



SESAR Solution PJ.05.02 SPR-INTEROP/OSED for V3 - Part II - Safety Assessment Report

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MRT

MULTIPLE REMOTE TOWER

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Abstract

This document collects the safety assurance activities that have been carried out by solution PJ.05-02 Multiple Remote Towers, in order to create necessary and sufficient Evidence for this Safety Assessment Report (SAR), the OSED/SPR/INTEROP and Validation activities.

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1 Executive Summary

This document contains the Specimen Safety Assessment for a typical application of the Multiple Remote Tower Solution 2 in PJ.05 operations. The report presents the assurance that the Safety Requirements for the V1-V2-V3 phases are complete, correct and realistic, thereby providing all material to adequately inform the Solution OSED/SPR/INTEROP.

- PJ.05-Solution 02 “Remotely Provided Air Traffic Services from a Multiple Remote Tower Module, MRTM”

For further reference, see the Executive Summary of the OSED/SPR/INTEROP document [1], the Project Management Plan [6] and the Safety assessment Plan [5].

2 Introduction

2.1 Background

This document considers the work done for the SESAR Solutions PJ.05-02.

The objective of PJ05 [1] is to enlarge the scope of the multiple remote tower solution from SESAR 1 addressing higher traffic volumes and higher number of airports that are simultaneously controlled by one ATCO in order to further increase cost efficiency. The validations will focus on evaluation of human performance and safety aspects. PJ05 addresses this in the following two solutions:

- Solution PJ.05-02
Remotely Provided Air Traffic Service for Multiple Aerodromes for up to three airports
- Solution PJ.05-03
Highly Flexible Allocation of Aerodromes to Multiple Remote Tower Modules

The two solutions describe the sequential steps for enlarging the scope of Multiple Remote Tower – MRT services and RTC functionality. Solution PJ.05-02 addresses the next implementation step aiming for V3 maturity level at the end of wave 1. This is complemented by more advanced features in solution PJ.05-03 for efficient Remote Tower Centres aiming for V2 maturity level at the end of wave 1 (and V3 level to be reached at the end of wave 2).

2.2 General Approach to Safety Assessment

This safety assessment is conducted as per the SESAR Safety Reference Material (SRM) [2] which itself is based on a two-fold approach:

- a success approach which is concerned with the safety of the Multiple Remote Tower operations in the absence of failure within the end-to-end MRT system
- a conventional failure approach which is concerned with the safety of the Multiple Remote Tower operations in the event of failures within the end-to-end MRT System.

Together, the two approaches lead to Safety Objectives and Safety Requirements which set the minimum positive and maximum negative safety contributions of the MRT System.

Remote Towers in SESAR1 developed the baseline for the concept of a Single Remote Towers. In SESAR2020 within the PJ05 Solution 02 we are looking at two different types of requirements:

- Those that are to be guaranteed for any Single Remote Tower before it can be added to a MRTM, also named as part of the **“Pack”** of Requirements from here on, are the SESAR 1 requirements also taken into account for PJ05 in SESAR 2020
- Those that are particular to the integration of two or more aerodromes into the same MRTM, also named as particular to the **“Multiple”** setting, are the new Safety Requirements developed in SESAR 2020

When performing the safety assessment, specific attention is put on some open issues from the assessment done in SESAR 1 for Multiple Remote Tower [14]. Some of the items that need further evaluation in the scope of both solutions in PJ05 are listed here after:

- Communication aspects
 - To ensure that the ATCO is aware which airport they communicate with (in and out) with traffic / vehicles under his/her responsibility or airport personnel
- Need of Advanced features supporting / improving the information in the Visualisation system. For example:
 - Ensuring detection of relevant objects and continuously monitoring them
 - Improving the capability of identifying aircraft
 - Ensuring the capability of evaluating distances and judging separations
 - For airports with high level of traffic density and complexity visual tracking feature may be required, this functionality becoming then a safety net for the prevention of runway incursions.
- expanding the role of ATCO (PJ05.02) in order to provide ATC service for the MRTM):
 - Management of degraded situations; e.g. related to technical failures.
 - This includes the definition of specific procedures, information, tools, etc., needed by the ATCO/Supervisor in order to manage the allocation of aerodromes to MRT modules and staffing within the RTC not only in a pre-tactical way, but also tactically.
- At the level of the MRTM/RTC:
 - To define potential criteria to set clusters of aerodromes to be allocated to a specific module and to define the corresponding module 'capacity'.

2.3 Scope of the Safety Assessment

The scope is depicted in the OSED/SPR/INTEROP [1] relating to Remote Tower Services in a Multiple Remote Tower Module (PJ.05-02) covering the concept of Operations (ConOps). The scope of this document covers this solution addressing multiple remote towers. More information can be found on the Safety assessment Plan [5].

In this document, the Safety Objectives were derived from the Services and completed by the Use Cases. This does not ensure that the Use Cases cover all situations.

To the date of this Safety Assessment Report, Solution PJ05.02 is in V3 maturity, and a specific SAR for Solution PJ05.03 in V2, is to be expected. This document is specific to PJ05.02 and only addresses Tower ATC services; no supervisor or Remote Tower Centre is considered either.

2.4 Layout of the Document

Section 1 provides the executive summary of this safety assessment report.

Section 2 provides an overview of the PJ.05-02 and PJ.05-03 Multiple Remote Towers.

Section 3 presents the safety specifications at the OSED level.

Founding Members

Section **4** details the safety specifications at SPR/INTEROP level.

Section **5** provides the list of acronyms and terminology.

Section **6** lists the documents referred to in this document.

3 Safety specifications at the OSED Level

3.1 Scope

Based on safety activities defined in the Safety Plan [5] this section addresses the following activities:

- description of the key properties of the Operational Environment that are relevant to the safety assessment – section **3.2**
- description of the airspace users requirements – section **3.3**
- identification of the pre-existing hazards that affect traffic in the Solution relevant operational environment (airspace, airport) and the risks of which operational services provided by the Solution may reasonably be expected to mitigate to some degree and extent – section **3.4**
- setting of the Safety Criteria [6] – sections **3.5**
- comprehensive determination of the operational services that are provided by the Solution to address the relevant pre-existing hazards and derivation of Safety Objectives (success approach) in order to mitigate the pre-existing risks under normal operational conditions – section **3.6**
- assessment of the adequacy of the operational services provided by the Solution under abnormal conditions of the Operational Environment – section **3.7**
- assessment of the adequacy of the operational services provided by the Solution in the case of internal failures and mitigation of the System-generated hazards (derivation of Safety Objectives (failure approach)) – section **3.8**
- impacts of PJ05 solution on adjacent airspace or on neighbouring ATM Systems – section **3.9**
- achievability of the Safety Criteria – section **3.10**
- validation & verification of the safety specification – section **3.11**

3.2 Solution Operational Environment and Key Properties

The operational safety assessment for Multiple Remote Towers will address a specific operational environment where the main characteristics are recalled below. More information can be found in OSED/SPR/INTEROP Part I [1].

Airspace Structure and Boundaries

Including Clearance delivery, Ground Control, Tower Control, TWR Apron Control

Types of Airspace – ICAO Classification

Class C and/or D

CTR: 10- 15 NM radius/rectangular, vertical extension up to 3000 ft MSL

Airspace Users

Founding Members



VFR and IFR

Mainly scheduled, charter and GA

All aircraft types

Note: RPAS were planned in the OSED/SPR/INTEROP but the SAR does not evaluate or validate if any differences would arise from the introduction of co-operative RPAS in the environment

Flight Rules

Specific IFR routes & approach procedures

Established VFR routes

Airport Layout

- One runway

Note: the OSED/SPR/INETROP Part I [1] described a layout with one or two runways and/or with a FATO; however this SAR does not cover these options as they have not been validated; some helicopter movements were tried during some of the validations but not in a specific FATO designated for it.

- Typically 1 or 2 aprons (ordinary and GA/freight)
- Typically one major taxiway parallel with the runway, number of runway intersections/entries varying typically between 1 and 3

Traffic levels and complexity

Corresponding to small and medium sized aerodromes (up to 20 movements per hour)

Solution PJ.05-02 only applies when the traffic volume can be controlled by one ATCO from the MRTM (which might be limited to certain time periods at medium size airports).

Note: The number of simultaneous movements depends on the traffic complexity.

Aircraft ATM capabilities

- Communication: ATC Voice Communications, VHF and UHF-transmitters/receivers, Ground Radio System, Autonomous VHF-radio, SAR radio.
- Surveillance:
 - PJ.05-02: air and ground surveillance (optional)

Staffing

One ATCO per MRTM with 1, 2 or 3 aerodromes per MRTM

ADI, possibly APP, APS/RAD (ratings are optional dependent on service delivered from the RTC or MRTM)

Significant weather and other meteorological conditions

Any weather condition that is currently typical at a given airport (snow, rain, sun, temperature, etc.)

3.3 Airspace Users Requirements

The Airspace Users Requirements refer to what the stakeholders expect from PJ05.

Section 4.2 of the Validation Plan Part I [4] gave us a table with the Stakeholder’s expectations, which is the same as Table 1 below.

Stakeholder	Involvement	Why it matters to stakeholder
ANS providers	ANSPs will be able to implement the systems	ANSPs expect a reduction of cost for running local air traffic service at aerodromes
Staff union and organisations (ETF/IFATCEA)	ATCOs will be the end user of the system	Staff working in a MRTM and RTC will be affected when working with more than one aerodrome at a time. Their expectations are that the technology will ensure that daily work can be performed safe and controlled.
ATM infrastructure and equipment suppliers	The technology set new demands on a reliable system for Multiple Remote Tower	Industries is affected by new requirements on multiple remote towers and the need for stable systems
Airspace users	Airspace users fly to and from aerodromes with RTC and Multi Remote Tower	Traffic to and from airports expect to continue to traffic aerodromes without impact on scheduled traffic with a kept availability for each of the aerodromes controlled in Multiple mode
Affected NSA	NSA will issue approval for any new ANS systems	NSA expect that any new technology is safe and stable for air traffic service and that methodology is properly adapted to the technology
Airport owners/providers	Airport owners are customers to ANS providers	Airports expect prices for ANS to be lowered with Multiple Remote Tower without a negative impact on their availability for flying customers.

