and general working environment as well as the various concept element / enhanced visual features; • Utility & usability of enhanced features, • Impact on situation awareness & trust. • ATCO roles, tasks and responsibilities • Investigate ATCO situation awareness on detecting hazardous situations in the area of control • In addition the aim was to support the development of procedures under normal, abnormal and degraded modes of operation •
RELATED VALIDATION OBJECTIVE ID	OBJ-06.09.03-VALP-0060-0012 OBJ-06.09.03-VALP-0060-0022 OBJ-06.09.03-VALP-0060-0032 OBJ-06.09.03-VALP-0060-0033 OBJ-06.09.03-VALP-0060-0042 OBJ-06.09.03-VALP-0060-0051 OBJ-06.09.03-VALP-0060-0061 OBJ-06.09.03-VALP-0060-0074 OBJ-06.09.03-VALP-0060-0073 OBJ-06.09.03-VALP-0060-0102
INPUTS/TOOLS/METHOD	Observations, questionnaire and debriefs were used to obtain feedback from the ATCOs on the single remote tower concept. SASHA questionnaire was used to assess situation awareness and was administered at the end of each exercise. A detailed post-trial questionnaire was developed specifically to assess acceptability of the concept in general as well in relation to specific elements, usability and utility of the various component of the remote tower set up and ATCO in the concept trust using questions from the SHAPE SATI questionnaire. The feedback obtained from questionnaire was complemented by observations as well as semi-structured debriefs conducted during the trial. To support the development of procedures, where possible certain events / scenarios were scripted and the ATCOs were asked to walk through procedures that had been

	developed by Operational experts specifically for such events/ scenarios.
ISSUES ADDRESSED / INVESTIGATED	1.1.2.1, 1.1.2.2, 1.1.2.3, 1.1.3.1, 1.2.1.1, 1.2.2.1, 1.2.3.1, 1.2.3.2, 1.2.3.6, 1.2.3.7, 1.2.4.1, 1.2.5.1, 1.2.5.2, 1.3.1.1, 1.3.3.1, 2.1.1.1., 2.1.2.1, 2.1.5.1, 2.1.6.1, 2.2.1.1, 2.2.1.2, 2.3.1.1, 2.3.2.1, 2.3.3.1, 2.3.3.2, 2.3.5.1, 2.3.5.2, 2.3.5.3, 2.3.6.1, 2.3.7.1, 2.3.7.2, 2.3.7.3, 2.3.7.4, 2.3.7.6, 2.3.7.7, 2.3.7.9, 2.3.7.10, 2.3.7.11, 2.3.7.12, 2.3.7.15, 2.3.9.1, 2.3.9.2, 2.3.9.3, 3.3.2.1, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.2.1, 4.1.2.2, 4.2.1.1, 4.2.1.3,
RESULTS	For the results obtained relating to each issue in the row above see table 8 in section 3.4.1 Detailed description of the results for EXE-VP-057 can be found in [7]

Table 6: EXE-VP-058 – AFIS SHADOW MODE TRIAL

EXE-VP-058 SHADOW MODE TRIAL	
DESCRIPTION	The AFIS trials were separate into two sessions: The first session was in passive shadow mode and; the second session was in advanced shadow mode. The passive shadow mode entailed the AFISO observing life traffic in a non-obtrusive manner. In the advanced mode the AFISO was to provide AFIS services to the aircraft as the AFISO in the loop using the prototype remote tower system. For both trials the platform was based in Bodo and on a mast at Vaeroy heliport were14HD cameras which provided a 360 degree visual view of the heliport, which was presented on 55inch LCD portrait orientated monitors in the RTC. As in previous trials the CWP in the RTC included flight plan, met, aerodrome lights, navaids, alarms with interfaces to the heliport. Sound was also transmitted to the RTC from microphones placed at the helipad. Picture processing and quality of visual reproduction was the same with 30FPS. Radar was available to GND level, PTZ was available but operability / usability had been improved since EXE-057, The Infra-red camera was available as before as was visual and radar tracking (plus combined tracking), there were also e-Strip system (with manual activation of strips) and integrated Met (automatic weather observations). Passive mode trials involved a Tower AFISO and 2 retired AFIS. operators and tool place from 26th November 2012 to the 18th January 2013. The same three AFISO took part in the advanced mode trials.
OBJECTIVE	The aim of the passive mode trial was to assess confidence and assurance amongst stakeholders that the system could be used to provide ATS in live traffic in the advance mode trial. From a HP perspective the aim of the AFIS trials was to assess the remote tower concept for AFIS in terms of: • Acceptability of the concept in general HMI, CWP and general working environment as well as the various concept element / enhanced visual features; • Utility & usability of AFIS set up and enhanced features • Impact on situation awareness & trust, AFIS workload and task performance (i.e. human error / efficiency). • AFISO roles, tasks and responsibilities • In addition the aim was to support the development of procedures for AFIS operations under normal, abnormal and if possible degraded modes of operation.
RELATED VALIDATION OBJECTIVE ID	OBJ-06.09.03-VALP-0060-0016 OBJ-06.09.03-VALP-0060-0022 OBJ-06.09.03-VALP-0060-0032 OBJ-06.09.03-VALP-0060-0042 OBJ-06.09.03-VALP-0060-0052

	OBJ-06.09.03-VALP-0060-0063 OBJ-06.09.03-VALP-0060-0064 OBJ-06.09.03-VALP-0060-0075 OBJ-06.09.03-VALP-0060-0076 OBJ-06.09.03-VALP-0060-0103 OBJ-06.09.03-VALP-0060-0104 OBJ-06.09.03-VALP-0060-0105
INPUTS/TOOLS/METHOD	Observations, questionnaire and debriefs were used to obtain feedback from the AFISOs on the single remote tower concept. SASHA questionnaire was used to assess situation awareness and was administered at the end of each exercise and workload was assessed using the NASA-TLX. A detailed post-trial questionnaire was developed specifically to assess acceptability of the concept in general as well in relation to specific elements, usability and utility of the various component of the remote tower set up and ATCO in the concept trust using questions from the SHAPE SATI questionnaire. The feedback obtained from questionnaire was complemented by observations as well as semi-structured debriefs conducted during the trial. In addition a log book was kept by the AFISO to note any technical errors / issues that needed to be addressed.
ISSUES ADDRESSED / INVESTIGATED	1.1.2.2, 1.1.3.1, 1.2.1.1, 1.2.3.2, 1.2.5.2, 1.3.2.1, 1.3.3.1, 2.1.6.1, 2.2.1.1, 2.3.2.1, 2.3.5.2, 2.3.5.3, 2.3.5.4, 2.3.5.5. 2.3.7.3, 2.3.7.7, 2.3.7.9, 2.3.7.11, 2.3.7.14, 3.2.2.1, 3.3.5.1,4.1.2.1, 4.2.1.3
RESULTS	For the results obtained relating to each issue in the row above see table 8 in section 3.4.1 Detailed description of the results for EXE-VP-058 can be found in [7]

Table 7: EXE-VP640 – ATCO PASSIVE SHADOW MODE TRIAL

EXE-VP640 PASSIVE SHADOW MODE TRIAL	
DESCRIPTION	The exercise EXE-06.08.04-VP640 validates remote ATS to a single aerodrome by letting Air Traffic Control Officers (ATCOs) observe traffic from a Remote Tower Working Position (CWP-remote). Passive shadow-mode trials for medium sized airports (Low Capacity Needs) were conducted to cover human performance, operational and safety aspects. DFS ATCOs have answered questions addressing operational relevant decisions and ATCOs' perception. The change between the CWP-tower and CWP-remote refers mainly to the OTW view. Because nowadays' camera technology has not reached the quality of the human eye, the quality of the presented panorama view is limited. Starting with this technical fact, it is necessary to quantify the extent to which the CWP-remote impacts the ATC task and whether the ATC service might anyhow be provided with the expected and required level. EXE-06.08.04-VP640 addresses this topic at Saarbrücken airport with medium traffic scenarios. The substance of the validation is based on the OFA 06.03.01 OSED for Single Remote Tower.
OBJECTIVE	The task of the participating ATCOs is to monitor the medium traffic situation at the airport of Saarbrücken with the system under test in passive shadow mode. Thus, the shadow mode trials will not interfere with the actual operational business of the real ATCOs in the operational tower or airspace users as the CWP-remote reflects a system under test which will be further validated before it is operationally fit for purpose. The validation exercise EXE-06.08.04-VP640 also aims for a high external validity. For this reason, the CWP-remote is considered as a whole. The CWP-remote is equipped with standard DFS systems complemented by a video image prototype

	• Air situation display • Panoramic view • PTZ camera • Radio (only passive) • Electronic Flight Strip System (only passive/display) • Weather information display The following scope of the validation exercise was defined in a cooperative workshop: • Assurance of required level of Safety • Human Performance under CWP-remote conditions with respect to detectability • Provision of ATS services under a variety of scenarios • Usability / utility of the RTO system • Acceptance of the RTO system • Situational awareness and trust in automation in relation to the RTO system
RELATED VALIDATION OBJECTIVE ID	OBJ-06.08.04-VALP-VS20.1010 OBJ-06.08.04-VALP-0060.1024 OBJ-06.08.04-VALP-SF20.1025 OBJ-06.09.03-VALP-0060.1042 OBJ-06.08.04-VALP-HP20.1064 OBJ-06.08.04-VALP-HP20.1065 OBJ-06.08.04-VALP-HP20.1066 OBJ-06.08.04-VALP-0060.1073 OBJ-06.08.04-VALP-AC20.1077 OBJ-06.09.03-VALP-0060.1091 OBJ-06.08.04-VALP-UU20.1106 OBJ-06.08.04-VALP-UU20.1107 OBJ-06.08.04-VALP-AB20.1010
INPUTS/TOOLS/METHOD	Observations, questionnaires and debriefs were used to obtain feedback from the ATCOs on the single remote tower concept. SASHA questionnaires were used and administered at the end of each exercise to assess situation awareness. Moreover, tailored questionnaires as well as detailed debriefings were executed specifically to assess acceptability of the concept in general as well as in relation to specific elements Usability and utility of the various components of the remote tower set up as well as ATCO trust were analysed using questions from the SHAPE SATI questionnaire. The feedback obtained from the questionnaires was complemented by observations as well as semi-structured discussions during the trial.
ARGUMENTS ADDRESSED / INVESTIGATED	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3
RESULTS	For the results obtained relating to each argument in the row above see Table 10 in section 3.4.3 Detailed description of the results for EXE-VP640 can be found in [17]

A summary of the evidence / results obtained from the activities conducted, along with the resulting recommendations and / or requirements are presented in section 3.4.1 for each HP issue / benefit and HP argument identified and considered in the HP assessment conducted for P06.09.03. The status of each HP issue / benefit following the above HP related activities conducted to date is also stated.

3.4 Step 4 Collate findings

3.4.1 Summary of HP activities results & recommendations / requirements

Table 8 provides a summary of the main results / evidence, status of the HP issue and the HP recommendations / requirements for each of the HP issues/benefits identified from the activities related to small aerodromes conducted to date, i.e. the Task analysis (Annex C) and shadow mode trials ([7]). In chapter 3.4.3 (synthesis of arguments and recommendations) the main results of VP-640 were added for medium traffic volume aerodromes.

The recommendations resulting from the activities conducted are proposed as a potential means to mitigate the HP issues identified relating to the single remote tower concept. It should be noted that the recommendations required additional analysis, that is, refinements and / or validation before they are mature enough to become a requirement.

The requirements are statements that specify the required characteristics of the solution from a HP point of view. HP requirements can be seen as relatively stable and either lead to a redefinition of the operational concept or the specification of the technical solution.

The HP recommendations and requirements fall into one of several classes, among others:

- Technical system and HMI design
- Operational concept and procedures
- Training of end user

In addition, HP recommendations can relate to test and validation activities that need to be conducted in later V phases in order to investigate issues/benefits and potential mitigation in more detail.

It should be noted that Table 8 is a means to check and track what issues have or have not been addressed by the HP activities conducted to date. The current status of the issue/benefit is either said to be:

- Closed: An issue is considered ‘closed’ when the issue had been sufficiently answered or no additional activities relating to that issue are foreseen as necessary
- On-going: An issue is considered as being ‘on-going’ 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. On-going issues need to be further investigated in the future activities.
- Not addressed: An issue is considered as being ‘not addressed’ when no activities relating to the issue have been conducted**.**

Table 8: Summary of the HP results and recommendations/ requirements for each identified issue & related argument

Arg. 1.1 Roles and responsibilities of human actors are clear and exhaustive.			
ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED PLUS RESULTS / EVIDENCE	ISSUE STATUS / REQUIREMENTS & RECOMMENDATION S
Arg. 1.1.1: The description of roles & responsibilities cover all affected human actors.			
1.1.1.1	Not all human actors impacted by the Remote Tower concept are identified	The main focus of the HP assessment has been on the Tower ATCO/AFISO, as they are the human actors most impacted by the concept. Other human actors impacted by the RT to an extent that have been identified to date include ground staff at the aerodrome that is being remotely controlled, pilots and technical engineers	*Closed*
1.1.1.2 (RT3)	Role of ATS representative 'tower chief' disappears - who will represent ATS in local community?	Not investigated	*Not addressed* *Recommendation(s)* -Investigate issues relating to ATS representation in local community where the aerodrome is located, as well as, feasibility of aerodrome manager taking on this responsibility in stakeholder workshops. -If necessary develop training program for ATS representative at aerodrome
Arg. 1.1.2: The description of roles & responsibilities cover all tasks to be performed by a human actor.			
1.1.2.1	The description of roles and responsibilities is not complete	**Task analysis, EXE-VP-056 & EXE-VP-057** The roles and responsibilities for ATCO and AFISO were seen to be complete. The Task Analysis (Appendix D) plus debriefs with ATCOs in the EXE-VP-056 & EXE-VP-057indicate that the roles, responsibilities of ATCOs do not change under single remote tower compared to current tower operations, except for those tasks e.g. METOBs, runway inspection that have to be performed on-site at the aerodrome. Role and responsibilities of technical engineers given introduction of cameras, visual reproduction screens plus accompanying hardware, software need to be considered in	On-going Requirement(s) -Ensure responsibility for tasks performed currently by ATCO/AFISOs that have to be performed onsite , e.g. METOBS, runway inspection, representation of ATS in local community are re-allocated appropriately. (Re-allocation of tasks can either involve the allocation of tasks to a staff member located onsite at the aerodrome or automation). *Recommendation(s)*

		more detail	- Consider introducing automatic meteorological observations (optional) -Define any changes to role of the technical engineers given introduction of cameras, visual reproduction screens plus accompanying hardware, software
1.1.2.2 (RT4)	ATCO/AFISOs will no longer be able to conduct METOBS from the remote tower cabin. If the ATCO/AFISOs are no longer located onsite then they will no longer be able to perform METOBS, therefore this task will have to be performed by personnel located on-site at the aerodrome, this may impact *efficiency*	**Task analysis** ATCOs felt that the fact that METOBS would be performed by personnel located onsite at the aerodrome and not ATCO/AFISO was not a problem as in many aerodromes currently it is the ground staff that are responsible for performing this task and not the ATCO/AFISO was not responsible for METOBS [Appendix D]. **EXE-VP-057** Not seen as a problem as this happens today in many aerodromes but potential mitigation suggested e.g. introducing automatic observations; ensuring there is a windsock at the aerodrome that can be easily viewed by the ATCO/AFISO in the remote tower Being offsite also means that they may lose local knowledge including knowledge about the weather and this is particularly important in aerodromes close to mountains where there is snow, fog and changeable weather, as this information may be critical in affecting decisions & overall SA.**EXE-VP-058** In AFIS trials, the Automatic weather observations plus out of the window view had confidence in the accuracy of the MET information. However, some comments from the AFISO did include a slight distrust of the automatic weather observations and reliance on local staff at the heliport at times. IR camera was able to 'detect' weather e.g. showers in the vicinity, & given a good indication of cloud ceiling levels when visibility not good, providing AFISOs with more information than they were used to	*On-going* *Requirement(s)* -A weather status display should be provided for the CWP-remote as in current day CWP-tower *Recommendation(s)* - If a windsock is located at the aerodrome being controlled remotely it should be easily viewed by ATCO/AFISO in remote tower, - Consider having a pre-setting for the PTZ or additional fixed cameras which could facilitate ATCO/AFISOs in finding the windsock - Consider introducing automatic meteological / weather observations (optional)

1.1.2.3 (RT7)	ATCO/AFISOs tasks / roles and responsibilities under remote tower operations change	**Task analysis, EXE-VP-056 & EXE-VP-057** The roles and responsibilities for ATCO and AFISO were seen to be complete. The Task analysis [Appendix D] plus debriefs with ATCOs in the EXE-VP-056 & 2 indicate that the roles, responsibilities of ATCOs and AFISOs do not change significantly under single remote tower compared to current tower operations, except for those tasks e.g. METOBs that have to be performed on-site at the aerodrome. The main change is the source of information i.e. the visual reproduction display and not the 'Out of the Tower Window' View	*Closed*
Arg. 1.1.3: Roles and responsibilities are clear and consistent.			
1.1.3.1	Tasks allocation is confused and either tasks get duplicated by personnel or more likely and even worse not performed. Task duplication or omission may have serious safety repercussions	**Task analysis, EXE-VP-056 & EXE-VP-057 & EXE-VP058** The roles and responsibilities for ATCO and AFISO were seen to be clear and consistent. The Task Analysis [Appendix D] plus debriefs with ATCOs in the trials indicate that the roles, responsibilities of ATCOs and AFISOs do not change under single remote tower compared to current tower operations, except perhaps if they have to perform METOBS in current operations but this change in task responsibility is considered clear & consistent. Feedback from ATCOs in the debriefs in EXE-VP-056, EXE-VP-057, EXE-VP-058 also supported the fact that task allocation was clear and consistent.	*Closed*
Arg. 1.2: Operating methods are exhaustive and support human performance.			
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**ACTIVITY CONDUCTED RESULTS / EVIDENCE**	**ISSUE STATUS / RECOMMENDATION**
Arg. 1.2.1: Operating methods cover normal operating conditions.			
1.2.1.1	Operating methods do not cover normal operating condition. If the existing operating methods are no longer appropriate under single RT and / or normal operating conditions change and there are no operating methods to cover these conditions then it may lead to reduced efficiency and in the worst case have negatively impact safety by increasing potential for human error	EXE-VP-057 Certain procedures developed (see [8]) have been reviewed and tested in the shadow mode trial using walk-through / talk-through techniques. Feedback provided by the ATCOs relating to suitability and appropriateness of the procedures have been considered and where appropriate the procedures have been updated / amended based on the ATCO feedback received.	*On-going* *Requirement(s)* -Develop procedures for Infra-Red (Thermal imaging) use if implemented *Recommendation(s)* -Investigate in future validation activities the

		Overall ATCOs did not feel capable of applying visual separation[1] in the 'basic' RT. Thus vertical & procedural separations can be applied but not visual separation based on OTW view in the 'basic' R/T set--up used in EXE-VP-057. More ATCOs felt that visual separation could be applied with the 'advanced' RT when radar and automatic a/c identification were available compared to the 'basic' system when there was no radar and automatic a/c identification and labelling. However, all agreed that reduced visual separation should not be applied in the 'Advanced' RT setup investigated in EXE-VP-057. EXE-VP-058 For AFIS in the advanced shadow mode the AFISO 'strongly agreed' that the working methods for normal conditions relating to VMC, the use of Infra-Red and observation in weather were all acceptable.	feasibility of visual / reduced visual separation with different RT set ups / support tools -Consider introducing support tools to help ATCOs assess distance / separation -The procedures developed and updated following EXE-VP-057 8] need to be validated in active mode trials.
Arg. 1.2.2: Operating methods cover operations in abnormal operating conditions			
1.2.2.1	Operating methods do not cover operations in abnormal conditions. If existing operating methods are no longer appropriate under single RT and /or new abnormal conditions arise and there are no operating methods to cover these conditions then it may lead to reduced efficiency in terms of both and in the worst case have negatively impact safety by increasing potential for human error	**EXE-VP-057** With the support of the Safety, HF and Operational procedures teams certain abnormal events were identified and prioritised. Where appropriate, procedures were developed. These procedures developed for abnormal operating condition [10] have been reviewed and tested in the shadow mode trial using walk-through / talk-through techniques. Feedback provided by the ATCOs relating to suitability and appropriateness of the procedures have been considered and where appropriate the procedures have been updated / amended based on the ATCO feedback received.	*On-going* *Recommendation(s)* - Validate the updated procedures following EXE-VP-057 [10] active mode trials
Arg. 1.2.3: Operating methods cover degraded modes of the ATM system.			
1.2.3.1	If new degraded modes arise as a result of the RT concept or if existing procedures for the existing degraded modes	**EXE-VP-057** With the support of the Safety, HF and Operational procedures	*On-going*

[1] Visual separation in this context refers to the separation provided by the aerodrome controller when each aircraft is continuously visible to this controller, Under these conditions controllers can reduce the separation minima in the vicinity of the aerodromes if so desired, this is what is meant by reduced visual separation.

	are no longer appropriate and there are no operating methods to cover these conditions then it may lead to reduced efficiency in terms of HP and KPA and in the worst case have negatively impact safety by increasing potential for human error	teams certain abnormal events, including degraded modes, were identified and prioritised. Where appropriate procedures were developed. These procedures developed for abnormal operating conditions, including degraded modes, [10] have been reviewed and tested in the shadow mode trial using walk-through / talk-through techniques. Feedback provided by the ATCOs relating to suitability and appropriateness of the procedures have been considered and where appropriate the procedures have been updated / amended based on the ATCO feedback received.	*Recommendation(s)* - Validate the updated procedures following EXE-VP-057 [10] in active mode trials
1.2.3.2 *(SR1)*	Remote tower system fails, e.g. system fails to display panoramic view of aerodrome under remote control i.e. panoramic screen goes down' or freezes	**EXE-VP-056** In EXE-VP-056 debriefs, ATCOs said they would revert to procedural control / LVP when system failures such as panoramic screen 'going down/ blacking out' occurred. However, ATCOs also said that such system errors meant they had less trust in the system. One ATCO reported that as a result of the failures he no longer used the panoramic display as his primary source of info. and that he preferred to use the radar as his primary source of info. with the panoramic screens as back up. When the display froze during the trial this was not thought to be a problem as ATCOs said they could revert to procedural control/LVP. However, in the Trial the fact that there was no indicator on the screen to inform ATCOs that picture had not been updated was considered a problem. **EXE-VP-057** Specific contingency procedures for specific system failures, [10] were developed by operational experts prior to the trials and tested by walking through the procedures with the ATCOs. Feedback was obtained from the ATCOs to improve the procedures developed. The procedures have subsequently been updated based on the feedback received see [8] for the updated	*On-going* *Requirement(s)* -Ensure screens have an indicator / alert to inform ATCOs that screen has not been updated, & screen has frozen. -Have procedural control / LVP as contingency procedure for such events as failure relating to the visual reproduction -Ensure there is a back-up system e.g. back up visual reproduction screens *Recommendation(s)* -Validate the updated procedures following EXE-VP-057 [10] in active mode trials

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		procedures for identified abnormal or degraded modes of operation. More details regarding system failures can be found in the safety case. **EXE-VP-058** Various unusual/unexpected events occurred through the trials that were unscripted e.g. screen black outs, power cuts at the helipad, problems with the VCS. The AFISO was not able to agree or disagree that the procedures for such events were acceptable.	
1.2.3.3 *(SR2)*	No surveillance input is provided for a real target (missing data)	Not explicitly investigated in trials	*On-going* To be investigated in the Safety assessment in V3
1.2.3.4 *(SR3)*	The surveillance data is provided for a real target but some aspects of the data are incorrect / inaccurate (erroneous / misleading data)	Not explicitly investigated in trials	*On-going* To be investigated in the Safety assessment in V3
1.2.3.5 *(SR4)*	The data presented on a display does not correspond to a real target at the aerodrome (false data)	Not explicitly investigated in trials	*On-going* To be investigated in the Safety assessment in V3
1.2.3.6 (SR5)	Communication link between site and aerodrome fails	**EXE-VP-057** Not specifically investigated in EXE-VP-057 although 'walk throughs' with similar failures e.g. screen failure, were conducted and feedback on the contingency procedures obtained. The procedures have subsequently been updated based on the feedback received **[10].**	*On-going* *Requirement(s)* -Ensure screens have an error warning to inform ATCOs that there is a communication link failure -Have procedural control / LVP as contingency procedure for such events as failure relating to the visual reproduction -Ensure there is a back-up system e.g. back up

			visual reproduction screens *Recommendation(s)* - Validate the updated procedures following EXE-VP-057[10] in active mode trials - Investigate degraded modes further in future validation activities e.g. RTS
1.2.3.7 (SR6)	Disturbance/ interruption while controlling traffic	**EXE-VP-056** See 1.2.3.2 Also in relation to this issue, ATCOs commented that when managing an a/c and attention was diverted to a secondary task, it took more/too much time and effort to re-establish visual contact compared to in current tower operations. Aid to help track a/c e.g. an indicator, label or radar information projected onto the panoramic screen to help ATCOs in such situations, plus help ATCOs to more quickly identify a/c, objects & enhance SA were said to be strongly needed. **EXE-VP-057** Specific contingency procedures for specific system failures, e.g. frozen screen, black out were developed by operational experts prior to the trials and tested. Feedback was obtained from the ATCOs to improve the procedures developed (see [8]). In EXE-VP-057 an automatic a/c identification and tracking function was available and this was found to remove the problem that had been experienced by ATCOs in trials 1, whereby if their attention was diverted to a secondary task it was difficult and took more time / effort to re-establish visual contact compared to in current tower operations.	*On-going* *Recommendation(s)* -The procedures developed and updated for such events [10] need to be validated in active mode trials. -Automatic a/c identification and tracking function is highly recommended to ensure ATCO SA is maintained and optimised in remote tower. This will also facilitate continuous tracking of a/c in the aerodrome vicinity.
1.2.3.8 (SR7)	Recovery from failure becomes more difficult	Not explicitly investigated	*Not addressed* To be investigated in the Safety assessment in V3

1.2.3.9 (SR8)	Maintenance in order to recover from system failure become more difficult and system intervention is more complicated because service and technology are split on two sites	Not explicitly investigated in trials	*Not addressed* To be investigated in the Safety assessment in V3
Arg. 1.2.4: The content of operating methods is clear and consistent.			
1.2.4.1	The content of operating methods is not clear and consistent this could lead to reduced efficiency both in terms of human performance and KPA and in the worst case increase the potential for error so impacting safety	**EXE-VP-057** 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/ talk-through techniques in EXE-VP-057. Feedback from the ATCOs was obtained and the procedures consequently updated as a result[10]. 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* *Recommendation(s)* -The procedures developed and updated for abnormal and degraded modes in remote tower operations following EXE-VP-057 [10] [10] need to be validated in active mode trials.
Arg. 1.2.5: Operating methods can be followed in an accurate, efficient and timely manner			
1.2.5.1 (P1)	The procedures are not suitable i.e. easy to use / apply and / or are generally not appropriate in new working environment. The procedure for current operations in tower control may not be easy to apply and / or appropriate for remote tower operations (RTO) for either nominal and / non-nominal conditions. This will lead to an *increase in ATCO/AFISO workload* and increase the potential for *human error*. Furthermore, ATCO/AFISOs will be less likely to accept remote tower operations	EXE-VP-056 Due to the quality of the picture presented on the panoramic display monitors ACTOs felt that proven methods of separating using visual separation might have to be rethought, going back to more procedural separation or using radar to a greater extent to ensure separation at the threshold EXE-VP-057 Certain procedures developed [10] have been reviewed and some tested in the shadow mode trial using walk-through / talk-through techniques. Feedback provided by the ATCOs relating to suitability and appropriateness of the procedures have been considered and where appropriate the procedures have been updated / amended based on the ATCO feedback received [8]. Overall ATCOs did not feel capable of applying visual separation in the 'basic' RT set-up. Thus vertical & procedural separations can be applied but not visual separation based on OTW view in	*On-going* *Recommendation(s)* -Investigate in future validation activities the feasibility of visual / reduced visual separation with different remote tower set-ups & automation support -The procedures developed and updated for abnormal and degraded modes in remote tower operations following EXE-VP-057 [10] need to be validated in active mode trials. -Radar should be implemented if ATCOs are providing Approach services and the number of simultaneous air movements exceeds two

		the 'basic' set-up tested. More ATCOs felt that visual separation could be applied with the 'advanced' RT when radar and automatic a/c identification were available compared to the 'basic' system when there was no radar and automatic a/c identification and labelling. However, all agreed that reduced visual separation should not be applied in the 'Advanced' RT setup investigated in EXE-VP-057. EXE-VP-058 For AFIS in the advanced shadow mode the AFISO 'strongly agreed' that the working methods for normal conditions relating to VMC, the use of Infra-Red and observation in weather were all acceptable.	
1.2.5.2 (P2)	The procedures for the aircrew are no longer suitable under remote tower operations. The pilot / aircrew procedures for current operations may not be easy to apply and / or appropriate for remote tower operations (RTO) for either nominal and / non-nominal conditions. This will lead to an *increase in pilot workload* and increase the potential for *human error*.	**EXE-VP-057** Initial feedback from airspace users observing the Remote tower trial suggest this is not an issue. But needs to be investigated more systematically & in more detail. **EXE-VP-058** In the AFIS trials no such issues relating to aircrew procedures were mentioned. However, communication, information provision, co-ordination and accuracy of MET were all rated by pilots as acceptable. Pilots also felt that the RVT strongly contributed to improving weather information and safety.	On-going *Recommendation(s)* -Issues relating to pilots/aircrew need to be addressed more systematically and in more detail in workshop with airspace users.
Arg. 1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).			
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**ACTIVITY CONDUCTED RESULTS / EVIDENCE**	**ISSUE STATUS / RECOMMENDATION**
Arg. 1.3.1: The potential for human error is reduced as far as possible.			
1.3.1.1	The potential for human error is increased as a result of the introduction of single RT. This will have a significant impact on safety	**EXE-VP-057** From the safety survey, in the 'advanced' setup radar tracking was found to be the main advanced feature that supported 'air operations related tasks' followed closely by the radar based surveillance display and the video tracking. For ground ops. The two main advanced features that supported this activity were the video tracking and additional cameras.	*On-going* *Recommendation(s)* -Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g.

		Radar based surveillance display considered essential by ATCOs if there are 2 or more simultaneous[2] movements. With one movement not necessary.	type & number of simultaneous movements that can be safely handled in future RT set-ups to be defined -Video & radar a/c tracking should be implemented to support human performance , in particular SA and reduce the potential for error *To be more fully investigated in the safety assessment in V3*
Arg. 1.3.2: Tasks can be achieved in a timely manner.			
1.3.2.1	ATCOS & AFISOs are not able to achieve tasks in a timely manner. This will impact overall efficiency & hence capacity. In the worst case this could result in an increase in potential for human error and hence impact safety	Not explicitly investigated in trials as trials were passive shadow mode. **EXE-VP-058** AFISO was able to perform all the tasks as required in a timely manner in the advanced shadow mode trial	*Not addressed* *Recommendation(s)* -Investigate whether or not tasks can be achieved in a timely manner in active ATCO TWR mode trials
Arg. 1.3.3: The level of workload (induced by cognitive and/or physical task demands) is acceptable			

[2] In this context two or more simultaneous movements can refer to either two a/c (or more) or one a/c and one ground vehicle (or more)

1.3.3.1 (RT6)	ATCO/AFISOs tasks / role under remote tower operations cannot be performed by one ATCO/AFISOs. If the ATCO/AFISOs tasks and roles change then the demand placed on the ATCO/AFISOs may also change. It is currently assumed that the *workload / demand* placed on ATCO/AFISOs under remote tower operations will not be significantly impacted and so the same number of personnel as today will be required to provide ATS remotely. However, if the *task demand* placed on the ATCO/AFISOs under remote tower operations do increase significantly then this may impact safety & efficiency or increase the number of ATCO/AFISOs required to provide ATS remotely which would then affect cost effectiveness	**EXE-VP-057** 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 was passive shadow mode WL was not considered an issue by ATCOs **EXE-VP-058** Overall workload was found to be acceptable in all weather conditions and visibility. In fact workload was rated to be very low (which is as expected with only 4 movements a day). The radar was said to contribute most to reducing workload in the advanced shadow mode trials.	*On-going* *Recommendation(s)* -Workload to be assessed in active mode trials under high taskload normal operating conditions as well as abnormal & degraded modes of operation.
Arg. 1.3.4: The level of trust in the new concept/the new procedures is appropriate.			
	See Arg. 2.1.6		
Arg. 1.3.5: Human actors can maintain a sufficient level of situation awareness.			
	See Arg 2.3.7		
Arg. 1.3.6: Human performance satisfies the expected TA target levels.			
Arg. 1.3.6.1: Safety requirements on human performance are satisfied.			
1.3.6.1.1	Safety in terms of potential for human error should not increase compared to current operations in traditional control towers		To be assessed in V3
Arg. 1.3.6.2: Security requirements on human performance are satisfied.			
	No target level identified		
Arg. 2.1: There is an appropriate allocation of tasks between the human and machine (i.e. level of automation).			
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 2.1.1: The task allocation between the human and the machine is consistent with automation principles.			

2.1.1.1	If the automatic identification & tracking function implemented does not adhere to automation principles this automation may lead to reduced efficiency and hence impact capacity and also in worst case increase the potential for human error, so negatively impacting safety.	**EXE-VP-057** The a/c automatic identification & tracking function was found to support human performance and enhance ATCO SA. It was found to overcome the problem identified in EXE-VP-056 in which ATCOs found it difficult to re-locate an a/c in the aerodrome vicinity once they had focused attention away from the a/c. The a/c automatic identification & tracking function was said to be an essential component of the remote tower facilities as it enhanced SA and overcame some of the problems associated with the visual reproduction, and picture quality. However, there was a tendency for the automatic identification & tracking function to identify and track non related objects such as birds. Thus this function needs to be refined so that only relevant objects e.g. a/c and aerodrome vehicles are identified and tracked.	On-going *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. *Recommendation(s)* -The automatic identification & tracking function should be included in the basic R/T set-up, in order to optimise SA.
Arg. 2.1.2: Changes to the task allocation between human and machine support human performance.			