Table 1: Stakeholders' expectations

3.4 Relevant Pre-existing Hazards

The same hazardous situations and risks to be mitigated as for Single Remote Tower operations (which are the baseline for Multiple Remote Tower) are to be considered for Multiple Remote Towers. These hazardous situations, called pre-existing hazards, have been identified from the list provided in the guidance for applying SRM [3]. They are listed in the table here-after, along with the related type of accident, the AIM Model used and the corresponding Safety Criteria (as explained in previous section):

Pre-existing Hazards to be mitigated by the AT services	Leading to (type of)	AIM Model
---	----------------------	-----------

	remotely provided using MRT	accident)	Used
Hp#1	Situation in which A/C trajectories can lead to mid-air collision	Mid Air Collision	MAC-TMA
Hp#2	Situation leading to collision with an obstacle, ground vehicle, another aircraft on apron or taxiway	Taxiway Collision	TWY-Col
Hp#3	Situation leading to collision with an obstacle, ground vehicle, another aircraft on the runway	Runway Collision	RWY-Col
Hp#4	Another aircraft or vehicle inside the Obstacle Free Zone - OFZ	Runway Collision	RWY-Col
Hp#5	Situation in which missed approach can lead to mid-air collision	Mid Air Collision	MAC-TMA
Hp#6	Situation leading to Wake vortex encounter in final approach	Wake Turbulence Accident	WV-FAP
Hp#7	Situation leading to Controlled Flight Into Terrain	Controlled Flight Into Terrain	CFIT
Hp#8	Bird close to/in path of aircraft or animal on the runway	Bird-strike Animal-strike	RWY-Col
Hp#9	Adverse weather conditions like violent winds or severe crosswind	Hard landing, runway excursion, Landing accident	RWY-EXC
Hp#10	Snow/slush on the runway	Loss of control on the runway, Landing accident	RWY-EXC
Hp#11	Low runway surface friction	Runway excursion ((veer-off, overrun) Landing accident	RWY-EXC
Hp#12	Runway undershoot	Off-runway touchdown, Landing accident	None
Hp#13	Aircraft using a closed taxiway	Taxiway Collision	TWY-Col
Hp#14	Aircraft landing in/taking off from a wrong/closed runway	Runway Collision (wrong/closed RWY in which a AC, vehicle, obstacle is present) Landing accident (closed runway because of maintenance: RWY surface not operational)	RWY-Col
Hp#15	Another aircraft or vehicle inside landing-aid protection area during CATII/III instrument	Landing accident	RWY-EXC

	approach		
Hp#16	Foreign Object Debris within the Runway protected area	(Loss of control on the runway) Landing accident	RWY-EXC
Hp#17	Aircraft attempt to land with undercarriage retracted	(Gears-up landing) Landing accident	RWY-EXC
Hp#18	Loss/interruption of ATC services (to one or more aerodromes)	All types of accidents	None
Hp#19	Aircraft entering a restricted area (airspace)	Airspace infringement	MAC-TMA

Table 2: List of pre-existing hazards

3.4.1 Initial determination of the Operational Services to Address the Pre-existing Hazards

The ATC services that are provided by the Multiple Remote Tower in the relevant operational environment to address (all/some of) the pre-existing hazards identified above are listed in section 3.6.1.

Note that as for the pre-existing hazards, these services are the same as the ones provided in Single Remote Tower operations.

3.5 Safety Criteria

The Multiple Remote Tower Module concept is not safety driven, i.e. the purpose is not to improve safety, but mainly to reduce ATS related costs. Hence, the safety acceptance criteria to be applied must ensure that the level of safety is at least maintained. In other words, the aim is that providing ATC/AFIS services remotely for multiple airports shall be as safe as if the services were provided by an ATCO/AFISO physically located in each corresponding airport.

Unlike other SESAR 2020 Solutions, PJ05.02 (V3) covers the entirety of the systems that provide ATC service in the MRTM, and therefore **the rationale for all Safety Criteria** is the same, based on the fact that the change could potentially affect all the risk targets.

Safety Criteria are defined considering risk targets for each aerodrome when ATC service is provided through Remote Towers, but also considering other safety and regulatory requirements. The standards and regulations for multiple remote tower operations need to be developed by EASA and EUROCAE based on the ones provided for single remote tower.

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

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

The Safety Criteria presented as risk targets are described in the following subsections:

With respect to Mid-Air Collision CTR area

- SAC#1** There shall be no increase of ATC induced tactical conflict in each aerodrome for which ATS are remotely provided using Multiple Remote Tower
- SAC#2** There shall be no increase of Imminent Infringement in each aerodrome for which ATS are remotely provided using Multiple Remote Tower
- a. as a function of Ineffective ATCO induced conflict management
 - b. as a function of Ineffective externally-induced conflict management
 - c. as a function of Ineffective plan induced conflict management
- SAC#3** There shall be no increase of Imminent Collision in each aerodrome for which ATS are remotely provided using Multiple Remote Tower
- a. as a function of Ineffective ATCO Collision prevention
- SAC#4** There shall be no increase of ATC pre-tactical conflict in each aerodrome for which ATS are remotely provided, using Multiple Remote Tower.

With respect to Controlled Flight into Terrain

- SAC#5** There shall be no increase of Flight Towards Terrain commanded by ATC in each aerodrome for which ATS are remotely provided using Multiple Remote Tower
- SAC#6** There shall be no increase of Imminent Controlled Flight Into Terrain (CFIT) in each aerodrome for which ATC are remotely provided using Multiple Remote Tower
- a. as a function of Ineffective ATCO warning

Safety Criteria related to Wake Vortex Induced Accidents

- SAC#7** There shall be no increase of under-spacing allowing for Wake Vortex Encounter in each aerodrome for which ATS are remotely provided using Multiple Remote Tower
- a. as a function of Insufficient Wake Turbulence approach spacing imposed by ATC
 - b. as a function of Insufficient Separation to prevent Wake Vortex Encounter spacing provided by ATC

Safety Criteria related to Taxiway Collision

- SAC#8** There shall be no increase of Taxiway conflicts in each aerodrome for which ATS are remotely provided using Multiple Remote Tower
- a. as a function of ineffective ATCO taxiway planning
- SAC#9** There shall be no increase of Imminent Taxiway Infringement in each aerodrome for which ATC are remotely provided using Multiple Remote Tower
- a. as a function of Inadequate ATCO taxiway conflict management
- SAC#10** There shall be no increase of Imminent Taxiway Collision in each aerodrome for which ATC are remotely provided using Multiple Remote Tower
- a. as a function of Ineffective ATCO taxiway collision avoidance

SAC#11 There shall be no increase of pre-Tactical taxiway conflicts in each aerodrome for which ATC are remotely provided, in sequence or in parallel, using Multiple Remote Tower

Safety Criteria related to Runway Collision

SAC#12 There shall be no increase of Runway Incursion in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

- a. as a function of Ineffective ATCO runway entry procedures
- b. as a function of Ineffective ATCO awareness to recognise pilot/driver entering
- c. as a function of ineffective ATCO landing management
- d. as a function of ineffective ATCO take off management

SAC#13 There shall be no increase of Runway Conflict in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

- a. as a function of Ineffective ATCO awareness to detect Aircraft/Vehicle and Animal/Person runway incursions prior to issuing landing/take-off clearance
- b. as a function of ATCO providing a clearance inducing a conflict in the runway

SAC#14 There shall be no increase of Imminent Runway Collision in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

- a. as a function of Ineffective ATCO Runway Collision Avoidance

SAC#15 There shall be no increase of Inadequate Potential Runway Use in each aerodrome for which ATC services are remotely provided using Multiple Remote Tower

- a. as a function of medium/long term failure to balance operational airport capacity/demand
- b. as a function of Ineffective Tower (Runway) Failure to balance arrivals or departures

Safety Criteria related to "Landing accidents"

SAC#16 There shall be no increase of Runway Excursions in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

- a. as a function of ineffective ATCO weather conditions affecting RWY monitoring affecting arriving aircraft (leading to runway excursion)
- b. as a function of ineffective check of the runway surface (with respect to snow, slush, RWY surface friction, FOD, ...) (leading to runway excursion)
- c. as a function of ineffective ATCO monitoring of AC trajectory on final approach (leading to runway excursion)

SAC#17 There shall be no increase of other Landing related Accidents in each aerodrome for which ATC are remotely provided, using Multiple Remote Tower

- a. as a function of ineffective ATCO weather conditions monitoring affecting arriving aircraft (leading to landing accident)
- b. as a function of ineffective check of the runway surface (with respect to snow, slush, RWY surface friction, FOD, ...) (leading to loss of control on the runway)

- c. as a function of ineffective ATCO monitoring of AC trajectory on final approach (leading to undershoot, AC landing in wrong/closed RWY, AC landing with undercarriage retracted)
- d. as a function of ineffective monitoring of potential intrusions inside the landing-aid protection area (affecting landing AC) as a function of inefficient management of landing-aid light

3.6 Mitigation of the Pre-existing Risks – Normal Operations

3.6.1 Operational Services to Address the Pre-existing Hazards

This section provides the list of ATC operational services that are provided for each corresponding aerodrome by the MRT in the relevant operational environment to address the pre-existing hazards identified in section 3.4. These services are the same as for Single Remote Tower.

ID	Service Objective	Pre-existing Hazards
MRT.ATC-01	Traffic planning and synchronisation	Hp#1
MRT.ATC-02	Traffic monitoring, separation provision, conflict detection and resolution in the vicinity of the aerodrome	Hp#1 , Hp#5, Hp#19
MRT.ATC-03	Potential collision detection and avoidance in the vicinity of the aerodrome	Hp#1 , Hp#5
MRT.ATC-04	Start-up Push-back Stand/Parking Taxiway Routing	Hp#2 , Hp#13
MRT.ATC-05	Traffic Monitoring on the manoeuvring area and TWY Conflict resolution	Hp#2 , Hp#13
MRT.ATC-06	Potential TWY collision detection TWY Collision avoidance	Hp#2
MRT.ATC-07	Runway Entry/exit management Take-off Management Landing Management	Hp#3 , Hp#4 , Hp#13
MRT.ATC-08	Traffic Monitoring on the runway and RWY Conflict resolution	Hp#3 Hp#8 Hp#14
MRT.ATC-09	Potential RWY collision detection RWY Collision avoidance	Hp#3 Hp#8
MRT.ATC-10	Traffic monitoring with respect to terrain	Hp#7

MRT.ATC-11	Traffic monitoring and Separation provision	Hp#6
MRT.ATC-12	ATC detection and recovery of weather affected runways situations (that may potentially lead to a runway excursion)	Hp#9 Hp#10 Hp#11
MRT.ATC-13	ATC detection and recovery of runway infrastructure/suitability issues (that may potentially lead to a runway excursion)	Hp#8 Hp#16 Hp#14
MRT.ATC-14	ATC detection and recovery of unstable approaches (that may potentially lead to a runway excursion)	Hp#12
MRT.ATC-15	ATC prevention of / recovery from other events potentially leading to other landing related accidents	Hp#3 Hp#17 Hp#15
MRT.ATC-16	Ensure availability/continuity of the ATC service	Hp#18
MRT.ATC-17	Pre-tactical and tactical management of resources	All
MRT.ATC-18	Pre-tactical and tactical demand and capacity balancing	All

Table 3: ATC operational services and Pre-existing Hazards

3.6.2 Derivation of Safety Objectives (Functionality & Performance – success approach) for Normal Operations

This section provides the functional Safety Objectives (concerning the success part of the assessment). The Safety Objectives describe WHAT the Multiple Remote Tower system must operationally deliver in order to provide the ATC services mentioned in the previous section. The whole set of safety objectives aims to achieve the Safety Criteria defined in section 3.5. They are the same as per Single Remote Tower, applicable to each aerodrome allocated to the same MRTM.