2.1.2.1	The automatic identification, labelling and tracking function does not increase ATCO SA and support human performance, this could lead to reduced efficiency and hence impact capacity and also in worst case increase the potential for human error, so negatively impacting safety.	**EXE-VP-057** The a/c automatic identification & tracking function was found to support human performance and enhance ATCO SA. It was found to overcome the problem identified in EXE-VP-056 in which ATCOs found it difficult to re-locate an a/c in the aerodrome vicinity once they had focused attention away from the a/c. The a/c automatic identification & tracking function was said to be an essential component of the remote tower facilities as it enhanced SA and overcame some of the problems associated with the visual reproduction, and picture quality. However, there was a tendency for the automatic identification & tracking function to identify and track non related objects such as birds. Thus this function needs to be refined so that only relevant objects e.g. a/c and aerodrome vehicles are identified and tracked. Comparison of the 'advanced' RT system (which included radar and the automatic identification, labelling and tracking function) to the 'basic' RT system showed that: Overall situation awareness (SA) found to be significantly greater for Advanced system compared to Basic. • Significant improvement found for ratings on SASHA dimensions 'surprised by an event' and 'search for information' • Improvement in situation awareness reported to be mainly due to radar and video tracking labels The main contributory factor for this improved SA was unanimously attributed by the ATCOs to the automatic identification, labelling and tracking function	On-going *Requirement(s)* -The a/c automatic identification & tracking function if implemented needs to be re-fined to ensure and acceptably low false positive and sufficiently high success rate i.e. only relevant objects e.g. a/c and aerodrome vehicles are identified and tracked. *Recommendation(s)* -The automatic identification & tracking function should be included in the basic R/T set-up, in order to improve SA
Arg. 2.1.3: Transition from automatic to manual modes and vice versa, human-intended or failure induced, can be performed by the human actors in a timely, efficient and accurate manner.			
	N/A		
Arg. 2.1.4: The level of workload (induced by the allocation of tasks between the human and the machine) is acceptable.			
	N/A		
Arg. 2.1.5: Human actors can acquire an adequate mental model of the machine and its automated functions.			
2.1.5.1	If ATCO/AFISOs do not have an adequate mental model of the automatic a/c identification, tracking & labelling	**EXE-VP-057** ATCOs were able to identify errors with the automatic a/c	Closed

	function they may not be able to identify when errors with this functionality occur / arise. Given the nature of the functionality this may affect ATCO/ AFISO SA and in turn overall efficiency. There could may also be certain safety implications	identification, tracking & labelling function e.g. when the function identified and tracked non- relevant objects such as birds and also when there was a discrepancy between the video and radar tracking functions. Automation function quite simple and easy to understand	
Arg. 2.1.6: The level of trust in automated functions is appropriate.			
2.1.6.1	ATCO / AFISO trust in the automatic a/c identification, tracking & labelling function is too high they may not notice errors, e.g. the system tracking non-a/c objects, this could reduce SA and increase potential for error this may have safety implications. If ATCOs / AFISOs trust in the automatic a/c/ identification, tracking & labelling function is too low then ATCOs / AFISO may not benefit from the functionality & their SA will not be enhanced by the automation & efficiency could be impacted. This will impact cost effectiveness for remote tower solution.	**EXE-VP-057** ATCOs were able to identify errors with the automatic a/c identification, tracking & labelling function e.g. when the function identified and tracked non- relevant objects such as birds and also when there was a discrepancy between the video and radar tracking functions. Trust in automatic a/c identification, tracking & labelling function at an acceptable level Overall levels of trust greater for 'Advanced' (i.e. 'basic' system set-up plus automatic a/c identification & tracking function, radar & additional camera views) compared to 'Basic' system set-up. In 'basic' set-up although ATCOs generally understand the system they felt it was less robust and reliable than the 'Advanced' system set up tested in EXE-VP-057. ATCOs reported to be much more confident and comfortable using the system in the 'Advanced' set up compared to the 'Basic' system set-up. **EXE-VP-058** Trust in the advanced set up was found to acceptable according to the SATI ratings obtained from the AFISO. The most trusted technical systems included the IR, PTZ camera and 'out of the window' (OTW) view as well as the ambient sound. The VCS was the least trusted operational system as it caused many problems for the AFISO during the trials.	Closed *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. *Recommendation(s* -Radar and automatic a/c identification & tracking function should be implemented not only to enhance SA but also ATCO/AFISO trust and confidence in the remote tower system and hence acceptability of the concept.
Arg. 2.2: The performance of the technical system supports the human in carrying out their task.			

Issue ID	HP issue / Benefit & impact	Activity conducted results / evidence	Issue status / recommendation
Arg. 2.2.1: The accuracy of information provided by the system is adequate for carrying out the task.			
2.2.1.1 *(IR3)*	The accuracy of the information presented to the ATCO/AFISOs in the remote tower is reduced due to technical latency. If the information presented on the panoramic screen is not timely and hence accurate due to technical latency then ATCO/AFISOs may not have the correct information they need at a specific point in time, this could lead to *certain human errors* e.g. untimely issue of clearances, which could have serious consequences. The lack of timely accurate information will also mean the ATCO/AFISOs will *not trust* the information presented and in turn may *not accept* remote tower operations.	**EXE-VP-056** Overall, feedback indicated that the technical latency (20FPS) was at the minimum required level in this version of the system , if possible the technical latency should be improved, and it should certainly not get any worse. Often when vehicles were moving perpendicular to the screen the vehicle was found to 'jump', which was not really satisfactory as it made it difficult to judge distances accurately & was tiring on the eyes. **EXE-VP-057** Accuracy of information presented to ATCO seemed OK in EXE-VP-057, improvements had been made since EXE-VP-056. Picture quality on the 30FPS considered sufficient but could still be improved (50% of the ATCOs felt the resolution was sufficient for air-borne movements). **EXE-VP-058** Picture quality on the 30FPS considered acceptable. However at dawn and dusk, i.e. at times when the light was fading,the visual reproduction picture froze quite often and there was a lot of pixilation on the screens that reduced the quality of the picture.	On-going *Requirement(s)* -Picture quality under different light / dark conditions and low visibility conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date, clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the aerodrome vicinity as required. *Recommendation(s* -Need to re-assess picture quality in active mode trials under various conditions e.g. different light / dark conditions to ensure that quality of picture in terms of picture resolution, freezing, pixilation are acceptable to the end users and enables them to continuously monitor a/c in the aerodrome vicinity as required .
2.2.1.2 *(IR5)*	There is inconsistency with the information presented (e.g. due to the same information being presented in different formats or on different interfaces i.e. CWP or panoramic display). If the same information is presented to the ATCO/AFISO in different formats or on different interfaces (e.g. CWP and panoramic display), they may be a time when the information presented is not consistent. This may occur due to a system failure or to different equipment having different configurations / algorithms or information sources. This will lead to a *lack of trust* in the	**EXE-VP-056** Information was not found to be unnecessarily duplicated in this version of the system-set in this first trial. **EXE-VP-057** No inconsistency of information was identified during the trials **EXE-VP-058** No inconsistency of information was identified during the trials. Although as mentioned the a/c automatic identification and	On-going *Recommendation(s* -To be re-assessed each time modifications are made to the CWP and / or visual reproduction in terms of information presentation - A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance , in particular SA and reduce the potential for error but needs to

	system and information presented and hence a *lack of acceptance*.	tracking function was not stable and jumping so providing information that was not always reliable this was found to negatively impact situation awareness and trust in the function to a degree.	fine-tuned to be more stable, identify only relevant objects e.g. a/c & ground vehicles and prevent jumping
Arg. 2.2.2: The timeliness of information provided by the system is adequate for carrying out the task.			
2.2.2.1	Information, i.e. images of aerodrome and the vicinity are not presented to the ATCO/AFIS is delayed / not presented in real time	Not explicitly investigated but see 2.2.1.1	On-going *Recommendation(s* -Assess timeliness of information presentation
Arg. 2.3: The design of the human-machine interface supports the human in carrying out their tasks.			
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 2.3.1: The type of information provided satisfies the information requirements of the human.			
2.3.1.1 (IR1)	The information presented on the HMI (i.e. CWP and 3D panoramic screen) does not support the ATCO/AFISO in his/her work. It is important that only the necessary information is presented to the ATCO/AFISOs to support them in their tasks. Presenting information that does not support them in their tasks can lead to information overload and adds clutter both of which can lead to an *increase in mental workload, reduced situation awareness* and hence *increase potential for human error*.	EXE-VP-056 All necessary information required for ATCOs to perform their job was said to be presented. Additional information that could be useful was cloud base indicators & visibility indicators. Layout / organisation of information on the CWP could be improved, i.e. EFS. Plus it was suggested PTZ and IR pictures should be integrated into the visual reproduction display screens, as when displayed on separate screens on the CWP it took ATCOs attention away from the visual reproduction screen. **EXE-VP-057** 64% ATCOs felt that all the information was available to perform their services in (15% neither agreed or disagreed, & 21% disagreed). Ability to assess weather and met. conditions using the visual	On-going *Requirement(s)* - Picture quality under different light / dark conditions and low visibility conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the aerodrome vicinity. *Recommendation(s* -Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g. type & number of simultaneous movements that can be safely handled in future RT set-ups to

		reproduction in both the 'basic' & 'advanced' set-up assessed in trial was questioned, (36% ATCOs said they could assess weather conditions, the rest were undecided or felt they could not assess weather / met conditions). In particular the ATCOs felt it was difficult to judge wind & rain conditions in the remote tower. So improvements are still required to help the ATCOs 'assess the weather conditions impacting operations' & 'determine RWY conditions: including FODs & presence of animals'. One ATCO recommended putting a windsock to increase wind awareness. Furthermore, the picture quality at night time was not so well received. However, as no live darkness scenarios were encountered (only recorded) many ATCOs felt they were unable to comment. In the advanced set up some ATCOs would have liked to have seen type of a/c & speed in the label instead of destination/ arrival apt. some ATCOs suggested having labels (with identify information) for the ground vehicles. From the safety survey, in the 'advanced' setup radar tracking was found to be the main 'advanced' feature that supported 'air operations related tasks' followed closely by the radar based surveillance display and the video tracking. For ground ops. The two main 'advanced 'features that supported this activity were the video tracking and additional cameras. Radar based surveillance display considered essential if there are 2 or more simultaneous movements. With one movement radar considered not necessary. 71% ATCOs agreed the layout of the CWP was acceptable, some felt that more space was needed for the mouse and keyboard. Some ATCOs suggested that the visual reproduction screens should be portrait orientated to give more view of the sky. **EXE-VP-058** The image of the aerodrome vicinity on the visual reproduction screens did not include all the climb area of the helicopter, this was considered to not be acceptable and could have potential safety implications.	be defined -radar should be implemented if ATCOs are providing Approach services and the number of simultaneous air movements exceeds two more -Provide metrological information including cloud base indicators & visibility indicator & if a windsock is present at the aerodrome ensure the windsock is visible to the ATCO/AFISO - The set-up of the visual reproduction screens in terms of number of screens, layout orientation, area covered and included in the panoramic view, viewing angle etc. should be tailored and assessed and for each environment in which RT is implemented so that climbing and landing areas are fully captured on the visual reproduction visual reproduction screens - A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance , in particular SA and reduce the potential for error but needs to fine-tuned to be more stable and prevent jumping -Include type of a/c & speed in the label instead of destination/ arrival apt in the a/c automatic identification label -Consider introducing labels (with identify information) for the ground vehicles.

Arg. 2.3.2: Input devices (e.g. keyboard, mouse, touch screen) correspond to HF principles			
2.3.2.1 *(U1)*	The input & output control devices on the CWP are not intuitive and easy to use. If the control input / output devices are not initiative and easy to use then ATCO/AFISOs the efficiency will be reduced and there may be an *increase* in *potential for error*. In addition, if a system is intuitive and easy to use the amount of training required should theoretically be reduced.	**EXE-VP-056** Generally speaking the visual reproduction presented on the visual display monitors in terms of the quality of the image needs to be improved – both in terms of resolution (as some objects are not sharp and focus is not optimal) and frame rate (as moving images should be smooth and not jump & picture should not flicker). See 2.3.7.3 for more detailed info. In this version of the system the usability of PTZ controls was not considered good, see issue 2.3.5.4 for details. It was also recommended that the PTZ & IR screens should if possible be integrated into the visual reproduction display as the separate screens on the CWP caused the ATCOs to turn their attention away from the overall aerodrome picture, and this impacted SA. Usability must be tested again in the future with active mode trials so that the ATCOs have to really use and interact with the R/T system/controls. **EXE-VP-057** Overall opinion on the functionality of the IR was positive, but usability needs to be improved as does picture quality (some ATCOs expressed concerns that the IR might increase their workload) Concept of the Pan Tilt and Zoom camera (PTZ) well received but the PTZ as implemented in the trials was found not to be very useful or usable / intuitive, PTZ picture quality also needs to be improved Additional Camera Viewpoints (ACV), opinion was very positive, they were found to be very useful and intuitive and thought to be a means to increase SA. Number & location of each ACV would have to be determined for each APT. Some ATCOs commented that they would like to have the PTZ function on	On-going *Requirement(s)* - Picture quality under different light / dark conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the vicinity. - PTZ must be implemented in basic set up but picture quality and usability needs to be improved *Recommendation(s)* -Infra red (IR) (Thermal imaging) function should be implemented to facilitate operations in dark and low visibility conditions. IR usability needs to be improved -Additional Camera Viewpoints (ACV) should be available in the basic system set-up. Attention needs to be given as to where these ACV are located e.g. at hot spots, and the number required needs to be assessed on a aerodrome by aerodrome basis -A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance, in particular SA and reduce the potential for error. However, this function must be fine-tuned so that it tracks only relevant objects e.g. a/c and aerodrome vehicles -Investigate feasibility of a connection between

		these cameras & perhaps the images could be integrated & presented on the visual reproduction display (LCD screens). Tracking label overlays ATCOs opinion was very positive, with 93% saying it was easy to use and 86% saying its useful. The video tracking needs some fine tuning as birds, trucks and other moving objects were also identified and tracked which could distract the ATCOs attention away from something more important. **EXE-VP-058** PTZ camera had been improved since EXE-VP-O57, AFISO found it intuitive and easy to use, although the picture quality needed improvement Tracking labels overlays were found to be very useful but were unstable and jumping which was said to negatively impact situation awareness. This needs to be improved. The AFISO felt the font size on the CWP system were too small and needed to be made bigger	the PTZ and PTZ automatic tracking function -Review font size on the CWP system and ensure it conforms to HF standards
2.3.2.2 *(U3)*	Interactive touch displays are located outside the reaching area. Based on the calculated distance by the maximum viewing angle, we need to consider small and large reaching areas, if not, ATCOs may not be able to perform their tasks efficiently. The small reaching area is within 35-45 cm, the large reaching are is within 55-65 cm.	Not an issue in any of the trials conducted	On-going *Recommendation(s)* -If interactive touch displays are implemented they will have to be assessed following any changes to the CWP configuration / layout
Arg. 2.3.3: Visual displays and other types of output devices adhere to HF principles.			
2.3.3.1 (WE6)	Essential information presented on the screens is outside the human's viewing angle. The presentation of the outside view is represented via LCD screens instead of a window view. This can cause different issues in terms of presentation size, view angle and overall working position design	**EXE-VP-057** Not really considered an issue in EXE-VP-057, although one of the ATCOs that was over 2 metres in height did want the screens to be placed higher. Hence recommendation to ensure there is a certain degree of flexibility in the design of the CWP / work environment.	On-going *Requirement(s)* -Ensure there is a certain degree of flexibility in the design of the CWP / work environment

	If the maximum required vertical and horizontal fields are not observed and important information could be outside human's viewing angle, which may impact ATCO/AFISOs situation awareness.		*Recommendation(s)* -Assess usability of different working position set ups whenever any changes are made to the CWP set up -Ensure the appropriate HF guidelines & standards are considered & applied in the design & development of the CWP. Such guidelines / standards include: FAA's Human Factors Design Guide, Ch6 Control and visual indicators, page 6-55 and MIL-STD-1472F, 1999, page 17, the visual fields for Eye Rotation
2.3.3.2 (WP5)	Important information located on the screens in the background is obscured by the CWP monitors in front. In current towers, the CWP monitors often obscure the view to the runway, this can impact situation awareness and also efficiency, as ATCOS may have to stand up or move to gain the required information from the outside view.	**EXE-VP-056** This was not considered to be a problem in the set up investigated in EXE-VP-056. Although it was suggested that to reduce the viewing angle on the vertical axis the display monitors presenting the OTW view will be lowered in future trials to try and reduce head movement & make the viewing angle more comfortable **EXE-VP-057** Not considered an issue in EXE-VP-057. Mitigations are as recommended	On-going *Recommendation(s)* -Assess visibility of screens from CWP during implementation
Arg. 2.3.4: Alarms and alerts have been developed according to HF principles.			
	N/A		
Arg. 2.3.5: The usability of the user interface (input devices, visual displays/output devices, alarm& alerts) is acceptable.			
2.3.5.1 *(IR4)*	Too much information is presented to the ATCO/AFISO (i.e. on the panoramic display and CWP). The presentation of too much information can have two potential negative consequences on ATCO/AFISOs work:	**EXE-VP-056** ATCOs did not feel that unnecessary information was displayed that added clutter.	On-going *Recommendation(s)* -Assess usability of information presented whenever any changes are made to the

	Too much information i.e. information overload, may *increase ATCO/AFISOs' cognitive workload* as ATCO/AFISOS would have to monitor, interpret and integrate more sources of information to be able to make the necessary decisions. The presentation of unnecessary information adds clutter, and this may help to reduce ATCO/AFISOs situation awareness's by making it more difficult for ATCO/AFISOs to find the essential information when necessary	**EXE-VP-057** Quantity of information presented not considered an issue in EXE-VP-057.	information presented to the ATCO/AFISO on the CWP and / or visual reproduction screens
2.3.5.2 *(IR6)*	The information presented on the HMI (CWP and panoramic display) is not intuitive and easy to interpret. If the information displayed is not intuitive and easy to interpret then ATCO/AFISOs will spend time having to interpret the information presented. This will reduce *increase ATCO/AFISOs cognitive workload, reduce efficiency* and even lead to an increase in the *potential for error* in terms of information interpretation. In addition, if a system is intuitive and easy to use the amount of training required should theoretically be reduced.	**EXE-VP-056** No problems were raised regarding the intuitiveness of information presented on the HMI in this version of the system. **EXE-VP-057** The majority of ATCOs agreed that that the information presented on the CWP was intuitive & easy to interpret (14% disagreed, 28% neither agreed nor disagreed). No specific problems were raised regarding the intuitiveness. The majority of ATCOs agreed that the information on the CWP was way to access (21% disagreed, 14% neither agreed nor disagreed). The majority of the ATCOs felt they did not have access to the MET information required (this could be due to the trial set up but needs to be looked at again) **EXE-VP-058** Font size on the CWP was considered too small	On-going *Requirement* -A weather status display should be provided for the CWP-remote like for CWP-tower *Recommendation(s)* -Metrological / weather information presented to ATCO/AFISO should include cloud base indicators, visibility indicators, if a windsock is present at the aerodrome being controlled remotely then it should be made visible to the ATCO/AFISO -Assess usability of information presented whenever any changes are made to the information presented to the ATCO/AFISO. Also investigate usability of information presented in future trials with representative scenarios & in active mode so that the ATCOs have to perform / execute certain tasks using specific information
2.3.5.3 (IR2)	The overlaid / highlighted information (e.g. enhanced geographical information, meteo, labels), obscures important information on the panoramic view. Overlaid information or highlighted information on the panoramic display aimed at increasing ATCO/AFISOs situation	**EXE-VP-056** No information was overlaid / highlighted on the panoramic displays / screens – so not addressed	On-going *Recommendation(s)* - A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to

	awareness, if not well designed may actually cover and obscure other information displayed on the panoramic display which ATCO/AFISOs may also need. This could result in ATCO/AFISOs global situation awareness being reduced or required information not being visible; both may result in an increase in the potential for error.	**EXE-VP-057** Tracking information (from radar and video) presented on the visual reproduction generally received very positive feedback - Tracking information (both radar & video) perceived to be very useful (13/14 responses say its very useful). 7 agree that the tracking information is intuitive (7 responses agree (2 disagree) – some fine tuning needed with the video tracking information as sometimes flocks of birds were tracked. **EXE-VP-058** The a/c automatic identification and tracking function was not stable and jumping so providing information that was not always reliable this was found to negatively impact situation awareness and trust in the function to a degree. But acceptance of this function overall was very high (90%).	support human performance, in particular SA and reduce the potential for error. But this function must be fine-tuned so that it tracks only relevant objects e.g. a/c and aerodrome vehicles and is more stable
2.3.5.4 (U2)	Degeneration in manoeuvring the PTZ camera compared with the use of binoculars. If ATCO/AFISOs find it difficult to manoeuvre the PTZ camera, it make take time to locate the object on the screen (*reduced efficiency*) and zoom in to gain a closer look, this will impact ATCO/AFISO *situation awareness*	EXE-VP-056 PTZ function appreciated and seen as a necessity but PTZ camera controls were not found to be easy to use and were considered much more difficult to use than binoculars. Manoeuvring the PTZ cameras with the mouse was found to be cumbersome & resource demanding. The PTZ camera screen on the CWP was also not found to be easy to use as the resolution of the screen was poor and 'grainy'. The closer you zoomed in on an object the worse the resolution became. Plus the fact that the PTZ camera screen was placed on CWP meant that when looking closely at an object using the PTZ camera the ATCOs attention was taken away from the panoramic LCD display and overall picture of the aerodrome – which could have serious safety implications. Humidity on camera lens made zoom view very difficult to see as background was very light due to the low sun.	On-going *Requirement(s)* -PTZ must be implemented in basic set up but picture quality and usability needs to be improved *Recommendation(s)* -Pre-settings for the PTZ should be implemented to aid usability

		EXE-VP-057 PTZ camera was not considered useable in EXE-VP-057. EXE-VP-058 PTZ camera was found to be easy and intuitive to use but the picture quality needed to be improved	
2.3.5.5 (WE7)	Lens on camera becomes covered e.g. snow, ice, rain drops, bird poop so visibility is impacted (WP12.4.7) (from EXE-VP-056)	EXE-VP-056 Rain drops & condensation on the camera were found to reduce visibility. **EXE-VP-057** Not addressed **EXE-VP-058** Compressor and windscreen wipers stopped working and this resulted in snow blocking the OTW view. However, staff at the local heliport intervened and cleaned the camera lens. Build -up of salt on the camera lens from the sea was said to be problematic	On-going *Requirement(s)* -Cameras located at the aerodrome must function correctly in snowy, icy, rainy conditions and the camera picture on the visual reproduction screens must not be impacted. -Cameras located at the aerodrome must be able to be automatically cleaned remotely
2.3.5.6 (WE8)	Performance of equipment e.g. picture quality resolution, depicted on panoramic screens degrades over time (from EXE-VP-056)	EXE-VP-056 Identified as an issue	On-going *Requirement(s)* -After installation of the remote tower system engineers should be available to assess picture quality at regular intervals to ensure picture quality is maintained. .
Arg. 2.3.6: The interface design reduces human error as far as possible.			

2.3.6.1 (WE1)	There are too many small / different work areas on the CWP which may increase potential for human error. If the controller has to work with too many different small screens and pieces of equipment, it may result in too many different input / output devices being required to manoeuvre/ control the screens, e.g. the use of mouse, mouse –pen and finger-touch. This may also force the controller to perform non ergonomic handles and can result in *human error* with the wrong device being use to perform a certain action.	**EXE-VP-056** In the EXE-VP-056 set up, ATCOs did comment that the IR & PTZ screens on the CWP did take their attention away from the panoramic displays & overall view of the aerodrome. ATCOs recommended that the PTZ & IR images should be integrated into the visual reproduction / panoramic displays. ATCOs also felt that EFS would be beneficial. **EXE-VP-057** Not considered an issue in EXE-VP-057, PTZ images were integrated into the visual reproduction / panoramic displays but this needed to be improved e.g. positioning of images often overlapped hotspots or areas that needed visibility on the visual reproduction screens,	On-going *Recommendation(s)* -Re-assess feasibility of integrating PTZ & IR images in the visual reproduction with images, looking at different possible options e.g. reposition of PTZ images or use of smaller images -Adhere HF recommended practices / guidelines / standards adhere to HMI design - **Limit the number of screens on the CWP to a minimum and ensure number of input & output devices is minimised, (have an integrated CWP. refer to SESAR P6.9.2 a-CWP)**
Arg. 2.3.7: The user interface supports a sufficient level of individual situation awareness.			
2.3.7.1 (IR2)	The overlaid / highlighted information on the panoramic display directs ATCO/AFISOs attention / focus away from other necessary information. Overlaid or highlighted information may help to draw ATCO/AFISOs attention to a specific object or piece of information but a potential consequence of that is that the ATCO/AFISOS attention and focus is taken away from perhaps other more important information (i.e. *attention distraction / tunnelling*). If that happens then the *potential for error* is increased.	**EXE-VP-056** No overlaid / highlighted information in EXE-VP-056 **EXE-VP-057** Tracking information (from radar and video) presented on the visual reproduction generally received very positive feedback - Tracking information (both radar & video) perceived to be very useful (13/14 responses say it's very useful). 7 agree that the tracking information is intuitive (7 responses agree (2 disagree) – some fine tuning needed with the video tracking information as sometimes flocks of birds were tracked.	On-going *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. *Recommendation(s)* -Impact of overlaid /high-lighted information on ATCO/AFISO attention needs to be re-evaluated in the future as more overlaid / highlighted features are added and as current features are improved -Ensure that overlaid and highlighted

			information on the panoramic display support ATCOs /AFISOs only in their primary tasks i.e. highlighted or overlaid information should be kept to a minimum & non-essential information should not be highlighted or overlaid
2.3.7.2 *(IR8)*	Too much overlaid / highlighted information on the panoramic screens may decrease ATCO situation awareness. The aim of the overlaid / highlighted information is to draw ATCO/AFISOs attention to important information / objects displayed on the panoramic screen, so enhancing ATCO/AFISO SA & ultimately safety. However, if too much information is highlighted / overlaid then ATCO/AFISOs SA may be negatively affected as ATCO/AFISOs may not be able to distinguish between critical and less critical information.	**EXE-VP-056** Not investigated **EXE-VP-057** Only tracking function resulted in certain information being highlighted on the visual reproduction and this was not considered to decrease ATCO SA. In fact the automatic tracking function that highlighted incoming a/c was reported to increase ATCO SA.	On-going *Recommendation(s)* -Impact of overlaid /high-lighted information on ATCO/AFISO SA to be re-assessed each time modifications are made in terms of overlaid / highlighted information
2.3.7.3 *(SA1)*	ATCO/AFISO situation awareness is reduced under good visibility & poor visibility conditions e.g. darkness, fog etc due to the picture quality of the visual reproduction screens. One of the main concerns that may cause SA to be reduced under good visibility conditions is the quality of the view / picture of the aerodrome environment displayed on the 3D panoramic screens. If the view is of lower quality than the current 'real world view', e.g. due to poor picture resolution some details may not be not visible, such as the detection of small fast moving objects (e.g. animals on the runway). Transmission latency may also lead to untimely information (both visual and verbal) being presented which would also reduce ATCO/AFISOs situation *Reduced situation awareness* will increase the potential for *human error* and be unacceptable to ATCO/AFISOs. *ATCO/AFISO workload* may also increase as more time may be spent looking for specific information and hence *reduce efficiency*.	**EXE-VP-056** In good visibility / *day light* conditions SA for predicted and expected traffic was easy to maintain. Flocks of bird could be easily identified. However, resolution, pixilation & flickering of screen were found to be annoying and needed to be improved, as it also was said to contribute to tiredness and eyestrain. Quality of the picture was said to be useable but at a minimum i.e. must be improved and definitely must not be any worse. *At night* the picture quality / resolution was lower than in the day, and the picture became very pixilated with some artefacts plus the screens flickered. The contrast between lights at the aerodrome and background picture was said to be too much i.e. too bright, and too dispersed. ATCOs were unable to distinguish between the different TWY & RWY lights at the aerodrome. ATCOs commented that when managing an a/c and attention was diverted to a secondary task, it took more/too much time and effort to re-establish visual contact compared to in a tower. Aid to help track a/c e.g. an indicator, label or radar information projected onto the panoramic screen to help ATCOs in such	**On-going** *Requirement(s)* -Picture quality under different light / dark conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c/ in the vicinity as required *Recommendation(s)* -ATCO SA needs to be assessed more systematically using different scenarios / events. SA is so essential to ATCOs performance it should be re-assessed in all future TWR validation activities (in active mode trials) in both CAVOK & low visibility / light conditions -Need to re-assess picture quality in a future

		situations, plus help ATCOs to more quickly identify a/c, objects & enhance SA were said to be strongly needed. The infra-red (IR) facility were found to be very useful & improved ability to identify a/c in poor visibility conditions e.g. darkness & fog especially when contrast was high e.g. on manoeuvring area / asphalt. But when contrast between back-ground was not good e.g. on horizon to see plane on approach, IR was not so useful. IR needs to be further evaluated e.g. to investigate if it can support the handling of one or more a/c or a/c vehicle, and also with ATCOs in an active mode of work as opposed to passive mode. IR overlay on panoramic screen that could be switched on or off by ATCO was suggested by ATCOs. SA to be further rated in active mode. **EXE-VP-057** SA overall very good in daylight, in good visibility conditions (CAVOK), the advanced features i.e. ACV, tracking label overlays, radar display, were found to improve SA particularly with regards to being surprise by an event and searching for information (SASHA criteria). The a/c automatic identification & tracking function was found to support human performance and enhance ATCO SA. It was found to overcome the problem identified in EXE-VP-056 in which ATCOs found it difficult to re-locate an a/c in the aerodrome vicinity once they had focused attention away from the a/c. The a/c automatic identification & tracking function was said to be an essential component of the remote tower facilities as it enhanced SA and overcame some of the problems associated with the visual reproduction, and picture quality. However, there was a tendency for the automatic identification & tracking function to identify and track non related objects such as birds. Thus this function needs to be refined so that only	trials under various conditions e.g. different light / dark conditions to ensure that quality of picture in terms of picture resolution, freezing, pixilation are acceptable to the end users & ATCOS can continuously monitor a/c in the vicinity as required -Infra red (IR) (Thermal imaging) function should be implemented to facilitate operations in dark and low visibility conditions. IR usability & picture quality needs to be improved -Additional Camera Viewpoints (ACV) should be available in the basic system set-up. Attention needs to be given as to where these ACV are located e.g. at hot spots, and the number required needs to be assessed on a aerodrome by aerodrome basis - A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance, in particular SA and reduce the potential for error. But this function must be fine-tuned so that it tracks only relevant objects e.g. a/c and aerodrome vehicles and is more stable. - Investigate additional automation functions for the PTZ might to enhance usability of the PTZ feature, e.g. Pre-sets for the PTZ, automatic a/c tracking function. - The set-up of the visual reproduction screens in terms of number of screens, layout, and orientation, area covered and included in the panoramic view to be further investigated / Assess more systematically what set-up . viewing angle regarding the visual reproduction screen is needed to optimise human performance, e.g. 360 degree view on a 360 degree screen, or 200

		relevant objects e.g. a/c and aerodrome vehicles are identified and tracked. Comparison of the advanced RT system which included radar and the automatic identification, labelling and tracking function showed that: Overall situation awareness (SA) found to be significantly greater for Advanced system compared to Basic. • Significant improvement found for ratings on SASHA dimensions 'surprised by an event' and 'search for information' • Improvement in situation awareness reported to be mainly due to radar and video tracking labels The main contributory factor for this improved SA was unanimously attributed by the ATCOs to the automatic identification, labelling and tracking function **EXE-VP-058** Situation awareness rated using SASHA was high throughout the trials. The PTZ and IR camera were said to contribute most to the high situation awareness. The tracking overlay of the a/c automatic identification and tracking function was unstable and jumping within 10NM of the helipad and said to negatively impact SA. The ambient sound was said to help enhance the AFSO situation awareness. At dusk and dawn the visual reproduction screens were prone to freezing and pixilation.	degree on 140
2.3.7.4 (SA2)	ATCOs are unable to accurately judge aircraft separations visually under remote tower operations. If ATCOs are unable to accurately judge aircraft separations visually under remote tower operations for example, if the resolution on the panoramic screen is relatively poor, this will lead to an increase in the potential for separation infringements and *other human related errors*, which would be *unacceptable* for pilots and ATCO/AFISOs.	**EXE-VP-056** Most of the ATCOs reported that it was difficult to judge distances and separation between a/c using the panoramic displays and so proven methods of separating using visual separation may have to be rethought. In CAVOK judging distances without the help of RDP (radar data processing) was said by 1 ATCO .to be close to impossible on distances further than 2km & the scenarios where visual	On-going *Recommendation(s)* -Investigate in future validation activities the feasibility of visual separation with different RT set ups / support tools -Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g.

	Furthermore if ATCOs are unable to accurately judge aircraft separation then ATCO/s will have to revert to procedural control. If this is the case ATCO workload will increase and furthermore, efficiency and capacity benefits will not be realised.	separation are used in real life would probably require different working method in RTO.' ATCOs commented that with this current version of this system if VFR traffic was involved, the number of movements should be restricted should be as it is not possible to visually separate IFR &VFR flights. **EXE-VP-057** Overall ATCOs reported that they were unable to accurately assess distance and depth[3] (50% & 64% either disagreed or strongly disagreed to be able to judge distance & depth acceptability using the visual reproduction) As a result opinion was divided on the ability to assess a/c separation in the air using the visual reproduction. The majority of ATCOs (8/14) felt able to assess separation in air, but 4/14 strongly disagree that they were able to – further investigation required. Overall ATCOs did not feel capable of applying visual separation in the 'basic' RT set-up. Thus vertical & procedural separations can be applied but not visual separation based on OTW view. More ATCOs felt that visual separation could be applied with the 'advanced' RT set-up when radar and automatic a/c identification were available compared to the 'basic' system when there was no radar and automatic a/c identification and labelling. However, all agreed that reduced visual separation should not be applied in the Advanced RT setup investigated in EXE-VP-057.	type & number of simultaneous movements that can be safely handled in future RT set-ups to be defined - Radar should be implemented if ATCOs are providing Approach services and the number of simultaneous air movements exceeds two - Feasibility of some aid / tool to help ATCOs judge distance, separation to be investigated - Ability to accurately judge aircraft separations visually under remote tower operations to be re-assessed in future validation activities (RTS and/or trials). -The impact of familiarity / experience on ability to judge separation visually in the remote tower should be assessed over a relatively long period of time to see if experience working with remote tower facilitates ATCOs ability to judge distances.
2.3.7.5 (SA3)	Pilots are aware of something (e.g. an object on the runway), but ATCO/AFISOs are not aware and cannot confirm. There may be an occasion when pilots are aware of something such as an object on the runway but ATCO/AFISOs are not aware and cannot confirm themselves so would have to contact and ask personnel	**EXE-VP-058** Scenario not specifically investigated but feedback from pilots regarding communication, information provision, co-ordination and accuracy of MET were all rated by pilots as being acceptable. Furthermore, in relation to the level of service provided 90% indicated a positive response. In addition 3 out 5 of the pilots	Not addressed *Recommendation(s)* -Scenario to be investigated in future trials

[3] It should be noted that in research literature 'the human ability for depth perception is in terms of stereoscopic vision, eye accommodation, etc. is limited to a range of 7 metres and that depth perception above this range is dependent on judgement of other factors (size, speed, position) based on ATCOs experience'. [16]This suggests that depth perception is a function of experience and image quality.

	located on-site to verify. This may lead to a lack of trust on the pilots'' behalf, and they may be less likely to follow and accept clearance instructions from ATS. In addition it may lead to them not accepting remote tower operations, so reducing aircrew *acceptance* of the concept.	agreed and 2 out of 5 strongly agreed that the level of AFIS service received via the remote tower was at least the same as would be received from a local aerodrome tower.	
2.3.7.6 (SA4)	ATCO/AFISOs have difficulty judging distances between aircraft and other objects with the panoramic screen. ATCO/AFISOs may find that it is more difficult to judge distances using the 3D panoramic screens compared to the real world view from the tower. This will reduce ATCO/AFISO*s situation awareness* and hence lead to an *increase* in the potential for *human error*. (SA4)	**EXE-VP-056** ATCOs feedback indicates that ATCOs found it difficult to assess distances between a/c and other objects using the panoramic LCD displays. Ability to judge depth & separation was most difficult to judge for flight in the air but easier on ground as there were references around each object at all times. ATCOs generally felt that methods of separating using visual separation with RTO might have to be rethought, e.g. going back to procedural separation or using radar to a larger extent to ensure separation to the threshold. Some ATCOs suggested that the position of cameras could be more optimal and this may help to better judge separations / distances. **EXE-VP-057** As 2.3.7.4. Overall ATCOs reported that they were unable to accurately assess distance and depth (50% & 64% either disagreed or strongly disagreed to be able to judge distance & depth acceptability using the visual reproduction). Opinion was divided on the ability to assess a/c separation in the air using the visual reproduction. The majority of ATCOs (8/14) felt able to assess separation, but 4/14 strongly disagree that they were able to. **EXE-VP-058** AFISO requested that the adjustments to the OTW angle to improve the view of the helipad.	On-going *Recommendation(s)* -Investigate in future validation activities the feasibility of visual separation with different R/T set-ups -Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g. type & number of simultaneous movements that can be safely handled in future RT set-ups to be defined -Feasibility of some aid to help ATCOs judge distance, separation to be investigated -Assess impact of position of cameras to help assess distances between objects & depth - Ability to accurately judge aircraft separations visually under remote tower operations to be re-assessed in future validation activities (RTS and/or trials). -The impact of familiarity / experience on ability to judge separation visually in the remote tower should be assessed over a relatively long period of time to see if experience working with remote tower facilitates ATCOs ability to judge distances.

2.3.7.7 *(SA5)*	Lack of external sound from aerodrome reduces controller situation awareness. Controller will not be able to hear the number of revolutions for both aircraft on ground as well as aircraft on final. This lack of auditory information may result in controller *situation awareness being reduced*. The transmission of the external sound from the aerodrome may help to increase SA	**EXE-VP-056** External sound was found to be beneficial to most ATCOS especially when visibility was low as it was another source of information that could be used to help determine the location of an a/c, e.g. go around in low visibility conditions could be heard but not seen. A couple of ATCOs found the external sound too sensitive & this caused them to turn off the sound e.g. birdsong. Overall, it was agreed that the transmission of external noise from the aerodrome should be provided but should be adjustable within certain degrees. **EXE-VP-057** Feedback on ambient sound was mixed. 7/14 ATCOs agreed (some strongly) that it was useful, 1 strongly disagreed and 6 neither agreed nor disagreed. The ATCOs that said it was useful said that it acted as a useful addition and was an auditory cue to check on a/c. However, 1 ATCO admits they mistook a motorbike for a ATR revving its engine. In addition there were some technical problems and the sound was not working all the time, so certain ATCOs felt they could not give an opinion. **EXE-VP-058** The ambient sound was reported to help enhance the AFISOs situation awareness	On-going *Recommendation(s)* -Provide external sound that can be adjustable within certain degrees
2.3.7.8 *(SA6)*	Visual and /or auditory cues (e.g. a puff of smoke from the wheels when landing, sound of birds, weather phenomena, lightning) are lost. Reduced picture quality and sound quality may mean that the more subtle auditory cues used by ATCOs, e.g. a puff of smoke from the wheels when landing, are lost. Thus situation awareness would be reduced due to the reduced picture	**EXE-VP-056** Auditory cues e.g. the sound of birds were detectable see 2.3.7.7. Observed changes in the weather / met conditions e.g. clouds, cloud base were difficult for ATCOs to judge in the present version of the system. Therefore perhaps some indication of	On-going *Recommendation(s)* -Provide metrological information including cloud base indicators & visibility indicator, if a windsock is present at the aerodrome, it should

	quality and sound, which may result in an increase potential for *human error* and reduce ATCO *acceptance* of RTO	cloud coverage, cloud base was needed on the CWP. Also to note: a engine failure on take-off was simulated, the ATCO was able to detect a problem as s/he could clearly see the slow angle of climb and the change to a higher angle when both engines were introduced. **EXE-VP-057** Not explicitly investigated. **EXE-VP-058** Not explicitly investigated.	be in ATCOs viewing range - Specific scenarios / events (e.g. a puff of smoke from the wheels when landing, gear down (or not) on landing, sound of birds, weather phenomena, lightning) to be agreed on with safety & operational experts) to be scripted into future validation activities (RTS/ trials) to assess ATCO situation awareness under varying conditions.
2.3.7.9 (SA7)	The automation (EFS, automatic a/c identification and tracking) reduces ATCO/AFISOS' *situation awareness.* The introduction of automation e.g. EFS, a/c identification and tracking, may result in the ATCO/AFISOs feeling more 'out-of-the-loop' leading to ATCO/AFISO *vigilance being negatively impacted* and *situation awareness* being reduced. Both of which could result in *increased potential for human error* and ATCO/AFISOs being *reluctant to accept* the automation being introduced.	**EXE-VP-056** Not investigated **EXE-VP-057** The advanced system with ACV, automatic tracking & radar displays was found to enhance SA, particularly with regards to 'being surprised by an event' and 'searching for information' (SASHA criteria). In the advanced RT ATCOs felt more able to 'detect potential hazardous situations in the air' between a/c than in the basic configuration (9/12 compared to 7/10) – this was said to be mainly due to the radar surveillance & tracking functionality. The 'detection of potential conflicts on the manoeuvring area' is also improved in the advanced RT configuration in particular for runway incursion detection (11/12). This improvement is said to be due to the video tracking and additional cameras. **EXE-VP-058** The automatic a/c identification and tracking function was not stable and was jumping around and the AFISO reported that as this function was not working properly it had a negative impact on situation awareness	On-going *Recommendation(s)* -Additional Camera Viewpoints (ACV) should be available in the basic system set-up. Attention needs to be given as to where these ACV are located e.g. at hot spots, and the number required needs to be assessed on a aerodrome by aerodrome basis - A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance, in particular SA and reduce the potential for error. But this function must be fine-tuned so that it tracks only relevant objects e.g. a/c and aerodrome vehicles -If additional automation is added then it must be assessed in terms of its impact on SA in future validation activities.

2.3.7.10 *(SA8)*	Lack of depth in the presentation on the screens means its difficult for ATCO/AFISOs to judge distances. The ATCO/AFISOs may have difficulty estimating distance and the possibility for fast action might decrease and affect the ATCO/AFISO *situation awareness, efficiency* and increase the potential for *human error*.	**EXE-VP-056** ATCOs reported that overall depth / distances were generally difficult to judge, due to the poor picture quality and picture 'jumping'. It was most difficult to judge depth / distance for flights in the air and easier on the ground as you have references around each object at all times. Ability to judge depth & separation was most difficult to judge for flight in the air but easier on ground as there were references around each object at all times. See 2.3.7.4 & 2.3.7.6 for more / related information. **EXE-VP-057** Overall ATCOs reported that they were unable to accurately assess distance and depth (50% & 64% either disagreed or strongly disagreed to be able to judge distance & depth acceptability using the visual reproduction). However, it should be noted that depth perception over long distances (above approx. 6m) is usually determined relative to different objects so this could be something that is acquired with knowledge of the environment and experience [14]. Mitigation based on reference to other objects to be considered.	On-going *Recommendation(s)* -Consider introduction of an aid/tool to support ATCOs judge distance, separation to be investigated. -The impact of familiarity / experience on ability to judge separation visually in the remote tower should be assessed over a relatively long period of time to see if experience working with remote tower facilitates ATCOs ability to judge distances.
2.3.7.11 (SA9)	Variation of light in the picture. The cameras affect the visual presentation as each camera has got its own settings which may cause differences in the view from one camera to another. Sun glare, too bright sky and dark ground – can occur as a result of the cameras built in automatic control. This reduced image quality / reduce might have impact on ATCOs *situation awareness* and *decision making*.	**EXE-VP-056** Light variation in the picture did affect visibility, at times the picture on display was too bright and there no picture contrast e.g. when the cameras were humid, and when the sun was shining directly into the cameras. In such conditions ATCOs did not have much chance to detect a/c. In real life ATCOs have sun-blinds and /or sunglasses to overcome this problem. The automatic contrast control may be useful & give benefits but only to a certain degree, e.g. ATCOs feedback was that the real world conditions should be followed so that wrong information is not given to the pilots e.g. light / visibility, but perhaps technology could be used to stretch the day for 1-2 hours in the	On-going *Requirement(s)* -Automatic contrast control should be implemented *Recommendation(s)* -Parameters of automatic contrast control as well as Enhanced Visualisation Features (EVF) (e.g. improving visibility using technical means need to be defined and should be investigated to ensure light conditions are not distorted to such

		evening and morning **EXE-VP-057** Light variation not reported to be an issue **EXE-VP-058** More filters were requested on the cameras at the helipad	a degree that it provides ATCO/AFISOs with an inaccurate picture of the lighting levels in the real world that may impact ATCO decision making . More generally Enhanced Visualisation Features (EVF) (e.g. improving visibility using technical means) need to be tested more systematically to find the optimum level in which only benefits are provided in terms of SA & performance and no negative impacts result -Provide ATCO/AFISOs with additional information relating to light/dark conditions at aerodrome to be assessed
2.3.7.12 (SA10)	Disturbance by joint seam covering between the screens. The joint / seem between the different screens may have a negative impact when maneuvering the PTZ camera as well as the static picture and might interfere with e.g. TWY taxiway and foreign object detection. This could impact ATCO/AFISO *situation awareness*	**EXE-VP-056** In this current system version seams were considered to be a bit disturbing for some ATCOs. The positioning of seams at hot spots e.g. holding positions, TWY entrance / exits, run-up areas and stop bars, must be avoided. **EXE-VP-057** Joint seams were reduced in size in EXE-VP-057 but one or two ATCOs still considered them a slight issue in EXE-VP-057.	*Closed* *Requirement:* -Ensure joint seam are not located at 'hot spot' places. The positioning of seams at hot spots e.g. holding positions, TWY entrance / exits, run-up areas and stop bars, must be avoided.
2.3.7.13 *(SA11)*	Cognitive discrepancy and variance between 360 degrees of view and the same view presented on 180 degrees screen presentation may disorient ATCO/AFISOs & impact their situation awareness. ATCO/AFISOs *situation awareness* might be affected when a passing aircraft doing a 360 circuit can be seen on a 180 degrees presentation. It is also more difficult to judge distances using 180º screens compared to the real world view from the tower, which is 360	**EXE-VP-056** Not investigated as 360 degree view of aerodrome used. But with 360 degree view there was a lot of light / reflection due to the number of screens that were positioned in a circle around the ATCO that was said to cause eyestrain. **EXE-VP-057** Not systematically investigated	On-going *Recommendation(s)* -Assess more systematically what set-up . viewing angle regarding the visual reproduction screen is needed to optimise human performance, e.g. 360 degree view on a 360 degree screen, or 200 degree on 140
2.3.7.14 *(SA12)*	Infra-red (Thermal imaging) camera does not increase ATCO/AFISO SA in poor visibility conditions e.g. darkness,	**EXE-VP-056** IR camera was found to beneficial and said to increase ATCO SA	On-going

	fog etc. The aim of the introduction of the infrared cameras is to increase ATCO/AFISO SA in poor visibility conditions e.g. darkness & fog. If the infra-red cameras do not achieve this benefit then ATCOs will have to resort to LVP. This may impact capacity / aerodrome throughput.	in poor visibility conditions compared to current tower operations, especially when there was a contrast, e.g. on the asphalt, IR was not so effective when the contrast was low e.g. tracking an a/c in the sky. The IR also made it easy to determine cloud coverage at night / in darkness. **EXE-VP-057** IR not working reliably in EXE-VP-057 so not really investigated systematically in EXE-VP-057. **EXE-VP-058** The IR camera was said to enhance situation awareness and along with the PTZ camera was said to be the function that contributed most to the AFISO situation awareness, as it was used to help assess the weather situation, and used to assess cloud base and consistency in the dark.	*Recommendation(s)* -Infra red (IR) (Thermal imaging) function should be implemented to facilitate operations in dark and low visibility conditions. -IR to be further investigated in TWR environment in terms of usability & utility (picture quality when contrast is low e.g. tracking an a/c in the sky)
2.3.7.15 (WM1)	Increased head down time. If ATCO/AFISOS feel that the outside view of the aerodrome environment presented on the screens is not of a good quality they may tend to rely more at the information displayed on the CWP, e.g. radar, EFS. This may impact controller *situation awareness* in some way e.g. ATCO/AFISOs may be less likely to spot unusual objects in the aerodrome vicinity as they are not using the out of the window view (due to its poor quality) and may *increase potential for human error.*	**EXE-VP-056** Not fully investigated in EXE-VP-056 but one of the ATCOs in week 2 did report that his working method had changed in RTO due to the fact that he did not trust the image presented on the panoramic displays due to the screens blacking out, as well as the fact that sometimes the picture on the visual reproduction panoramic screens was not very clear. As a result he used the radar as his primary source of information and the OTW view presented on the visual reproduction screen as a secondary information source which is the opposite of the recommended & trained working method in current tower operations and. This could also have some safety implications. **EXE-VP-057** Not raised as an issue in EXE-VP-057, PTZ & hot spot cameras were integrated onto the visual reproduction screen.	On-going *Recommendation(s)* -Re-assess feasibility of integrating PTZ & IR images in the visual reproduction with images, looking at different possible options e.g. reposition of PTZ images or use of smaller images

		EXE-VP-058 Not raised as an issue.	
2.3.7.16 (WE2)	The size and design of the remote control room may limit the number of screens that can be implemented. This may restrict the view of the aerodrome environment that can be presented to ATCO/AFISOs in the remote tower and may impact visibility and hence ATCO/AFISO *situation awareness.*	**EXE-VP-056** In the trial a 360 degree view from Angelhome tower was captured by 9 50degree LCD monitors each showing 40degree which circled the CWP, so was not considered an issue. Most of ATCOs commented that they could see more of the APT environment in the RT than in normal ops. However, the fact that the LCD visual reproduction screens were located in a circle around the ATCOs was seen as a potential issue as it increased the lighting contrast in the RT ops room and this was said to contribute to eyestrain & tiredness. During the trial the 4 back monitors were temporary switched off. Working with only the 5 front monitors was said to improve eye strain and was not seen as a problem for SA. **EXE-VP-057** In EXE-VP-057 9x 42inch LCD visual reproduction screens / monitors were arranged in a 'broken' circle – 6 in front and 3 to the rear (I screen for each of the 9 cameras fitted at the aerodrome) providing a broken 360 degree view of the aerodrome vicinity. This set up was considered acceptable to the ATCOs. **EXE-VP-058** In the AFIS trial 9 were14HD cameras which provided a 360 degree visual view of the heliport, which was presented on 55inch LCD portrait orientated monitors in the RTC in a 'broken' circle – 6 in front and 3 to the rear (I screen for each of the 9 cameras fitted at the aerodrome) providing a broken 360 degree view of the aerodrome vicinity. This set up was considered acceptable to the ATCOs.	On-going *Recommendation(s)* -Assess more systematically what set-up / viewing angle regarding the visual reproduction screen is needed to optimise human performance, e.g. 360 degree view on a 360 degree screen, or 200 degree on 140
2.3.7.17	Enhanced visualization features (e.g. improving visibility	**EXE-VP-056**	On-going

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(SA13)	of aerodrome on screens) actually distorts ATCOs awareness of the operational environment (identified in EXE-VP-056)	Identified as an issue.	*Recommendation(s)* -Enhanced Visualisation Features (EVF) (e.g. improving visibility using technical means) need to be tested more systematically to find the optimum level in which only benefits are provided in terms of SA & performance and no negative impacts result
2.3.7.17	The IR (thermal imaging) increases situation awareness with regards to certain aspects compared to current day operations, for example ATCOs ability to see in the dark and low visibility conditions, e.g. in identifying and monitoring a/c & vehicles, determining cloud coverage & consistency	**EXE-VP-056 & EXE-VP-058** Identified as a benefit of IR in R/T	
Arg. 2.3.8: The user Interface design supports a sufficient level of team situational awareness.			
	N/A		
Arg. 2.3.9: Workstations (e.g. cockpit layout and consoles) adhere to ergonomic principles.			
2.3.9.1 (WE3)	The size of screen may be limited by the space available in the remote tower operations room as well as by cost. In addition large screens require cooling system that can be noisy and which may distract the controller and mask other sounds in the remote tower. However, small screen may also cause potential problems as if they are too small it may cause ATCO/AFISOs to strain their eyes and hence lead to *fatigue* and *other symptoms* such as headache.	**EXE-VP-056** The size of the LCD monitors was not said to be a problem for ATCOs in EXE-VP-056. **EXE-VP-057** Size of screens was considered adequate by most of the ATCOs (24% disagreed). A couple of ATCOs suggested changing the orientation of the screens to portrait so they could see more of the sky/ aerodrome vicinity.	On-going *Recommendation(s)* -The set-up of the visual reproduction screens in terms of number of screens, layout orientation, area covered and included in the panoramic view, viewing angle etc. should be tailored and assessed for each environment in which RT is implemented
2.3.9.2 (PE1)	Artificial light inside the remote tower operations room cabin / no daylight leads to fatigue.	**EXE-VP-056** The artificial ambient light together with the light being emitted from each of the 9 LCD display monitors was found to cause eye strain & fatigue. This was found to be a real problem. The contrast in lighting from the background and the various light sources need to be reduced in some way & the number of different light sources minimised. It should be noted that when the 4 back monitors were switched off it eased the level of eye strain experienced and so this questions the need / benefit of a	On-going *Recommendation(s)* - Ensure there are controls to adjust monitor brightness and room illumination -Ensure there is natural light source in operations room -Investigate impact of RT set-up / environment on fatigue. If fatigue is found to be an issue

		360degree view that encircles the CWP. **EXE-VP-057** Fatigue not reported to be a problem	investigate possible means to prevent or mitigate fatigue e.g. reduce hours per shift or introduce more frequent breaks within a shift, make adjustments to the lighting ambient environment or R/T set-up
2.3.9.3 (PE7)	The contrast between the ambient lighting and light emitted from LCD monitors/visual reproduction screens causes eyestrain & fatigue (from EXE-VP-056)	**EXE-VP-056** ATCOs reported that the contrast between the ambient lighting and screens and other light sources caused eyestrain & fatigue and could contribute to headaches. In week 2 & 3 the 4 back LCD monitors were switched off and this was found to immediately reduce the eye strain experienced by ATCOs. This suggests that the number of screens should be limited to the minimum required for ATCOS to perform their work safely, efficiently & expeditiously, and opens the questions to whether a 360degree perspective of the aerodrome presented on 9 screens circling the ATCO position is necessary. **EXE-VP-057** The lighting conditions in the remote tower operations room were considered appropriate (only 1 ATCO disagreed, 2 neither agreed nor disagreed, and the rest agreed).	On-going *Recommendation(s)* -Ensure the lighting conditions in the remote tower are considered in the design of the remote tower operations room – use HF recommended practice/ guidelines/ standards-Ensure there are controls to adjust monitor brightness and room illumination -Ensure there is natural light source in operations room
Arg. 3.1: Effects on team composition are identified.			
ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 3.1.1: Changes to existing roles in the team are identified (including roles that become obsolete).			
	N/A		
Arg. 3.1.2: The introduction of new roles to a team is identified.			
3.1.2.1	New roles emerge as a result of single remote operations e.g. technicians to maintain cameras, visual reproduction display & associated software etc.	**Task analysis & EXE-VP-056** 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	On-going *Recommendation(s)* -Define new responsibilities/task of technical engineers

		software and hardware. The technical engineers must be available at all times in case of any technical failure	-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

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

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 3.2.1: Changes to the task allocation between human actors do not lead to adverse effects on human tasks.			
3.2.1.1	Allocating certain tasks, e.g. met obs to aerodrome staff, negatively impacts efficiency of how tasks are performed increases potential for error. This may impact overall system efficiency and depending on what type of errors occur perhaps safety	Not explicitly investigated although feedback from ATCOs indicates this is not a major issue for the meteological 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
Arg. 3.2.2: The proposed task allocation between human actors is supported by technical systems/the HMI.			
3.2.2.1	ATCO/AFISO have trouble contacting with aerodrome staff. This may negatively impact efficiency.	**EXE-VP-058** In the advanced mode technical problems with the Voice Communication System (VCS) made it very difficult for the AFIS to communicate with the staff at the heliport	Not addressed *Recommendation(s)* -Ensure facility to enable direct communication between ATCO/AFISOs and the necessary aerodrome staff is available at all times, e.g. investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower
Arg. 3.2.3: The potential for human error in team tasks is reduced as far as possible.			
3.2.3.1	The fact that certain tasks e.g. met obs., will be performed by aerodromes staff and not ATCO, increases the potential for human error.	**EXE-VP-058** Not explicitly investigated in the advanced AFIS trial	Not addressed *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 active mode trials
Arg. 3.2.4: Team tasks can be achieved in a timely and efficient manner.			
3.2.4.1	The fact that certain tasks e.g. met obs., will be performed by aerodromes staff and not ATCO, increases the time taken to perform those task and hence reduces efficiency.	**EXE-VP-058** Not explicitly investigated in the advanced AFIS trial	Not addressed *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 active shadow mode trials

Arg. 3.3: The communication between team members supports human performance.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED PLUS RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 3.3.1: Intra-team and inter-team communication supports the information requirements of team members			
3.3.1.1 (RT2)	Pilots try to 'cheat' if they know ATCO/AFISO is not there. If the aircrew know the ATCO/AFISOs are not present onsite at the aerodrome, they may assume they are less aware of what is going on and so try to 'cheat' by perhaps not providing all the necessary / correct information in order to try an earlier arrival or departure slot.	Not investigated	Not addressed *Recommendation(s)* -Conduct workshop with ATCO/AFISO & pilot to investigate issue
3.3.1.2 (TD1)	There is a perceived shift in authority due to absence of ATCO/AFISO at aerodrome e.g. between aircrew and ATCO/AFISOs' and local staff. The absence of the ATCO/AFISOs may mean that aircrew and local aerodrome staff may be less inclined to follow ATCO/AFISO instructions and / or may make decisions that currently need to be verified by ATS without consulting ATCO/AFISOs. This may have serious *safety consequences*.	Not investigated	Not addressed *Recommendation(s)* -Conduct workshop / interviews with AU and ATCO/AFISOs to brainstorm issues as well as possible mitigations -Develop an information campaign to ensure roles, tasks and procedures and chain of command are clarified for ATCO/AFISOs, aerodrome staff, aircrew and airlines. -Allow onsite aerodrome staff representatives and airline representatives to visit the remote tower so they can understand remote tower operations and communicate back to their staff

			members
Arg. 3.3.2: The phraseology supports communication in all operating conditions.			
3.3.2.1	Current phraseology used by ATCO/AFISOs & aircrew is no longer appropriate or acceptable under normal, abnormal and degraded modes of operation. This may result in communication errors between ATCO/AFISO and aircrew	**EXE-VP-057** Recommendation from the two airspace users attending the trial is for ATCO/AFISOs to inform aircrew that they are remotely located in initial contact with aircrew.	On-going *Recommendation(s)* -Issues relating to phraseology need to be investigated more systematically in a SME workshop. Conduct workshop / interviews with AU and ATCO/AFISOs / phraseology experts to identify any additional relevant phraseology or required changes to current phraseology and if necessary develop appropriate phraseology
Arg. 3.3.3: Changes in communication means & modalities are identified and acceptable.			
3.3.3.1 (CM1)	Co-ordination with on-site aerodrome personnel e.g. fire-fighters, may be more difficult. In the remote tower, ATCO/AFISOs will not be able to have direct (face to face) interaction and communication with aerodrome personnel if necessary for whatever reason on an ad hoc basis. Hence, communication with aerodrome personnel will be via radio or telephone, and this may reduce communication efficiency and lead to an increase in communication related errors, i.e. the message not getting to the intended person in the required time.	EXE-VP-057 Mentioned as a concern in EXE-VP-057, mitigations as recommended	Not addressed *Recommendation(s)* -Ensure facility to enable direct communication between ATCO/AFISOs and the necessary aerodrome staff is available at all times, e.g. investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower
Arg. 3.3.4: The communication load of team members is acceptable in normal and abnormal conditions and degraded mode of operations.			
3.3.4.1 (RT1)	ATCO/AFISOs requests for pilot information and information confirmation are increased. If ATCO/AFISOs do not trust the information displayed in the remote tower or if the visibility in the remote tower is not as good as current day operations in the tower ATCO/AFISOS may request more information or confirmation of information from the aircrew. This would increase the amount of communications between the pilot and ATCO/AFISO and so increase ATCO/AFISO and pilot task load and hence may lead to an increase in ATCO/AFISO and pilot workload. This in turn would result in RTO being less acceptable and	**EXE-VP-058** Not considered an issue in the advanced AFIS trial, but needs to be more explicitly investigated in TWR trials	Not addressed *Recommendation(s)* - Investigate impact of RT on communication load in future trials (active mode) / post implementation monitoring

	accepted by ATCO/AFISOs and aircrew.		
Arg. 3.3.5: Team members can maintain a sufficient level of shared situation awareness.			
3.3.5.1	Being remotely located impacts ATCO SA of with regards to what the GND staff is doing and vice versa. This may impact efficiency and increase potential for error, and hence have certain safety implications	**EXE-VP-058** Not explicitly investigated but not considered an issue by the AFISO in the AFIS advanced trials, however the AFISO had had intensive training at the helipad and knew the GND staff well as a result the AFISO emphasised the importance of having training on the at the helipad / aerodrome being controlled remotely before actively controlling traffic to that heliport / aerodrome remotely and building a relationship with the ground staff to ensure the AFISO have a good understanding of the GND staff, their work and local environment	Not addressed *Recommendation(s)* -Ensure facility to enable direct communication between ATCO/AFISOs and the necessary aerodrome staff is available at all times, e.g. investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower -Ensure ATCOs are fully aware of the GND staff role, tasks and working methods by arranging visits to the aerodromes being controlled remotely and also regular meetings and vice versa

Arg. 4.1: The proposed solution is acceptable to affected human actors.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED	RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 4.1.1: Changes in roles and responsibilities are acceptable to the affected human actors.				
4.1.1.1 (TD2)	Team work / confidence between aerodrome staff and ATCO/AFISOs due to change in relationships as a result of being located remotely. As above, the absence of ATCO/AFISOs onsite at the aerodrome may change the current relationship between ATCO/AFISOs and aerodrome staff. They may be less inclined to work as a team and a *lack of trust* between onsite and remote tower workers may develop.	**EXE-VP-057** Mentioned as a concern, suggested mitigations as recommended		On-going *Recommendation(s)* -Select representatives from on-site and off-site locations to ensure there is a continuous dialogue between both staff members -Ensure regular meetings between remote and on-site staff ideally face to face but if that's not possible video conference -Conduct a workshop with aerodrome staff and ATCO/AFISOs to brainstorm potential consequences of this issue & mitigations
4.1.1.2 (WP1)	Aircrew are not aware ATCO/AFISOs are not in the tower located onsite at aerodrome.	**EXE-VP-057** General feedback from airspace users attending EXE-VP-057 indicates that ATCO in remote tower should state that they are		On-going *Recommendation(s)*

		remotely located in initial contact with aircrew	-Issues relating to phraseology need to be investigated more systematically in a SME workshop. Conduct workshop / interviews with AU and ATCO/AFISOs / phraseology experts to identify any additional relevant phraseology or required changes to current phraseology and if necessary develop appropriate phraseology -Information campaign to inform airlines / pilots that remote tower operations are in place at specific aerodrome and also to explain remote tower operations -Workshop with aerodrome staff and ATCO/AFISOs might be necessary to brainstorm potential consequences of this issue as well as mitigations
4.1.1.3 (WP3)	Sensation of working in a control room or simulator. Being away from the aerodrome environment and not having the outside tower view may result in some ATCO/AFISOs feeling they are working in a simulator or control centre. In this way they may lose the sensation of reality and may feel detached from the operational environment. This could impact their *situation awareness, performance* in general and hence *safety*.	**EXE-VP-056 & EXE-VP-057** Not investigated although mentioned as a concern	On-going *Recommendation(s)* -Keep the TWR-atmosphere as far as possible i.e. aim to have the same look and feel as a tower control room OR maximise the differences as it is a new job with new equipment and representation of the tasks -Introduce as many cues as possible and keep local knowledge alive (from both sides) -Ensure regular meetings between remote and on-site staff ideally face to face but if that's not possible video conference -Investigate feasibility of using intercom, webcam
4.1.1.4 (WP4)	Decreased possibilities to physically interact with aerodrome staff. Limited possibilities for face to face interaction with aerodrome staff and pilots, may reduce communication, this may reduce *trust* between staff located onsite at aerodrome and offsite in the remote	**EXE-VP-056 & EXE-VP-057** Not investigated although mentioned as a concern **EXE-VP-058**	On-going *Recommendation(s)* -Verify relevance of interaction with APT staff on services provided i.e. does the possibility to

	tower, this may also lead to *lack of acceptability* of remote tower concept.	Not explicitly investigated. However, the AFISO had had intensive training at the helipad and knew the GND staff well as a result the AFISO emphasised the importance of having training on the at the helipad / aerodrome being controlled remotely before actively controlling traffic to that heliport / aerodrome remotely and building a relationship with the ground staff to ensure the AFISO have a good understanding of the GND staff, their work and local environment .	interact with the APT staff improve the ATS provided? - Ensure regular meetings between remote and on-site staff ideally face to face but if that's not possible video conference -Investigate feasibility of using intercom, webcam
4.1.1.5	Controller acceptance Organisational issues based on consequences within management and direction. ATCO/AFISOs experience a lack of interaction with the management which might cause an overall effect on concept acceptance.	**EXE-VP-056** Overall ATCOs could not see why the concept for single remote tower operations could not work but the current system needs to be improved to make it workable in terms of the reliability of the system, resolution, update/refresh rate, PTZ & CWP Younger ATCOs seemed to be quite accepting of the RT concept, one even questioned why this had not been done before. Management is considered to be of great importance to the project success, e.g. information, communication & ATCO involvement is important.	Not addressed
4.1.1.6 (S4)	Lack of TWR controller involvement during phase of development. Failure to involve the ATCO/AFISOs in the development of the remote tower concept may lead to ATCO/AFISOs not accepting and/or trusting remote tower operations.	ATCO/AFISOs are actively involved in the design and development of the remote tower concept for single tower operations – the HP assessment process facilitates and systematises this involvement	On-going *Recommendation(s)* -Adopt / continue to use a human centred approach in the concept design & development process
4.1.1.7 (S6)	ATCO/AFISO do not accept the remote tower concept in general	Human centred approach adopted as far as possible on the project by performing a HP assessment this helps to ensure that the ATCO/AFISP issues and concerns regarding the concept are addressed in the design and development phases and help to ensure the concept is more acceptable to the end users. **EXE-VP-056** Overall ATCOs could not see why the concept for single remote tower operations could not work but the current system needs	On-going *Recommendation(s)* -Adopt / continue to use a human centred approach in the concept design & development process -Frequent information sharing and RTC campaigns. Make external understanding for the concept and create acceptance by the use of

		to be improved to make it workable in terms of the reliability of the system, resolution, update/refresh rate, PTZ & CWP Younger ATCOs seemed to be quite accepting of the RT concept, one even questioned why this had not been done before. Management is considered to be of great importance to the project success, e.g. information, communication & ATCO involvement is important.	open channels. -Feedback from ATCOs from trials shows that the main point to increase ATCOs' acceptance is addressed by the improvement of the visual reproduction screen. Therefore, enhance picture quality of the visual reproduction screen - ATCOs' acceptance to work CWP-remote might improve in the long term with an appropriate employee selection for the role plus specializations for CWP-remote.
Arg. 4.1.2: The impact of changes on the job satisfaction of affected human actors has been considered.			
4.1.2.1 (TD3)	Team participation and identity plus local knowledge and awareness are lost. Loss of team participation and identity may impact job satisfaction. The loss of local knowledge & awareness may have some impact on ATCO/AFISO performance, and in the worst case scenario, impact safety.	**EXE-VP-057** Mentioned as a concern, mitigations as recommended **EXE-VP-058** The AFISO had had intensive training at the helipad and knew the GND staff well as a result the AFISO emphasised the importance of having training on the at the helipad / aerodrome being controlled remotely before actively controlling traffic to that heliport / aerodrome remotely and building a relationship with the ground staff to ensure the AFISO have a good understanding of the GND staff, their work and local environment	On-going *Recommendation(s)* -Ensure regular meetings / briefing sessions between remote and on-site staff ideally face to face but if that's not possible video conference -Ensure ATCO/AFISOs are able to visit the aerodromes they are controlling to ensure their local knowledge and awareness, as well as relationships with the onsite aerodrome staff are maintained -Training for remote ATCO/AFISOS should involve some onsite training at the aerodrome they will be controlling so they gain local knowledge and awareness, as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower -Workshop with aerodrome staff and ATCO/AFISOs might be necessary to brainstorm issues as well as mitigations
4.1.2.2 (WP2)	ATCO/AFISOs find it less stimulating / more boring to work in a remote tower. Some ATCO/AFISOs may miss actually working on-site at the aerodrome and being at the centre of the aerodrome operational environment and this may	**EXE-VP-057** Considered a potential issue, but not much can be done, it may result in certain people not being as interested in working in a remote tower as a real tower – this may result in 'self-selection'	Closed

	impact job satisfaction.	to the job of remote tower ATCO/AFISO	
4.1.2.2	ATCO/AFISOs prefer to work in an environment that is less isolated, in which there are more co-workers and more possibilities to interact with other ATCOS	**EXE-VP-056 & EXE-VP-057** Raised as a potential benefit	

Arg. 4.2: Changes in competence requirements are analysed.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED	RESULTS / EVIDENCE
Arg. 4.2.1: Knowledge, skill and experience requirements for human actors have been identified.			
4.2.1.1 (SK1)	ATCO/AFISOs lose certain knowledge/skills due to the filtering of reality e.g. knowledge of aircraft behaviour, local environment, local weather. The loss of certain knowledge and skills due to the filtering of reality may lead to ATCO/AFISOs' *performance being degraded* and the potential for *human error* to be increased	EXE-VP-057 Concern was expressed about the fact that the ATCOs might lose a sense of reality in their daily tasks by being remote, as well as losing extra 'information' and 'feeling' by having daily contact with field duty officers, rescue services, flight crew etc.. Being offsite also means that they may lose local knowledge including knowledge about the weather and this is particularly important in aerodromes close to mountains where there is snow, fog and changeable weather, as this information may be critical in affecting decisions & overall SA.	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 -Training for remote ATCO/AFISOS should involve some onsite training at the aerodrome they will be controlling so they gain local knowledge and awareness, as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower and also gain a knowledge of aircraft behaviour and performance
4.2.1.2 (SK2)	Skill requirements for the job change and ATCO/AFSIO no longer have the competence to perform their job. This will impact efficiency & perhaps safety, and cost effectiveness.	**Task analysis** The task analysis (Appendix D) suggests that the tasks of the ATCOs would not significantly change under remote tower operations. However, certain changes to current skills & knowledge would need to be acquired by the ATCO/AFISOs e.g. judging distances, local knowledge of aerodrome being controller etc. but some will be necessary to ensure current ATCOs are competent to perform their tasks under remote tower operations	On-going *Recommendation(s)* -Training would be necessary to ensure ATCOs are able to perform their work in remote tower environment.(exact training required needs to be defined). Develop a complete training programme for all actors impacted by the remote tower concept with pre-specified performance criteria that need to be achieved

			before they can 'go operational'
4.2.1.3 (WP6)	Important knowledge of local environment may be lost (identified in EXE-VP-056). The required level of local knowledge that is required to support ATCOs work must be identified and included in the training of remote tower operations, otherwise human performance may be negatively impacted and this could impact safety	**EXE-VP-056** Identified as a potential issue **EXE-VP-057** Mentioned as a major concern in EXE-VP-057, mitigations as recommended. In particular lack of local weather knowledge may be an issue as being offsite also means that they may lose local knowledge including knowledge about the weather and this is particularly important in aerodromes close to mountains where there is snow, fog and changeable weather, as this information may be critical in affecting decisions & overall SA. See RT4 for potential mitigations relating to lack of local weather knowledge. **EXE-VP-058** The AFISO had had intensive training at the helipad and knew the GND staff well as a result the AFISO emphasised the importance of having training on the at the helipad / aerodrome being controlled remotely before actively controlling traffic to that heliport / aerodrome remotely and building a relationship with the ground staff to ensure the AFISO have a good understanding of the GND staff, their work and local environment	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 -Training for remote ATCO/AFISOS should involve some onsite training at the airport they will be controlling so they gain local knowledge and awareness, as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower and also gain a knowledge of aircraft behaviour and performance (for AFISO from EXE-VP-058a minimum of two weeks training on-site is recommended)
4.2.1.4	There will be a larger centralised pool of ATCO/AFISOs available who are all trained and rated to use the same standardised equipment/CWP and working procedures. This will facilitate training ATCO/AFISOs to work other aerodromes being controlled using the remote tower which in turn should improve cost effectiveness as a result of reduced training costs.	Not considered	On-going
Arg. 4.2.2: The impact on operator licensing (as defined by the regulating bodies) has been identified.			