See **Appendix A** for the full list of Safety Objectives.

Ref	Phase of Flight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
MRT.ATC-01	Climb Descend	Traffic Planning and synchronisation (MAC)	SO-001 SO-002 SO-003
MRT.ATC-02	Climb Descend	ATC Conflict Management (MAC)	SO-004 SO-005 SO-006
MRT.ATC-03	Climb	ATC Mid-air collision Prevention (MAC)	SO-007 SO-008 SO-009 SO-

Ref	Phase of Flight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
	Descend		010
MRT.ATC-04	Surface-in Surface-out (Apron/Taxi-in/Taxi-out)	Tactical TWY planning (TWY Col)	SO-011 SO-012 SO-013 SO-014 SO-015 SO-018
MRT.ATC-05	Surface-in Surface-out (Apron/Taxi-in/Taxi-out)	TWY conflict management (TWY Col)	SO-016 SO-017
MRT.ATC-06	Surface-in Surface-out (Apron/Taxi-in/Taxi-out)	ATC TWY Collision preventions(TWY Col)	SO-016 SO-017
MRT.ATC-07	Surface-in Surface-out (Runway)	Runway Incursion Prevention (RWY Col)	SO-019 SO-020 SO-021 SO-022 SO-023 SO-024 SO-025
MRT.ATC-08	Surface-in Surface-out (Runway)	Runway Conflict Prevention (RWY Col)	SO-026 SO-027
MRT.ATC-09	Surface-in Surface-out (Runway)	ATC Runway Collision Prevention (RWY Col)	SO-026 SO-027
MRT.ATC-10	Climb Descend	CFIT ATCO warning (CFIT)	SO-028 SO-029
MRT.ATC-11	Climb Descend	Wake spacing management (WV ind.Acc)	SO-030
MRT.ATC-12	Climb Descend	Management of RWY conditions for landing with respect to weather	SO-031
MRT.ATC-13	Climb Descend	Management of RWY suitability for landing	SO-032
MRT.ATC-14	Descend / Landing	Management of stabilisation in final approach	SO-033
MRT.ATC-15	Descend / Landing	No associated model	SO-034 SO-035
MRT.ATC-16	All	All models affected	SO-036 SO-037 SO-038 SO-

Ref	Phase of Flight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
			039 SO-040 SO-041 SO-042
MRT.ATC-17	All	All models affected	SO-043 SO-044
MRT.ATC-18	All	All models affected	SO-045 SO-046

Table 4: PJ05 Solution Operational Services & Safety Objectives (success approach)

Table 5 below describes the Safety Objectives referred to above.

ID	Description
SO-01	MRTM shall enable coordination and transfer procedures with adjacent ATS unit concerning inbound/outbound traffic (including as necessary aircraft identification) for all aerodromes allocated to the same MRTM
SO-02	MRTM shall enable to manage inbound traffic (including as necessary management of the approach, visual acquisition, entry into traffic circuit and landing sequence) for all aerodromes allocated to the same MRTM
SO-03	MRTM shall enable to manage outbound traffic (including as necessary aircraft identification and departure sequence on the runway) for all aerodromes allocated to the same MRTM
SO-04	MRTM shall enable to separate traffic, with respect to other traffic, applying the corresponding separation minima to the airspace under control responsibility (in the vicinity of the aerodrome) or allowing reduction in separation minima in the vicinity of the aerodrome for all aerodromes allocated to the same MRTM
SO-05	MRTM shall enable to separate traffic with respect to restricted areas on the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-06	MRTM shall enable to manage missed approaches situations (including detection of need for go-around, monitoring of involved aircraft and proposal for resolution) for all aerodromes allocated to the same MRTM
SO-07	MRTM shall enable the detection of conflicts or potential collisions between aircraft (within departing, within arriving and between both traffic) on the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-08	MRTM shall enable the detection of restricted areas infringements by aircraft in the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-09	MRTM shall enable the provision of ATC instructions to resolve conflicts/ avoid collisions on the airspace under control responsibility for all aerodromes allocated to the same MRTM

SO-10	MRTM shall enable the provision of ATC instructions to resolve airspace infringements for all aerodromes allocated to the same MRTM
SO-11	MRTM shall enable to identify departing AC on the stand for providing ATC service for all aerodromes allocated to the same MRTM
SO-12	MRTM shall enable start-up procedures for departing aircraft (including as appropriate the provision of necessary aerodrome information - operational and meteorological) for all aerodromes allocated to the same MRTM
SO-13	MRTM shall enable push-back and towing procedures for all aerodromes allocated to the same MRTM
SO-14	MRTM shall enable the provision of conflict-free routing and taxi instructions to aircraft in the manoeuvring area for all aerodromes allocated to the same MRTM
SO-15	MRTM shall enable the provision of taxi instructions to vehicles in the manoeuvring area for all aerodromes allocated to the same MRTM
SO-16	MRTM shall enable the detection of conflicting situations in the manoeuvring area (involving aircraft, vehicles, and obstacles) for all aerodromes allocated to the same MRTM
SO-17	MRTM shall enable the provision of taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions in the manoeuvring area for all aerodromes allocated to the same MRTM
SO-18	MRTM shall enable to support AC and vehicle movements in the manoeuvring area (through visual aids on the airport surface) for all aerodromes allocated to the same MRTM
SO-19	MRTM shall enable to manage runway entry for departing aircraft (this includes RWY status/occupancy/correctness check before issuing line-up clearance) for all aerodromes allocated to the same MRTM
SO-20	MRTM shall enable to manage runway exit for arriving aircraft (this includes exit TWY status/occupancy check) for all aerodromes allocated to the same MRTM
SO-21	MRT shall enable to manage aircraft/vehicles runway crossing (this includes RWY status/occupancy/correctness check before issuing runway crossing clearance) for all aerodromes allocated to the same MRTM
SO-22	MRTM shall enable to support aircraft for take-off and landing operations (though visual-aids on the airport surface) for all aerodromes allocated to the same MRTM
SO-23	MRTM shall enable to carry out vehicle related tasks on the runway (inspections, etc.) for all aerodromes allocated to the same MRTM
SO-24	MRT shall enable to manage aircraft take-off (this includes RWY status/occupancy/correctness check before issuing take-off clearance) for all

	aerodromes allocated to the same MRTM
SO-25	MRTM shall enable to manage aircraft landing (this includes RWY status/occupancy/correctness check before issuing landing clearance) for all aerodromes allocated to the same MRTM
SO-26	MRTM shall enable ATC detection and resolution of runway incursions (AC, vehicle, animal, person incursions) for all aerodromes allocated to the same MRTM
SO-27	MRTM shall enable ATC detection and instructions provision to prevent or resolve runway collisions for all aerodromes allocated to the same MRTM
SO-28	MRTM shall enable the detection of flight towards terrain situations for all aerodromes allocated to the same MRTM
SO-29	MRTM shall enable to warn/support pilot on Controlled Flight Towards Terrain situations for all aerodromes allocated to the same MRTM
SO-30	MRTM shall enable to establish/maintain sufficient wake turbulence spacing between arriving and/or departing aircraft for all aerodromes allocated to the same MRTM
SO-31	MRTM shall enable to support taking off and landing operations taking account of weather conditions affecting arriving / departing aircraft (applying corresponding procedures and informing pilots as necessary) for all aerodromes allocated to the same MRTM
SO-32	MRTM shall enable to support landing and taking off aircraft taking account of runway surface conditions and potential foreign objects debris - FOD (applying corresponding procedures and informing pilots as necessary) for all aerodromes allocated to the same MRTM
SO-33	MRTM shall enable to support arriving aircraft on final approach (providing relevant information and instructions as necessary) for all aerodromes allocated to the same MRTM
SO-34	MRTM shall enable to provide “navigation” support to aircraft during landing operations (using available non-visual navigation aids as necessary) for all aerodromes allocated to the same MRTM
SO-35	MRTM shall enable the detection of potential intrusions inside landing-aid protection area for all aerodromes allocated to the same MRTM
SO-36	MRTM shall enable to assess the operational environmental conditions on each corresponding aerodrome in order to provide appropriate remote ATC service (for example “visualisation” related conditions: daylight, dawn, darkness, dusk, CAVOK and low visual conditions)
SO-37	MRTM shall enable the provision of appropriate ATC services in the several operational environmental conditions on each corresponding aerodrome (e.g. low

	visual procedures in low visual conditions)
SO-38	MRTM shall enable the provision of seamless ATC service to airspace users in the several operational environment conditions on each corresponding aerodrome (e.g. daylight, dawn, darkness, dusk, CAVOK and low visual conditions)

Table 5: List of Safety Objectives (success approach) for Normal Operations

3.6.3 Analysis of the Concept for a Typical Flight

In the OSED/SPR/INTEROP Part I [1] certain Use Cases were depicted in order to ensure the completeness of the concept of MRTM. The safety study of these Use Cases demonstrated that the aforementioned Safety Objectives covered most of the Use Cases in all their flows, but **Table 6** lists the Safety Objectives derived from the Use Cases that complete the previous list.