4.2.2.1	New ATCO/AFISO need to have a different license to work in remote tower centre	**Early Regulatory Impact assessment [9]** The eRIA recommendation is to wait for the final report from EASA. However, it is recommended that a specific unit endorsement at each remote tower unit for applicable aerodromes be created and the associated training should be included in the UNP. The unit endorsement should aim for the technical features at the specific unit i.e. how the system works and e.g. how many cameras are installed, description of degraded modes and procedures, etc. for each specific aerodrome. ATCOs are already rated for tower operations and it should not be necessary to have a new rating for Remote Tower operations	*Recommendation(s)* -Develop specific unit endorsements at each remote tower unit for applicable aerodromes be created and the associated training should be included in the UNP. -No new rating for single Remote Tower operations is currently seen as necessary
Arg. 4.2.3: Preliminary training needs are identified for affect human actors			
4.2.3.1 (TR1)	ATCO/AFISOs are not adequately trained to work with remote tower. Failure to train ATCO/AFISOs adequately to work in the remote tower may have serious consequences relating to *efficiency & safety.*	Not addressed in trials	On-going *Recommendation(s)* -Develop a complete training programme for all actors impacted by the remote tower concept remote tower operations with pre-specified performance criteria that need to be achieved before they can 'go operational' -Ensure ATCOs involvement plus training experts are involved in the development of the training programme
4.2.3.2 (SK3)	Negative transfer of skills and behaviour may impact human performance in terms of efficiency and increase the potential for error	Not investigated / not currently considered an issue	Closed
Arg. 4.3: Changes in staffing requirements and staffing levels are identified.			
ID	HP ISSUE / BENEFIT & IMPACT	ACTIVITY CONDUCTED RESULTS / EVIDENCE	ISSUE STATUS / RECOMMENDATION
Arg. 4.3.1: The impact on staff levels is identified.			

4.3.1.1	The remote tower concept for single tower increases the number of staff required compared to current day e.g. due to additional technical engineers required. This may reduce cost effectiveness	Not explicitly investigated. Although the single remote tower concept is based on the assumption that there will be no changes to the staffing levels of ATCO/AFISOs compared to current day	Not addressed *Recommendation(s)* -Cost of technical 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.)
4.3.1.2	If shorter shifts are required (see Issue 4.3.2.1) then more ATCOs / AFISOs may be required compared to current day operations. This will impact cost effectiveness.	Not explicitly investigated	Not addressed *Recommendation(s)* -Conduct a fatigue study to determine the shift schedules and required breaks / rest periods -Ensure appropriate regulation on shift design are adhered to
Arg. 4.3.2: The impact on shift organisation is identified.			
4.3.2.1 (S3)	Changes in staffing due to increased need for breaks. Due to risk of increased fatigue in the context of reduced daylight and screens, it might be taking into consideration that the ATCO/AFISOs needs more breaks and shorter shifts than in a tower located onsite at the airport. This may lead to more ATCO/AFISOs being required and hence *increase the cost.*	Not explicitly investigated	Not addressed *Recommendation(s)* -Conduct a fatigue study to determine the shift schedules and required breaks / rest periods -Ensure appropriate regulation on shift design are adhered to
Arg. 4.3.3: The impact on workforce (re-)location is considered.			
4.3.3.1	Not all ATCO/AFISO want to relocate (S1)	Not explicitly investigated	Not addressed *Recommendation(s)* -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
4.3.3.1	Remote tower centres will be located in less	**EXE-VP-056 & EXE-VP-057**	

	remote/isolated/ rural locations and this may attract ATCOs who want to relocated and more new recruits who would prefer to live in less isolated/remote/rural areas	Raised as a potential benefit	

3.4.2 Maturity of the project

The HP maturity criteria checklist for transition from V3 to V4 was used to determine the HP maturity of the single remote tower concept following the HP related activities conducted to date (see Table 9 below). The checklist was completed based on the activities conducted and the evidence collected to date, as described in Table 9.

Table 9: Questions for finalising the HP assessment process for V3

Checklist for finalising the V3 assessment			
Checklist for finalising the V3 assessment			
ID	**Question**	**Answer** *Fill in 'yes' or 'no'.*	**Comments** *Please substantiate your answer.*
1	Have all relevant arguments been addressed and appropriately supported?	yes	All relevant arguments have been addressed in V2 and V3 validations in different environemnts (passive shadow mode trials) as well as in workshops. The focus was on Arg 2 and Arg 3 but also addressing Arg 1 and Arg 4. Especially Safety and human performance related issues and the related requirements on technical system have been addressed.
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	All the benefits and issues have been addressed in V2 and V3 validations in different environments. Most of the issues could be closed. It should be highlighted that solution #71 has fully reached V3 maturity while solution #12 (for medium size airports) needs further investigations.
3	Have all the parts of the solution/concept been considered?	yes	It should be highlighted that solution #71 has fully reached V3 maturity while solution #12 (for medium size airports) needs further investigations. All the following validation objectives were addressed in the validations: OBJ-06.09.03-VALP-0060.0010 - OBJ-06.09.03-VALP-0060.0100
4	Have potential interactions with related projects/concepts been considered and addressed?	yes	The operational aspects of the solutions were co-ordinated between P06.09.03 and P06.08.04. The respective TS was developed by 12.04.07. The Safety and Human Performance aspects were covered by P16.06.01 and P16.06.05

5	Is the level of human performance needed to achieve the desired system performance for the proposed solution consistent with human capabilities?	yes	Human Performance related measures for solution #71 in terms of workload, situational awareness and human error were taken and all aspects rated positively. For solution #12 the human performance related measures were taken but ATCO rated the prototype under test as not being mature enough.
6	Has the proposed solution been tested with end-users and under sufficiently realistic conditions, including abnormal and degraded conditions?	yes	Both solutions (#71 and #12) were tested in realistic conditions using passive shadow mode. Abnormal and degraded conditions were considered. The validations were conducted by ATCOs working in these environments.
7	Have all relevant SESAR documentation been updated according to the HP activities outcomes (OSED, SPR)?	yes	The OSED, SAR and HP were iteratively updated after the validations.
8	Do the outcomes satisfy the HP issues/benefits in order to reach the expected KPA?	yes	While the main driver for remote tower applications is increased cost efficiency, the validations all focused on human factors and safety being the baseline for the concept. All Arguments of the HP have been addressed.
9	Have HP recommendations and HP requirements correctly been considered in HMI design, procedures/documentation and training?	yes	HP requirements were formulated and are covered by OSED requirements
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	Single Remote tower has already been implemented by LFV in Sweden, proving that transmission issues have been addressed.
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.	no	No changes to regulation in terms of HP have been identified. Regulation is ongoing by EASA and standardization in EUROCAE WG100.
12	Has the next V-phase sufficiently been prepared (additional testing conditions, open HP issues to be addressed)?	yes	There are some open HP issues that can be addressed in the next V-phase.

From the completion of the HP maturity criteria checklist for transition from V3 to V4 which is based on the 'evidence' obtained from the HP related validation activities conducted within SESAR P06.09.03 it can be concluded that the single remote tower concept plus enhanced visual features tested in the shadow mode trials (i.e. the basic remote tower setup which consists of the visual reproduction screens, PTZ camera and infra-red (thermal imaging) plus radar, automatic video and radar a/c identification and tracking function and additional camera views) **has reached the V3 level of HP maturity, for both Tower and AFIS.**

3.4.3 Synthesis of Arguments, Results and Recommendations & Requirements:

The recommendations / requirements relating to each HP argument that have been identified from the activities conducted to date on the single remote tower concept are presented in Table 10 below.

The recommendations resulting from the activities conducted are proposed as a means to mitigate the HP issues identified relating to the single remote tower concept. It should be noted that the recommendations required additional analysis, that is, refinements and / or validation before they are mature enough to become a requirement.

The requirements are statements that specify the required characteristics of the solution from a HP point of view. HP requirements can be seen as relatively stable and either lead to a redefinition of the operational concept or the specification of the technical solution.

The HP recommendations and requirements fall into one of several classes, among others:

- Technical system and HMI design
- Operational concept and procedures
- Training of end user

In addition, HP recommendations can relate to test and validation activities that need to be conducted in later V phases in order to investigate issues/benefits and potential mitigation in more detail.

The HP related recommendations and requirements listed in Table 10 will need to be discussed with the project manager and project team to decide on appropriate actions for each recommendation and requirement listed.

More information relating to the HP recommendations in terms of the rationale for the recommendation justification of the status of the recommendation can be found in recommendation register in Annex A.

More information relating to the HP requirements in terms of the rationale for the recommendation justification of the status of the recommendation can be found in recommendation register in Annex B.

Findings of EXE-VP640 were included in version 00.01.02. Results of this V3 validation trial have been added in the following chapter. Consequently all arguments in version 00.01.01 of this document with argument status "On-going" have been analysed and added with appropriate comments.

Table 10: Synthesis of recommendations &/or requirements relating to each argument addressed

Argument 1.1 The roles and responsibilities of the human are clear & exhaustive		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Future HP / validation activities** -Investigate issues relating to ATS representation in local community where the aerodrome is located, in stakeholder workshops. - Define any changes to role of the technical engineers given introduction of cameras, visual reproduction screens plus accompanying hardware, software - Assess feasibility introducing automatic observations (optional) - Assess feasibility of pre-setting for the PTZ or additional fixed cameras in order to facilitate ATCOs in finding the windsock	- Stakeholder meetings have been conducted with local NGOs, the aerodrome authority, aerodrome users etc. - Training to technical engineers to be established - Pre-settings for the PTZ established for various points of interest (e.g. windsock). Moreover individual points of interest may be configured.
	Roles & responsibilities - Ensure responsibility for tasks performed currently by ATCO/AFISOs that have to be performed onsite, e.g. METOBS, runway inspection, representation of ATS in local community are re-allocated appropriately e.g. METOBS can be performed by ground staff at aerodrome or automated, aerodrome manager could take on responsibility for ATS in the local community. (Re-allocation of tasks can either involve the allocation of tasks to a staff member located onsite at the aerodrome or automation). -Define any changes to role of the technical engineers given introduction of cameras, visual reproduction screens plus accompanying hardware, software	- Re-allocation of tasks to be considered in preparation of transition - Training to technical engineers to be established
	System design / HMI - Consider Implementing automatic meteorological observations (optional) If a windsock is located at the aerodrome being controlled remotely ensure it can be easily viewed by ATCO/AFISO in remote tower -Consider introducing pre-setting for the PTZ or additional fixed cameras	- Meteorological observations conducted by German MET provider. Hence, no issue. - Pre-settings for the PTZ established for various points of interest (e.g. windsock). Moreover individual points of interest may be configured.
	Training -If necessary, develop training program for ATS representative at aerodrome	- To be considered once re-allocation of tasks has been evaluated
Requirement(s)	**System design / HMI** - Weather status display should be provided for the CWP-remote like for CWP-tower	- Identical system/display is used

Arg 1.2 The operating methods are exhaustive and support human performance		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Future HP / validation activities** -Investigate the feasibility of visual / reduced visual separation with different RT set ups / support tools -The procedures for normal, abnormal and degraded modes of operation developed and updated following Trial 2 need to be validated in active mode trials in V3. -Issues relating to aircrew need to be addressed more systematically and in more detail in workshop with airspace users. e.g. Assess whether procedures for pilots / aircrew are suitable for remote tower operations in more detail in workshop with airspace users and ATCOs. - Investigate degraded modes further in future validation activities e.g. RTS	- Feasibility of visual / reduced visual separation to be further analysed - Active mode trial outstanding - As service provided to aircrew will remain the same as today, no elaborate workshops are required - Degraded and non-nominal modes have been investigated. However, additional analyses will follow
	System design / HMI -Consider introducing a tool to support ATCOs in judging distances / separation -Automatic a/c identification and tracking function is highly recommended to ensure ATCO SA is maintained and optimised in remote tower. This will also facilitate continuous tracking of a/c in the aerodrome vicinity (and also acceptability of the concept to ATCOs). - Radar should be implemented if ATCOs are providing Approach services and the number of simultaneous air movements exceeds two	- Such tool has been introduced and deemed helpful by the ATCOs (both distances and separation). Further investigation (inter alia concerning accuracy) needed - Both object bounding and object tracking introduced and deemed helpful by the ATCOs. Algorithms to be further adapted. - Radar available by default
Requirement(s)	**Operating methods (procedures / working methods)** -If Infra-Red (thermal imaging) is implemented, develop procedures for Infra-Red (Thermal imaging) use if implemented -Use procedural control / LVP as contingency procedure for such degraded mode events as failure relating to the visual reproduction	- Infrared available and fixed in procedures - Contingency procedures to be evaluated
	System design / HMI -Ensure screens have an error warning / alert to inform ATCOs that screen has not been updated, & screen has frozen, system communication failure etc.. -Ensure there is a back-up system e.g. back up visual reproduction screens	- Error warnings / alerts to be included - Back-up configurations have been analysed but need further thoughts

Arg 1.3 Human actors can achieve their tasks in normal, abnormal and degraded modes of operation		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	Closed (passive shadow mode); On-going (active shadow mode)
Recommendations	**Future HP / validation activities** -Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g. type & number of simultaneous movements that can be safely handled in future RT set-ups to be defined -Investigate in active TWR mode trials whether or not ATCO tasks can be achieved in a timely manner -Assess ATCO workload in active mode trials under high taskload normal operating conditions as well as abnormal & degraded modes of operation.	- Technical setup is designed to comply with designated traffic constellations - Analysis conducted in live passive shadow mode. Live active shadow mode trials outstanding - High task load as well as degraded / non-nominal modes analysed in live passive shadow mode. Live active shadow mode trials outstanding
	System design / HMI -Video & radar a/c tracking should be implemented to support human performance, in particular to enhance SA and reduce the potential for error. This also increases ATCOs perceived trust in the system and acceptability of the single remote tower concept.	- Object bounding and object tracking introduced and analysed. Algorithms to be further adapted.
Requirement(s)	**System design / HMI** Radar is necessary if ATCOs are providing Approach services	- Radar available by default

Arg 2.1 There is appropriate allocation of tasks between the human and the machine		Comments following EXE-VP639 and EXE-VP640
Argument Status	Closed	Closed
	System design / HMI -The automatic identification & tracking function should be included in the basic R/T set-up, not only to enhance SA but also ATCO/AFISO trust and confidence in the remote tower system and hence acceptability of the concept.	- Object bounding and object tracking functionality introduced and analysed. Algorithms to be further optimized.
Requirement(s)	**System design / HMI** -If implemented, the a/c automatic identification & tracking function if implemented needs to be re-fined to i.e. ensure that only relevant objects e.g. a/c and aerodrome vehicles are identified and tracked	- Functionalities introduced and analysed. Algorithms to be optimized in terms of: o Reliability / accuracy o Relevant areas o Intuitive control

Arg 2.2 The performance of the technical system supports the human in carrying out their tasks		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	Closed
Recommendations	**Future HP / validation activities** -Need to re-assess picture quality in active mode trials under various conditions e.g. different light / dark conditions to ensure that quality of picture in terms of picture resolution, freezing, pixilation are acceptable to the end users and enables them to continuously monitor a/c in the aerodrome vicinity as required . -Re-assess information consistency each time modifications are made to the CWP and / or visual reproduction in terms of information presentation -Assess timeliness of information presentation on visual reproduction screens / LCD screens	- Picture quality under various conditions (light, dark, low visibility etc.) has been analysed and deemed acceptable (this also applies for varying CWP configurations) - Timeliness provision of information assessed through direct comparison between information on panorama display and local conditions
	System design / HMI - -A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance , in particular SA and reduce the potential for error but needs to fine-tuned to be more stable, identify only relevant objects e.g. a/c & ground vehicles and prevent jumping	- Object bounding and object tracking functionality introduced and analysed. Algorithms to be further optimized.
Requirement(s)	**System design / HMI** - Picture quality under different light / dark conditions and low visibility conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the aerodrome vicinity.	- Picture quality accepted by ATCOs in terms of: o Different light / dark / low visibility conditions o No freezing of monitors Ideal composition of monitor size, resolution and distance between ATCO and screens to be defined.

Arg 2.3 The design of the HMI supports the human in carrying out their tasks		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Future HP / validation activities** -Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g. type & number of simultaneous movements that can be safely handled in future RT set-ups to be defined -Investigate in future validation activities the feasibility of visual separation with different RT set ups / support tools -Investigate feasibility of having labels (with identify information) for the ground vehicles	- Technical setup is designed to comply with designated traffic constellations - Visual separation based only on panorama display currently not possible. With the help of functionalities expected feasibility. Further investigation needed. - Introduction of labelling as overlay information outstanding

Arg 2.3 The design of the HMI supports the human in carrying out their tasks		Comments following EXE-VP639 and EXE-VP640
	-If interactive touch displays are implemented they will have to be assessed following any changes to the CWP configuration / layout -Assess usability of different working position set ups whenever any changes are made to the CWP set up. Ensure in future trials usability is assessed with representative scenarios & in active mode trials so that the ATCOs have to perform / execute certain tasks using specific information. -Assess visibility of visual reproduction screens and information presented on CWP during implementation -Re-assess feasibility of integrating PTZ & IR images in the visual reproduction screens with images, looking at different possible options e.g. reposition of PTZ images or use of smaller images -Impact of overlaid /high-lighted information on ATCO/AFISO attention needs to be re-evaluated in the future as more overlaid / highlighted features are added and as current features are improved -ATCO Situation Awareness (SA) needs to be assessed more systematically using different scenarios / events. SA is so essential to ATCOs performance it should be re-assessed in all future TWR validation activities (in active mode trials) in both CAVOK & low visibility / light conditions -Investigate in future validation activities the feasibility of visual separation with different automation support / Feasibility of some aid to help ATCOs judge distance, separation to be investigated -Ability to accurately judge aircraft separations visually under remote tower operations to be re-assessed in future validation activities (RTS and/or trials). -The impact of familiarity / experience on ability to judge separation visually in the remote tower should be assessed over a relatively long period of time to see if experience working with remote tower facilitates ATCOs ability to judge distances. -Scenario in which pilot are aware of something (e.g. an object on the runway), and require ATCO/AFISOs to confirm to be investigated in future trials -Assess impact of position of cameras to help assess distances between objects & depth -Provide external sound that can be adjustable within certain degrees -If additional automation is added then it must be assessed in terms of its impact on SA in future validation activities. -Feasibility of providing ATCO/AFISOs with additional information relating to light/dark conditions at aerodrome -Assess more systematically what set-up. visual viewing angle regarding the visual reproduction screen is needed to optimise human performance, e.g. 360 degree view on a 360 degree screen, or 200 degree on 140 -Enhanced Visualisation Features (EVF) (e.g. improving visibility using technical means) need to be	- WACOM displays continuously adapted to CWP configuration. Acceptance level is good. - CWP set-up (incl. assignment of degree of view on degree of screens) continuously adapted in order to reach most appropriate working environment. Feedback provided by ATCOs during live shadow mode trials assure a demand-oriented layout - Visibility of visual reproduction screens and information presented on CWP assessed on the way towards implementation. Ideal composition of monitor size, resolution and distance between ATCO and screens to be defined. - PTZ image and visual reproduction available in both video and IR representation. Combination of images assessed during live shadow mode - Overlay information only available to a minor extent (e.g. RWY outlines, holding point identifier etc.). Further investigation needed - ATCO SA systematically assessed and evaluated in live shadow mode throughout various scenarios and conditions (e.g. day/night, CAVOK/LVC, normal operations, non-nominal and degraded modes etc.) - Tool for judging distances and separations has been introduced and deemed helpful by the ATCOs. Further investigation (inter alia concerning accuracy) needed - Specific scenarios / events (e.g. a puff of smoke from the wheels when landing, gear down (or not) on landing, sound of birds, weather phenomena, lightning, detection of objects on RWY etc.) not assessable based on intended scenario. Such non-nominal modes rather have to take place by chance - Elaborate investigations concerning camera location and orientation have taken place - Investigations have taken place that external sound needs not inevitably to be implemented

Arg 2.3 The design of the HMI supports the human in carrying out their tasks		Comments following EXE-VP639 and EXE-VP640
	tested more systematically to find the optimum level in which only benefits are provided in terms of SA & performance and no negative impacts result -Specific scenarios / events (e.g. a puff of smoke from the wheels when landing, gear down (or not) on landing, sound of birds, weather phenomena, lightning) to be agreed on with safety & operational experts) to be scripted into future validation activities (RTS/ trials) to assess ATCO situation awareness. --Investigate impact of RT set-up / environment on fatigue. If fatigue is found to be an issue investigate possible means to prevent or mitigate fatigue e.g. reduce hours per shift or introduce more frequent breaks within a shift, make adjustments to the lighting ambient environment or R/T set-up -Investigate whether it is necessary to reduce hours per shift or introduce more frequent breaks within a shift -Feasibility of some aid to help ATCOs judge distance, separation to be investigated. -The impact of familiarity / experience on ability to judge separation visually in the remote tower should be assessed over a relatively long period of time to see if experience working with remote tower facilitates ATCOs ability to judge distances.	- New functionalities are continuously adapted according to ATCOs' feedback - Investigation on fatigue and eventual adaption concerning working hours outstanding
	Roles & responsibilities -After installation of the remote tower technical system engineers should be available to assess picture quality at regular intervals to ensure picture quality is maintained.	- Safeguarded during validation trials. To be assured in the context of transition / implementation as well
	System design / HMI - The set-up of the visual reproduction screens in terms of number of screens, layout orientation, area covered and included in the panoramic view, viewing angle etc. should be tailored and assessed and for each environment in which RT is implemented so that climbing and landing areas are fully captured on the visual reproduction visual reproduction screens - Radar should be implemented if ATCOs are providing Approach services and the number of simultaneous air movements exceeds two - A/c identification and tracking (i.e. both video & radar a/c tracking) should be implemented to support human performance, in particular SA and reduce the potential for error. However, this function must be fine tuned so that it tracks only relevant objects e.g. a/c and aerodrome vehicles -Include type of a/c & speed in the label instead of destination/ arrival apt in the a/c automatic identification label -Consider introducing labels (with identify information) for the ground vehicles -Infra red (IR) (Thermal imaging) function should be implemented to facilitate operations in dark and low visibility conditions. IR usability needs to be improved	- CWP set-up (incl. horizontal and vertical viewing angle) continuously adapted in order to reach most appropriate working environment. Feedback provided by ATCOs during live shadow mode trials assure a demand-oriented layout - Radar available by default - Both object bounding and object tracking introduced and deemed helpful by the ATCOs. Algorithms to be further adapted. - Flight strips and radar labels arranged as in today's operations. - Introduction of labelling as overlay information outstanding - Infrared available and fixed in procedures - Additional Camera Viewpoints have been installed. For instance, two fixed cameras cover the apron view.

	Arg 2.3 The design of the HMI supports the human in carrying out their tasks	Comments following EXE-VP639 and EXE-VP640
	-Additional Camera Viewpoints (ACV) should be available in the basic system set-up. Attention needs to be given as to where these ACV are located e.g. at hot spots, and the number required needs to be assessed on a aerodrome by aerodrome basis -Pre-sets for the PTZ should be implemented to aid usability -Provide metrological information including cloud base indicators & visibility indicator & if a windsock is present at the aerodrome ensure the windsock is visible to the ATCO/AFISO -Cameras located at the aerodrome must function correctly under a variety of weather conditions e.g. in snowy, icy, rainy conditions and the camera picture on the visual reproduction screens must not be impacted. -Cameras located at the aerodrome must be able to be automatically cleaned remotely - PTZ & IR images should be integrated in the visual reproduction screens with images but they need to be repositioned or smaller those assessed than in EXE-VP-057 -Ensure that overlaid and highlighted information on the panoramic display support ATCOs /AFISOs only in their primary tasks i.e. highlighted or overlaid information should be kept to a minimum & non-essential information should not be highlighted or overlaid highlighted or overlaid -Introduce a support tool to help ATCOs judge distance, separation -Position camera in a way that supports ATCOs to assess distances between objects & depth (need to assess feasibility of this) -Parameters of automatic contrast control need to be defined and should be investigated to ensure light conditions are not distorted to such a degree that it provides ATCO/AFISOs with an inaccurate picture of the lighting levels in the real world that may impact ATCO decision making . More generally Enhanced Visualisation Features (EVF) (e.g. improving visibility using technical means) need to be tested more systematically to find the optimum level in which only benefits are provided in terms of SA & performance and no negative impacts result -Additional information relating to light/dark conditions at aerodrome should be provided to ATCO/AFISOs -Ensure there are controls to adjust monitor brightness and room illumination -Limit the number of screens to a minimum to reduce amount different light sources in operations room -Ensure the appropriate HF guidelines & standards are considered & applied in the design & development of the CWP e.g. FAA's Human Factors Design Guide, -The number of screens on the CWP should be limited to a minimum and ensure number of input & output devices is minimised, (have an integrated CWP. refer to SESAR P6.9.2 a-CWP)	Furthermore, the PTZ camera is configured to view hotspots - Meteorological observations conducted by German MET provider. Information provided to ATCO identically as in today's operations - Cameras tested under various weather conditions (e.g. low / high temperature, strong wind, rain etc.) - Automatic cleaning function for cameras available - PTZ image and visual reproduction available in both video and IR representation. Combination of images assessed during live shadow mode - Overlay information only available to a minor extent (e.g. RWY outlines, holding point identifier etc.). Further investigation needed - Tool for judging distances and separations has been introduced and deemed helpful by the ATCOs. Further investigation (inter alia concerning accuracy) needed - Elaborate investigations concerning camera location and orientation have taken place - Picture quality under various conditions (light, dark, low visibility etc.) has been analysed and deemed acceptable (this also applies for varying CWP configurations) - Ideal composition of number of screens, monitor size, resolution and distance between ATCO and screens to be defined.

Arg 2.3 The design of the HMI supports the human in carrying out their tasks		Comments following EXE-VP639 and EXE-VP640
	Other -Ensure there is a certain degree of flexibility in the design of the CWP / work environment so that it is adaptable for different ATCO/AFISOs -Ensure there is natural light source in operations room -Ensure the lighting conditions in the remote tower is considered in the design of the remote tower operations room – use HF recommended practice/ guidelines/ standards	- In preparation for the transition to the actual Remote Tower Centre, HF recommended practice/ guidelines/ standards are used in order to construct a working environment that is accepted from an ergonomic view point
Requirement(s)	**System design / HMI** -Picture quality under different light / dark conditions and low visibility conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the aerodrome vicinity. -The quality of the visual reproduction screen should be improved such that all relevant objectives (especially aircraft in the vicinity of the aerodrome) can better be detected and continuously monitored. -PTZ camera must be implemented in basic set up but picture quality and usability of the PTZ camera needs to be improved -If implemented the a/c identification and tracking (i.e. both video & radar a/c tracking) function must be fine-tuned so that it tracks only relevant objects e.g. a/c and aerodrome vehicles -Automatic contrast control should be implemented -Ensure joint seam of the visual reproduction screens are not located at 'hot spot' places. The positioning of seams at hot spots e.g. holding positions, TWY entrance / exits, run-up areas and stop bars, must be avoided.	- Picture quality accepted by ATCOs in terms of: o Different light / dark / low visibility conditions o No freezing of monitors Ideal composition of monitor size, resolution and distance between ATCO and screens to be defined - Picture quality of the PTZ camera is deemed adequate. What need improvement though is the intuitive control of the PTZ camera (e.g. activation of automatic tracking, quick adjustment onto moving objects etc.) - Object bounding and object tracking functionality introduced and analysed. Algorithms to be further optimized - No hotspots configured in such way that they are collocated with monitor seams

Arg. 3.1 Effects on team composition		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Roles & responsibilities** -Define new responsibilities/task of technical engineers -Technical engineers must be available at all times in case technical failures or maintenance issues	- Re-allocation of tasks to be considered in preparation of transition - Technical engineer available during validation trials. To be assured in the context of transition / implementation as well
	Training	- Training to technical engineers to be established

Arg. 3.1 Effects on team composition		Comments following EXE-VP639 and EXE-VP640
	-Ensure technicians with the required skills and knowledge are trained and available prior to implementation	- Training course to be executed once re-allocation of tasks has been determined
Requirement(s)		

Arg. 3.2 The allocation on tasks between human actors support human performance		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Future HP / validation activities** -Assess impact of allocating certain tasks to aerodrome staff on human performance i.e. efficiency and potential for error in future validation activities i.e. active mode trials -Investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower	- To be assessed prior to implementation / transition
	System design / HMI -Ensure facility to enable direct communication between ATCO/AFISOs and the necessary aerodrome staff is available at all times, e.g. investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower	- To be assessed prior to implementation / transition
Requirement(s)		

Arg.3.3 The communication between team members supports human performance		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	Closed
Recommendations	**Future HP / validation activities** -Conduct stakeholder workshop with ATCO/AFISO, airlines & airspace users to investigate all issues relating to airspace users and identify possible mitigation e.g. issues such as: whether 'Pilots try to 'cheat' if they know ATCO/AFISO is not there' and the potential consequences of this issues as well as possible mitigation; relating to perceived changes in authority-sharing with the remote tower concept; to identify any additional relevant phraseology and if necessary develop appropriate phraseology -Investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower -Investigate impact of RT on communication load in future trials (active mode) / post implementation monitoring	- Stakeholder workshops have been conducted with local NGOs, the aerodrome authority, aerodrome users etc. - As service provided to aircrew will remain the same as today, no adaption concerning phraseology or RT is required

Arg.3.3 The communication between team members supports human performance		Comments following EXE-VP639 and EXE-VP640
	Operating methods (procedures / working methods) -Phraseology – ATCO/AFISO should state when making initial contact with aircrew that they are remotely located	- As service provided to aircrew will remain the same as today, no such information is required. Instead, a general information should be given in the AIP
	System design / HMI -Ensure facility to enable direct communication between ATCO/AFISOs and the necessary aerodrome staff is available at all times, e.g. investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower	- To be assessed prior to implementation / transition
	Training -Develop an information campaign to ensure roles, tasks and procedures and chain of command are clarified for ATCO/AFISOs, aerodrome staff, aircrew and airlines. -Allow onsite aerodrome staff representatives and airline representatives to visit the remote tower so they can understand remote tower operations and communicate back to their staff members -Ensure ATCOs are fully aware of the GND staff role, tasks and working methods by arranging visits to the aerodromes being controlled remotely and also regular meetings and vice versa	- Informative meetings and exchange of ideas have taken place and will further be promoted
Requirement(s)		

Arg. 4.1 The proposed solution is acceptable to the affected human actors		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	Closed
Recommendations	**Future HP / validation activities** -Conduct a workshop with aerodrome staff and ATCO/AFISOs to brainstorm potential consequences of impact & mitigations of remote tower concept of communication and team work between staff located on-site at the aerodrome and staff located in the remote tower facility -Workshop with aerodrome staff and ATCO/AFISOs might be necessary to brainstorm potential consequences of Airspace users not being aware that ATCO/AFISOs are remotely located as well as mitigations -Verify relevance of interaction with APT staff on services provided i.e. does the possibility to interact with the APT staff improve the ATS provided? -Investigate feasibility of using intercom, webcam and assess the benefits	- Stakeholder workshops have been conducted with local NGOs, the aerodrome authority, aerodrome users etc. - Informative meetings and exchange of ideas have taken place and will further be promoted

Arg. 4.1 The proposed solution is acceptable to the affected human actors	Comments following EXE-VP639 and EXE-VP640
-Workshop with aerodrome staff and ATCO/AFISOs might be necessary to brainstorm consequences if team participation and identity between ATCO/AFISOs and aerodrome staff / pilots as well as local knowledge and awareness are lost, as well as mitigations	
System design / HMI -Investigate feasibility of using intercom, webcam to ensure ATCO/AFISOs can contact and interact easier with aerodrome staff -Feedback from ATCOs from trials shows that the main point to increase ATCOs' acceptance is addressed by the improvement of the visual reproduction screen. Therefore, enhance picture quality of the visual reproduction screen	- Use of intercom / webcam to be assessed prior to implementation / transition - Picture quality accepted by ATCOs in terms of: o Different light / dark / low visibility conditions o No freezing of monitors Ideal composition of monitor size, resolution and distance between ATCO and screens to be defined
Training -Information campaign to inform airlines / pilots that remote tower operations are in place at specific aerodrome and also to explain remote tower operations -Frequent information sharing and RTC campaigns. Make external understanding for the concept and create acceptance by the use of open channels. -Ensure ATCO/AFISOs are able to visit the aerodromes they are controlling to ensure their local knowledge and awareness, as well as relationships with the onsite aerodrome staff are maintained -Training for remote ATCO/AFISOS should involve some onsite training at the aerodrome they will be controlling so they gain local knowledge and awareness, as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower	- Stakeholder workshops have been conducted with local NGOs, the aerodrome authority, aerodrome users etc. - Informative meetings and exchange of ideas have taken place and will further be promoted - Training for remote ATCOs is twofold (prior to transition to actual Remote Tower Centre): 1. Detailed simulations and introduction to new working environment 2. Long term familiarization with training Remote Tower Module (located at local Tower)
Other -Select representatives from on-site and off-site locations to ensure there is a continuous dialogue between both staff members -Ensure regular meetings between remote and on-site staff ideally face to face but if that's not possible video conference -Keep the TWR-atmosphere as far as possible i.e. aim to have the same look and feel as a tower control room OR maximise the differences as it is a new job with new equipment and representation of the tasks -Introduce as many cues as possible and keep local knowledge alive (from both sides)?? -Adopt / continue to use a human centred approach in the concept design & development process - An appropriate employee selection for the remote tower ATCO / AFISO role plus specializations for	- All items have been and are still thoroughly addressed, e.g.: o Working groups containing affected ATCOs o Project management groups o Regular face to face meetings o Continuous exchange between affected members o Information distribution to affected personnel

Arg. 4.1 The proposed solution is acceptable to the affected human actors		Comments following EXE-VP639 and EXE-VP640
	CWP-remote may help acceptance of the remote tower concept in the long term	
Requirement(s)		

Arg 4.2 Changes in competence requirements are analysed		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Future HP / validation activities** -Perform training needs analysis for ATCO/AFISOs	- Training for remote ATCOs is twofold (prior to transition to actual Remote Tower Centre): 1. Detailed simulations and introduction to new working environment 2. Long term familiarization with training Remote Tower Module (located at local Tower)
	Training -Ensure ATCO/AFISOs are able to visit regularly the aerodromes they are controlling to ensure their local knowledge and awareness are somewhat maintained -Training for remote ATCO/AFISOS should involve some onsite training at the aerodrome they will be controlling so they gain local knowledge and awareness, as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower and also gain a knowledge of aircraft behaviour and performance -Training would be necessary to ensure ATCO/s are able to perform their work in remote tower environment.(exact training required needs to be defined) -Develop a complete training programme for remote tower operations with pre-specified performance criteria that need to be achieved before they can 'go operational' -Ensure ATCOs involvement plus training experts are involved in the development of the training programme	- Informative meetings and exchange of ideas have taken place and will further be promoted - Training for remote ATCOs is twofold (prior to transition to actual Remote Tower Centre): 1. Detailed simulations and introduction to new working environment 2. Long term familiarization with training Remote Tower Module (located at local Tower)
	Other -A specific endorsement for Remote tower controllers. This endorsement should be awarded to the tower environment in which the ATCO is going to work and this training should be included in the unit training plan.	- This represents the envisaged approach

Arg 4.2 Changes in competence requirements are analysed		Comments following EXE-VP639 and EXE-VP640
	-No new rating for single RT operations is currently seen as necessary	
Requirement(s)		

Arg. 4.3: Changes in staffing requirements and staffing levels are identified.		Comments following EXE-VP639 and EXE-VP640
Argument Status	On-going	On-going
Recommendations	**Future HP / validation activities** -Conduct training needs analysis for all actors impacted by the single remote tower concept -Conduct a fatigue study to determine the shift schedules and required breaks / rest periods	- Training to technical engineers to be established - Training for remote ATCOs is twofold (prior to transition to actual Remote Tower Centre): 1. Detailed simulations and introduction to new working environment 2. Long term familiarization with training Remote Tower Module (located at local Tower) - Investigation on fatigue and eventual adaption concerning working hours outstanding
	Training -Technical engineers will need to be trained to enable then to maintain and repair all the equipment related to the remote tower including the associated hardware and software -Develop a complete training programme for all actors impacted by the remote tower concept with pre-specified performance criteria that need to be achieved before they can 'go operational' -Ensure ATCOs involvement plus training experts are involved in the development of the training programme	- Training to technical engineers to be established - Training course to be executed once re-allocation of tasks has been determined - Training for remote ATCOs is twofold (prior to transition to actual Remote Tower Centre): 1. Detailed simulations and introduction to new working environment 2. Long term familiarization with training Remote Tower Module (located at local Tower)
	Other -Cost of technical 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 -Ensure appropriate regulation on shift design are adhered to --If there is a problem findings ATCO/AFISOs that want to relocate offer incentives e.g. a relocation package, salary increase for ATCO/AFISOs that have to relocate	- To be considered in relation with implementation / transition
Requirement(s)		

4 References

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[17] SESAR P06.08.04 D111 Human Performance Assessment - Contingency Tower, Edition 00.02.00, 17/05/2016

[18] WPB.01 Integrated Roadmap version DS15 release note, D83, 00.01.00, July 01 2015

Appendix A – HP Issue & Benefits Register

The following table lists the HP issues and benefits identified from the the HP assessment process [1]. Those issues that do not have a reference in brackets associated are issues that have been identified from reviewing the HP argument structure for V2. Issues which do have a reference in brackets associated have been identified from either the literature review, HP issue and benefit analysis and / or HP validation activities conducted to date i.e. task analysis or trials, the 'source' of the issue, i.e. literature review, HP issue analysis, trial is reference in [3].
For each potential issue / benefit identified the impact on human performance and system performance is defined together with the priority of the issue[4]. In addition where possible a potential means to mitigate the impact of the issue is defined, together with the HP / validation objective relating to the issue and also the recommended HP / validation activity(ies) that should be conducted to assess the issue.