ID	Description
SO-39	Prior to remotely providing ATC services, MRTM capabilities shall be assessed/verified for all aerodromes allocated to the same MRTM
SO-40	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware / notified when the remote provision of ATC service is initiated in each aerodrome (as per planned schedules)
SO-41	Remote provision of ATC service shall appropriately (safely) be stopped for planned terminations for one or more aerodromes while continuing the service provision in the other/s if needed
SO-42	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware / notified when the remote provision of ATC service is terminated in one or more aerodromes (as per planned schedules)
SO-43	The MRTM cluster of aerodromes is planned considering weather forecast, traffic demand and any other factors impacting the capacity of the MRTM to provide relevant ATC/AFIS services to concerned aerodromes
SO-44	MRTM shall enable tactical management of ATC resources (ATCO) ensuring safe service to all aerodromes in charge with respect to weather conditions, traffic overloads/peaks and unexpected events.
SO-45	MRTM shall enable to safely split aerodromes in charge (either transferring it/them to another MRTM in the same RTC or by transferring the responsibility to another ATCO in the same MRTM)
SO-46	MRTM shall enable to safely merge an aerodrome to the MRTM (either transferring from another MRTM in the same RTC or by starting service provision to an aerodrome)

Table 6: Additional Safety Objectives (success approach)

The full list of Safety Objectives can be found in **Appendix A.1**.

3.7 PJ05 Solution Operations under Abnormal Conditions

The purpose of this section is to assess the ability of the Multiple Remote Tower to work through (robustness), or at least recover from (resilience) any abnormal conditions, external to the Remote Tower System, that might be encountered relatively infrequently.

3.7.1 Identification of Abnormal Conditions

The following abnormal conditions have been identified. This list includes the typical abnormal conditions identified already in SESAR1 and already applicable for Single Remote Tower, which have been confirmed with HP during the HP and Safety workshop.

- Unexpected / unplanned flight in airspace
- Aircraft with emergency
- Crash on an airport’s vicinity
- Fire on one or more aerodromes
- Unplanned closing of ATC service in one or more aerodromes
- (Unplanned) ATCO Overload

Note: some ATCOs considered “unexpected/unplanned flights” as a nominal condition they are used to deal with; this depends on the type of airspace, traffic, complexity, etc. that they face every day – as compared to an anecdotal encounter.

3.7.2 Potential Mitigations of Abnormal Conditions

The abnormal conditions listed in 3.7.1 are assessed in this section, on Table 7.

Ref	Abnormal Conditions	Operational Effect	Mitigation of Effects / [SO xx]
1	Unexpected / unplanned flight in airspace	This may induce conflict with other traffic within the same area, as it overloads RTCO and/or unexpectedly changes their way of managing traffic	MRTM shall enable, as in current operations, the detection of unexpected flights in the area of responsibility where ATC services are being provided for all aerodromes allocated to the same MRTM [SO-047]
2	Aircraft with emergency (gear problem, brakes overheating - fire on the tyres, tail strike, bird strike, etc.).	All these emergencies may induce landing or take-off accidents	RTCO must be able to potentially detect those situations [SO-048] and provide appropriate support for solving them [SO-049]
3	Crash on an	In this case the objective is to trigger the	RTCO must be able to detect the loss of an aircraft on the vicinity of the

	airport's vicinity	corresponding services for rescue as quick as possible	aerodrome/s. Then they must be able to activate alarm service and trigger appropriate rescue procedure, contacting relevant personnel and units and providing available information [SO-050]
4	Fire on one or more aerodromes	Operations on the aerodrome/s may need to be stopped as conditions may not be safe for aircraft, passengers and airport personnel.	RTCO must be informed about the situation and if necessary interrupt arrival and departure operations, or they may even terminate provision of ATC service in the area [SO-051, SO-052]. Airspace users are also to be informed [SO-053]
5	Closing ATC service in one or more aerodromes	In case there is a situation significantly affecting the safety of the operations in a corresponding aerodrome, the airport operations manager may decide to close the aerodrome hence stopping ATC services.	RTCO must be informed about the situation in the aerodrome/s in order to apply appropriate termination procedure [SO-051, SO-052]. Airspace users are also to be informed [SO-053]
6	(Unplanned) ATCO Overload	ATCO has a sudden increase in traffic or complexity and must delay or stop ATC service provision	MRTM cluster of aerodromes is planned tactically with a conservative approach [SO-44, SO-45].

Table 7: Additional Safety Objectives (success approach) for Abnormal Conditions

ID	Description
SO-47	MRTM shall enable, as in current operations, the detection of unexpected flights in the area of responsibility where ATC services are being provided for all aerodromes allocated to the same MRTM
SO-48	MRTM shall enable, as in current operations, to detect emergency situations on an aircraft (gear problems, fire on tyres or aircraft, tail strike, etc.) for all aerodromes allocated to the same MRTM
SO-49	MRTM shall enable to initiate emergency procedures and follow emergency situations affecting aircraft for all aerodromes allocated to the same MRTM
SO-50	MRTM shall enable to detect and manage a crash situation on the aerodrome/s allocated to the same MRTM or in their vicinity

SO-51	MRTM shall enable to have awareness of potential abnormal situations (abnormal weather, fire on terminal or aerodrome building, overload on the apron, etc.) in the aerodrome/s allocated to the same MRTM that could affect or even force the termination (unplanned terminations) of the provision of ATC services
SO-52	In case of abnormal situation in one of the aerodromes (emergency situations, crash, overload, etc.), ATCO has to keep ensuring safe provision of service by: - splitting aerodromes (to another MRTM or handover the responsibility to another ATCO in the same MRTM) - terminating the service progressively
SO-53	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware/notified when the remote provision of ATC service is terminated in an unplanned manner in one or more aerodromes
SO-54	ATC service provision shall be safely stopped in case of MRTM inadequate capability, or the concerned aerodromes could be split or transferred to another working MRTM
SO-55	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware/notified when the ATC service provision is stopped or transferred to another MRTM (technical system failure, merging of aerodromes, etc.).

Table 8: List of Safety Objectives (success approach) for Abnormal Operations

3.8 Mitigation of System-generated Risks (failure approach)

This section concerns Multiple Remote Tower operations under internal failure conditions.

The same operational hazards identified for Single Remote Tower are applicable for Multiple Remote Towers. No additional operational hazard has been specifically identified due to the multiple application of remote tower concept.

The complete list of hazards and their corresponding analysis is presented in section 4.5.

As in previous section, these Safety Objectives expresses WHAT we expect, in terms of integrity, from the MRTM as a whole. The safety requirements and recommendations that will be derived from them will cover the HOW these Safety Objectives are to be satisfied, in terms of technical equipment, ATCO tasks and procedures.

3.8.1 Identification and Analysis of System-generated Hazards

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
OH-01	MRTM fails to coordinate and/or transfer with adjacent ATS unit concerning inbound/outbound traffic for one or several aerodromes	SO-01	Tactical Conflict (planned)	SO-04, SO-07, SO-09	MAC-SC4b

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
	allocated to the same MRTM		(MF5.1)		
OH-02	MRTM fails to manage inbound traffic for one or several aerodromes allocated to the same MRTM	SO-02	Imminent Infringement (MF5-8)	SO-04, SO-07, SO-09	MAC-SC3
OH-03	MRTM fails to manage outbound traffic for one or several aerodromes allocated to the same MRTM	SO-03	Imminent Infringement (MF5-8)	SO-04, SO-07, SO-09	MAC-SC3
OH-04	MRTM fails to separate traffic for one or several aerodromes allocated to the same MRTM	SO-04	Imminent Infringement (MF5-8)	SO-07, SO-09	MAC-SC3
OH-05	MRTM fails to separate traffic with respect to restricted areas on the airspace under control responsibility for one or several aerodromes allocated to the same MRTM	SO-05	Tactical Conflict (crew/aircraft induced) (MF6.1)	SO-08, SO-10	MAC-SC4a
OH-06	MRTM fails to manage missed approach situations for one or several aerodromes allocated to the same MRTM	SO-06	Imminent Infringement (MF5-8)	SO-04, SO-25	MAC-SC3
OH-07	MRTM fails to detect conflicts or potential collisions between aircraft (within departing, within arriving and between both traffic) on the airspace under control responsibility for one or several aerodromes allocated to the same MRTM	SO-07	Imminent Collision (MF4)		MAC-SC2b
OH-08	MRTM fails to timely detect restricted areas infringements for one or several aerodromes allocated to the same MRTM	SO-08	Tactical Conflict (crew/aircraft induced) (MF6.1)		MAC-SC4a
OH-09	MRTM fails to provide ATC instructions to resolve conflicts/ avoid collisions on the airspace under control responsibility for one or several aerodromes allocated to the same	SO-09	Imminent Collision (MF4)		MAC-SC2b

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
	MRTM				
OH-10	MRTM fails to provide appropriate instructions to solve airspace infringements for one or several aerodromes allocated to the same MRTM	SO-10	Tactical Conflict (crew/aircraft induced) (MF6.1)		MAC-SC4a
OH-11	MRTM fails to identify departing aircraft on the stand for providing ATC service for one or several aerodromes allocated to the same MRTM	SO-11	Tactical Taxiway Conflict (TP3)		TWY-SC5
OH-12	MRTM fails to apply start-up procedures for departing aircraft for one or several aerodromes allocated to the same MRTM	SO-12	Tactical Taxiway Conflict (TP3)	SO-16, SO-17, SO-18	TWY-SC5
OH-13	MRTM fails to apply push-back and towing procedures for one or several aerodromes allocated to the same MRTM	SO-13	Tactical Taxiway Conflict (TP3)	SO-16, SO-17, SO-18	TWY-SC5
OH-14	MRTM fails to provide conflict-free routing and taxi instructions to aircraft in the manoeuvring area for one or several aerodromes allocated to the same MRTM	SO-14	Imminent Taxiway Infringement (TP2)	SO-16, SO-17, SO-18	TWY-SC4
OH-15	MRTM fails to provide taxi instructions to vehicles in the manoeuvring area for one or several aerodromes allocated to the same MRTM	SO-15	Imminent Taxiway Infringement (TP2)	SO-16, SO-17, SO-18	TWY-SC4
OH-16	MRTM fails to detect conflicting situations in the manoeuvring area for one or several all aerodromes allocated to the same MRTM	SO-16	Imminent Taxiway Collision (TP1)		TWY-SC3
OH-17	MRTM fails to provide taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions in the manoeuvring area for one or several aerodromes allocated to the	SO-17	Imminent Taxiway Collision (TP1)		TWY-SC3