It should also be noted that at the time the HP assessment was started on the single remote tower concept the argument and evidence based HP assessment process had not been developed. Therefore, the P6.9.3 HP plan for single tower was developed using the former HP assessment process [8] . However, the issues and benefits identified from the HP Issue and benefit analysis have since been mapped onto the P16.4.1 SESAR HP arguments and re-numbered according to the new SESAR argument structure described in [1] in order to bring the HP assessment for the single remote tower in line with the new argument and evidence based HP assessment process being used within SESAR by P16.06.05. The previous issue number as allocated under the former HP assessment process in the HP Plan is given for each issue in brackets to aid traceability from the assessment HP Plan [3] to this HP assessment report. Issues that do not have an additional reference number in brackets are new issues identified from the application of the HP argument structure for V2.

[4] High priority**: Negative and significant Impact on safety, a safety concern, or a serious degradation of safety performance.**
Medium priority**: Negative and significant impact on KPA other than safety, for instance, a degradation in efficiency or capacity, a negative impact on environment.**
Low priority**: No significant impact on HP and/or KPAs.**

Arg. 1.1 Roles and responsibilities of human actors are clear and exhaustive.					
ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 1.1.1: The description of roles & responsibilities cover all affected human actors.					
1.1.1.1	Not all human actors impacted by the Remote tower concept are identified	High	Ensure all human actors impacted by the remote tower concept are identified and their roles and responsibilities defined	Identify list of human actors impacted by the change and check against the description of roles & responsibilities	Task analysis
1.1.1.2 (RT3)	Role of ATS representative 'tower chief' disappears - who will represent ATS in local community?	Low / Medium	The aerodrome manager could to be trained on ATS and have a strong link to ATS so s/he can represent ATS in the local community if and when necessary		Training needs analysis for ATS representatives at aerodromes
Arg. 1.1.2: The description of roles & responsibilities cover all tasks to be performed by a human actor.					
1.1.2.1	The description of roles and responsibilities is not complete	Medium	Ensure description of roles and responsibilities are complete and cover all tasks	Identify the tasks of the human actors impacted by remote tower and ensure they are all included in the description of roles and responsibilities	Task analysis
1.1.2.2 (RT4)	ATCO/AFISOs will no longer be able to conduct METOBS from the remote tower cabin. If the ATCO/AFISOs are no longer located onsite then they will no longer be able to perform METOBS, therefore this task will have to be performed by personnel located on-site at the aerodrome, this may impact *efficiency*	Medium	- Ensure responsibility for the METOBS is allocated to a staff member located onsite at the aerodrome - Introduce automatic observations	Ensure roles, tasks and responsibilities are appropriately allocated under remote tower ops	Task analysis
1.1.2.3 (RT7)	ATCO/AFISOs tasks / roles and responsibilities under remote tower operations change	High	-identify changes & ensure description of roles and responsibilities are complete and cover all tasks	Identify changes to ATCO/AFISO tasks / roles & responsibilities & ensure description of each actors roles & responsibilities is complete	Task analysis

Arg. 1.1.3: Roles and responsibilities are clear and consistent.					
1.1.3.1	Tasks allocation is confused and either tasks get duplicated by personnel or more likely and even worse not performed. Task duplication or omission may have serious *safety* repercussions	High	Ensure all onsite and remotely located staff's roles and tasks are completely and clearly defined	Review description of roles & responsibilities & tasks to ensure they are clear consistent.	• Task analysis RTS/trials

Arg. 1.2: Operating methods are exhaustive and support human performance.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 1.2.1: Operating methods cover normal operating conditions.					
1.2.1.1	Operating methods do not cover normal operating condition. If the existing operating methods are no longer appropriate under single RT and / or normal operating conditions change and there are no operating methods to cover these conditions then it may lead to *reduced efficiency* and in the worst case have negatively impact *safety* by increasing potential for human error	High	- Identify situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against scope of existing operating methods. -Liaise with procedure team to define operating methods for normal operating conditions if necessary.	- Identify situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. -Liaise with procedure team to define operating methods for normal operating conditions if necessary. -Validate procedures for normal operating conditions in RTS / trials	- Expert review / judgement -RTS/Trials
Arg. 1.2.2: Operating methods cover operations in abnormal operating conditions					
1.2.2.1	Operating methods do not cover operations in abnormal conditions. If existing operating methods are no longer appropriate under single RT and /or new abnormal conditions arise and there are no operating methods to cover these conditions then it may lead to reduced *efficiency* in terms of both and in the worst case have negatively impact *safety* by increasing potential for human error	High	- Identify situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists & check against the scope of operating methods. -Liaise with procedure team to define operating methods for abnormal operating	- Identify situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists & check against the scope of operating methods. -Liaise with procedure team to define operating methods for abnormal operating conditions if necessary.	- Expert review / judgement -RTS/Trials

			conditions if necessary.	-Validate procedures for abnormal operating conditions in RTS / trials	
Arg. 1.2.3: Operating methods cover degraded modes of the ATM system.					
1.2.3.1	If new degraded modes arise as a result of the RT concept or if existing procedures for the existing degraded modes are no longer appropriate and there are no operating methods to cover these conditions then it may lead to reduced *efficiency* in terms of HP and KPA and in the worst case have negatively impact *safety* by increasing potential for human error	High	- Identify situations that constitute degraded modes of operation in cooperation with the safety and operational specialists & check against the scope of operating methods. -Liaise with procedure team to define operating methods for degraded modes if necessary.	- Identify situations that constitute degraded modes of operation in cooperation with the safety and operational specialists & check against the scope of operating methods. -Liaise with procedure team to define operating methods for degraded modes if necessary. -Validate procedures for degraded modes of operation RTS / trials	- HAZID / safety input -Expert review / judgement -RTS/Trials
1.2.3.2 *(SR1)*	Remote tower system fails, e.g. system fails to display panoramic view of aerodrome under remote control i.e. panoramic screen goes down' or freezes	High	Safety implications of such an issue to be assessed in more detail in Safety Case Ensure redundancy is built in to system e.g. back up system available (WP12.4.7) Develop appropriate contingency procedures e.g. LVP for such a scenario Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events	-Support the development of contingency procedures for remote tower system failures -Assess contingency procedures for system failures in validation exercises Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	RTS/trials

			Implement an alarm / alert to alert ATCO/AFISOs to the fact that a screen has frozen		
1.2.3.3 ***(SR2)***	No surveillance input is provided for a real target (missing data)	High	Safety implications of such an issue to be assessed in more detail in Safety Case Develop appropriate contingency procedures for such a scenario Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events Implement an alarm to identify missing data to alert ATCO/AFISOs to the problem	-Support the development of contingency procedures for remote tower system failures -Assess contingency procedures for system failures in validation exercises -Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	RTS/trials
1.2.3.4 ***(SR3)***	The surveillance data is provided for a real target but some aspects of the data are incorrect / inaccurate (erroneous / misleading data)	High	Safety implications of such an issue to be assessed in more detail in Safety Case Develop appropriate contingency procedures for such a scenario Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events Implement an alarm to identify incorrect / corrupted	-Support the development of contingency procedures for such a system failures -Assess contingency procedures for system failures in validation exercises -Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	RTS/trials

			data to alert ATCO/AFISOs		
1.2.3.5 ***(SR4)***	The data presented on a display does not correspond to a real target at the aerodrome (false data)	High	Safety implications of such an issue to be assessed in more detail in Safety Case Develop appropriate contingency procedures for such a scenario Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events Implement an alarm to identify false data to alert ATCO/AFISOs	-Support the development of contingency procedures for remote tower system failures -Assess contingency procedures for system failures in validation exercises -Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	RTS/trials
1.2.3.6 (SR5)	Communication link between site and aerodrome fails	High	Safety implications of such an issue to be assessed in more detail in Safety Case Ensure redundancy is built in to system e.g. back up system available Develop appropriate contingency procedures for such a scenario Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events	-Support the development of contingency procedures for remote tower system failures -Assess contingency procedures for system failures in validation exercises -Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	RTS/trials

			Implement an alarm to identify a communication link failure to alert ATCO/AFISOs (if failure of communication link is not easily identifiable)		
1.2.3.8 (SR7)	Recovery from failure becomes more difficult	High	Safety implications of such an issue to be assessed in more detail in Safety Case Develop appropriate contingency procedures for such a scenario e.g. LVP Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events	-Support the development of contingency procedures for remote tower system failures -Assess contingency procedures for system failures in validation exercises -Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	RTS/trials
1.2.3.9 (SR8)	Maintenance in order to recover from system failure become more difficult and system intervention is more complicated because service and technology are split on two sites	High	Safety implications of such an issue to be assessed in more detail in Safety Case Develop clear and unambiguous contingency procedures for such scenarios Train ATCO/AFISOs on these contingency procedures before implementation & ensure there is regular refresher training for such non-nominal events	-Support the development of contingency procedures for remote tower system failures -Assess contingency procedures for system failures in validation exercises -Support development of a training programme to ensure ATCO/AFISOs are trained on such failure situations & contingency procedures	• RTS/trials • Training needs analysis
Arg. 1.2.4: The content of operating methods is clear and consistent.					
1.2.4.1	The content of operating methods is not clear and consistent this could lead to	High	Review operating methods to	-Review / validate operating	- Expert review /

	reduced efficiency both in terms of human performance and KPA and in the worst case increase the potential for error so impacting *safety*		ensure they are clear and consistent. The review should be carried out with end users.	methods to ensure they are clear and consistent. The review should be carried out with end users.	judgement -RTS/Trials
Arg. 1.2.5: Operating methods can be followed in an accurate, efficient and timely manner					
1.2.5.1 (P1)	The procedures are not suitable i.e. easy to use / apply and / or are generally not appropriate in new working environment. The procedure for current operations in tower control may not be easy to apply and / or appropriate for remote tower operations (RTO) for either nominal and / non-nominal conditions. This will lead to an *increase in ATCO/AFISO workload* and increase the potential for *human error*. Furthermore, ATCO/AFISOs will be less likely to accept remote tower operations	High	• Assess the suitability / usability of procedures for normal, abnormal and degraded modes of operations in validation activities Amend or develop procedures specifically for remote tower operations for those current procedures that are found to be unsuitable.	-Support the development of procedures for normal, abnormal & degraded modes of operation where necessary -Assess suitability / usability of procedures for normal, abnormal and degraded modes of operations in validation activities	RTS/trials
1.2.5.2 (P2)	The procedures for the aircrew are no longer suitable under remote tower operations. The pilot / aircrew procedures for current operations may not be easy to apply and / or appropriate for remote tower operations (RTO) for either nominal and / non-nominal conditions. This will lead to an *increase in pilot workload* and increase the potential for *human error*.	High	Assess the suitability of procedures for aircrew under normal, abnormal and degraded modes of operations in validation activities	A-ssess the suitability of procedures for aircrew under normal, abnormal and degraded modes of operations in validation activities	RTS/trials
Arg. 1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**POTENTIAL MITIGATION**	**HP / VALIDATION OBJECTIVE**	**RECOMMENDED ACTIVITY**
Arg. 1.3.1: The potential for human error is reduced as far as possible.					
1.3.1.1	The potential for human error is increased as a result of the introduction of single RT. This will have a significant impact on *safety*	High		- Review errors and recovery means in the solution ATM system (e.g. using fault trees of Accident/Incident Models) & compare with likely errors and recovery means in the reference ATM system. -Perform Human Reliability Analysis.	-HAZID -HRA -RTS / trials

				-Assess errors and recovery means in Real-Time Simulation or operational trials	
Arg. 1.3.2: Tasks can be achieved in a timely manner.					
1.3.2.1	ATCOS & AFISOs are not able to achieve tasks in a timely manner. This will impact overall efficiency & hence capacity. In the worst case this could result in an increase in potential for human error and hence impact *safety*	High		Assess timeliness of actions in Real-Time Simulation or operational trials	-RTS / trials
Arg. 1.3.3: The level of workload (induced by cognitive and/or physical task demands) is acceptable					
1.3.3.1 (RT6)	ATCO/AFISOs tasks / role under remote tower operations cannot be performed by one ATCO/AFISOs. If the ATCO/AFISOs tasks and roles change then the demand placed on the ATCO/AFISOs may also change. It is currently assumed that the *workload / demand* placed on ATCO/AFISOs under remote tower operations will not be significantly impacted and so the same number of personnel as today will be required to provide ATS remotely. However, if the *task demand* placed on the ATCO/AFISOs under remote tower operations do increase significantly then this may impact *safety & efficiency* or increase the number of ATCO/AFISOs required to provide ATS remotely which would then affect *cost effectiveness*	Medium / High		Assess impact of remote tower operations on ATCO/AFISO workload	-RTS/trials
Arg. 1.3.4: The level of trust in the new concept/the new procedures is appropriate.					
	See Arg. 2.1.6				
Arg. 1.3.5: Human actors can maintain a sufficient level of situation awareness.					
	See Arg 2.3.7				
Arg. 1.3.6: Human performance satisfies the expected TA target levels.					
Arg. 1.3.6.1: Safety requirements on human performance are satisfied.					
1.3.6.1.1	Safety in terms of potential for human error should not increase compared to current operations in traditional control towers	High	Provide input to Safety Requirements based on data from: - Cognitive Task Analysis (CTA); - Human Reliability Analysis (HRA); - Real-Time Simulations (RTS); or	Check & Provide input to Safety Requirements based on data from: - Cognitive Task Analysis (CTA); - Human Reliability Analysis (HRA); - Real-Time Simulations (RTS); or - Operational Trials	-CTA -HRA -RTS / trials

			- Operational Trials		
Arg. 1.3.6.2: Security requirements on human performance are satisfied.					
	No target level identified				

Arg. 2.1: There is an appropriate allocation of tasks between the human and machine (i.e. level of automation).					
ISSUE ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**POTENTIAL MITIGATION**	**HP / VALIDATION OBJECTIVE**	**RECOMMENDED ACTIVITY**
Arg. 2.1.1: The task allocation between the human and the machine is consistent with automation principles.					
2.1.1.1	If the automatic tracking and labelling function implemented does not adhere to automation principles this automation may lead to reduced efficiency and hence impact *capacity* and also in worst case increase the potential for human error, so negatively impacting *safety.*	High	Ensure design of automatic tracking & labelling function adheres to good automation practice e.g. deliverables of 16.5.1 and/ or other automation guidelines.	Check design of automatic tracking & labelling function adheres to good automation practice e.g. deliverables of 16.5.1 and/ or other automation guidelines.	-Review relevant HF automation guidelines & check design of automation
Arg. 2.1.2: Changes to the task allocation between human and machine support human performance.					
2.1.2.1	The automatic identification, labelling and tracking function does not increase ATCO SA and support human performance, this could lead to reduced efficiency and hence impact *capacity* and also in worst case increase the potential for human error, so negatively impacting *safety*.	High	Ensure design of automatic tracking & labelling function adheres to good automation practice & supports human performance	Assess SA & human performance i.e. efficiency & accuracy in performing tasks in RTS / operational trials when using The automatic identification, labelling and tracking function	-RTS/ trials
Arg. 2.1.3: Transition from automatic to manual modes and vice versa, human-intended or failure induced, can be performed by the human actors in a timely, efficient and accurate manner.					
	N/A				
Arg. 2.1.4: The level of workload (induced by the allocation of tasks between the human and the machine) is acceptable.					
	N/A				
Arg. 2.1.5: Human actors can acquire an adequate mental model of the machine and its automated functions.					
2.1.5.1	If ATCO/AFISOs do not have an adequate mental model of the automatic a/c identification, tracking & labelling function they may not be able to identify when errors with this functionality occur / arise. Given the nature of the functionality this may affect ATCO/ AFISO SA and in turn overall efficiency. There could may also be certain *safety* implications	Med / High		-Assess end users' understanding of the technical system's behaviour using questionnaires and debriefings in Real-Time Simulations or operational trials.	RTS / trials
Arg. 2.1.6: The level of trust in automated functions is appropriate.					

2.1.6.1	ATCO / AFISO trust in the automatic a/c identification, tracking & labelling function is too high they may not notice errors, e.g. the system tracking non-a/c objects, this could reduce SA and increase potential for error this may have *safety* implications. If ATCOs / AFISOs trust in the automatic a/c/ identification, tracking & labelling function is too low then ATCOs / AFISO may not benefit from the functionality & their SA will not be enhanced by the automation & efficiency could be impacted. This will impact *cost effectiveness* for remote tower solution.	Med / High		-Assess trust in automated functions in Real-Time Simulation and operational trials using data recordings, questionnaires and observations.	RTS / trials

Arg. 2.2: The performance of the technical system supports the human in carrying out their task.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 2.2.1: The accuracy of information provided by the system is adequate for carrying out the task.					
2.2.1.1 (IR3)	The accuracy of the information presented to the ATCO/AFISOs in the remote tower is reduced due to technical latency. If the information presented on the panoramic screen is not timely and hence accurate due to technical latency then ATCO/AFISOs may not have the correct information they need at a specific point in time, this could lead to *certain human errors* e.g. untimely issue of clearances, which could have serious *safety* consequences. The lack of timely accurate information will also mean the ATCO/AFISOs will *not trust* the information presented and in turn may *not accept* remote tower operations.		• Define clear and strict system requirements relating to necessary timeliness and accuracy of information presentation on the remote panoramic screen (WP12.4.7 activity) Ensure system is rigorously tested before and after implementation to ensure the above requirements are met and adhered to (WP12.4.7 activity)	-Assess acceptability of technical latency with ATCO/AFISOs in RTS /trials	-RTS / Trials
2.2.1.2 (IR5)	There is inconsistency with the information presented (e.g. due to the same information being presented in different formats or on different interfaces i.e. CWP or panoramic display). If the same information is presented to the ATCO/AFISO in different formats or on different interfaces (e.g. CWP and panoramic display), they may be a time when the information presented is not consistent. This may occur due to a system failure or to different equipment having different configurations / algorithms or information sources. This will lead to a *lack of trust* in the system and information presented and hence a *lack of acceptance*.	High	• Minimise the unnecessary duplication of information, i.e. only duplicate information if it is found to better support the ATCO/AFISOs work. • Inconsistent information could be automatically highlighted to ATCO/AFISO	• Identify HMI design requirements to ensure usability • Assess usability of the information presented (specifically, duplicated information presented) • Support the design of procedures for HMI related	-Review & identify relevant HF standards / design guidelines to ensure usability -Mock ups / Prototyping

			and if possible the reason for this inconsistency automatically diagnosed • Develop procedures to help ATCO/AFISOs diagnose why there is an inconsistency in the information presented • ATCO/AFISOs should be given training to understand the system and how it works and also trained on the types of errors that may occur, why they occur and how to resolve them	errors e.g. inconsistent information presentation • Assess the usability of the procedures developed for HMI related errors • Support the development of training programme to ensure ATCO/AFISOs understand the system & are familiar with the procedures to deal with known errors	sessions -RTS/trials
Arg. 2.2.2: The timeliness of information provided by the system is adequate for carrying out the task.					
2.2.2.1	Information, i.e. images of aerodrome and the vicinity are not presented to the ATCO/AFIS is delayed / not presented in real time	High		-Assess timeliness of information and ensure it is adequate to perform tasks	-RTS / trials
Arg. 2.3: The design of the human-machine interface supports the human in carrying out their tasks.					
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 2.3.1: The type of information provided satisfies the information requirements of the human.					
2.3.1.1 (IR1)	The information presented on the HMI (i.e. CWP and 3D panoramic screen) does not support the ATCO/AFISO in his/her work. It is important that only the necessary information is presented to the ATCO/AFISOs to support them in their tasks. Presenting information that does not support them in their tasks can lead to information overload and adds clutter both of which can lead to an increase in mental workload, reduced situation awareness and hence increase potential for human error and hence negatively impact system *safety*.	High		- Perform Task Analysis to identify information requirements of human actors, and check consistency with 16.5.3 deliverables -Assess Human Performance & Usability during Real-Time Simulation or operational trials: -subjective methods: questionnaire, debriefings & interviews (feedback on system support)	-Task analysis -RTS / trials

				-objective methods: data recordings, observations (task performance).	
Arg. 2.3.2: Input devices (e.g. keyboard, mouse, touch screen) correspond to HF principles					
2.3.2.1 (U1)	The input & output control devices on the CWP are not intuitive and easy to use. the control input / output devices are not initiative and easy to use then ATCO/AFISOs the efficiency will be reduced and there may be an increase in potential for error and hence *safety*. In addition, if a system is intuitive and easy to use the amount of training required should theoretically be reduced and this will benefit *cost effectiveness*.	High	• Ensure good HMI design practice is adopted and define HMI control input / output device requirements to ensure usability • Assess the usability of the control input / output devices on the CWP in validation activities	• Identify & define HF requirements for input / output devices • Assess usability of the control input / output devices on the CWP in validation activities	-Review & identify relevant HF standards / design guidelines to ensure usability of control devices -Mock ups / Prototyping sessions RTS/trials
2.3.2.2 (U3)	Interactive touch displays are located outside the reaching area. Based on the calculated distance by the maximum viewing angle, we need to consider small and large reaching areas, if not, ATCOs may not be able to perform their tasks efficiently. The small reaching area is within 35-45 cm, the large reaching are is within 55-65 cm.	Medium	• Consider that interactive displays should be located within the small reaching area (35 – 45 cm) • Interactive displays shall be located separately from the viewing displays which need to be further afar.	• Identify & define HF requirements for input / output devices • Assess usability of the control input / output devices on the CWP e.g. PTZ zoom function in validation activities	-Review & identify relevant HF standards / design guidelines to ensure usability of control devices -Mock ups / Prototyping sessions -RTS/trials
Arg. 2.3.3: Visual displays and other types of output devices adhere to HF principles.					
2.3.3.1 (WE6)	Essential information presented on the screens is outside the human's viewing angle. The presentation of the outside view is represented via LCD screens instead of a window view. This can cause different issues in terms of presentation size, view angle and overall working position design	High	• Ensure the appropriate HF guidelines & standards are considered & applied in the design & development of the CWP. Such guidelines /	Support the design of the CWP	• Review relevant HF standards / design guidelines & identify HF

	If the maximum required vertical and horizontal fields are not observed and important information could be outside human's viewing angle, which may impact ATCO/AFISOs situation awareness and negatively impact *safety*.		standards include: FAA's Human Factors Design Guide, Ch6 Control and visual indicators, page 6-55 and MIL-STD-1472F, 1999, page 17, the visual fields for Eye Rotation • Assess usability of different working position set ups		design requirements for remote tower ops room • Mock ups / Prototyping sessions RTS/trials
2.3.3.2 (WP5)	Important information located on the screens in the background is obscured by the CWP monitors in front. In current towers, the CWP monitors often obscure the view to the runway, this can impact situation awareness and also efficiency, and hence *safety* as ATCOS may have to stand up or move to gain the required information from the outside view.	High	• Ensure the appropriate HF guidelines & standards are considered & applied in the design & development of the CWP, e.g. based on the maximum top vertical viewing angle of 40° we need to subtract 15° which is reserved for the monitors in front. This results in a maximum of 25° for the vertical viewing angle. • Assess visibility of screens from CWP	Support the design of the CWP	• Review relevant HF standards / design guidelines & identify HF design requirements for remote tower ops room • Mock ups / Prototyping sessions RTS/trials
Arg. 2.3.4: Alarms and alerts have been developed according to HF principles.					
	N/A				
Arg. 2.3.5: The usability of the user interface (input devices, visual displays/output devices, alarm& alerts) is acceptable.					
2.3.5.1 (IR4)	Too much information is presented to the ATCO/AFISO (i.e. on the panoramic display and CWP). The presentation of too much information can have two potential negative consequences on ATCO/AFISOs work: • Too much information i.e. information overload, may *increase ATCO/AFISOs' cognitive workload* as ATCO/AFISOS would have to monitor, interpret and integrate more sources of information to be able to make the necessary decisions. The presentation of unnecessary information adds clutter, and this may help to reduce ATCO/AFISOs situation awareness's by making it more difficult for ATCO/AFISOs to find the essential information when necessary. Both may have	High	• Support the design & development of the HMI by identifying what information is required for ATCO/AFISOs to perform their tasks efficiently and effectively e.g. a task analysis could be used to identify ATCO/AFISOs primary and secondary information	• Identify ATCO/AFISO information requirements • Identify HMI design requirements to ensure utility & usability of information presented Assess utility & usability of information presented in validation activities	• Task analysis • Review & identify relevant HF standards / design guidelines to ensure utility & usability • Mock ups /

	safety implications		requirements • Ensure good design practice relating to information display / HMI design (for both the CWP and panoramic display) is adopted in the system design and development process and define the necessary HF / system requirements relating to HMI design Assess ATCO/AFISOs information requirements during validation activities (i.e. is there too much information presented or information missing)		Prototyping sessions RTS/trials
2.3.5. (IR6)	The information presented on the HMI (CWP and panoramic display) is not intuitive and easy to interpret. If the information displayed is not initiative and easy to interpret then ATCO/AFISOs will spend time having to interpret the information presented. This will reduce *increase ATCO/AFISOs cognitive workload, reduce efficiency* and even lead to an increase in the *potential for error* in terms of information interpretation, so impacting *safety*. In addition, if a system is intuitive and easy to use the amount of training required should theoretically be reduced and this will benefit *cost effectiveness*.	High	• Ensure good HMI design practice is adopted and define HMI information display requirements to ensure usability • Assess the usability of the information presented on the CWP and panoramic screen in validation activities	• Identify & define HMI information display requirements to ensure usability • Assess the usability of the information presented on the CWP and panoramic screen in validation activities	Review & identify relevant HF standards / design guidelines to ensure usability Mock ups / Prototyping sessions RTS/trials
2.3.5.3 (IR2)	The overlaid / highlighted information (e.g. enhanced geographical information, meteo, labels), obscures important information on the panoramic view. Overlaid information or highlighted information on the panoramic display aimed at increasing ATCO/AFISOs situation awareness, if not well designed may actually cover and obscure other information displayed on the panoramic display which ATCO/AFISOs may also need. This could result in ATCO/AFISOs global situation awareness being reduced or required information not being visible; both may	High	• Ensure HF / system requirements for the overlaid / highlighted information on the panoramic screen are included in the requirement spec. to ensure such information does not	• Identify & define HMI requirements for the overlaid / highlighted information on the panoramic screen Assess the utility & usability of the HMI with regards to the overlaid / highlighted	• Task analysis to identify information priorities • Review & identify relevant HF

	result in an increase in the potential for error, and hence impact *safety*.		obscure other important information • Identify the priority of different information and ensure the overlaid / highlighted information does not obscure information considered to be more important • Limit the amount of information that is overlaid or highlighted to a minimum • Assess during the validation activities that the overlaid / highlighted information does not obscure other important information	information in the validation exercises	standards / design guidelines to ensure usability overlaid /highlighted information • Mock ups / Prototyping sessions RTS/trials
2.3.5.4 (U2)	Degeneration in manoeuvring the PTZ camera compared with the use of binoculars. If ATCO/AFISOs find it difficult to manoeuvre the PTZ camera, it make take time to locate the object on the screen (*reduced efficiency*) and zoom in to gain a closer look, this will impact ATCO/AFISO *situation awareness* and this may impact *safety*.	High	• Control devices for PTZ camera must be intuitive & easy to use. • Assess usability of control devices in the validation activities • End users should be trained on how to use the PTZ camera	• Identify & define HF requirements for input / output devices • Assess usability of the control input / output devices on the CWP e.g. PTZ zoom function in validation activities • Support the identification & definition of training requirements	-Review & identify relevant HF standards / design guidelines to ensure usability of control devices -Mock ups / Prototyping sessions -RTS/trials
2.3.5.5 (WE7)	Lens on camera becomes covered e.g. snow, ice, rain drops, bird poop so visibility is impacted (WP12.4.7) (from EXE-VP-056), this may impact situation awareness and hence *safety*.	High	For snow and ice make sure the cameras at the aerodrome are heated so that in snowy, icy conditions the camera picture is not impacted.		

			For rain & bird poops ensure there is a way to automatically clean the camera lens remotely		
2.3.5.6 (WE8)	Performance of equipment e.g. picture quality resolution, depicted on panoramic screens degrades over time (from EXE-VP-056), this may impact visibility and hence have *safety* implications	High	After installation of the remote tower system engineers should be available to assess picture quality at regular intervals to ensure picture quality is maintained. Initially it is recommended that ensure the picture quality is assessed every day then progressing to every week, then every month if no degradation is identified.		
Arg. 2.3.6: The interface design reduces human error as far as possible.					
2.3.6.1 (WE1)	There are too many small / different work areas on the CWP which may increase potential for human error. If the controller has to work with too many different small screens and pieces of equipment, it may result in too many different input / output devices being required to manoeuvre/ control the screens, e.g. the use of mouse, mouse –pen and finger-touch. This may also force the controller to perform non ergonomic handles and can result in *human error* with the wrong device being use to perform a certain action, hence impacting *safety*	High	• Limit the number of screens on the CWP to a minimum, have an integrated CWP • Ensure the type of input/output devices is minimised.	Assess usability of CWP	-Trials / RTS
Arg. 2.3.7: The user interface supports a sufficient level of individual situation awareness.					
2.3.7.1 (SIR2)	The overlaid / highlighted information on the panoramic display directs ATCO/AFISOs attention / focus away from other necessary information. Overlaid or highlighted information may help to draw ATCO/AFISOs attention to a specific object or piece of information but a potential consequence of that is that the ATCO/AFISOS attention and focus is taken away from perhaps other more important information (i.e. *attention distraction / tunnelling*). If that happens then the *potential for error* is increased and *safety* is negatively impacted.	High	• Ensure that overlaid information / highlighted information on the panoramic display supports ATCO/AFISOs only in their primary tasks, i.e. non-essential information should not be highlighted or overlaid • Support the design & development of the HMI by identifying and prioritising	• Identify the information required for ATCO/AFISOs to perform their tasks • Assess utility of the information displayed on the CWP and panoramic display in validation activities • Assess ATCO / AFISO SA in validation activities	• Task analysis • Review & identify relevant HF standards and design guidelines to ensure usability of overlaid / highlighted information

			the information required for ATCO/AFISOs primary tasks e.g. using task analysis,. • Ensure that overlaid and highlighted information on the panoramic display support ATCOs /AFISOs only in their primary tasks i.e. highlighted or overlaid information should be kept to a minimum & non-essential information should not be highlighted or overlaid highlighted or overlaid • Assess the impact of the overlaid / highlighted information on ATCO/AFISOs situations awareness (both generally & specifically on attention distraction / tunnelling)		• Mock ups / Prototyping sessions RTS/trials
2.3.7.2 (IR8)	Too much overlaid / highlighted information on the panoramic screens may decrease ATCO situation awareness. The aim of the overlaid / highlighted information is to draw ATCO/AFISOs attention to important information / objects displayed on the panoramic screen, so enhancing ATCO/AFISO SA & ultimately safety. However, if too much information is highlighted / overlaid then ATCO/AFISOs SA may be negatively affected as ATCO/AFISOs may not be able to distinguish between critical and less critical information, this may have *safety* implications.	High	Overlaid / highlighted information must be limited to ensure ATCO/AFISOs attention is drawn only to the important / critical information being displayed on panoramic screens	Assess the impact of the overlaid / highlighted information on ATCO/AFISO SA	• Mock ups / Prototyping sessions RTS/trials
2.3.7.3 (SA1)	ATCO/AFISO situation awareness is reduced under good visibility & poor visibility conditions e.g. darkness, fog etc. due to the picture quality of the visual reproduction screens. One of the main concerns that may cause SA to be reduced under good visibility conditions is the quality of the view / picture of the aerodrome environment displayed on the 3D panoramic screens. If the view is of lower quality than the current 'real world view', e.g. due to poor picture resolution some details may not be not visible, such as the detection of	High	• System requirements for picture resolution and transmission latency must be clearly defined & verified (WP12.4.7 activity) • State of the Art' technology should be implemented to	Assess ATCO SA under good & reduced visibility conditions e.g. darkness, fog in validation activities	RTS/trials

	small fast moving objects (e.g. animals on the runway). Transmission latency may also lead to untimely information (both visual and verbal) being presented which would also reduce ATCO/AFISOs situation *Reduced situation awareness* will increase the potential for *human error* and be unacceptable to ATCO/AFISOs. *ATCO/AFISO workload* may also increase as more time may be spent looking for specific information and hence *reduce efficiency*. Thus there is a potential negative impact on *safety*.		ensure picture quality / resolution is optimised and latency of information presented is minimised (i.e. picture quality and latency requirements are met). (WP12.4.7 activity) • Use of augmented reality to highlight certain information / objects when / if necessary • Assess impact of remote tower operations on ATCO/AFISOs situation awareness under good visibility conditions in validation activities		
2.3.7.4 (SA2)	ATCO/AFISOs are unable to accurately judge aircraft separations visually under remote tower operations. If ATCO/AFISOs are unable to accurately judge aircraft separations visually under remote tower operations for example, if the resolution on the panoramic screen is relatively poor, this will lead to an increase in the potential for separation infringements and *other human related errors*, which would be *unacceptable* for pilots and ATCO/AFISOs due to the potential impact on *safety*. Furthermore if ATCO/AFISOs are unable to accurately judge aircraft separation then ATCO/AFISOs will have to revert to procedural control. If this is the case ATCO/AFISO workload will increase and furthermore, efficiency and capacity benefits will not be realised.	High	• Introduce ASMGCS / radar • Implement some sort of tool to help ATCO/AFISOs accurately determine aircraft separations • Ensure cameras at aerodrome are positioned appropriately to optimise ATCO/AFISOs view in order to facilitate separation judgements • Use procedural control	Assess whether ATCOs/AFISOs can accurately determine aircraft separations in validation activities	RTS/trials
2.3.7.5 (SA3)	Pilots are aware of something (e.g. an object on the runway), but ATCO/AFISOs are not aware and cannot confirm. There may be an occasion when pilots are aware of something such as an object on the runway but ATCO/AFISOs are not aware and cannot confirm themselves so would have to contact and ask personnel located on-site to verify. This may lead to a lack of trust on the pilots'' behalf, and they may be less likely to follow and accept clearance instructions from ATS. In addition it may lead to them not accepting remote tower operations, so reducing aircrew a*cceptance* of the concept.	High	• Ensure the technology implemented allows ATCO/AFISOs to have the same level of visibility of aerodrome environment as current day e.g. positioning of cameras, facility to adapt view and gain close up of	Assess ATCO/AFISO SA in validation activity	RTS/trials

			aerodrome environment • Ensure there is a open communication channel with on-site personnel so they can check out pilot queries if ATCO/AFISO are unable to whenever necessary – this communication channel must be quick and always available (e.g. intercom)		
2.3.7.6 (SA4)	ATCO/AFISOs have difficulty judging distances between aircraft and other objects with the panoramic screen. ATCO/AFISOs may find that it is more difficult to judge distances using the 3D panoramic screens compared to the real world view from the tower. This will reduce ATCO/AFISO*s situation awareness* and hence lead to an *increase* in the potential for *human error* and hence negatively impact *safety*.	High	• Implement tools to help ATCO/AFISOs better judge / assess distances between aircraft and perhaps other objects • Ensure cameras at aerodrome are positioned appropriately to optimise ATCO/AFISOs view in order to facilitate separation judgements • Adapt procedures (Use procedural control)	Assess ATCOs/AFISOs ability to judge distances between a/c & other objects in validation activity	RTS/trials
2.3.7.7 (SA5)	Lack of external sound from aerodrome reduces controller situation awareness. Controller will not be able to hear the number of revolutions for both aircraft on ground as well as aircraft on final. This lack of auditory information may result in controller *situation awareness being reduced*, this may have *safety* implications The transmission of the external sound from the aerodrome may help to increase SA.	High	• Transmit ambient sound from aerodrome to the remote tower. • Sound quality requirements must be clearly defined • Loudspeaker volume controls should be on the CWP so ATCO/AFISOs can adjust volume of the transmitted sound if necessary.	Assess impact of the external sound from aerodrome on ATCO/AFISO SA in validation activities	RTS/trials
2.3.7.8 (SA6)	Visual and /or auditory cues (e.g. a puff of smoke from the wheels when	High	• Requirements for picture	Assess ATCO/AFISO SA of	RTS/trials

	landing, sound of birds, weather phenomena, lightning) are lost. Reduced picture quality and sound quality may mean that the more subtle auditory cues used by ATCOs, e.g. a puff of smoke from the wheels when landing, are lost. Thus situation awareness would be reduced due to the reduced picture quality and sound, which may result in an increase potential for *human error* and hence *safety* and reduce ATCO *acceptance* of RTO		quality e.g. resolution requirements, on panoramic display in remote tower must be clearly defined • Ensure cameras at aerodrome are positioned appropriately to optimise ATCO/AFISOs view in order to facilitate separation judgements • Transmit ambient sound from aerodrome to the remote tower. Sound quality requirements must be clearly defined.	specific visual &/or auditory cues in validation activities	
2.3.7.9 (SA7)	The automation (EFS, a/c id and tracking) reduces ATCO/AFISOS' *situation awareness.* The introduction of automation e.g. EFS, a/c identification and tracking, may result in the ATCO/AFISOs feeling more 'out-of-the-loop' leading to ATCO/AFISO *vigilance being negatively impacted* and *situation awareness* being reduced. Both of which could result in *increased potential for human error* and negatively impact *safety* and ATCO/AFISOs being *reluctant to accept* the automation being introduced.	High	• Ensure good design practice relating to automation is adopted in the system design and development process by defining the necessary HF / system requirements relating to automation • Assess whether ATCO/AFISO vigilance / SA is affected in the validation activities	Assess the impact of automation e.g. EFS, a/c identification & tracking on ATCO/AFISO SA in validation activities	RTS/trials
2.3.7.10 (SA8)	Lack of depth in the presentation on the screens means its difficult for ATCO/AFISOs to judge distances. The ATCO/AFISOs may have difficulty estimating distance and the possibility for fast action might decrease and affect the ATCO/AFISO *situation awareness, efficiency* and increase the potential for *human error*, and hence negatively impact *safety*.	High	• Optimize resolution • Ensure cameras at aerodrome are positioned appropriately to optimise ATCO/AFISOs view in order to facilitate separation judgements • Artificial references for increased experience of 3D	• Assess depth perception in validation activities • Assess need for artificial references for increased experience of 3D in validation activities	RTS/trials
2.3.7.11 (SA9)	Variation of light in the picture. The cameras affect the visual presentation as	High	• Direct feedback from	Assess impact of light variation	RTS/trials