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
	same MRTM				
OH-18	MRTM fails to support aircraft and vehicle movements in the manoeuvring area for one or several aerodromes allocated to the same MRTM	SO-18	Tactical Taxiway Conflict (TP3)	SO-16, SO-17	TWY-SC5
OH-19	MRTM fails to manage runway entry for departing aircraft for one or several aerodromes allocated to the same MRTM	SO-19	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-20	MRTM fails to manage runway exit for arriving aircraft for one or several aerodromes allocated to the same MRTM	SO-20	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-21	MRTM fails to manage aircraft/vehicles runway crossing for one or several aerodromes allocated to the same MRTM	SO-21	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-22	MRTM fails to support aircraft for take-off and landing operations for one or several aerodromes allocated to the same MRTM	SO-22	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-23	MRTM fails to carry out vehicle related tasks on the runway for one or several aerodromes allocated to the same MRTM	SO-23	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-24	MRTM fails to manage aircraft take-off for one or several aerodromes allocated to the same MRTM	SO-24	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-25	MRTM fails to manage aircraft landing for one or several aerodromes allocated to the same MRTM	SO-25	Runway Conflict (RP2)	SO-26, SO-27	RWY-SC3
OH-26	MRTM fails to enable ATC detection and resolution of runway incursions for one or several aerodromes allocated to the same MRTM	SO-26	Runway Incursion (RP3)		RWY-SC4

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
OH-27	MRTM fails to detect and provide instructions to prevent or resolve runway collisions for one or several aerodromes allocated to the same MRTM	SO-27	Runway Incursion (RP3)		RWY-SC4
OH-28	MRTM fails to detect flight towards terrain situations for one or several aerodromes allocated to the same MRTM	SO-28	Imminent CFIT (CF3)		CFIT-SC2
OH-29	MRTM fails to warn/support pilot on CFIT situations for one or several aerodromes allocated to the same MRTM	SO-29	Imminent CFIT (CF3)		CFIT-SC2
OH-30	MRTM fails to establish/maintain sufficient wake turbulence spacing between arriving and/or departing aircraft for one or several aerodromes allocated to the same MRTM	SO-30	Imminent Wake Encounter (WE6) [WE7F for Vienna]		WAKE-SC3a
OH-31	MRTM fails to support taking off and landing operations taking account of weather conditions affecting arriving/departing aircraft for one or several aerodromes allocated to the same MRTM	SO-31	Imminent Runway Excursion		RExc-SC2b
OH-32	MRTM fails to support taking off and landing operations taking account of runway surface conditions and potential foreign objects debris - FOD for one or several aerodromes allocated to the same MRTM	SO-32	Imminent Runway Excursion		RExc-SC2b
OH-33	MRTM fails to support arriving aircraft on final approach for one or several aerodromes allocated to the same MRTM	SO-33	Unstable Approach / Imminent Runway Excursion		RExc-SC2b/3
OH-34	MRTM fails to provide "navigation" support to aircraft during landing operations for one or several	SO-34	Unstable Approach		RExc-SC3

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
	aerodromes allocated to the same MRTM				
OH-35	MRTM fails to detect of potential intrusions inside landing-aid protection for one or several aerodromes allocated to the same MRTM	SO-35	Imminent Runway Excursion		RExc-SC2b
OH-36	MRTM fails to assess the operational environmental conditions on each corresponding aerodrome allocated to the same MRTM in order to provide appropriate remote ATC service	SO-36	Imminent Runway Excursion		
OH-37	MRTM fails to provide appropriate ATC services in the several operational environmental conditions on each corresponding aerodrome allocated to the same MRTM	SO-37	N/A - this hazard is already covered by the previous list of hazards as it might be a cause leading to several of them.		
OH-38	MRTM fails to provide seamless ATC service to airspace users in the several operational environment conditions on each corresponding aerodrome allocated to the same MRTM	SO-38	N/A - this hazard is already covered by the previous list of hazards as it might be a cause leading to several of them.		
OH-39	MRTM capabilities are not assessed/verified for one or several aerodromes allocated to the same MRTM before remotely providing ATC services	SO-39	N/A - this hazard is already covered by the previous list of hazards as it might be a cause leading to several of them.		
OH-40	Actors are not aware/notified when the remote provision of ATC service is initiated in one or several aerodromes allocated to the same MRTM (as per planned schedules)	SO-40	The consequences are as in current operations. The information is available in the corresponding AIP and NOTAMS when the pilots prepare their flight. In any case, communication contact will be established with the ATCO once in the CTR		
OH-41	Remote provision of ATC service fails to appropriately be stopped for planned terminations in one or several or all aerodromes allocated to the	SO-41	The consequence of this hazard is the same as OH-57.		

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
	same MRTM				
OH-42	Actors are not aware/notified when the remote provision of ATC service is terminated in one or several aerodromes allocated to the same MRTM (as per planned schedules)	SO-42	The consequence of this hazard is the same as OH-57.		
OH-43	RTC fails the planning of ATC resources considering weather forecast, traffic demand and any other factors impacting the capacity of the MRTM to provide relevant ATC services to concerned aerodromes	SO-43	N/A - this hazard is already covered by Assumption-01 and by previous hazards as it might be a cause leading to several of them		
OH-44	RTC fails to enable tactical management of ATC (ATCO) ensuring safe service to all aerodromes in charge with respect to weather conditions, traffic overload/peaks and unexpected events	SO-44	N/A this hazard is already covered by the previous hazards as it might be a cause leading to several of them.		
OH-45	MRTM fails to split aerodromes in charge and safely transfer one/several aerodromes to another MRTM in the same RTC	SO-45	N/A – similar to OH-44, already covered by previous hazards as it might be a cause leading to several of them.		
OH-46	MRTM fails to properly merge an aerodrome transferred to the MRTM with all capabilities to provide ATC services	SO-46	N/A - already covered by previous hazards as it might be a cause leading to several of them		
OH-57	MRTM fails to provide remote ATC service to one/some/all aerodromes allocated to the same MRTM	SO-57	Same consequences as in Single Remote Tower		
OH-58	MRTM fails to provide communication to a/c and/or vehicles in one/some/all aerodromes allocated to the same MRTM	SO-58	Same consequences as in Single Remote tower.		
OH-59	MRTM presents a failure on the screens which prevents ATCO from visually assessing traffic in one/some/all aerodromes allocated to	SO-59	Same consequences as in Single Remote Tower		

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
	the same MRTM				
OH-60	Partial failures in the MRTM (e.g. some screens failing, communication in only one aerodrome is interrupted, etc.)	SO-60	Same consequences as in Single Remote Tower		

Table 9: System-Generated Hazards and Analysis

The Operational Hazards (OH) identified above were completed with four additional operational hazards that lead to four additional Safety Objectives:

ID	Description
SO-57	Contingency procedures are to be in place in case the MRTM fails to provide remote ATC service to one/some/all aerodromes allocated to the same MRTM
SO-58	Fallback procedures are to be in place in case the MRTM fails to communicate with a/c and/or vehicles in one/some/all aerodromes allocated to the same MRTM
SO-59	Fallback procedures are to be in place in case the MRTM presents a failure on the screens which prevents ATCO from visually assessing traffic in one/some/all aerodromes allocated to the same MRTM
SO-60	Split of aerodromes should be available to ATCO in the case a partial failure can be dealt with this way

Table 10: Additional Safety Objectives (functionality and performance) in the case of internal failures

3.8.2 Derivation of Safety Objectives (integrity/reliability)

Table 11 below contains the list of Safety Objectives for integrity/reliability (also called SO for failure) expressed in terms of likelihood and in relation to the Operational Hazards that were identified.

ID	Safety Objectives	
OH-01	SOf-01	The likelihood that MRTM fails to coordinate and/or transfer with adjacent ATSU concerning inbound/outbound traffic shall be no more than 3.33e-4 per flight.hour
OH-02	SOf-02	The likelihood that MRTM fails to manage inbound traffic shall be no more than 4e-6 per flight.hour
OH-03	SOf-03	The likelihood that MRTM fails to manage outbound traffic shall be no more than 4e-6 per flight.hour
OH-04	SOf-04	The likelihood that MRTM fails to separate traffic shall be no more than 4e-6

		per flight.hour
OH-05	SOf-05	The likelihood that MRTM fails to separate traffic with respect to restricted areas on the airspace under control responsibility shall be no more than 3.33e-5 per flight.hour
OH-06	SOf-06	The likelihood that MRTM fails to manage missed approach situations shall be no more than 4e-6 per flight.hour
OH-07	SOf-07	The likelihood that MRTM fails to detect conflicts or potential collisions between aircraft on the airspace under control responsibility shall be no more than 1e-6 per flight.hour
OH-08	SOf-08	The likelihood that MRTM fails to timely detect restricted areas infringements shall be no more than 3.33e-5 per flight.hour
OH-09	SOf-09	The likelihood that MRTM fails to provide ATC instructions to resolve conflicts/avoid collisions on the airspace under control responsibility shall be no more than 1e-6 per flight.hour
OH-10	SOf-10	The likelihood that MRTM fails to provide appropriate instructions to resolve airspace infringements shall be no more than 3.33e-5 per flight.hour
OH-11	SOf-11	The likelihood that MRTM fails to identify departing aircraft on the stand for providing ATC service shall be no more than 0.01 per movement
OH-12	SOf-12	The likelihood that MRTM fails to provide appropriate information to departing aircraft for the start-up shall be no more than 0.01 per movement
OH-13	SOf-13	The likelihood that MRTM fails to apply push-back-towing procedures shall be no more than 0.01 per movement
OH-14	SOf-14	The likelihood that MRTM fails to provide conflict-free routing and taxi instructions to aircraft in the manoeuvring area shall be no more than 3.33e-03 per movement
OH-15	SOf-15	The likelihood that MRTM fails to provide taxi instructions to vehicles in the manoeuvring area shall be no more than 3.33e-03 per movement
OH-16	SOf-16	The likelihood that MRTM fails to detect conflicting situations in the manoeuvring area shall be no more than 5e-04 per movement
OH-17	SOf-17	The likelihood that MRTM fails to provide taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions in the manoeuvring area shall be no more than 5e-04 per movement
OH-18	SOf-18	The likelihood that MRT fails to support aircraft and vehicle movements on the manoeuvring area shall be no more than 0.01 per movement
OH-19	SOf-19	The likelihood that MRTM fails to manage runway entry for departing aircraft

		shall be no more than 5e-7 per movement
OH-20	SOf-20	The likelihood that MRTM fails to manage runway exit for landing aircraft shall be no more than 5e-7 per movement
OH-21	SOf-21	The likelihood that MRTM fails to manage aircraft/vehicle runway crossing shall be no more than 5e-7 per movement
OH-22	SOf-22	The likelihood that MRTM fails to support aircraft for take-off and landing operations shall be no more than 5e-7 per movement
OH-23	SOf-23	The likelihood that MRTM fails to carry out vehicle related tasks on the runway shall be no more than 5e-7 per movement
OH-24	SOf-24	The likelihood that MRTM fails to manage aircraft take-off shall be no more than 5e-7 per movement
OH-25	SOf-25	The likelihood that MRTM fails to manage aircraft landing shall be no more than 5e-7 per movement
OH-26	SOf-26	The likelihood that MRTM fails to detect runway incursions and potential collisions on the runway shall be no more than 3.33e-6 per movement
OH-27	SOf-27	The likelihood that MRTM fails to provide instructions to resolve runway incursions and prevent collisions on the runway shall be no more than 3.33e-6 per movement
OH-28	SOf-28	The likelihood that MRTM fails to detect flight towards terrain situations shall be no more than 1e-7 per flight
OH-29	SOf-29	The likelihood that MRTM fails to warn/support pilot on CFIT situations shall be no more than 1e-7 per flight
OH-30	SOf-30	The likelihood that MRTM fails to establish/maintain sufficient wake turbulence spacing between landing/departing aircraft shall be no more than 4e-5 per flight

Table 11: Safety Objectives (integrity/reliability)

3.9 Impacts of PJ05 Solution operations on adjacent airspace or on neighbouring ATM Systems

This is already covered by the Safety Objectives referring to coordination with adjacent sector for nominal, abnormal and degraded mode cases. No new Safety Objectives were identified.

3.10 Achievability of the Safety Criteria

As for Single Remote Tower, no quantitative evidence on the achievability of the Safety Criteria through the specification of the Safety Objectives has been collected for Multiple Remote Tower.

From the Safety Criteria listed in section **3.5**, and following the SRM process, the Safety Objectives and Operational Hazards have been developed and identified. Therefore the Safety Criteria are implicitly achieved through the demonstration of the aforementioned.

The Validation Report **[17]** captured the Safety Validation Objectives, among others. These Safety Validation Objectives were covered by the Validation exercises and/or the HP and Safety workshop (see **Appendix E** and Appendix C of the Validation Report **[17]**).

Appendix A.4 presents the traceability table that links the Safety Objectives covering all Safety Validation Objectives.

All **nominal** Safety Objectives have been covered by either the Validation exercises or the Safety and HP workshop. Particularities on how to implement different aspects are to be developed in local implementation and therefore considered covered in V3.

The Safety Validation Objectives for **abnormal conditions** were validated in some cases during Validation Exercises. Discussions show that the Multiple Remote Tower setting would not impede ATCOs to deal with abnormal situations, although further assessment needs to be conducted locally for implementation, including the mitigations (additional ATCO, silent communication, etc.).

As in the previous case, the Safety Validation Objectives related to **degraded modes** of operations have been partially covered during the validations and discussions during the HP and Safety workshop. At this stage of V3 we observe that further assessment before implementation needs to be performed before we can consider that this solution is ready for implementation. We consider that at V3 this is OK as the degraded modes need to be studied locally.

Issue: evidences collected for abnormal and failure conditions are mainly subjective feedback from operational people involved in the project and in the validation exercises, together with some scenarios that were simulated but that do not cover all cases. This feedback has been collected by questionnaires and group discussions in a Safety and Human Performance workshop with ATCOs in Brussels, 03-04 April 2019.

3.11 Validation & Verification of the Safety Specification

The validation exercises performed in the frame of Multiple Remote Tower concept have been the following ones:

- EXE-05.02-V3-2.2 COOPANS
- EXE-05.02-V3-2.3 INDRA
- EXE-05.02-V3-2.4 FRQ/HC
- EXE-05.02-V3-2.5 ENAV

Regarding Safety, the outcomes from the Validation Exercises were completed with the HP and Safety workshop. See previous section **3.10** for details and section **4.6** for further information on the Safety Requirements. And as mentioned in the previous section, the full results can be found in the Validation Report **[17]**, with the generic results of the Safety questionnaires and workshop on **Appendix C** of the Validation Report **[17]**.

4 Safe Design at SPR Level

4.1 Scope

Based on the safety assurance activities defined in the Safety Plan [5], this section addresses the following activities:

- description of the SPR level Model of the MRTM system – section **4.2.1**
- derivation, from the Functional and Performance Safety objectives of section 3, of the Functional Safety Requirements for the MRTM system previously described – section **4.2.3**
- analysis of the SPR-level model for normal and abnormal conditions – sections **4.3** and **4.4**
- design analysis – section **4.5**
- satisfaction for the Safety Criteria by the MRTM system – section **4.6**
- realism of the MRTM system – section **4.7**

4.2 The PJ05 Solution SPR-level Model

The SPR-level Model in this context is a high-level architectural representation of the Multiple Remote Tower system design that is entirely independent of the eventual physical implementation of the design (which should be addressed in next phase of the life cycle).

The SPR-level Model (see **Figure 1**) describes the main human tasks and machine functions as well as their interactions. In order to avoid unnecessary complexity, human-machine interfaces are not shown explicitly on the model. More detailed Human Machine interactions are addressed in PJ05.02 HP assessment report [15]. Additional enhanced features and details on the model are described in the following sub-sections. They are further described in the OSED/SPR/INTEROP Part I [1].

Note that different configurations to support the ATCO in performing ATS tasks have been tested during the Validation Exercises.

4.2.1 Description of SPR-level Model

The following **Figure 1** shows the several elements composing the Multiple Remote Tower Module (MRTM) and providing ATS services. For completeness, external elements interacting with the MRTM are also shown in this MRTM system. The Figure is based on SESAR1 on Multiple Remote Towers.

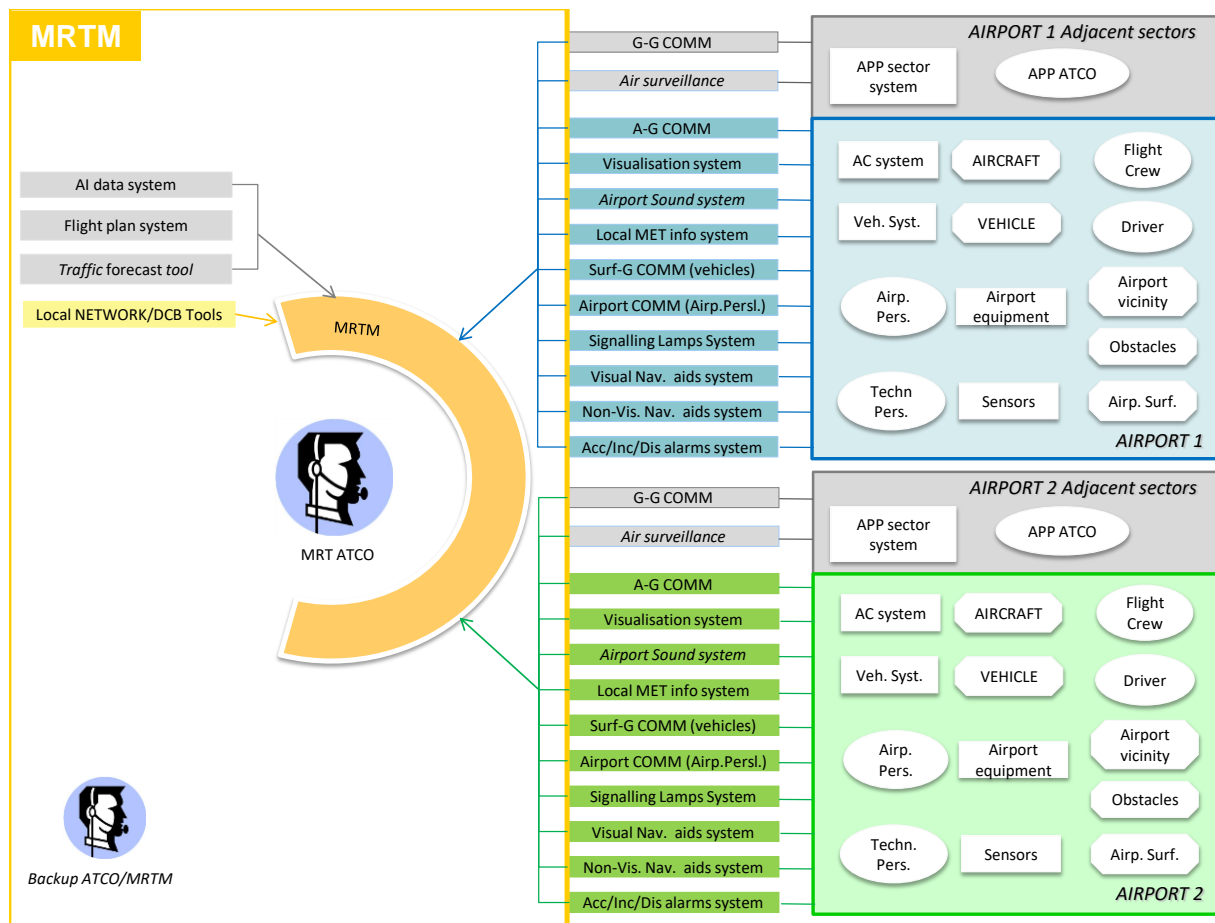


Figure 1: PJ05.02 Solution SPR-level Model

4.2.1.1 Aircraft Elements

Aircraft

- Flight Crew
- Aircraft (functions: SURV, COM, NAV, etc.)
- Aircraft (physical element)

4.2.1.2 Ground Elements

ATCO Working Position (MRTM)

- ATCO
- AI data system
- Flight Plan System – e-strips
- Traffic forecast tool
- Ground-Ground Communications
- Air-Ground Communications
- Surface-Ground Communications
- Airport Communication
- Air Surveillance system (optional)

- Signalling Lamps system
- Visual Nav. Aids system
- Non-visual Nav. Aids system
- Accident, incident and distress alarms
- Airport Sound System (optional)
- Visualisation system – object bounding, PTZ, etc.
- Local MET system – MET report overlay
- Backup ATCO and/or MRTM (optional)

Technical Supervision

- Data Recorder
- Technical System status monitoring
- Voice Recorder
- Technical personnel

Airport Premises

- Signalling Lamps System
- Visualisation System
- Visual Nav. aids System
- Non-Visual Nav. Aids System
- Airport Sound System
- Local MET system

4.2.1.3 External Entities

Other ATC Unit

- Other ATS Unit ATCO – approach ATCO(s) for each corresponding aerodrome
- Other ATS Unit System – approach centre for each corresponding aerodrome

E-NETWORK

- Local NETWORK system

Airport Premises

- Driver
- Vehicle (functions: COM, etc.)
- Vehicle (physical element)
- Airport Personnel
- Technical Personnel
- Airport Surface
- Obstacles
- Airport Vicinity

4.2.2 Task Analysis

A task analysis has not been developed in the framework of the HP assessment in SESAR202. This task was however performed in SESAR1 and provided the detail of the tasks done by the ATCO for the provision of the ATC services described in section **3.6.1**.