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	each camera has got its own settings which may cause differences in the view from one camera to another. Sun glare, too bright sky and dark ground – can occur as a result of the cameras built in automatic control. This reduced image quality / reduce might have impact on ATCOs *situation awareness* and *decision making*, and hence *safety*		adjusting the settings. • Possibility to reset the system to default settings. • Manual light/contrast settings for each camera / screen to override automation.	on ATCO/AFISO work , SA in validation activities	
2.3.7.12 (SA10)	Disturbance by joint seam covering between the screens. The joint / seem between the different screens may have a negative impact when maneuvering the PTZ camera as well as the static picture and might interfere with e.g. TWY taxiway and foreign object detection. This could impact ATCO/AFISO *situation awareness,* and hence *safety.*	High	• Evaluate impact of the joint /seam during validation activities on situation awareness and controller performance • Implement seamless screens by using latest technology (WP12.4.7).	Assess impact of the joint /seam during validation activities on situation awareness and controller performance	RTS/trials
2.3.7.13 (SA11)	Cognitive discrepancy and variance between 360 degrees of view and the same view presented on 180 degrees screen presentation may disorient ATCO/AFISOs & impact their situation awareness, so having *safety* implications. ATCO/AFISOs *situation awareness* might be affected when a passing aircraft doing a 360 circuit can be seen on a 180 degrees presentation. It is also more difficult to judge distances using 180º screens compared to the real world view from the tower, which is 360.	High	• Validate ATCO/AFISO situation awareness of such an event in validation activities i.e. either in a simulated environment or within already existing validation equipment for remote TWR business. • Set up 360degree view in remote tower	Assess ATCO/AFISO SA in certain events e.g. a/c performing a 360 circuit	RTS/trials
2.3.7.14 (SA12)	Infra-red (Thermal imaging) camera does not increase ATCO/AFISO SA in poor visibility conditions e.g. darkness, fog etc. The aim of the introduction of the infrared cameras is to increase ATCO/AFISO SA in poor visibility conditions e.g. darkness & fog. If the infra-red cameras do not achieve this benefit then ATCOs will have to resort to LVP. This may impact capacity / aerodrome throughput and hence *capacity*.	Medium		Assess utility & impact of IR (Thermal imaging) camera on ATCO/AFISO SA in poor visibility conditions e.g. darkness, fog etc.	RTS/trials
2.3.7.15 (WM1)	Increased head down time. If ATCO/AFISOS feel that the outside view of the aerodrome environment presented on the screens is not of a good quality they may tend to rely more at the information displayed on the CWP, e.g. radar, EFS.	High	Assess whether ATCO/AFISO reliance on information displayed on the CWP (i.e.	Assess changes to working method & impact of any changes on SA / potential for	RTS/trials

	This may impact controller situation awareness in some way e.g. ATCO/AFISOs may be less likely to spot unusual objects in the aerodrome vicinity as they are not using the out of the window view (due to its poor quality) and may increase potential for human error and hence have *safety* implications.		and not the OTW view) & head down time is an issue in validation activities	human error	
2.3.7.16 (WE)	The size and design of the remote control room may limit the number of screens that can be implemented. This may restrict the view of the aerodrome environment that can be presented to ATCO/AFISOs in the remote tower and may impact visibility and hence ATCO/AFISO situation awareness and hence *safety*.	High	• Consider using large sized screens • Ensure size & design of remote tower operations room are such that the required screens & equipment can be accommodated	Assess visibility of aerodrome environment & vicinity and SA of ATCO/AFISOS	RTS/trials
2.3.7.17 (SA13)	Enhanced visualization features (e.g. improving visibility of aerodrome on screens) actually distorts ATCOs awareness of the operational environment (identified in EXE-VP-056), this may have *safety* implications, e.g. the enhanced features may make the visibility conditions look more positive than in reality.	high		Assess systematically to identify optimal level of enhanced visualisation features	RTS/trials
Arg. 2.3.8: The user Interface design supports a sufficient level of team situational awareness.					
	N/A				
Arg. 2.3.9: Workstations (e.g. cockpit layout and consoles) adhere to ergonomic principles.					
2.3.9.1 (WE3)	The size of screen may be limited by the space available in the remote tower operations room as well as by cost. In addition large screens require cooling system that can be noisy and which may distract the controller and mask other sounds in the remote tower. However, small screen may also cause potential problems as if they are too small it may cause ATCO/AFISOs to strain their eyes and hence lead to *fatigue* and *other symptoms* such as headache, this could impact *acceptance* as well as *safety*.	High	-The size of the panoramic screens must be evaluated so that the optimum size is implemented.	-Assess psycho-physiological impact on screens on ATCO/AFISO e.g. in terms of eye strain, fatigue	-Mock-ups -RTS/ trials
Arg. 3.1: Effects on team composition are identified.					
ID	**HP ISSUE / BENEFIT & IMPACT**	**PRIORITY**	**POTENTIAL MITIGATION**	**HP / VALIDATION OBJECTIVE**	**RECOMMENDED ACTIVITY**
Arg. 3.1.1: Changes to existing roles in the team are identified (including roles that become obsolete).					
	N/A				
Arg. 3.1.2: The introduction of new roles to a team is identified.					
3.1.2.1	New roles emerge as a result of single remote operations e.g. technicians to	Med/		-Identify the description of	-Task analysis

	maintain cameras, visual reproduction display & associated software etc.	High		human actors affected by the change.	

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

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 3.2.1: Changes to the task allocation between human actors do not lead to adverse effects on human tasks.					
3.2.1.1	Allocating certain tasks, e.g. met ops to aerodrome staff, negatively impacts efficiency of how tasks are performed increases potential for error. This may impact overall system *efficiency* and depending on what type of errors occur perhaps *safety*	Med		-Assess impact of changes to task allocation in trials on potential for human error	-Trials
Arg. 3.2.2: The proposed task allocation between human actors is supported by technical systems/the HMI.					
3.2.2.1	ATCO/AFISO have trouble contacting with aerodrome staff. This may negatively impact *efficiency* and potentially *safety*	Med.	-Use intercom to ensure ATCO/AFISOs can always get in touch with aerodrome staff	-Assess impact of changes resulting from new technical systems on human performance e.g. efficiency, potential for error in RTS / trials	-RTS / Trials
Arg. 3.2.3: The potential for human error in team tasks is reduced as far as possible.					
3.2.3.1	The fact that certain tasks e.g. met obs., will be performed by aerodromes staff and not ATCO, increases the potential for human error and may reduce *efficiency.*	Med.		-Assess impact of changes to task allocation in trials on potential for human error	-RTS / Trials
Arg. 3.2.4: Team tasks can be achieved in a timely and efficient manner.					
3.2.4.1	The fact that certain tasks e.g. met obs., will be performed by aerodromes staff and not ATCO, increases the time taken to perform those task and hence reduces *efficiency*.	Med		-Assess impact of changes of new task allocation on human performance e.g. efficiency, potential for error in RTS / trials	-RTS / Trials

Arg. 3.3: The communication between team members supports human performance.

ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 3.3.1: Intra-team and inter-team communication supports the information requirements of team members					
3.3.1.1 (RT2)	Pilots try to 'cheat' if they know ATCO/AFISO is not there. If the aircrew know the ATCO/AFISOs are not present onsite at the aerodrome, they may assume they are	Low / Medium	• Information campaign to explain remote tower	- Identify mitigation for potential pilot 'cheating	Expert judgement /

	less aware of what is going on and so try to 'cheat' by perhaps not providing all the necessary / correct information in order to try an earlier arrival or departure slot.		operations / procedures to airlines and aircrew • Aircrew to be responsible for accomplishing the slots/eobt time, etc..		workshops
3.3.1.2 (TD1)	There is a perceived shift in authority due to absence of ATCO/AFISO at aerodrome e.g. between aircrew and ATCO/AFISOs' and local staff. The absence of the ATCO/AFISOs may mean that aircrew and local aerodrome staff may be less inclined to follow ATCO/AFISO instructions and / or may make decisions that currently need to be verified by ATS without consulting ATCO/AFISOs. This may have serious *safety consequences.*	Medium / High	• Develop an information campaign to ensure roles, tasks and procedures and chain of command are clarified for ATCO/AFISOs, aerodrome staff, aircrew and airlines. • Allow onsite aerodrome staff representatives and airline representatives to visit the remote tower so they can understand remote tower operations and communicate back to their staff members	Support development of an information campaign / training programme for aircrew, airlines & local aerodrome staff (i.e. to support change management)	-Expert judgement / workshops - TNA
Arg. 3.3.2: The phraseology supports communication in all operating conditions.					
3.3.2.1	Current phraseology used by ATCO/AFISOs & aircrew is no longer appropriate or acceptable under normal, abnormal and degraded modes of operation. This may result in confusion, and may impact efficiency.	Medium	Identify normal/abnormal operating conditions and degraded modes & check against proposed phraseology. -Assess the phraseology in Real-Time Simulation or operational trials:	-Identify normal/abnormal operating conditions and degraded modes & check against proposed phraseology. - Assess the phraseology in Real-Time Simulation or operational trials:	-Task analysis -RTS/trials
Arg. 3.3.3: Changes in communication means & modalities are identified and acceptable.					
3.3.3.1 (CM1)	Co-ordination with on-site aerodrome personnel e.g. fire-fighters, may be more difficult. In the remote tower, ATCO/AFISOs will not be able to have direct (face to face) interaction and communication with aerodrome personnel if necessary for whatever reason on an ad hoc basis. Hence, communication with aerodrome personnel will be via radio or telephone, and this may reduce communication	Medium	Ensure facilities to enable direct communication between ATCO/AFISO and the necessary aerodrome staff is available at all times,	-Assess requirement for new tools / communication devices e.g. intercom	-RTS/ Trials

	efficiency and lead to an increase in communication related errors, i.e. the message not getting to the intended person in the required time, and this could impact *safety*.		(staff that ATCO/AFISOs need to be able to communicate / contact at all times - required need to be defined perhaps something like an intercom system between ground staff at aerodrome and staff working in remote tower)		
Arg. 3.3.4: The communication load of team members is acceptable in normal and abnormal conditions and degraded mode of operations.					
3.3.4.1 (RT1)	ATCO/AFISOs requests for pilot information and information confirmation are increased. If ATCO/AFISOs do not trust the information displayed in the remote tower or if the visibility in the remote tower is not as good as current day operations in the tower ATCO/AFISOS may request more information or confirmation of information from the aircrew. This would increase the amount of communications between the pilot and ATCO/AFISO and so increase ATCO/AFISO and pilot task load and hence may lead to an increase in ATCO/AFISO and pilot workload. This in turn would result in RTO being less acceptable and *accepted* by ATCO/AFISOs and aircrew.	High	• Assess impact of remote tower operations on ATCO/AFISO / pilot communications (number and type of communication should be addressed) in validation activities.	Assess impact on ATCO/AFISO & pilot communication / task load & workload	RTS/trials (with pilot participation)
Arg. 3.3.5: Team members can maintain a sufficient level of shared situation awareness.					
3.3.5.1	Being remotely located impacts ATCO SA of with regards to what the GND staff is doing and vice versa. This may impact efficiency and increase potential for error, and hence have certain *safety* implications	High	-Use intercom to ensure ATCO/AFISOs can always get in touch / communicate with aerodrome staff?	Assess team situational awareness in operational trials	-Trials
Arg. 4.1: The proposed solution is acceptable to affected human actors.					
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 4.1.1: Changes in roles and responsibilities are acceptable to the affected human actors.					
4.1.1.1 (TD2)	Team work / confidence between aerodrome staff and ATCO/AFISOs due to change in relationships as a result of being located remotely. As above, the absence of ATCO/AFISOs onsite at the aerodrome may change the current relationship between ATCO/AFISOs and aerodrome staff. They may be less inclined to work as a team and a *lack of trust* between onsite and remote tower workers may develop.	Low / Medium	• Select representatives from on-site and off-site locations to ensure there is a continuous dialogue between both staff members • Ensure regular meetings between remote and on-site	Identify required change management initiatives?	- stakeholder workshops

			staff ideally face to face but if that's not possible video conference		
4.1.1.2 (WP1)	Aircrew are not aware ATCO/AFISOs are not in the tower located onsite at aerodrome.	Low / Medium	Information campaign to inform airlines / pilots that remote tower operations are in place at specific aerodrome and also to explain remote tower operations	-Support development of an information campaign / training programme for aircrew & airlines	-Training needs analysis -Stakeholder workshops
4.1.1.3 (WP3)	Sensation of working in a control room or simulator. Being away from the aerodrome environment and not having the outside tower view may result in some ATCO/AFISOs feeling they are working in a simulator or control centre. In this way they may lose the sensation of reality and may feel detached from the operational environment. This could impact their *situation awareness, performance* in general and hence *safety*.	Low / Medium	Keep the TWR-atmosphere as far as possible i.e. aim to have the same look and feel as a tower control room	-Support design of the remote tower control room	-Stakeholder workshops
4.1.1.4 (WP4)	Decreased possibilities to physically interact with aerodrome staff. Limited possibilities for face to face interaction with aerodrome staff and pilots, may reduce communication, this may reduce *trust* between staff located onsite at aerodrome and offsite in the remote tower, this may also lead to *lack of acceptability* of remote tower concept.	Low	Use of regular meetings via video conferencing facilities	Support identification of training & other pre-and post-implementation requirements for ATCO/AFISO, aircrew & aerodrome staff	-Stakeholder workshops
4.1.1.5	Controller acceptance Organisational issues based on consequences within management and direction. ATCO/AFISOs experience a lack of interaction with the management which might cause an overall effect on concept *acceptance*, and this may impact *cost-effectiveness*.	Med	Frequent information sharing and RTC campaigns. Make external understanding for the concept and create acceptance by the use of open channels.	Support identification of pre- and post-implementation requirements for ATCO/AFISO, aircrew & aerodrome staff	-Stakeholder workshops
4.1.1.6 (S4)	Lack of TWR controller involvement during phase of development. Failure to involve the ATCO/AFISOs in the development of the remote tower concept may lead to ATCO/AFISOs *not accepting* and/or trusting remote tower operations. This could impact *cost effectiveness*	High	Adopt a human centred design approach by performing an HF assessment in order to ensure the end users are involved in the design and development process	Support identification of pre- and post-implementation requirements for ATCO/AFISO, aircrew & aerodrome staff	-Stakeholder workshops

4.1.1.7 (S6)	ATCO/AFISO do not *accept* the remote tower concept in general. This could impact *cost effectiveness*	High	-Adopt / continue to use a human centred approach in the concept design & development process -Frequent information sharing and RTC campaigns. Make external understanding for the concept and create acceptance by the use of open channels.		-Conduct HP assessment process
Arg. 4.2: Changes in staffing requirements and staffing levels are identified.					
ISSUE ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 4.1.2: The impact of changes on the job satisfaction of affected human actors has been considered.					
4.1.2.1	Team participation and identity plus local knowledge and awareness are lost. Loss of team participation and identity may impact job satisfaction. The loss of local knowledge & awareness may have some impact on ATCO/AFISO performance, and in the worst case scenario, impact *safety*.	Medium	• Ensure regular meetings / briefing sessions between remote and on-site staff ideally face to face but if that's not possible video conference • Ensure ATCO/AFISOs are able to visit the aerodromes they are controlling to ensure their local knowledge and awareness, as well as relationships with the onsite aerodrome staff are somewhat maintained • Training for remote ATCO/AFISOS should involve some onsite training at the aerodrome they will be controlling so they gain local knowledge and awareness,	Support identification of training & other pre-and post-implementation requirements for ATCO/AFISO?	-Training needs analysis

			as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower		
4.1.2.2	ATCO/AFISOs find it less stimulating / more boring to work in a remote tower. Some ATCO/AFISOs may miss actually working on-site at the aerodrome and being at the centre of the aerodrome operational environment and this may impact job satisfaction.	Low		Support identification of pre- and post-implementation requirements for ATCO/AFISO, aircrew & aerodrome staff	-Stakeholder workshops
Arg. 4.2.1: Knowledge, skill and experience requirements for human actors have been identified.					
4.2.1.1 (SK1)	ATCO/AFISOs lose certain knowledge/skills due to the filtering of reality e.g. knowledge of aircraft behaviour, local environment, local weather. The loss of certain knowledge and skills due to the filtering of reality may lead to ATCO/AFISOs' performance being degraded and the potential for human error to be increased, and hence *safety* being compromised.	HIgh	• Regular visits to the aerodromes ATCO/AFISOS are controlling remotely • Ensure ATCO/AFISOS have regular refresher training to ensure such skills / knowledge are maintained. Exact content of such training to be determined by training needs analysis. • Add more buffers such as stricter procedures and ensure adherence to procedures	Identify ATCO/AFISOS training requirements for single remote towers	-Training needs analysis -Stakeholder workshops
4.2.1.2 (SK2)	Skill requirements for the job change and ATCO/AFSIO no longer have the competence to perform their job. This will impact efficiency & perhaps *safety*, and *cost effectiveness*.	High	Perform a task / job analysis to identify how tasks change and whether skill requirements for the job have changed as a result	-Assess changes to skill & knowledge requirements	-Task /job analysis to identify skill changes
4.2.1.3 (WP6)	Important knowledge of local environment may be lost (identified in EXE-VP-056). The required level of local knowledge that is required to support ATCOs work must be identified and included in the training of remote tower operations, otherwise human performance may be negatively impacted and this could impact *safety*	High	• Regular visits to the aerodromes ATCO/AFISOS are controlling remotely • Ensure ATCO/AFISOS have regular refresher training to		

			ensure such skills / knowledge are maintained. Exact content of such training to be determined by training needs analysis.		
4.2.1.4	There will be a larger centralised pool of ATCO/AFISOs available who are all trained and rated to use the same standardised equipment/CWP and working procedures. This will facilitate training ATCO/AFISOs to work other aerodromes being controlled using the remote tower which in turn should improve *cost effectiveness* as a result of reduced training costs. (added following review comment)	Medium			-CBA
Arg. 4.2.2: The impact on operator licensing (as defined by the regulating bodies) has been identified.					
4.2.2.1	New ATCO/AFISO need to have a different license to work in remote tower centre	Medium	Identify list of relevant regulation concerning licensing & check against identified changes in competence requirements.	Identify list of relevant regulation concerning licensing & check against identified changes in competence requirements (using eRIA)	-Review licensing regulation & identify changes -Stakeholder workshop
Arg. 4.2.3: Preliminary training needs are identified for affect human actors					
4.2.3.1 (TR1)	ATCO/AFISOs are not adequately trained to work with remote tower. Failure to train ATCO/AFISOs adequately to work in the remote tower may have serious consequences relating to *efficiency & safety.*	High	Develop a complete training programme for remote tower operations	Support the development of a training programme for remote tower operations and determine the training content for each actor group (e.g. WP16.4.3. TACAT-HP)	-Training needs analysis
Arg. 4.3: Changes in staffing requirements and staffing levels are identified.					
ID	HP ISSUE / BENEFIT & IMPACT	PRIORITY	POTENTIAL MITIGATION	HP / VALIDATION OBJECTIVE	RECOMMENDED ACTIVITY
Arg. 4.3.1: The impact on staff levels is identified.					
4.3.1.1	The remote tower concept for single tower increases the number of staff required compared to current day e.g. due to additional technical engineers required. This may reduce *cost effectiveness*	Med		Assess impact of single remote tower operations on staff levels	-Task analysis -Stakeholder workshop

4.3.1.2	If shorter shifts are required (see Issue 4.3.2.1) then more ATCOs / AFISOs may be required compared to current day operations. This will impact cost effectiveness.	Med			
Arg. 4.3.2: The impact on shift organisation is identified.					
4.3.2.1 (S3)	Changes in staffing due to increased need for breaks. Due to risk of increased fatigue in the context of reduced daylight and screens, it might be taking into consideration that the ATCO/AFISOs needs more breaks and shorter shifts than in a tower located onsite at the aerodrome. This may lead to more ATCO/AFISOs being required and hence *increase the cost.*		Due to risk of increased fatigue in the context of reduced daylight and screens, it might be taking into consideration that the ATCO/AFISOs needs more breaks and shorter shifts than in a tower located onsite at the aerodrome. This may lead to more ATCO/AFISOs being required and hence *increase the cost.*		
Arg. 4.3.3: The impact on workforce (re-)location is considered.					
4.3.3.1	Not all ATCO/AFISO want to relocate. RT will result in workforce having to relocate	Low / Med		Identify changes in the required location of the workforce, using for instance the material developed in 16.4.4.	-Stakeholder workshops

Appendix B – HP recommendations register

The following table is a register of the HP recommendations that have been identified to date with regards to the remote tower concept.

Each recommendation has a specific ID which is constructed using the following key:

Key for defining recommendation ID:

First segment: Defines the project – 'RT' (Remote Tower)

Second segment: Specifies that it's a recommendation – REC (RECommendation)

Third segment: Defines the type of recommendation; DESIGN ; PROCEDURE; ROLE; TRAINING; VAL (VALidation activities or test) or OTHER for recommendations relating to organisational management, cost effectiveness etc.,;

Fourth segment: The number of the recommendation specific to the type of recommendation

HP recommendations open

HP Recommendations Register
This 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.

ID	Source	Recommendation *Describe the recommendation.*	Rationale *Describe the rationale of the recommendation.* **Note:** that the rationale for each recommendation can be found by looking at the appropriate source / issue in table 8 section 3.4.1**.**	Type *Specify the type of the recommendation: Design, Procedure, Roles, Training, or Test / Validation activity*	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.*
RT_REC_DESIGN-004	Iss_1.2.1.1, Iss_1.2.5.1, Iss_2.3.7.4 Iss_2.3.7.10	Consider introducing support tools to help ATCOs assess distance / separation	ATCOs felt they were unable to accurately judge distance / separation in the remote tower set-up. A support tool may be able to help ATCOs, this needs to be investigated	Design	Open	
RT_REC_VAL_002	Iss_1.2.1.1, Iss_1.2.5.1	Investigate feasibility of visual / reduced visual separation with different RT set ups / support tools	Visual / reduced separation was not considered feasible by ATCOs in the RT set-ups tested in the TWR trials, need to re-assess with other RT set-ups and support tools	Validation activity	Open	
RT_REC_VAL_004	Iss_1.2.3.6 Iss_1.2.3.7	Investigate degraded modes further in future validation activities e.g. RTS, trials, safety assessment	Certain degraded modes could not be assessed in trials. Assess degraded modes not tested in trials in future validation activities, e.g. RTS. Active mode trials, safety assessment	Validation activity	Open	
RT_REC_VAL_006	Iss_1.3.1.1	Need for ATS surveillance system should be more systematically investigated in future validation exercises with future RT set-ups, e.g. type & number of simultaneous movements that can be safely handled in future RT set-ups to be defined	ATCOs felt in EXE-VP-057 that if there were two or more simultaneous movements ATS surveillance was necessary. This needs to be more systematically investigated in future validation activities	Validation activity	Open	
RT_REC_DESIGN-011	Iss_2.3.1.1	Include type of a/c & speed in the label instead of destination/ arrival apt in the a/c automatic identification label	ATCOs reported that it would be more useful to have the a/c type and speed presented in the label rather than the destination/arrival APT	Design	Open	

RT_REC_VAL_017	Iss_2.3.7.4	Ability to accurately judge aircraft separations visually under remote tower operations to be re-assessed in future validation activities (RTS and/or trials).	Ability to accurately judge aircraft separations visually is an important factor that impacts on safety. This should be investigated during each validation activity	Validation activity	Open	
RT_REC_VAL_018	Iss_2.3.7.4 Iss_2.3.7.6 Iss_2.3.7.10	The impact of familiarity / experience on ability to judge separation visually in the remote tower should be assessed over a relatively long period of time to see if experience working with remote tower facilitates ATCOs ability to judge distances.	Familiarity and experience using the remote tower may enhance ATCOs ability to judge separation visually in the remote tower. This 'hypothesis' needs to be investigated in a longitudinal study.	Validation activity	Open	
RT_REC_VAL_020	Iss_2.3.7.6	Assess impact of position of cameras to help assess distances between objects & depth	The positioning of cameras may impact the ATCOs ability to assess distance and depth. – Therefore the positioning of cameras should be investigated to ensure the ATCOs ability to just distances and depth are optimised. The optimum position for cameras may vary depending on the aerodrome so should be done in V4, V5.	Validation activity	Open	
RT_REC_DESIGN-020	Iss_2.3.7.11	Provide ATCO/AFISOs with additional information relating to light/dark conditions at aerodrome	The visual reproduction screens may not accurately display the real world external light/dark conditions (either intentionally as a means to improve ATCOs visibility or un-intentionally), therefore it is recommended that additional information is displayed to the ATCOs to ensure they are aware of the real light/dark conditions at the aerodrome they are controlling remotely as this may impact their decision making.	Design	Open	
RT_REC_VAL_024	Iss_2.3.9.2	Investigate impact of RT set-up / environment on fatigue.	Working with monitors has been found to cause eyestrain and fatigue. Therefore the impact of the remote tower work environment on eye strain and fatigue needs to be investigated over the period of a shift. If fatigue is found to be an issue investigate possible means to prevent or mitigate fatigue e.g. reduce hours per shift or introduce more frequent breaks within a shift, make	Validation activity	Open	

			adjustments to the lighting ambient environment or R/T set-up			
RT_REC_TRAINING_003	Iss_3.3.1.2	Develop an information campaign to ensure roles, tasks and procedures and chain of command are clarified for ATCO/AFISOs, aerodrome staff, aircrew and airlines.	An information campaign is recommended to ensure that all parties impacted by the remote tower concept are informed and aware of any changes in terms of roles, tasks and procedures and chain of command.	Training	Open	
RT_REC_TRAINING_006	Iss_4.1.1.7	Frequent information sharing and RTC campaigns. Make external understanding for the concept and create acceptance by the use of open channels.	Information campaign should be used to raise awareness to all stakeholders that remote tower operations are in place at specific aerodrome and explain what this means. This will help to avoid any confusion and help promote general acceptance of the concept,	Training	Open	
RT_REC_TRAINING_007	Iss_3.3.5.1 Iss_4.1.2.1	Ensure ATCO/AFISOs are able to visit the aerodromes they are controlling to ensure their local knowledge and awareness, as well as relationships with the onsite aerodrome staff are maintained	Ensuring ATCO/AFISOs are able to visit the aerodromes they are controlling to ensure their local knowledge and awareness, as well as relationships with the onsite aerodrome staff are maintained is thought to be essential in helping to minimise the impact of ATCO/AFISOs being remotely located in terms of local knowledge and relationships with the aerodrome staff.	Training	Open	
RT_REC_TRAINING_008	Iss_4.1.2.1 Iss_4.2.1.1 Iss_4.2.1.3	Training for remote ATCO/AFISOS should involve some onsite training at the aerodrome they will be controlling so they gain local knowledge and awareness, as well as build a relationship with the onsite aerodrome staff before the start working in the remote tower	Providing ATCO/AFISOs with training at aerodromes they are controlling has shown to be important in developing local knowledge and awareness, as well as developing and maintaining relationships with the onsite aerodrome staff	Training	Open	
RT_REC_TRAINING_009	Iss_4.2.1.2 Iss_4.2.3.1	Develop a complete training programme for all actors impacted by the remote tower concept with pre-specified performance criteria that need to be achieved before they can 'go operational'	Failure to train all actors impacted by remote tower to work with remote tower operations to a satisfactory level prior to implementation will have serious safety implications. And failure to train all actors impacted in time for implementation would delay remote tower operations and this will negatively impact cost effectiveness. The exact training	Training	Open	

			required by each end user group needs to be defined using a training needs analysis)			
RT_REC_VAL_035	Iss_4.3.1.2 Iss_4.3.2.1	Conduct a fatigue study to determine the shift schedules and required breaks / rest periods	Working in a remote tower facility rather than a tower may impact fatigue. This needs to be investigated and also appropriate shift schedules and required breaks / rest periods need to be considered as a result	Validation	Open	
RT_REC_TRAINING_010	Iss_4.2.3.1	-Ensure ATCOs involvement plus training experts are involved in the development of the training programme	This is a recommendation based on knowledge of training best practice as it ensure that the training provided is accepted by the ATCOs, achieves the required results and delivered to the required standard.	Training	Open	

HP recommendations closed

HP Recommendations Register						
This 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.						
ID	Source	Recommendation *Describe the recommendation.*	Rationale *Describe the rationale of the recommendation.* **Note:** that the rationale for each recommendation can be found by looking at the appropriate source / issue in table 8 section 3.4.1.	Type *Specify the type of the recommendation: Design, Procedure, Roles, Training, or Test / Validation activity*	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.*

RT_REC_DESIGN-002	Iss_1.1.2.2 Iss_2.3.5.4	Introduce pre-setting for the PTZ or additional fixed cameras	Pre-settings to aid usability should be introduced. This was requested by ATCOs to facilitate them in finding the windsock as pre-settings on the PTZ camera or additional cameras focused on the windsock would make it easier for ATCO/AFISOs to obtain this information / observe the windsock	Design	Closed	Recommendation closed as implemented in EXE-VP640 and rated OK by ATCOs.
RT_REC_DESIGN-003	Iss_1.1.2.2	Ensure windsock located at the aerodrome being controlled remotely is easily viewed by ATCO/AFISO in remote tower	Windsock gives important information regarding wind direction & strength so if it is present at the aerodrome it should be visible to the ATCO/AFISO in the remote tower	Design	Closed	Recommendation closed as implemented in EXE-VP639 and rated OK by ATCOs
RT_REC_VAL_003	Iss_1.2.1.1, Iss_2.3.7.4 Iss_2.3.7.6	- Ability to accurately judge aircraft separations visually under remote tower operations to be re-assessed in future validation activities (RTS and/or trials).		Validation activity	Closed	Covered by RT_REC_VAL_002
RT_REC_PROCEDURE_001	Iss_1.2.1.1 Iss_1.2.2.1 Iss_1.2.3.1 Iss_1.2.3.2 Iss_1.2.3.6 Iss_1.2.3.7 Iss_1.2.4.1 Iss_1.2.5.1,	Procedures for normal, abnormal and degraded modes of operation developed and updated following Trial 2 [10]need to be validated in active mode trials in V3.	Procedures developed and evaluated by ATCOs in EXE-VP-057 have been updated based on ATCO feedback (see [10] for the procedures developed). These updated procedures need to be validated in future validation activities using active mode trials judge distance / separation in remote towers	Procedures	Closed	
RT_REC_DESIGN-005	Iss_1.2.5.1 Iss_2.3.1.1 Iss_2.3.7.4	Radar should be implemented if ATCOs are providing Approach services and the number of simultaneous air movements exceeds two		Design	Closed	
RT_REC_DESIGN-006	Iss_1.2.3.7 Iss_1.3.1.1 Iss_2.1.1.1 Iss_2.1.2.1 Iss_2.1.6.1 Iss_2.3.1.1	Implement automatic a/c identification and tracking function implemented to ensure ATCO SA is maintained and optimised in remote tower.	In trial EXE-VP-057 the automatic a/c identification and tracking function was shown to have a significant positive impact on ATCO SA, as it facilitates ATCOs continuous tracking of a/c in the aerodrome vicinity (and and in turn was also found to enhance ATCOs	Design	Closed	

	Iss_2.3.2.1 Iss_2.3.5.3 Iss_2.3.7.3 Iss_2.3.7.7		trust in the remote tower set-up and hence acceptability of the concept			
RT_REC_VAL_007	Iss_1.3.2.1	Investigate in active TWR mode trials whether or not ATCO tasks can be achieved in a timely manner.	Passive shadow mode trials are not the best means to assess whether ATCO tasks can be achieved in a timely manner. This needs to be done in a more setting where ATCOs can actually perform the tasks properly i.e. active mode trials	Validation activity	Closed	Evidence provided by implementation in Sundsvall
RT_REC_VAL_008	Iss_1.3.3.1	Assess ATCO workload in active mode trials under high taskload normal operating conditions as well as abnormal & degraded modes of operation.	Passive shadow mode trials are not the best means to assess ATCO subjective workload. This needs to be done in a more setting where ATCOs can actually perform the tasks, i.e. active mode trials.	Validation activity	Closed	Evidence provided by implementation in Sundsvall
RT_REC_VAL_009	Iss_2.2.1.1	Re-assess picture quality in active mode trials under various conditions e.g. different light / dark conditions and low visibility conditions	Picture quality was poor in all trials at dawn and dust i.e. low level light conditions i.e. there was a lot of pixilation and picture freezing. Therefore the quality of the picture under different light conditions needs to be re-assessed to ensure there is no pixilation and picture freezing and that the ATCO is able to continuously monitor a/c/ in the aerodrome vicinity	Validation activity	Closed	Evidence provided by implementation in Sundsvall
RT_REC_DESIGN-007	Iss_2.2.1.1	-Picture quality under different light / dark conditions and low visibility conditions needs to be improved (e.g. the visual reproduction screens should not freeze or become pixelated) to ensure that ATCO/AFISO has a up-to-date, clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the aerodrome vicinity as required.	Picture quality was poor in all trials at dawn and dust i.e. low level light conditions i.e. there was a lot of pixilation and picture freezing. Therefore the quality of the picture under different light conditions needs to be improved to ensure there is no pixilation and picture freezing and that the ATCO is able to continuously monitor a/c/ in the aerodrome vicinity	Design	Closed	Covered by RT_REC_VAL_009
RT_REC_VAL_010	Iss_2.2.1.2	Re-assess information consistency each time modifications are made to the CWP and / or visual reproduction	When changes are made the information presented on the CWP and / or OTW view the consistency of the information presented	Validation activity	Closed	Each validation covered evaluation of the whole

		in terms of information presentation	must be assessed to avoid any confusion / contradictions			working position
RT_REC_VAL_011	Iss_2.2.2.1	Assess timeliness of information presentation on visual reproduction screens / LCD screens	Information presented on the visual reproduction screens must not be delayed as this could result in ATCOs giving wrong information, clearances at the wrong time. See related functional requirements for minimum delay time of information presentation	Validation activity	Closed	Evidence provided by implementation in Sundsvall
RT_REC_DESIGN-008	Iss_2.3.1.1 Iss_2.3.5.2 Iss_2.3.7.8	Provide meteorological information which includes cloud base indicators, visibility indicators	ATCOs should have at least the same meteological information to them as today. Visibility indicators are essential especially in enhanced visual features are implemented which may distort the real visibility conditions that can be seen on the visual reproduction screen. Therefore information relating to the real visibility conditions at the aerodrome are be necessary. Also in a remote tower some information relating to the weather conditions at the remote tower may be lost. Therefore ATCO/AFISOs need all the weather related information available to help them determine the weather at the remotely located aerodrome they are controlling.	Design	Closed	Same weather information system as today is provided
RT_REC_DESIGN-009	Iss_2.3.1.1 Iss_2.3.7.3	- The set-up of the visual reproduction screens in terms of number of screens, layout orientation, area covered and included in the panoramic view, viewing angle etc. should be tailored and assessed and for each environment in which RT is implemented so that climbing and landing areas are fully captured on the visual reproduction	Set-up of the visual reproduction screens (as described) needs to be tailored for each RT environment	Design	Closed	Validated with different setups
RT_REC_DESIGN-012	Iss_2.3.2.1 Iss_2.3.7.3 Iss_2.3.7.14	Infra-red (thermal imagining technology) should be implemented to facilitate ATCOs in dark and low visibility conditions. If implemented IR usability needs to be improved.	In trials IR was reported to be very useful especially in dark and low visibility conditions but usability needs to be improved	Design	Closed	Recommendation closed as implemented in EXE-VP640 and rated OK by ATCOs.