4.2.3 Derivation of Safety Requirements (Functionality and Performance – success approach)

Remote Towers in SESAR1 developed the baseline for the concept of a Single Remote Towers. In SESAR2020 within PJ05.02 we are looking at two different types of requirements:

- Those that are to be guaranteed for any Single Remote Tower before it can be added to a MRTM, also named as part of the “Pack” of Requirements from here on
- Those that are particular to the integration of two or more aerodromes into the same MRTM, also named as particular to the “Multiple” setting

Both types of safety requirements satisfy the safety objectives (functionality and performance) presented in section 3 for both normal and abnormal conditions. These safety requirements and recommendations are defined at the level of the relevant elements of the SPR-level model shown in Figure 1.

This section will only present those requirements named “Multiple”, but the full list of requirements and their mapping to all Safety Objectives can be found in Appendix B. The full list of Safety Objectives includes traceability for all requirements as well.

The safety requirements and recommendations presented here have been obtained based on:

- Results from the Single and Multiple Remote Tower assessment in SESAR1
- Results from validation exercises
- Results from the HP and Safety workshop

SR#	Safety Requirement (functionality & performance)	Derived from Table 10
SR-02	ATCO shall be able to distinguish between aerodromes in the MRTM from which flight plan information is provided	SO-01
SR-04	ATCO shall be able to distinguish between ATSU's (APP units) from different aerodromes in the MRTM that communication is established with	SO-01 SO-49 SO-50
SR-06	ATCO shall be able to distinguish between aerodromes in the MRTM that communication with A/C is established with	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19 SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31 SO-35 SO-49 SO-53 SO-55
SR-07	A-G Comm in the MRTM shall allow to receive communication from all traffic in all aerodromes allocated to the MRTM and to communicate with A/C	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19 SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31

		SO-35 SO-49 SO-53 SO-55
SR-08	MRTM shall allow to communicate with A/C and Vehicles : - coupling A/C frequencies from all aerodromes allocated to the same MRTM and keeping vehicles in separate frequencies for each aerodrome	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19 SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31 SO-35 SO-49 SO-53 SO-55
SR-10	ATCO shall be able to distinguish between aerodromes in the MRTM that communication with Vehicles is established with	SO-15 SO-17 SO-21 SO-23 SO-26 SO-27 SO-35
SR-11	Communication function in the MRTM shall allow to transmit communication to Vehicles independently (not combined with A/C) for each aerodrome allocated to the MRTM	SO-15 SO-17 SO-21 SO-23 SO-26 SO-27 SO-35
SR-15	ATCO shall be able to distinguish between aerodromes in the MRTM that communication with Airport Personnel is established with	SO-41 SO-43 SO-44 SO-52 SO-53
SR-17	ATCO shall be able to prevent overload and manage workload by - giving the responsibility of one or several ADs to an additional ATCO (or assistant) in the same MRTM or - reducing capacity by slowing traffic down - terminating ATC service for one or several aerodromes if no other option is possible. In PJ05.03, ATCO can also prevent overload and manage workload by - transferring it/them to another MRTM	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35 SO-36 SO-37 SO-47 SO-48 SO-49 SO-50
SR-18	In case a spare controller takes responsibility of one or several aerodromes from the same MRTM, handover/coordination procedures between both controllers shall be applied	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35 SO-36 SO-37 SO-47 SO-

		48 SO-49 SO-50
SR-20	In case a split is needed and one or several aerodromes have to be transferred to another MRTM, transfer handover procedures between different MRTMs shall be applied	SO-38 SO-45 SO-46 SO-52
SR-26	Clusters of aerodromes allocated to an MRTM shall be defined at local level in order to ensure that traffic levels and complexity do not exceed limitations so the ATCO can safely provide ATS services in nominal, abnormal and degraded conditions	SO-43
SR-27	RTC Supervisor shall be able to access functions for planning, coordination (staffing, RTC, etc.) and monitoring of the upcoming and present traffic flow	SO-39 SO-56
SR-28	RTC Supervisor shall be able to provide relevant support to controllers in a the RTC in order to ensure safe ATC service (staffing, allocation of aerodromes)	SO-39 SO-56
SR-29	RTC Supervisor shall be able to access functions for the monitoring of weather for all the aerodromes in the RTC	SO-39
SR-46	Information on present and incoming traffic (as well as real time airport capacity if applicable) and weather forecast shall be provided to the ATCO in order to be able to plan and manage ATCO resources adequately for a specific MRTM position.	SO-39
SR-51	ATCO shall be able to activate accident/incident/distress alarms from one or more aerodromes allocated to the MRTM with relevant information	SO-49 SO-50
SR-52	ATCO shall be able to recognise alarms in order to prioritise and solve the possible situations	SO-49 SO-50

Table 12: Derivation of Safety Requirements (functionality and performance) from Safety Objectives

For traceability purposes, the table in **Appendix A.3** maps each Safety Objective with its relevant Safety Requirements, including those that are considered part of the “Pack” from Single Remote Towers.

4.3 Analysis of the SPR-level Model – Normal Operational Conditions

4.3.1 Scenarios for Normal Operations

For more details, see section 3.3 of PJ05.02 SPR/INTEROP/OSED V3 [1].

ID	Scenario
UC 1:1	Provide ATS with simultaneous movements (ground and air) at different aerodromes from one MRTM
UC 1:2	Provide ATS to co-operative RPAS and normal aircraft at a time to different aerodromes
UC 1:3	Control of Vehicles in the Manoeuvring Area at a time to different aerodromes
UC 1:4	Provide ATS to simultaneous landings to different aerodromes
UC 1:5	Provide ATS to simultaneous departures at different aerodromes
UC 1:6	Provide ATS to a landing and a departing aircraft simultaneously at different aerodromes
UC 1:7	VFR flight in the traffic circuit with an arriving IFR flight with simultaneous movements on another aerodrome
UC 1:8	Ensure that the ATCO is able to avoid task overload at a time (ATCO able to prioritize and control traffic to reduce current workload) e.g. RWY incursion, several simultaneous VFR arrivals, aircraft with malfunction
UC 1:9	Failure of parts of the technical system building the Remote Tower Service, e.g. Camera view, screens, voice com
UC 2:1	Split of aerodromes from a fixed MRTM to a spare MRTM.
UC 2:2	Merge of aerodromes to a fixed MRTM

Table 13: Operational Scenarios – Normal Conditions

4.3.2 Effects on Safety Nets – Normal Operational Conditions

No new Safety Objectives or Requirements were identified impacting Safety Nets. For more information see Validation Report [17].

4.3.3 Dynamic Analysis of the SPR-level Model – Normal Operational Conditions

No new Safety Objectives or Requirements were identified from Real Time Simulations. For more information see Validation Report [17].

4.4 Analysis of the SPR-level Model – Abnormal Operational Conditions

4.4.1 Scenarios for Abnormal Conditions

For details see section 3.3 of PJ05.02 SPR/INTEROP/OSED V3 [1].

ID	Scenario
UC 2:3	Emergency Situation / Supported by other ATCO in the MRTM during the emergency situation
UC 2:4	Emergency Situation / Split of Aerodrome to a spare MRTMs (emergency or other aerodrome)

Table 14: Safety Requirements or Assumptions to mitigate abnormal conditions

4.4.2 Derivation of Safety Requirements (Functionality and Performance) for Abnormal Conditions

Note: In this document, Abnormal Conditions are defined as for the SRM [2][3]. The PJ05.02 SPR/INTEROP/OSED V3 [1] uses a different definition, and therefore the following Abnormal Conditions listed in this section should be understood as for the SRM.

Abnormal Conditions and related Safety Objectives have been defined in section 3.7 of this document.

This section attributes Safety Requirements to those Safety Objectives.

Ref	Abnormal Conditions / SO (<i>Functionality and Performance</i>)	Mitigations (SR 0xx and/or A 0xx)	
1	Unexpected / unplanned flight in airspace SO-47	SR-16 SR-17 SR-18	SR-32 SR-33
2	Aircraft with emergency SO-48	SR-16 SR-17 SR-18 SR-32 SR-33	SR-35 SR-36 SR-37 SR-41 SR-42
3	Crash on airport's vicinity SO-50	SR-03 SR-04 SR-12 SR-16 SR-17 SR-18 SR-31 SR-32	SR-33 SR-35 SR-36 SR-37 SR-41 SR-42 SR-50 SR-51
4	Fire on one or more aerodromes SO-51, SO-52, SO-53	SR-12 SR-30 SR-14 SR-15	SR-48 SR-24 SR-05 SR-06

		SR-20 SR-22 SR-23	SR-07 SR-08
5	Closing of ATC service in one or more aerodromes SO-51, SO-52, SO-53	SR-12 SR-30 SR-14 SR-15 SR-20 SR-22 SR-23	SR-48 SR-24 SR-05 SR-06 SR-07 SR-08
6	(Unplanned) ATCO Overload SO-44, SO-45	SR-14 SR-15 SR-20	SR-22 SR-48

Table 15: Safety Requirements or Assumptions to mitigate abnormal conditions

These Safety Requirements can be found in full in Appendix **B.1**.

4.4.3 Effects on Safety Nets – Abnormal Operational Conditions

No new Safety Objectives or Requirements were identified impacting Safety Nets. For more information see Validation Report [17].

4.4.4 Dynamic Analysis of the SPR-level Model – Abnormal Operational Conditions

No new Safety Objectives or Requirements were identified from Real Time Simulations. For more information see Validation Report [17].

4.5 Design Analysis – Case of Internal System Failures

The objective of this analysis consists in determining how the functional system architecture (encompassing people, procedures, equipment) designed for the Multiple Remote Tower System be made safe in presence of internal system failures.