RT_REC_DESIGN-013	Iss_2.3.2.1	-Additional Camera Viewpoints (ACV) should be available in the basic system set-up. Attention needs to be given as to where these ACV are located e.g. at hot spots, and the number required needs to be assessed on a aerodrome by aerodrome basis	ACV were said to be very useful by ATCOs especially in terms of monitoring hotspots. .	Design	Closed	
RT_REC_DESIGN-016	Iss_2.3.6.1	Consider integrating PTZ & IR images in the visual reproduction screens	This recommendation is aimed at improving the usability of the PTZ and IR. Feasibility of integrating PTZ& IR images needs to be further investigated – prototyping sessions are recommended to investigate different presentation/integration options e.g. e.g. reposition of PTZ images or use of smaller images	Design	Closed	
RT_REC_VAL_015	Iss_2.3.7.1 Iss_2.3.7.2	Impact of overlaid /high-lighted information on ATCO/AFISO attention & SA needs to be re-evaluated in the future as more overlaid / highlighted features are added and as current features are improved	Overlaid / high-lighted information must not negatively impact ATCOs SA, therefore if information is overlaid or highlighted on the CWP its usefulness and usability needs to be assessed to ensure SA is not impacted and that it supports the ATCO in his/her work	Future HP/Validation activities System design & HMI	Closed	Recommendation closed as implemented in EXE-VP640 and rated OK by ATCOs.
RT_REC_DESIGN-017	Iss_2.3.7.1	Ensure that overlaid and highlighted information on the panoramic display support ATCOs /AFISOs only in their primary tasks. i.e	Highlighted or overlaid information should be kept to a minimum & non-essential information should not be highlighted or overlaid. This helps to optimise end-users situation awareness and this is why only 'primary' task information should be highlighted or overlaid.	System design & HMI	Closed	Recommendation closed as implemented in EXE-VP640 and rated OK by ATCOs.
RT_REC_VAL_016	Iss_2.3.7.3	ATCO Situation Awareness (SA) needs to be assessed more systematically using different scenarios / events.	SA is so essential to ATCOs performance it should be re-assessed in all future TWR validation activities (in active mode trials) in both CAVOK & low visibility / light conditions	Validation activity	Closed	Recommendation closed as implemented in EXE-VP640 and rated OK by ATCOs.

RT_REC_DESIGN-018	Iss_2.3.7.3	Consider introducing additional automation functions for the PTZ to enhance usability of the PTZ feature, e.g. Pre-sets for the PTZ, automatic a/c tracking function	Findings from validation activities show that the PTZ features was not easy to use and needs improvement in terms of usability.	Design	Closed	Recommendation closed as implemented in EXE-VP640 and rated OK by ATCOs.
RT_REC_DESIGN-019	Iss_2.3.7.7	-Provide external sound that can be adjustable within certain degrees .	External sound was shown to improve SA for many ATCOs but some found it distracting when the volume was too loud, therefore provision of external sound is recommended but it should be adjustable within a certain range	Design	Closed	
RT_REC_VAL_021	Iss_2.3.7.8	- Specific scenarios / events (e.g. a puff of smoke from the wheels when landing, gear down (or not) on landing, sound of birds, weather phenomena, lightning) to be agreed on with safety & operational experts) to be scripted into future validation activities (RTS/ trials) to assess ATCO situation awareness under varying conditions	Situation awareness or lack of it is one of the main concerns relating to the RT concept and so it need to be investigated thoroughly and systematically in future validation activities	Validation activity	Closed	Wide variety of scenarios were part of validations
RT_REC_VAL_023	Iss_2.3.7.13 Iss_2.3.7.16	Assess more systematically what set-up visual viewing angle regarding the visual reproduction screen is needed to optimise human performance, e.g. 360 degree view on a 360 degree screen, or 200 degree on 140	Need to identify the optimum set up and viewing angle for the visual reproduction screens, as this can impact ATCOs situation awareness and also have cost implications.	Validation activities	Closed	Recommendation closed as implemented in EXE-VP640 and ~200 degree on 140 rated OK by ATCOs.
RT_REC_DESIGN-023	Iss_2.3.9.2 Iss_2.3.9.3	Ensure there are controls to adjust monitor brightness and room illumination	Controls to adjust monitor brightness and room illumination are necessary to help reduce eye strain which may cause headaches	Design	Closed	
RT_REC_VAL_027	Iss_3.3.2.1	Conduct stakeholder workshop / interviews with AU and ATCO/AFISOs / phraseology experts to identify any additional relevant phraseology and if necessary develop appropriate phraseology	Changes to phraseology as a result of remote tower operations need to be investigated with all stakeholders	Validation activity	Closed	No changes in phraseology required

RT_REC_VAL_028	Iss_3.3.4.1	Investigate impact of RT on communication load	Impact of RT on communication load in future trials (active mode) / post implementation monitoring as a potential issue identified is that ATCOs may request more information from pilots at a critical stage of flight when pilot workload is high and this could have workload implications and at worst safety implications	Validation activity	Closed	No impact on RT communication load as procedures remain unchanged
RT_REC_ROLE_003	Iss_4.1.1.1	Select representatives from on-site and off-site locations to ensure there is a continuous dialogue between both staff members	There is concern about a lack of communication and information sharing between staff located on-site at the aerodrome and offsite in the remote tower control facility. Allocation formal roles/positions responsible for such communication could help to reduce the risk of this occurring and being a problem	Roles	Closed	No problems identified
RT_REC_VAL_030	Iss_4.1.1.4	Verify relevance of interaction with APT staff on services provided i.e. does the possibility to interact with the APT staff improve the ATS provided?	Concern was expressed about the lack of opportunities for remote tower staff to interact with staff located at the aerodrome. But is this actually a problem? What importance does the relationship between aerodrome staff and ATCO/AFISOs have on ATCO performance / day to day operations / safety?	Validation activity	Closed	No problems identified
RT_REC_VAL_031	Iss_4.1.2.1	Workshop with aerodrome staff and ATCO/AFISOs to brainstorm consequences if team participation and identity between ATCO/AFISOs and aerodrome staff / pilots as well as local knowledge and awareness are lost, as well as mitigations	More information needs to be gathered with regards to the impact of ATCOs being located remotely from the aerodrome with all stakeholders involved	Validation activity	Closed	No problems identified
RT_REC_ROLE_004	Iss_4.1.1.1 Iss_4.1.1.3 Iss_4.1.1.4 Iss_4.1.2.1	Ensure regular meetings between remote and on-site staff ideally face to face but if that's not possible video conference	The aim of this recommendation is to ensure communication between personal located onsite at the aerodrome and those personnel located at the remote tower facility.	Role	closed	No problem identified
RT_REC_VAL_032	Iss_4.1.1.6	Adopt / continue to use a human	A human centred approach to design in	Validation	Closed	This is not a specific requirement

	Iss_4.1.1.7	centred approach in the concept design & development process, i.e. perform HPAP	complex safety critical systems in which the human plays a central role has not only be found to ensure a concept is usable and meets expected performance benefots but also helps to ensure end user acceptance of a concept			for remote tower
RT_REC_VAL_033	Iss_4.1.1.7	An appropriate employee selection for the remote tower ATCO / AFISO role plus specializations for CWP-remote may help acceptance of the remote tower concept in the long term. Define appropriate employee selection criteria	Ensure selection criteria are defined to ensure appropriate selection of personnel to work as ATCO/AFISOs in the remote tower facilities	Validation activity	Closed	This is not a specific requirement for remote tower
RT_REC_VAL_034	Iss_4.2.1.2	Perform training needs analysis for ATCO/AFISOs in V3	A training needs analysis will ensure that the appropriate training is provided to all end users impacted by the remote tower concept prior to implementation	Validation activity	Closed	Need for training analysed

HP recommendations cancelled

HP Recommendations Register
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RT_REC_VAL_001	Iss_1.1.1.2,	Investigate issues relating to ATS representation in local community where the aerodrome is located, as well as, feasibility of aerodrome manager taking on this responsibility in stakeholder workshops.	As ATCOs not present on-site at the aerodrome under the remote tower concept, the responsibility for dealing with ATS issues in the local community must be allocated to someone that is located on-site. The person that could be responsible for ATS in the local community could be the aerodrome manager	- Validation activity	Cancelled	Recommendation not valid as any co-ordination that needs to be done with local community can be done via phone.
RT_REC_ROLE_001	Iss_1.1.2.1, Iss_3.1.2.1	Define any changes to role of the technical engineers given introduction of cameras, visual reproduction screens plus accompanying hardware, software	The remote tower concept introduces new technology i.e. cameras at the aerodrome, the visual reproduction screens in the remote tower centre therefore the technical engineers role will expand and new tasks relating to this new technology will be introduced. The exact changes to the technical engineers role need to be defined	-Roles	Cancelled	No specific Remote Tower recommendation. Engineers need to be qualified as for every new system
RT_REC_DESIGN-001	Iss_1.1.2.1, Iss_1.1.2.2,	Consider Introducing automatic meterological observations (optional)	As ATCO/AFISO s not located on site automatic observations may be a potential solution – this needs to be investigated	Design	Cancelled	Meterological observation is not always a responsibility of ANSP. Option to investigate if an ANSP has MET OBS as delegated task.
RT_REC_TRAINING_001	Iss_1.1.1.2	If necessary develop training program for ATS representative at aerodrome	As ATCOs no longer based at aerodrome the role of ATS representative needs to be allocated to someone to ensure that someone has responsibility for ATS in the local community where the aerodrome is based. The person taking on this role of ATS representative will need to be trained on this new task and his./her responsibilities.	Training	Cancelled	Compare RT_REC_VAL_001
RT_REC_VAL_005	Iss_1.2.5.2 Iss_3.3.1.1 Iss_3.3.1.2	Issues relating to pilots / aircrew need to be addressed more systematically and in more detail in stakeholder	More feedback/ input is required from airspace users relating to procedures & other issues identified in the HP assessment under	Validation activity	Cancelled	Remote Tower implies no change in procedures for pilot /

	Iss_3.3.2.1 Iss_3.3.3.1 Iss_4.1.1.1 Iss_4.1.1.2	workshop with airspace users, airlines & ATCO and where possible mitigation identified	remote tower operations. Issues identified relate to perceived shift in authority or pilots giving false information due to absence of ATCO/AFISO at aerodrome, phraseology requirements			aircrew
RT_REC_DESIGN-010	Iss_2.3.1.1 Iss_2.3.2.1	Consider introducing labels (with identify information) for the ground vehicles	Recommendation suggested ATCOs to help identify ground vehicles	Design	Cancelled	Contradicts cost efficient system
RT_REC_DESIGN-014	Iss_2.3.2.1	Ensure font size on the CWP system conforms to HF standards	Good design practice. If font size is too small then end users will not be able to read information presented on CWP. If too large perhaps not all the information required will be able to be presented	Design	Cancelled	This is not a specific requirement for remote tower
RT_REC_VAL_012	Iss_2.3.2.2	Assess any changes to the CWP configuration / layout in future validation activities, e.g. introduction of interactive touch displays	Anyway future changes made to the CWP need to be reassessed in future validation activities to ensure the changes support end users and are hence usable and useful. Ensure in future trials usability is assessed with representative scenarios & in active mode trials so that the ATCOs have to perform / execute certain tasks using specific information.	Validation activity	Cancelled	This is not a specific requirement for remote tower
RT_REC_VAL_013	Iss_2.3.3.1 Iss_2.3.5.1 Iss_2.3.5.2	Assess usability of information presentation & different working position set ups whenever any changes are made to the CWP set up. Ensure in future trials usability is assessed with representative scenarios & in active mode trials so that the ATCOs have to perform / execute certain tasks using specific information.	Anyway future changes made to the CWP need to be reassessed in future validation activities to ensure the changes support end users and are hence usable and useful. Ensure in future trials usability is assessed with representative scenarios & in active mode trials so that the ATCOs have to perform / execute certain tasks using specific information.	Validation activity	Cancelled	Addressed in various validations
RT_REC_DESIGN-015	Iss_2.3.3.1 Iss_2.3.6.1	-Ensure the appropriate HF guidelines & standards are considered & applied in the design & development of the CWP. Such guidelines / standards include: FAA's Human Factors Design Guide, Ch6 Control and visual	The use of appropriate HF guidelines & standards will help to ensure the CWP is useable and support the end user(s) in their work	Design	Cancelled	This is not a specific requirement for remote tower

		indicators, page 6-55 and MIL-STD-1472F, 1999, page 17, the visual fields for Eye Rotation				
RT_REC_VAL_014	Iss_2.3.3.2	Assess visibility of visual reproduction screens and information presented on CWP during implementation (V4 & V5)	This needs to be done as part of the usability assessment. CWP screens should not block OTW view being displayed on the panoramic reproduction screens	Validation activity	Cancelled	This is not a specific requirement for remote tower
RT_REC_VAL_019	Iss_2.3.7.5	Scenario in which pilot are aware of something (e.g. an object on the runway), and require ATCO/AFISOs to confirm to be investigated in future trials	This scenario provides an objective measure of situation awareness and needs to be investigate in future trials when possible	Validation activity	Cancelled	
RT_REC_VAL_022	Iss_2.3.7.9	If additional automation is added then it must be assessed in terms of its impact on SA in future validation activities.	It is well documented that automation can impact situation awareness (SA) both positively and negatively. Therefore, future validation activities must assess the impact of any additional automation introduced on situation awareness	Validation activity	Cancelled	This is not a specific requirement for remote tower
RT_REC_DESIGN-024	Iss_2.3.9.2 Iss_2.3.9.3	-Ensure there is natural light source in operations room	Natural light source in operations room helps to reduce fatigue	Design	Cancelled	Fatigue covered in RT_REC_VAL_024
RT_REC_VAL_024	Iss_2.3.9.2	Investigate impact of RT set-up / environment on fatigue.	Working with monitors has been found to cause eyestrain and fatigue. Therefore the impact of the remote tower work environment on eye strain and fatigue needs to be investigated over the period of a shift. If fatigue is found to be an issue investigate possible means to prevent or mitigate fatigue e.g. reduce hours per shift or introduce more frequent breaks within a shift, make adjustments to the lighting ambient environment or R/T set-up	Validation activity	Open	
RT_REC_DESIGN-025	Iss_2.3.9.3	Ensure the lighting conditions in the remote tower is considered in the design of the remote tower operations room – use HF recommended practice/ guidelines/ standards	Lighting conditions have been shown to impact fatigue. Therefore to prevent to minimise fatigue caused by ambient light conditions in the control room	Design	Cancelled	This is not a specific requirement for remote tower

RT_REC_TRAINING_002	Iss_3.1.2.1 Iss_4.3.1.1	Ensure technicians with the required skills and knowledge are trained and available prior to implementation	The remote tower set-up results in many new systems and technologies being introduced to ATM. Technical engineers will need to be trained to enable then to maintain and repair all the equipment related to the remote tower including the associated hardware and software This training must be provided and completed prior to implementation.	Training	Cancellled	This is not a specific requirement for remote tower
RT_REC_ROLE_002	Iss_3.1.2.1	Ensure technicians are available in case of technical failures or maintenance issues		Roles	Cancelled	This is not a specific requirement for remote tower
RT_REC_VAL_025	Iss_3.2.1.1 Iss_3.2.3.1 Iss_3.2.4.1	Assess impact of allocating certain tasks previously performed by ATCO/AFISO to aerodrome staff on human performance	Under remote tower operations tasks previously performed by ATCOs will be allocated to aerodrome staff, because ATCOs are no longer present at the aerodrome site. The impact of this re-allocation of tasks needs to be assessed in terms of efficiency (human performance related efficiency)and potential for error in active shadow mode trials	Validation activity	Cancelled	Responsibility is with provider of service
RT_REC_DESIGN-026	Iss_3.2.2.1. Iss_3.3.3.1 Iss_3.3.5.1 Iss_4.1.1.3 Iss_4.1.1.4	Consider introducing intercom system or webcams between ground staff at aerodrome and staff working in remote tower	Intercom and / or webcams have been suggested as a means to facilitate communication between ground staff at aerodrome and staff working in remote tower.	Design	Cancelled	Decision to be taken depending on local needs
RT_REC_VAL_026	Iss_3.2.2.1 Iss_3.3.3.1 Iss_3.3.5.1 Iss_4.1.1.3 Iss_4.1.1.4	Ensure facility to enable direct communication between ATCO/AFISOs and the necessary aerodrome staff is available at all times, e.g. investigate feasibility of an intercom system or webcams between ground staff at aerodrome and staff working in remote tower	Intercom and / or webcams have been suggested as a means to facilitate communication between ground staff at aerodrome and staff working in remote tower facility. The feasibility together with the benefits of this need to be investigated.	Validation activity	Cancelled	Decision to be taken depending on local needs
RT_REC_PROCEDURE_002	Iss_3.3.3.1 Iss_4.1.1.2	Phraseology – ATCO/AFISO should state when making initial contact with aircrew that they are remotely located	It is recommended that to ensure that aircrew are aware the ATCO/AFISO is	Procedures	Cancelled	No need to address this in phraseology

			remotely located the aircrew, the ATCO/AFISO should state when making initial contact with aircrew that they are remotely located. This recommendation should be further investigated in stakeholder workshops.			
RT_REC_TRAINING_004	Iss_3.3.1.2	Allow onsite aerodrome staff representatives and airline representatives to visit the remote tower so they can understand remote tower operations and communicate back to their staff members	To ensure all parties impacted are aware and understand the changes introduced by remote tower operations it is recommended that onsite aerodrome staff representatives and airline representatives to visit the remote tower so they can understand remote tower operations and communicate back to their staff members	Training	Cancelled	No need identified
RT_REC_VAL_029	Iss_4.1.1.1	Conduct a workshop with aerodrome staff and ATCO/AFISOs to brainstorm potential consequences of impact & mitigations of remote tower concept of communication and team work between staff located on-site at the aerodrome and staff located in the remote tower facility	Need to better understand potential consequences of impact remote tower concept of communication and team work between staff located on-site at the aerodrome and staff located in the remote tower facility and where possible identify mitigation.	Validation activity	Cancelled	No changes compared to current operations identified
RT_REC_TRAINING_005	Iss_4.1.1.2	Information campaign to inform airlines / pilots that remote tower operations are in place at specific aerodrome and also to explain remote tower operations	Information campaign should be used to raise awareness to pilots that remote tower operations are in place at specific aerodrome and explain what this means. This will help to avoid any confusion and help promote acceptance by the air users,	Training	Cancelled	As procedures for pilots /airlines do not change, no need is identified
RT_REC_OTHER_001	Iss_4.3.1.1	-Cost of technical 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		Other	Cancelled	This is not a specific requirement for remote tower
RT_REC_OTHER_002	Iss_4.3.1.2 Iss_4.3.2.1	-Ensure appropriate regulation on shift design are adhered to -	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	Other	Cancelled	This is not a specific requirement for remote tower

			have legal implications.			
RT_REC_OTHER_003	Iss_4.3.3.1	Offer incentives e.g. a relocation package, salary increase for ATCO/AFISOs that have to relocate	Some ATCO/AFISOs may be reluctant on relocate. Incentives could be used to encourage relocation if required	Other	Cancelled	This is not a specific requirement for remote tower

Appendix C – HP Requirements Register

The following table is a register of the HP requirements that have been identified to date with regards to the remote tower concept.

Each requirement has a specific ID which is constructed as defined in the following key:

Key for defining requirement ID:

First segment: Defines the project – 'RT' (Remote Tower)

Second segment: Specifies that it's a requirement – REQ (REQirement)

Third segment: Defines the type of requirement; DESIGN; PROCEDURE; ROLE; TRAINING; TEST.

Fourth segment: The number of the requirement specific to the type of requirement

HP Requirements - Closed

The following chapter shows the requirements that have already been closed.

HP Requirements Register *This table presents the list of HP requirements gathered in the project.*							
ID	Source *Reference of HP activity*	Requirement *Describe the requirement.*	Rationale *Describe the rationale of the requirement* **Note:** that the rationale for each requirement can be found by looking at the appropriate source / issue in table 8 section 3.4.1.	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.*	OSED Reference *Reference towards operational requirement in OSED*

RT_REQ_ PROCEDURE_002	Iss_1.2.1.1	If Infra-Red (thermal imaging) is implemented, develop procedures for Infra-Red (Thermal imaging) use if implemented	Feedback from ATCOs in the trails showed that Infra-Red (thermal imagining) helped ATCOs visualise objects in low visibility conditions. However, if implemented procedures for Infra-Red (Thermal imaging) use must be developed	Procedure	Closed	Requirement closed as implemented in EXE-VP640 and rated OK by ATCOs.	REQ-06.09.03-OSED-RTC3.0018
RT_REQ_ DESIGN_006	Iss_1.2.3.7 Iss_1.3.1.1 Iss_2.1.1.1 Iss_2.1.1.2 Iss_2.3.2.1 Iss_2.3.5.3 Iss_2.3.5.3 Iss_2.3.7.1 Iss_2.3.7.9	If implemented, the a/c automatic identification & tracking function shall only track/identify objects that are relevant for the service provision, e.g. a/c and aerodrome vehicles	In the trials the a/c automatic identification & tracking function would often track objects other than a/c and aerodrome vehicles e.g. cars on roads near but outside the aerodrome, moving clouds etc.	Design	Closed	Requirement closed as implemented in EXE-VP640 and rated OK by ATCOs.	REQ-06.09.03-OSED-VA03.1401
RT_REQ_ DESIGN_005	Iss_1.2.3.7 Iss_2.2.1.1 Iss_2.3.1.1 Iss_2.3.7.3 Iss_4.1.1.7	Visual presentation needs to function in all daylight/darkness conditions (e.g. the visual reproduction screens should not freeze or become pixelated)	Picture quality at dawn & dusk may not become degraded in areas, i.e. pixilated or frozen. It is necessary to ensure that ATCOs/AFISOs have an up-to-date, clear picture of the aerodrome and aerodrome vicinity they are controlling and can continuously monitor a/c in the aerodrome vicinity as required.	Design	Closed		REQ-06.09.03-OSED-VG03.1001 REQ-06.09.03-OSED-VG03.1002 REQ-06.09.03-OSED-VG03.1004
RT_REQ_ DESIGN_013	Iss_2.3.2.1, Iss_2.3.5.4	PTZ camera usability of PTZ camera must be improved.	Usability of the PTZ camera must be improved in terms of visualisation of the PTZ camera picture projected to the ATCO/AFISO and usability of the input devices used to control the PTZ camera. The PTZ camera images was very grainy and the	Design	Closed	Requirement closed as implemented in EXE-VP640 and rated OK by ATCOs.	

			PTZ device was found to cumbersome and even difficult to use				

HP Requirements - Open

The following chapter shows the requirements that are still open and need to be addressed in future phases.

HP Requirements Register

This table presents the list of HP requirements gathered in the project.

ID	Source *Reference of HP activity*	Requirement *Describe the requirement.*	Rationale *Describe the rationale of the requirement* **Note:** that the rationale for each requirement can be found by looking at the appropriate source / issue in table 8 section 3.4.1.	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.*	OSED Reference *Reference towards operational requirement in OSED*
RT_REQ_ PROCEDURE_003	Iss_1.2.3.2 Iss_1.2.3.6	Develop procedures for such degraded mode events as failure relating to the visual reproduction	In the degraded modes examined in the trials relating to the failure of the visual reproduction]it was agreed by all that procedural control / LVP should be used as contingency procedures if such an event would arise	Procedure	Open		REQ-06.09.03-OSED-RTC3.0019
RT_RE_ DESIGN_003	Iss_1.2.3.2 Iss_1.2.3.6	Ensure screens have an error warning / alert to inform ATCO/AFISOs that screen has not been updated, & screen has frozen, system communication failure	Based on good recommended practice/design guidelines an error warning / alert should be provided to inform ATCO/AFISOs	Design	Open		REQ-06.09.03-OSED-VC03.1107

		etc..	that screen has not been updated, & screen has frozen, system communication failure etc..				

HP Requirements - Cancelled

The following table contains the requirements that have been cancelled during the process of definition of requirements. The table is just kept for consistency reasons.

HP Requirements Register

This table presents the list of HP requirements gathered in the project.

ID	Source *Reference of HP activity*	Requirement *Describe the requirement.*	Rationale *Describe the rationale of the requirement* **Note:** that the rationale for each requirement can be found by looking at the appropriate source / issue in table 8 section 3.4.1.	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.*	OSED Reference *Reference towards operational requirement in OSED*
RT_REQ_ ROLE_001	Iss_1.1.2.1	-Ensure responsibility for tasks performed currently by ATCO/AFISOs that have to be performed onsite, e.g. METOBS, runway inspection, representation of ATS in local community are re-allocated appropriately. (Re-allocation of tasks can either involve the allocation of tasks to a staff member located onsite at the aerodrome or automation).	As ATCO/AFISOs not present on-site at the aerodrome, responsibility for all tasks must either be assigned to personnel on-site or automated	Role	Cancelled	METOBS is not part of the ATS service, however it may still be possible to perform METOBS remote depending on the picture quality etc in a specific implementation (and e.g. regarding RTC Sundsvall it has been approved). Runway inspections are typically done by vehicles/personnel on site already in todays local operations, hence no change for remote ops in this aspect. In addition to that RWY inspections up to a certain level will still be possible to perform remote with help of the PTZ, possibly supported by a PTZ sweep functionality. All ATS/ATC related task will be possible to perform also from the RTM.	
RT_REQ_ DESIGN_002	Iss_1.1.2.2	If a windsock is present at the aerodrome	A windsock provides ATCOs with information regarding wind	Design	Cancelled	This is not a REQ even in current local operations. General REQs on	

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		being controlled remotely, ensure windsock at aerodrome being controlled remotely can be easily viewed by ATCO/AFISO in remote tower	direction and strength, and was said ATCOs to be a useful intuitive piece of information that would help them better understand weather condition relating to wind at the aerodrome they were controlling.			visualisation as well as some quality vis REQs as "what to see as a very minimum" might be relevant though and therefore already exists in the OSED. Ref: REQ-06.09.03-OSED-VG03.1001 REQ-06.09.03-OSED-VQ03.1201, .1202, .1203, .1204 and .1205	
RT_REQ_ PROCEDURE_001	Iss_1.2.1.1 Iss_1.2.5.1 Iss_2.3.7.4 Iss_2.3.7.6	Reduced visual separation must not be applied in current systems investigated (i.e. the basic version & the advanced version which includes radar, ACV, automatic a/c identification & tracking)	ATCO feedback from the trials showed that reduced visual separation procedures must not be applied in the two systems investigated d i.e. the basic version & the advanced version which includes radar, ACV, automatic a/c identification & tracking	Procedure	Cancelled	This is not a requirement on the concept level, perhaps feedback based on the particular validated platforms. There is nothing that indicates that reduced minimum separation (="visual separation") cannot be used in RVT, since such separation method is based on ATCO judgement for every specific occasion (based on what he/she can or cannot see). (Experiences from the validations of the operational implementation project RTC Sundsvall rather indicates that "visual separation" will be possible, but perhaps not to the same extent as in current local operations.)	
RT_REQ_ DESIGN_004	Iss_1.2.3.2 Iss_1.2.3.6	Ensure there is a back-up system e.g. back up visual reproduction screens	Good design practice to have redundancy in system design	Design	Cancelled	Its not sure that an ANSP would want back up visualisation screens. That would depend on the quality of the (primary) screens as well as requirements on availability for a particular implementation and needs to be determined in a safety assessment prior implementation. It might actually be ok to close the aerodrome sometimes, depending on cost vs availability requirement for a particular aerodrome. (It also depends on system design and set up, for example if an ANSP builds an RTC with several Tower modules, they in themselves can make up back up systems for each other.)	

RT_REQ_ DESIGN_008	Iss_2.3.3.1 Iss_2.3.6.1	Appropriate HF guidelines must be considered and where appropriate applied in the design of the CWP. Such guidelines / standards include:	The HF team in P12.4.7 is already using and applying HF guidelines from FAA's Human Factors Design Guide, Ch6 Control and visual indicators, page 6-55 and MIL-STD-1472F, 1999, page 17, the visual fields for Eye Rotation. This will help to ensure that the CWP ?HMI is well designed, usable and acceptable to the end users and also help to reduce the potential for human related error	Design	Cancelled	Requirement vague! Duplication of the HF req RT_REQ_ DESIGN_007?	
RT_REQ_ DESIGN_010	Iss_2.3.7.11	Automatic contrast control should be implemented	This is good design practice. Automatic contrast control should be implemented to accommodate different user preferences and different ambient lighting conditions	Design	Cancelled	This requirement is too detailed on a technical level. It would as such be more appropriate as a system requirement, but should in such case be stated by the industry when designing a system. Our operational OSED requirements stating what the controller needs to see is already stating just that (what the controller needs to be able to see) and are valid in all conditions described. In addition to that, the OSED contains a requirement about improving/enhancing the raw picture compared to unaided viewing, see REQ-06.09.03-OSED-VG03.1002. Automatic contrast control may be a good solution, but may not be the best, depending on the technical setup. Hence, these kind of technical design details should left to the industry.	
RT_REQ_ DESIGN_015	Iss_2.3.5.5	Cameras located at the aerodrome must be able to be automatically cleaned remotely	Camera lens must be kept clean to ensure the quality of the picture transmitted to the remote tower is maintained. In trials the aerodromes were located near the sea and sea salt would build up and impacted the picture quality transmitted to the remote tower.	Design	Cancelled	This could as well be done manually. Moreover, if one cannot see due to e.g. salt spraying from the sea, the OSED visualisation requirements are not fulfilled. Also refer to RT_REQ_ DESIGN_014, which says cameras must function in all weather conditions, so this HF requirement RT_REQ_DESIGN_015 is	

						already covered by RT_REQ_DESIGN_014.	
RT_REQ_ TEST_001	Iss_2.3.5.6	After installation of the remote tower technical system engineers should be available to assess picture quality at regular intervals to ensure picture quality is maintained.	Engineers stated concern that the picture quality may gradually degrade over time after installation of the remote tower, and as this degradation may be gradual it may not be detected as easily by the end users. Therefore following installation technical system engineers should be available to assess picture quality at regular intervals to ensure picture quality is maintained.	Test	Cancelled	Does not have to be engineers. Depends on the technical design and implementation. Visualisation REQs already exist on a concept level within the OSED, those are valid at all times. It is up to the industry to design a system that fulfils those requirements.	

Appendix D – Task Analysis

EXECUTION PHASE FOR THE TOWER CONTROLLER AT A SMALL AERODROME WITH CHANGES

It should be noted that this task analysis is a working document that has been used to support the HP assessment process conducted to date.

Current version does not include electronic flight strips (EFS).
Current version does not cover helicopter, gliders, gyroplanes. parachutes
Only normal conditions are considered. (The opening and closing of the tower are not considered).
Abnormal & degraded modes of operation are not addressed in this TA

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
1. Take over of responsibility for tower control				No change to task per se but the **information source** will change from the OTW view to the panoramic screens		
1.1Understand current and future traffic situation (build mental picture)	1.1.1 Self briefing on traffic situation & aerodrome status 1.1.1.1Check notices 1.1.1.2 Observe traffic situation 1.1.1.3 Observe wind weather information / weather forecast 1.1.1.4 Listen to frequencies 1.1.2 Gain briefing of current, recent & predicted traffic situation from outgoing controller 1.1.3 Log in name, time etc to confirm that they had been briefed	1.1.1 Notices, **OTW view**, radar, FPDS, FPS, AWOS, R/T 1.1.1.1 Notices 1.1.1.2 **OTW view**, radar, FPDS, FPS on strip bay 1.1.1.3 **OTW view** plus met information displayed on AWOS 1.1.1.4 R/T with or without headphones	1.1.3 paper or electronic database	1.1.1 Notices, **panoramic screens**, radar, FPDS, FPS, AWOS, R/T 1.1.1.2 **Panoramic screens**, radar, FPDS, FPS on strip bay 1.1.1.3 **Panoramic screens** plus met information displayed on AWOS	1.1.1.2 Quality of picture of panoramic screens in terms of resolution, update rate plus reliability of the picture transmission. If ATCOS feel that the picture transmitted on the panoramic screens is not reliable and accurate they may not have trust in the system & will rely more on other means e.g. radar, to gain an overall	The objective of task1.1 is to build up a mental picture of recent, current & future traffic situation Task 1.1.1 is the responsibility of the incoming ATCO. RTC may make it more difficult to detect / predict weather changes and currently use may factors to gain an indication of future weather e.g. cloud types,

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
		1.1.2 Outgoing ATCO			understanding of the traffic situation. 1.1.1.3 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on trees.	leaves of trees, colour of sky and this may be lost with the RTC. May also be difficult to determine whether or not it is raining or not, or if rain is coming plus, difficult to determine visually the altitude of the cloud base. Such visual information adds to the information presented in AWOS and is important for tailoring the approach.
1.2 Assume control	1.2.1 Take over tower position 1.2.1.1 Have verbal confirmation of handover	1.2.1 Outgoing ATCO		No change foreseen		
2. Manage departing aircraft				No change to task per se but the **information source** will change from the OTW view to the panoramic screens		

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
2.1 Receive or create FPS	For filed flight plans i.e. IFR 2.1.1 Receives FPS 2.1.2 Checks and Update Strip Data 2.1.2.1 Checks Wake Vortex – aircraft category 2.1.2.2 Check Call Sign 2.1.2.3 Check Stand 2.1.2.4 Check Aircraft Type & check routing verses destination 2.1.2.5 Record all relevant information (e.g. stand, aircraft type, SID) 2.1.3 Arrange FPS in appropriate order Or For non-filed flight plans e.g. VFR 2.1.4 Receive & answer call from departing VFR a/c 2.1.5 Create FPS if a/c in control zone under tower controller's active control and file it in the system FPDS 2.1.5.1 Obtain relevant information (e.g. stand, a/c type, registration (call-sign) destination, route, time, people onboard) 2.1.5.2 Check information provided by pilot 2.1.5.3 Record all relevant information (e.g. e.g. stand, a/c type, registration (call-sign)destination, route, time) 2.1.6 Arrange FPS in appropriate order	2.1.2 See details below 2.1.2.1 FPS plus **OTW view** 2.1.2.2 FPS 2.1.2.3 **OTW view** & AODB (if it exists) 2.1.2.4 **OTW view** plus FPS 2.1.4 R/T call from pilot 2.1.5.1 Information on destination, route, time, people onboard will be given by pilot, registration, a/c type 2.1.5.2 Certain information (e.g. a/c type, stand) will be checked using the **OTW view**, other information (e.g. routing verses	2.1.1 Printer prints out FPS 2.1.2.5 Record information on FPS 2.1.3 Place strip in strip bay 2.1.5 Paper strip for VFR flight (or note VFR flight down on paper) 2.1.5.3 Record information on FPS or note pad 2.1.6 Place strip in strip bay	2.1.2 See details below 2.1.2.1 FPS plus **panoramic screens** 2.1.2.2 FPS 2.1.2.3 **Panoramic screens &** AODB (if it exists) 2.1.2.4 **Panoramic screens** plus FPS 2.1.5.2 Certain information (e.g. a/c type, stand) will be checked using the **panoramic screens**, other information (e.g. routing verses destination will be checked based on ATCOs existing knowledge of routes & destinations)	2.1.2 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution, may make it more difficult to see / identify / check a/c category / type / stand . 2.1.5.2 as 2.1.2	• The printer prints out the FPS approximately 30 minutes before EOBT • In Angelholme VFR flights account for approximately 40% of flights and IFR approximately 60%. Although this varies depending on the time of year in the summer time (April–August) there are many more VFR flights. Also the number of crossing flights increases, so WL is generally higher in summer. • AODB – Aerodrome Operational Data Base

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
		destination will be checked based on ATCOs existing knowledge of routes & destinations)				
2.2 Identify a/c	2.2.1 Receive & answer start-up call (10 to 15 mins before EOBT) from pilot 2.2.2 Locate a/c stand 2.2.3 Verify a/c request 2.2.3.1 Identify a/c in stand 2.2.3.2 Ensure positive correlation between pilot report & visual confirmation of a/c location 2.2.3.3 Confirm start up request	2.2.1 R/T call from a/c 2.2.2 Locate a/c visually using **OTW view**	2.2.3 Confirm a/c request via R/T	2.2.2 Locate a/c visually using **panoramic screens**	2.2.2 Quality of picture of aerodrome & vicinity transmitted on panoramic screens may make it more difficult to located a/c visually	VFR more often than not don't need start up request the call up With VFR, the pilot calls up to request a departure & provides ATCO with information about the flight see 2.1 in addition the pilot may make certain requests. ATCO then confirms CTOT
2.3 Check FPS and update if necessary	2.3.1 Check Delay times & CTOT times 2.3.2 Update Flight Plan in FDPS if necessary	2.3.1 Check FDPS & FPS for delay times & CTOT	2.3.2 If there are delays or CTOT is incorrect, revert to pilot (IFR)			CTOT always obtained from the FDPS so new strip is issued automatically if CTOT is updated. Certain airlines must be informed via the pilot if the CTOT time is changed. Pilots may call ATCO for information if they hear that there are

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
						delays e.g. due to bad weather.
2.4 Issue ATC and Start-up Clearances	2.4.1 Issue Start-up Clearance 2.4.2 Obtain SSR code from ATCC 2.4.2.1 Call ATCC to inform time of expected departure 2.4.2.2 Receive SSR (transponder) code 2.4.2.3. Confirm & input SSR code into radar system 2.4.3 Issue ATC Clearance for Departures 2.4.3.1 Specify SID or track 2.4.3.1.1 Local Path 2.4.3.1.2 Level to climb to 2.4.3.2 Double-check Weather Information 2.4.3.3 Give weather forecast to pilot 2.4.3.4 Specify Airway (Route to Destination) 2.4.3.5 Confirm Departure Runway	2.4.2.2 Obtain SSR code from ATCC via intercom / telephone 2.4.3.1 FPS 2.4.3.2 AWOS & OTW view 2.4.3.4 FPS / FDPS 2.4.3.5 FPS	2.4.1 Issue clearance using R/T 2.4.2 Contact ATCC via telecom / telephone 2.4.2.1 Contact ATCC via telecom / telephone 2.4.3. Issue clearance using R/T 2.4.3.3 R/T to pilot	2.4.3.2 AWOS & **panoramic screens**	2.4.3.2Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on trees.	Two ways of issuing clearances for departures: 1. Pre-determined between ACC and TWR and responsibility for clearances delegated to tower (this is always the case for VFR) 2. Each clearance to be requested from ATCC (Stockholm) by tower
2.5 Decide whether to send DEP MSG to AFTN) or not	2.5.1 Send DEP MSG to either AFTN if LFV or FDO if VFR 2.5.2 Note if message is sent,	2.5.1 Telephone or intercom	2.5.2 Mark Flight strip accordingly			• Aeronautical fix tele-network (AFTN) is an automated communication centre where the DEP message is sent for LFV and some VFR flights. Foxtrot

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
						Delta Oscar (FDO) is where the departure message for local flights is sent. • ATCOs put a check mark on the strip whenever something is done to ensure everything is noted down for the record.
2.6 Issue Taxi Clearance	2.6.1 Receive & answer Request for Taxi 2.6.2 Check Departure Information 2.6.2.1 Check Slot Times (is slot time within the CTOT) 2.6.3 Select route 2.6.4 Check for aircraft and vehicles on taxiway 2.6.5 Issue Clearance to Taxi 2.6.5.1 Give Taxiways to follow 2.6.5.2 Specify Holding point and Runway Number	2.6.1 R/T call from a/c 2.6.2 Check slot times on FPS/FDPS to ensure slot time is within the CTOT 2.6.3 **OTW view** and other traffic in aerodrome vicinity & chosen RWY 2.6.4 **OTW view**	2.6.5 R/T to pilot	**2.6.3 Panoramic screens** and other traffic in aerodrome vicinity & chosen RWY **2.6.4 Panoramic screens**	2.6.3 Quality of picture of aerodrome & vicinity transmitted on panoramic screens may make it more difficult to located a/c / vehicles visually 2.6.4 as 2.6.3	
2.7 Monitor a/c on taxi way / build mental picture	2.7.1 Monitor progress of departing a/c on taxi way 2.7.2 Identify potential conflicts & erroneous taxi-ing 2.7.3 Issue tactical instructions (amended clearances) if potential conflict or erroneous taxi-ing identified	2.7.1 **OTW view** 2.7.2 **OTW view**	2.8.3 R/T to pilot	2.7.1 **Panoramic screens** 2.7.2 **Panoramic screens**	2.7.1 Quality of picture of aerodrome & vicinity transmitted on panoramic screens may make it more difficult to identify & locate a/c / vehicles visually e.g. due to resolution and / or judge a/c speed & distance accurately due to picture jumping / update rate 2.7.2 as 2.7.1	

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
2.8 Estimate Final Departure Sequence	2.8.1 Take into account all constraints 2.8.1.1 Refer to Departure times on strips 2.8.1.2 Take into account landing aircraft 2.8.1.3 Take into account Aircraft Types 2.8.1.4 Take into account Time Constraints 2.8.1.5 Take into account Aircraft Sequence 2.8.1.6 Take into account the availability of Taxiways and Exits 2.8.1.7 Take into account any pilot request(s) 2.8.1.8 Take into account airway clearance 2.8.2 Arrange strips in order of departure sequence	2.8.1 FPS, **OTW view**, FPDS, pilot 2.8.1.1 FPS 2.8.1.2 **OTW view**, 2.8.1.3 FPS, **OTW view** 2.9.1.4 FPS, FPDS 2.8.1.5 **OTW view** 2.8.1.6 **OTW view** , binoculars 2.8.1.7 Information via R/T from pilot 2.8.1.8 **OTW view**	2.8.2 Arrange strips in strip bay	2.8.1 **Panoramic screens**	2.8.1 Quality of picture of aerodrome & vicinity transmitted on panoramic screens may make it more difficult to identify a/c & obtain required info.	In small aerodromes this is not a high workload task as you may have more than one a/c to consider with the final departure sequence but never more than two. 2.8.1.6 Under certain weather (and light) conditions the use of the remote screens is not sufficient to check runway and taxiways are free, need infra-red camera. PTZ camera resolution is not good or easy to use and the picture resolution gets worse the closer in you zoom.
2.9 Issue Line-up Clearance	2.9.1 Check RWY available and free for line up 2.9.2 Check Position of other relevant traffic 2.9.3 Confirm traffic situation 2.9.4 Issue clearance for line up	2.9.1 **OTW view** 2.9.2 **OTW view** 2.9.3 **OTW view** compared to mental picture	2.9.4 R/T to pilot	2.9.1 **Panoramic screens** 2.9.2 **Panoramic screens** 2.9.3 **Panoramic screens** compared to mental picture	2.9.1 Quality of picture of aerodrome & vicinity e.g. poor resolution & slow update rate transmitted on panoramic screens may make it more difficult to identify a/c & obtain required info. 2.9.2 As 2.9.1 2.9.3 As 2.9.1	
2.10 Issue Take-off Clearance	2.10.1 Check Runway & a/c path is free / clear 2.10.2 Check Position of other	2.10.1 OTW view & binoculars if necessary		2.10.1 **Panoramic screens & PTZ camera** **2.10.2 Panoramic screens**	2.10.1 Quality of picture of aerodrome & vicinity e.g. poor resolution on	Binoculars are often used to zoom in on objects e.g. birds in the area

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	relevant traffic & ensure appropriate separations between a/c 2.10.3 Confirm traffic situation 2.10.4 Check and give relevant updates of information to pilot e.g. wind information if it has changed 2.10.5 Issue clearance for take off	2.10.2 **OTW view** 2.10.3 **OTW view** compared to mental picture 2.10.4 **OTW view** & wind altimeter reading	2.10.4 R/T to pilots 2.10.5 R/T to pilots	**2.10.3 Panoramic screens compared to mental picture** **2.10.4 Panoramic screens & wind altimeter reading**	panoramic screens may make it more difficult to identify a/c / objects on RWY / a/c/ path 2.10.2 Quality of picture of aerodrome & vicinity e.g. poor resolution / update rate on panoramic screens may make it more difficult to determine a/c spacing / separation 2.10.3 As 2.10.1 & 2.10.2 2.10.4 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on trees.	
2.11 Monitor departing aircraft	2.11.1 Visually confirm a/c has departed 2.11.2 Record any relevant information, i.e. airborne time. 2.11.3 Monitor departure of aircraft 2.11.4 Check altitude if required 2.11.5 If incorrect path or altitude,	2.11.1 **OTW view** & binoculars if necessary 2.11.3 **OTW view** & radar 2.11.4 Radar &	2.11.2 Write relevant information on FPS 2.11.5 R/T call to pilot or telephone adjacent	2.11.1 **Panoramic screens & PTZ camera if necessary** **2.11.3 Panoramic screens** & radar 2.11.4 Radar & **Panoramic**	2.11.1 Quality of picture of aerodrome & vicinity e.g. poor resolution & slow update rate on panoramic screens may it more difficult to confirm a/c has departed /	At Angelholme the ATCOS have to also confirm and input into a system the departure time for civil aviation so the actual departure time can be displayed to passengers in

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	contact pilot & issue correction or contact adjacent sector 2.11.6 Check squawk and call-sign correlation	**OTW view** 2.11.6 Radar	sector	**screens**	airborne time may not be so accurate 2.11.3 Quality of picture of aerodrome & vicinity e.g. poor resolution & slow update rate on panoramic screens may make it more difficult to monitor a/c / judge distance/identify abnormal events / problems with a/c. 2.11.4 Quality of picture of aerodrome & vicinity e.g. poor resolution & slow update rate on panoramic screens may make it more difficult to judge distance/altitude	the aerodrome. However, this is not the case at all aerodromes.
2.12 Transfer a/c to adjacent sector Controller	2.12.1 Communicate & co-ordinate with adjacent sector Controller if required 2.12.2 Check no conflicting traffic 2.12.3 Inform pilot of transfer & to change frequency to adjacent sector 2.12.4 Update FPS to indicate transfer of a/c to adjacent sector 2.12.5 Remove FPS from Bay	2.12.2 **OTW view** (if weather permits) & Radar (if available)	2.12.1 Co-ordinate using telephone 2.12.3 R/T to pilots 2.12.4 Write on FPS 2.12.5 Remove FPS from strip bay	2.12.2 **Panoramic screens** & radar	2.12.2 Quality of picture of aerodrome & vicinity e.g. poor resolution & slow update rate on panoramic screens may make it more difficult / impossible to see a/c at such a distance	
3. Manage arriving a/c				No change to task per se but the **information source** will change from		

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
				the OTW view to the panoramic screens		
3.1Recieve and check FPS	3.1.1 Receive Strips 3.1.2 Arrange Strips in Sequence	3.1.1 Obtain FPS from FPS printing machine	3.1.2 Arrange FPS on Strip-Board according to Inbound Flight order			
3.2 Co-ordinate transfer of inbound a/c with adjacent sector	3.2.1 Receive and answer call from adjacent sector informing ATCO of ETOA of a/c in sector 3.2.2 Coordinate transfer with adjacent sector as required, 3.2.3 Rearrange Strips if needed	3.2.1 Call from adjacent sector	3.2.1 Receive call via telephone or intercom 3.2.2 Co-ordinate using telephone or intercom 3.2.3 Re-arrange strips in strip bay			Several ways in which a/c can be transferred: 1. Pre-set release point and altitude 2. Or individual handover for each a/c from adjacent sector this involves co-ordination &/or communication from adjacent sector 3. System handover i.e. label handover IFR a/c not handed over by adjacent sector prior to frequency change then ATCO needs to confirm with the ACC the position of the flight. In small aerodromes a/c are usually transferred as described in point 2. At Angelholme when runway 3.2 is being used the ATCOs have to co-ordinate with the

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
						adjacent sector to gain the extra airspace required for this runway.If IFR a/c not handed over by adjacent sector prior to frequency change then ATCO needs to confirm with the ATCC the position of the flight but this is an error of the adjacent sector and rarely happens if it does, a complaint will be filed.
3.3 Identify a/c	3.3.1 Scan radar to identify inbound a/c 3.3.2 Monitor progress of inbound a/c	3.3.1 Radar 3.3.2 Radar				
3.4 Assume arrival a/c	3.4.1 Receive & answer inbound a/c call 3.4.2 Respond to aircraft call i.e. provide 'continue approach' clearance 3.4.3 Provide pilot with weather report and intention (e.g. visual approach)	3.4.3 **OTW view**, altimeter reading (for wind) & AWOS	3.4.1 Answer a/c call on R/T 3.4.2 Respond via R/T 3.4.3 Respond using R/T & information gained from OTW view, altimeter reading (for wind) & AWOS	3.4.3 **Panoramic screen**, altimeter reading (for wind) & AWOS	3.4.3 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on	Weather report provided by ATCO at this stage will give information such as wind direction, strength, cloud coverage & altitude, rain etc. – a lot of this information is obtained from the OTW view

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
					trees. Also if light / dark conditions look brighter / lighter on panoramic screen then there is a risk that ATCOs may OK a visual approach when lighting / visibility conditions are not sufficient.	
3.5 Monitor a/c approach / build mental picture	3.5.1 Monitor progress of inbound a/c 3.5.2 Scan area of responsibility to monitor other a/c in the vicinity 3.5.3 Call rescue team 10 minute in advance of landing a/c & ask to check runway is clear 3.5.4 Check separation on approach 3.5.5 If necessary, provide tactical instructions to ensure separation on approach or if go around has been instructed issue tactical instructions to ensure separation is maintained	3.5.1 OTW view & radar 3.5.2 OTW view & radar 3.5.4 OTW view & radar	 3.5.3 Give a/c landing information to ground staff via R/T or telephone 3.5.5 Give tactical instructions to pilot via R/T	3.5.1 **Panoramic screen** & radar 3.5.2 **Panoramic screen** & radar	3.5.1 Quality of picture may make it more difficult to monitor progress of inbound a/c due to picture resolution & update rate i.e. may be more difficult to initially identify and continuously track a/c. ATCOs may rely more on radar 3.5.2 As 3.5.1 3.5.4 Quality of picture due to picture resolution & update rate may make it more difficult to judge / check separation on approach	Holding
3.6 Issue landing clearance	3.6.1 Monitor progress of inbound a/c 3.6.2 Check runway to see if landing clearance can be given e.g. runway free of ground vehicles 3.6.3 Check wind & weather	3.6.1 OTW view 3.6.2 OTW view 3.6.3 Altimeter reading for wind plus OTW view	 3.6.4 Inform pilots of weather via R/T	3.6.1 **Panoramic screen** 3.6.2 **Panoramic screen** 3.6.3 Altimeter reading for wind plus **panoramic screen**	3.6.1Quality of picture may make it more difficult to monitor progress of inbound a/c due to picture resolution & update rate i.e. may be	• 'Go-arounds' given less often in small aerodromes than in large aerodromes At Angelholme as with

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	information 3.6.4 Relay wind and weather information to pilot 3.6.5 If runway is free & wind & weather Ok give clearance to land on specific runway 3.6.6 If landing clearance cannot be given, instruct a/c to go-around 3.6.7 Record required arrivals information i.e. landing time		3.6.5 Give clearance via R/T 3.6.6 Give instruction to go around via R/T 3.6.7 Note on FPS		more difficult to initially identify and continuously track a/c. ATCOs may rely more on radar 3.6.2Quality of picture may make it more difficult to check whether runway is free of vehicles due to picture resolution & update rate i.e. may be more difficult to initially identify and continuously track a/c. 3.6.3 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on trees	the departures the ATCOs are required to input the actual landing time into a system for civil aviation so that the actual departure time can be displayed to passengers in the aerodrome. However, this is not the case at all aerodromes.
3.7 Issue runway exit instructions	3.7.1 Monitor runway clear & aircraft landing 3.7.2 Issue runway exit instructions	3.7.1 OTW view	3.7.2 Issue instructions to pilot via R/T	3.7.1 **Panoramic view**	3.7.1 Quality of picture may make it more difficult to monitor a/c landing due to picture resolution & update rate i.e. may be more difficult	

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
					to initially identify and continuously track a/c, as well as identify any problems / abnormalities in terms of a/c performance or objects falling from a/c.	
3.8 Issue taxi clearance	3.8.1 Check taxiways are clear from any blockages & potential conflicts 3.8.2 Issue taxi clearance to arriving a/c	3.8.1 OTW view with perhaps binoculars	3.8.2 Issue clearance to pilot via R/T	3.8.1 **Panoramic view** & perhaps PTZ camera	3.8.1 Quality of picture on the panoramic screens & PTZ camera may make it more difficult to identify blockages, objects etc. due to resolution. Also PTZ camera may not be as easy to use i.e. it may not be so easy to manoeuvre camera as it is to use binoculars so it may take more time to actually scan & check taxiways due to the usability of the PTZ camera	Perhaps need to consider a runway where back-track is needed?
3.9 Monitor a/c on taxi way / Build mental picture	3.9.1 Monitor a/c progress on taxiways to stand 3.9.2 Identify potential conflicts & erroneous taxi-ing 3.9.3 Issue tactical instructions if potential conflict or erroneous taxi-ing identified 3.9.4 Update strips when a/c parked and arrange strips	3.9.1 OTW view 3.9.2 OTW view	3.9.3 Issue instructions to pilot via R/T 3.9.4 Note on FPS & remove FPS from panel	3.9.1 **Panoramic view**	3.9.1 Quality of picture may make it more difficult to monitor a/c progress on taxiways due to picture resolution & update rate 3.9.2 Quality of picture may make it more difficult to identify potential conflicts or	

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
					erroneous taxi-ing picture resolution & update rate	
4. Carry out Vehicle Related Tasks						
4.1 Control towed a/c	4.1.1Recieve & answer call from tow driver stating current position and callsign 4.1.2 Identify tow truck & a/c 4.1.3 Create strip / aide memoire & arrange 4.1.4 Scan apron taxiway & runway to check no obstacles or potential conflicts / create mental picture 4.1.5 Plan route for towed a/c 4.1.6 Issue clearance / taxi instructions to tow driver 4.1.7 Monitor towed a/c progress / update mental picture 4.1.8 If potential conflict identified, issue tactical instructions to avoid conflict 4.1.9 Receive & answer call from tow driver to say leaving manoeuvring area 4.1.10 Remove strip once towed a/c reached desired location	4.1.2 OTW view 4.1.4 OTW view 4.1.5 OTW view (and mental picture of traffic situation current and future) 4.1.7 OTW view	4.1.1 Answer radio call from vehicle 4.1.3 Create strip & arrange in strip bay (or note towed a/c on paper) 4.1.6 Issue clearance to vehicle via R/T 4.1.8 Issue conflict avoidance / tactical instructions via R/T 4.1.9 Answer radio call from vehicle via R/T 4.1.10 Remove FPS from strip bay	4.1.2 **Panoramic view** 4.1.4 **Panoramic view** 4.1.5 **Panoramic view** (and mental picture of traffic situation current and future) 4.1.7 **Panoramic view**	4.1.2 Quality of picture may make it more difficult to identify towed a/c landing due to picture resolution & update rate 4.1.4 Quality of picture may make it more difficult to check taxi-way & runway for obstacles / potential conflict due to picture resolution & update rate 4.1.5 As 4.1.4, as this information will be used to plan a route 4.1.7 Quality of picture may make it more difficult to monitor towed a/c due to picture resolution & update rate	• ATCOS have two different radio systems: One for a/c and one for cars (vehicles?) • A strip is always required for anything on the RWY
4.2 Control vehicles on taxiway& runway	4.2.1 Receive & answer call from ground staff / vehicles to request permission to enter / cross taxiways & runway(s) stating present position and call-sign & desired route	4.2.2 OTW view 4.2.4 OTW view with binoculars if	4.2.1 Telephone or R/T call from ground staff / vehicle 4.2.3 Write vehicle information on paper	4.2.2 **Panoramic view** **4.2.4 Panoramic view and PTZ camera if necessary**	4.2.2 Quality of picture may make it more difficult to identify vehicle	This could include an emergency service test

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	4.2.2 Identify vehicle & location 4.2.3 Create aide memoire or create strip & arrange 4.2.4 Check traffic situation to check no obstacles or potential conflicts 4.2.5 Co-ordinate with others (e.g. adjacent sectors) if necessary 4.2.6 Issue clearance / instructions for vehicles to enter taxiway / runway 4.2.7 Monitor vehicle(s) / update mental picture 4.2.8 If potential conflict identified, issue tactical instructions to avoid conflict 4.2.9 Receive report on foreign object status on RWY from ground staff / vehicle driver 4.2.10 Receive & answer call from vehicle driver to say leaving TAXI / RWY area 4.2.11 Remove aide memoire or strip once vehicle reached desired location	necessary 4.2.7 OTW view	or create a new strip & arrange on strip bay 4.2.5 Co-ordinate with adjacent sector via telephone 4.2.6 Issue clearance to vehicles via R/T for vehicles 4.2.8 Issue tactical instructions to vehicles via R/T for vehicles 4.1.9 Answer radio call from vehicle driver / ground staff via R/T for vehicles 4.1.10 Answer radio call from vehicle driver via R/T for vehicles 4.2.11 Remove FPS from strip bay	**4.2.7 Panoramic view**	due to picture resolution & update rate 4.2.4 Quality of picture may make it more difficult to check taxi-way & runway for obstacles / potential conflict due to picture resolution & update rate 4.2.7 Quality of picture may make it more difficult to monitor vehicle due to picture resolution & update rate	
4.3 Conduct runway inspection for foreign objects	4.3.1 Contact ground staff to request a runway inspection for a foreign object **or** 4.3.2 Receive & answer a call from ground staff for permission to conduct a run way inspection for a foreign object on RWY & OK 4.3.3 Create aide memoire / strip & arrange	 4.3.4 OTW view 4.3.5 OTW view	4.3.1 Call ground staff on telephone 4.3.2 Answer call from ground staff on telephone or R/T 4.3.3 Write vehicle information on paper or create a new strip & arrange on strip bay	 4.3.4 **Panoramic view** **4.3.5 Panoramic view**	 4.3.4 Quality of picture may make it more difficult to identify vehicle due to picture resolution	**PLAN:** 4.3.1 or 4.3.2 If 4.3.1 then 4.3.4. If 4.3.2 then 4.3.3. Then 4.3.4, 4.3.5, 4.3.6 in order. 4.3.7done when necessary. 4.3.8done continuously. 4.3.9done when

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	4.3.4 Identify vehicle 4.3.5 Check traffic situation to check no obstacles or potential conflicts 4.3.6 Co-ordinate with others (e.g. adjacent sectors) if necessary 4.3.7 Issue clearance / instructions for vehicles to enter taxiway / runway 4.3.8 Monitor vehicle(s) / update mental picture 4.3.9 If potential conflict identified, issue tactical instructions to avoid conflict 4.3.10 Receive & answer call from vehicle driver to say leaving TAXI / RWY area 4.3.11 Remove aide memoire or strip once vehicle reached desired location	4.3.8 OTW view	4.3.5 Co-ordinate with adjacent sector via telephone 4.3.7 Issue clearance to vehicles via R/T 4.3.9 Issue tactical instructions to vehicles via R/T for vehicles 4.3.10 Answer radio call from vehicle driver via R/T for vehicles 4.3.11 Remove FPS from strip bay	**4.3.8 Panoramic view**	& update rate 4.3.5 Quality of picture may make it more difficult to check taxi-way & runway for obstacles / potential conflict due to picture resolution & update rate 4.3.8 Quality of picture may make it more difficult to monitor vehicle(s) due to picture resolution & update rate	necessary, i.e. when, if potential conflict has been identified 4.3.10 done when vehicle has reached desired location.
4.4 Conduct braking tests	4.4.1 Contact ground staff to request a braking test on RWY **or** 4.4.2 Receive call from ground staff for permission to conduct a braking test on RWY & OK 4.4.3 Create strip & arrange / aide memoire 4.4.4 Identify vehicle 4.4.5 Check traffic situation to check no obstacles or potential conflicts 4.4.6 Co-ordinate with others (e.g. adjacent sectors) if necessary 4.4.7 Issue clearance / instructions for vehicles to enter taxiway /	4.4.4 OTW view 4.4.5 OTW view 4.4.8 OTW view	4.4.1 Call ground staff on telephone 4.4.2 Answer call from ground staff on telephone 4.4.5 Co-ordinate with adjacent sector via telephone 4.4.5 Write vehicle information on paper or create a new strip & arrange on strip bay 4.4.7 Issue clearance	4.4.4 **Panoramic view** 4.4.5 **Panoramic view** **4.4.8 Panoramic view**	4.4.4 Quality of picture may make it more difficult to identify vehicle due to picture resolution & update rate 4.4.5 Quality of picture may make it more difficult to check taxi-ways & runways for obstacles / potential	Triggers for braking test request are icy / snowy weather conditions, a request from the pilot and/or observing a/c performance on RWY *Potential issue:* Quality of picture may mean that subtle cues e.g. a/c performance on RWY & TWY, are not visible or as visible to ATCOs

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	runway 4.4.8 Monitor vehicle(s) /update mental picture 4.4.9 If potential conflict identified, issue tactical instructions to avoid conflict 4.4.10 Receive report on braking test / RWY conditions 4.4.11 Receive & answer call from vehicle driver to say leaving TAXI / RWY area 4.4.12 Remove aide memoire or strip once vehicle reached desired location		to vehicles via R/T 4.4.9 Issue tactical instructions to vehicles via R/T for vehicles 4.4.10 Answer radio call from vehicle driver via R/T for vehicles 4.4.11 Answer radio call from vehicle driver via R/T for vehicles 4.4.12 Remove FPS from strip bay		conflict due to picture resolution & update rate 4.4.8 Quality of picture may make it more difficult to monitor vehicle(s) due to picture resolution & update rate	The field duty officer guarantees the state of the RWY. SNOTAM is valid for 6hours (seems rather long?) Braking test depends on weather, precipitation, humidity Pilot may request a braking test
4.5 Clear snow off runway	4.5.1 Receive call from ground staff for permission for snow ploughs to clear snow from taxiway & RWY & OK 4.5.2 Create strip & arrange / aide memoire 4.5.3 Identify vehicle 4.5.4 Check traffic situation to check no obstacles or potential conflicts 4.5.5 Co-ordinate with others (e.g. adjacent sector) if necessary 4.5.6 Issue clearance / instructions for vehicles to enter taxiway / runway 4.5.7 Monitor vehicle(s) / update mental picture 4.5.8 If potential conflict identified, issue tactical instructions to avoid	4.5.3 OTW view 4.5.4 OTW view 4.5.8 OTW view	4.5.1 Answer call from ground staff on telephone 4.5.5 Co-ordinate with adjacent sector via telephone 4.5.6 Write vehicle information on paper or create a new strip & arrange on strip bay 4.5.7 Issue clearance to vehicles via R/T 4.5.8 Issue tactical instructions to vehicles via R/T for vehicles	4.5.4 **Panoramic view** 4.5.5 **Panoramic view** 4.5.8 **Panoramic view**	4.5.4 Quality of picture may make it more difficult to identify vehicle due to picture resolution & update rate 4.5.5 Quality of picture may make it more difficult to check taxi-ways & runways for obstacles / potential conflict due to picture resolution & update rate 4.5.8 Quality of picture may make it more	Field duty officer initiates this task.

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	conflict 4.5.9 Conduct brake test (see 4.4) 4.5.10 Receive & answer call from vehicle driver to say leaving TAXI & RWY area 4.5.11 Remove aide memoire or strip once vehicle reached desired location		4.5.10 Receive & answer call from vehicle driver to say leaving TAXI / RWY area 4.5.11 Remove FPS from strip bay		difficult to monitor vehicle(s) due to picture resolution & update rate	
4.6 Maintenance work	4.6.1 Receive call from ground staff for permission for conduct maintenance work on taxiway & RWY detailing impact on Ops & OK if appropriate 4.6.2 Identify vehicle 4.6.3 Create strip & arrange / aide memoire 4.6.4 Check traffic situation to check no obstacles or potential conflicts 4.6.5 Co-ordinate with others (e.g. adjacent sector) if necessary 4.6.6 Issue clearance / instructions for vehicles to enter taxiway / runway 4.6.7 Monitor vehicle(s) / update mental picture 4.6.8 If potential conflict identified, issue tactical instructions to avoid conflict 4.6.9 Obtain verbal confirmation that equipment is serviceable 4.6.10 Confirm / check that equipment is working	4.6.2 OTW view 4.6.4 OTW view 4.6.7 OTW view	4.6.1 Answer call from ground staff on telephone 4.6.3 Write vehicle information on paper or create a new strip & arrange on strip bay 4.6.5Co-ordinate with adjacent sector via telephone 4.6.6 Issue clearance/instructions to vehicles via R/T 4.6.8 Issue tactical instructions to vehicles via R/T for vehicles 4.6.9 Obtain info. via R/T for vehicles 4.6.10 Test equipment that was being serviced	4.6.2 **Panoramic view** 4.6.4 **Panoramic view** 4.6.7 **Panoramic view**	4.6.2 Quality of picture may make it more difficult to identify vehicle due to picture resolution & update rate 4.6.4 Quality of picture may make it more difficult to check taxi-ways & runways for obstacles / potential conflict due to picture resolution & update rate 4.6.7 Quality of picture may make it more difficult to monitor vehicle(s) due to picture resolution & update rate	

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
	4.6.11Receive & answer call from vehicle driver to say leaving TAXI & RWY area 4.6.12 Remove aide memoire or strip once vehicle reached desired location		4.6.11 Receive & answer call from vehicle driver to say leaving TAXI / RWY area 4.6.12 Remove FPS from strip bay			
5.0 Manage / Determine runway usage & procedures	**5.1 Runway selection** 5.1.1 Monitor weather 5.1.2 Decide runway selection 5.1.3 Change runway configuration **5.2 Plan & respond to runway closure** 5.2.1 Receive call / information relating to RWY status 5.2.2 Decide when & if to close RWY 5.2.3 Co-ordinate with necessary ground staff 5.2.4.Co-ordinate with adjacent sectors **5.3 Low visibility procedures** 5.3.1 Monitor weather & visibility 5.3.2 Decide to implement LVP			5.3.1 Panoramic view & IR camera	5.1.1 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on trees. Being remote and not having knowledge of local weather conditions is a potential issue that may impact decision making. 5.3.1 Quality of picture of aerodrome transmitted on panoramic screens in terms of resolution / colour / brightness may mean that some subtle	Runway selection is heavily dependent on wind direction, need to makes sure that windsocks are in camera view.

Task	Sub Tasks	Information source in tower operations	Control devices / equipment in tower operations	Changes under remote operations	Potential issue	Comment / notes
					cues / information that ATCOs use to help determine weather may be lost e.g. colour of sky, colour, texture, form & distance of clouds, movement of leaves on trees. IR camera may result in changes to the criteria required for using LVP 5.3.2 LVP may not be implemented as today	
6.0 Manage sectorisation / resources	6.1 **Manage military** 6.1.1 Co-ordinate with military and/or adjacent sector as necessary for traffic planning & synchronisation 6.1.2 Change sector configuration as agreed **6.2 Manage sectorisation with adjacent sectors** **6.2.1** Co-ordinate with adjacent sector as necessary for traffic planning & synchronisation 6.1.2 Change sector configuration as agreed	6.1 Incoming call from adjacent or military sector	6.1 Telephone & 6.1.1 Co-ordinate with military or adjacent sector via telephone 6.1.2 Select appropriate sector configuration from a list of pre-defined configurations on equipment 6.2 see below 6.2.1 Co-ordinate with adjacent sector via telephone 6.2.2 Select appropriate sector configuration from a list of pre-defined			

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	6.**3 Manage workload within tower** 6.3.1Determine future workload 6.3.2 Identify need for additional controller 6.3.3 Request assistance & brief incoming controller of traffic situation 6.3.4 Hand over control of new sector or other tasks to additional ATCO		configurations			
7.0 Handling emergencies / incidents	7.1 Monitor aerodrome & vicinity 7.2Identify an event / incident as an emergency 7.3 Decide category of emergency 7.4 Communicate with emergency services as required 7.5 Carry out upgrade actions with emergency services as required 7.6 Liaise with external agencies 7.7 Co-ordinate with tower controllers as required					7.0 Safety will develop thread analyses into specific emergency situations,
8.0 Handover control to incoming controller	8.1 Brief incoming controller of current and future traffic situation 8.2 When appropriate, i.e. when task load not too high, officially hand over control to incoming control					
9.0 Other tasks (non ATC)	9.1 Answer incoming telephone calls 9.2 Manage visitors 9.3 Handle maintenance and/or equipment failure 9.4 Manage work in progress /					9.1 Phone call cover a range of issues both tactical ATM control issues as well as more strategic issues that are

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	maintenance work 9.5 Ensure serviceability of systems (testing systems) (this is a supervisor role) 9.6 Develop roster 9.7 Amending procedures (admin task) 9.8 Met officer duties 9.8.1 Check meteorological data suggested by system 9.8.2 Monitor skies for sky coverage and cloud type 9.8.3 Check precipitation and wind direction 9.8.4 Compile report 9.9. Staff meeting both with and without ground staff 9.10 Extra administration jobs 9.10.1 Landing fees handling 9.10.2 Gate management 9.10.3 Fuelling figures 9.10.4 Pilot briefing, ensure publications, handbooks and manuals are updated	9.8.3 Go outside to check weather and obtain required info.	9.8.4 Either add report or edit the met report suggested by the computer	9.8 Met officer duties will be carried out by aerodrome personnel onsite at local aerodrome		not so urgent, plus non ATM issues. Perhaps there is a need to introduce separate lines 9.8 Met officer duties may be performed by ATCO or by ground staff this depends on the aerodrome 9.8.4 Met report is given to a/c and input into ATIS. The METAR is provided to the Swedish Metrological Society and for flight planning

- **END OF DOCUMENT -**