4.5.1 Causal Analysis

The purpose of the causal analysis is to increase the detail of risk mitigation strategy through the identification of all possible causes. This way it will be possible to identify the corresponding Safety Requirements to meet the Safety Objective of the Operational Hazard under consideration.

Causal analysis provides a list of causes, per SPR-model level element, leading to the hazards listed in section 3.8. The steps concerning the assessment of these causes [2][3] are the following ones:

- a. for each system-generated hazard, top-down identification of internal system failures that could cause the hazard in **Table 16**
- b. derivation of mitigations to reduce the likelihood that specific failures would propagate up to the Hazard (i.e. operational level) - these mitigations are then captured as **additional Safety Requirements (Functionality and Performance)** in **Table 17**
- c. Setting the Safety Requirements to limit the frequency with which each identified system failure could be allowed to occur, taking account of the above mitigations (**Table 18**)
- d. show that the Safety Requirements are achievable - i.e. can be satisfied in a typical physical implementation – **Appendix B**

PJ05 MRT uses the current Single Remote Towers documentation as a reference. Therefore the same causes that were identified in SESAR1 for Single Remote Towers for the several hazards apply to PJ05. Because operational hazards have been updated and modified (see section 3.8) including the numbering, the updated list of causes can be found in **Table 16** below. This table shows the link of each cause belonging to a different SPR-level model element and the Operational Hazards they can lead to. The specific list of causes for each Operational Hazard is provided in **Appendix D**.

PJ05 MRT presents some additional failure modes that need to be considered in a Multiple Remote Tower Module, in particular with respect to the communication system and the visualisation reproduction system as they support the provision of the Remote ATC Tower service to Multiple aerodromes.

For some causes related to human errors or failure to perform a specific task, additional requirements/recommendations have already been identified in section 4.2.3 based on results from validation exercises and workshops.

Cause ID		Cause description	
FDPS-001	Flight Data Processing System	Inappropriate information is provided by the Flight Data Processing System [1e-4fh]	OH-01 OH-02 OH-03
FDPS-001	Flight Data Processing System	Inappropriate information is provided by the Flight Data Processing System [1e-4/mov]	OH-12 OH-13 OH-30

AID-002	AI data system	Incorrect arriving/departing procedures are available or are not provided to the ATCO [1e-3/fh]	OH-02 OH-03
AID-001	AI data system	Information concerning restricted areas use is incorrect or missing [1e-4/fh]	OH-04 OH-08 OH-10
G-GCOM-001	G-G Comm	G-G communication failure or degradation [1e-4fh].	OH-01
S-GCOM-002	Surf-G Comm	Failure or degradation of the S-G communication with personnel in charge of the apron [1e-4/mov]	OH-13
S-GCOM-001	Surf-G Comm	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	OH-15 OH-17 OH-20 OH-21 OH-23 OH-27 OH-34
S-GCOM-003	Surf-G Comm	Failure or degradation of voice communication with personnel responsible of RWY inspections [1e-4/mov]	OH-32
SURV-001	Surveillance data	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4fh]	OH-01 OH-02 OH-03 OH-04 OH-05 OH-06 OH-07 OH-08 OH-09 OH-10
SURV-002	Surveillance data	Inappropriate Surveillance information concerning restricted areas in the vicinity of the aerodrome [1e-4/fh]	OH-05
SURV-003	Surveillance data	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/fh]	OH-08
SURV-001	Surveillance data	Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/mov]	OH-28 OH-29 OH-30
SURV-003	Surveillance data	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/mov]	OH-28 OH-29

VRS-003	Visualisation System	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	OH-02 OH-03 OH-04 OH-05 OH-06 OH-07 OH-08 OH-09 OH-10
VRS-001	Visualisation System	Loss of information on the vicinity of the aerodrome provided by VRS [1e-4/fh]	OH-08 OH-28
VRS-005	Visualisation System	Inappropriate information on APRON area is provided on VRS using binoculars-like function [1e-4/mov]	OH-12 OH-13
VRS-007	Visualisation System	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	OH-14 OH-15 OH-16 OH-17 OH-20 OH-23 OH-26 OH-27 OH-34
VRS-009	Visualisation System	Loss of information on manoeuvring area on the VRS [1e-4/mov]	OH-16 OH-26
VRS-008	Visualisation System	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	OH-19 OH-20 OH-21 OH-23 OH-24 OH-25 OH-26 OH-27 OH-31 OH-32 OH-34
VRS-010	Visualisation System	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	OH-19 OH-21 OH-23 OH-24 OH-25 OH-26 OH-28

			OH-29 OH-30 OH-31
VRS-012	Visualisation System	Loss of information on final approach on the VRS [1e-4/mov]	OH-26 OH-28
VRS-003	Visualisation System	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/mov]	OH-28 OH-29 OH-31
ATCO-008	ATCO	ATCo incorrectly coordinates with other ATSU for inbound/outbound traffic transfer [1e-3fh]	OH-01
ATCO-013	ATCO	ATCo fails to identify and aircraft near the traffic circuit [1e-3fh]	
ATCO-002	ATCO	ATCo fails to provide appropriate instruction for AC to entry into traffic circuit [1e-3/fh]	
ATCO-001	ATCO	ATCo fails to manage arriving traffic in the vicinity of the aerodrome [1e-3/fh]	OH-02
ATCO-038	ATCO	ATCo fails to manage departing traffic in the vicinity of the aerodrome [1e-3/fh]	OH-03
ATCO-003	ATCO	ATCO fails to apply appropriate separation between aircraft on the vicinity of the aerodrome[1e-3/fh]	OH-04
ATCO-014	ATCO	ATCO fails to appropriately separate aircraft from restricted areas on the vicinity of the aerodrome [1e-4fh]	OH-05
ATCO-011	ATCO	Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [1e-4/fh]	OH-05 OH-10
ATCO-006	ATCO	ATCo fails to manage go-around situations [1e-3/fh]	OH-06
ATCO-004	ATCO	ATCO fails to detect in time conflicts and potential collisions on the vicinity of the aerodrome [1e-3/fh]	OH-07
ATCO-009	ATCO	ATCO fails to detect in time restricted area infringement [1e-2/fh]	OH-08
ATCO-005	ATCO	ATCo fails to provide appropriate instruction to solve conflict on the aerodrome vicinity [1e-3/fh]	OH-09
ATCO-007	ATCO	ATCo fails to provide appropriate instruction to solve airspace infringement [1e-2/fh]	OH-10
ATCO-010	ATCO	ATCo identifies an incorrect departing AC for initiating	OH-12

		the remote ATC service [1e-2/mov]	OH-13
ATCO-039	ATCO	ATCo incorrectly provides information to departing aircraft during the start-up [1e-1/mov]	OH-12
ATCO-040	ATCO	ATCO incorrectly coordinated with airport personnel in charge of the apron for push-back/towing procedures [1e-2]	OH-13
ATCO-016	ATCO	ATCO identifies incorrect aircraft on the manoeuvring area (taxiways) [1e-2/mov]	OH-14
ATCO-015	ATCO	ATCo fails to provide appropriate route instruction to aircraft on the manoeuvring area [1e-2/mov]	OH-14
ATCO-017	ATCO	ATCO identifies incorrect vehicle on the manoeuvring area (taxiway) [1e-3]	OH-15
ATCO-018	ATCO	ATCO provides inappropriate route instruction to vehicle on the manoeuvring area (taxiway) [1e-3/mov]	OH-15
ATCO-019	ATCO	ATCo fails to detect in time conflict on the manoeuvring area [1e-1/mov]	OH-16
ATCO-020	ATCO	ATCo fails to provide appropriate instruction to solve conflicts on the manoeuvring area [1e-1/mov]	OH-17
ATCO-021	ATCO	ATCo fails to provide appropriate navigation support to AC and vehicle on the taxiway using Visual Navigation Aids [1e-1/mov]	OH-18
ATCO-024	ATCO	ATCO fails to correctly identify next aircraft in the departing sequence [1e-4/mov]	OH-19
ATCO-022	ATCO	ATCO allows aircraft to line-up in a runway already being used [1e-4/mov]	OH-19
ATCO-023	ATCO	Remote ATCo fails to provide appropriate runway exit instruction to landing aircraft [1e-4/mov]	OH-20
ATCO-025	ATCO	ATCO identifies an incorrect aircraft or vehicle for crossing the runway [1e-4/mov]	OH-21
ATCO-026	ATCO	ATCo fails to provide appropriate navigation support to departing/arriving AC on the runway using Visual Navigation Aids [1e-4/mov]	OH-22
ATCO-031	ATCO	ATCo allows vehicle to enter/operate in a runway which is being used [1e-4/mov]	OH-23

ATCO-027	ATCO	ATCO provides take-off clearance for departing AC in a runway already being used [1e-4/mov]	OH-24
ATCO-028	ATCO	ATCO provide landing clearance for a runway already being used [1e-4/mov]	OH-25
ATCO-029	ATCO	ATCO fails to detect in time a runway incursion [1e-4/mov]	OH-26
ATCO-032	ATCO	ATCo fails to provide appropriate instruction to solve runway incursion and prevent potential collision [1e-4/mov]	OH-27
ATCO-033	ATCO	ATCO fails to detect in time a flight towards terrain [1e-3/mov]	OH-28
ATCO-034	ATCO	ATCO fails to provide appropriate instructions and information for solving CFTT situation [1e-3/mov]	OH-29
ATCO-035	ATCO	ATCo fails to create sufficient WT spacing between landing/departing aircraft [1e-3/mov]	OH-30
ATCO-036	ATCO	ATCo fails to appropriately assess weather conditions [1e-3/mov]	OH-31
ATCO-041	ATCO	ATCo fails to appropriately provide weather related information to pilot for supporting landing/departing operations [1e-3/mov]	OH-31
ATCO-037	ATCO	ATCO fails to visually assess runway surface conditions [1e-3/mov]	OH-32
ATCO-042	ATCO	ATCo fails to provide appropriate navigation support to landing AC on the runway using Non Visual Navigation Aids [1e-4/mov]	OH-33
ATCO-043	ATCO	ATCo fails to detect an intrusion inside landing-air protection area [1e-3/mov]	OH-34
A-GCOM-001	A-G Comm	A-G communication failure or degradation [1e-4/fh→2e-4/controlh]	OH-02 OH-03 OH-04 OH-05 OH-06 OH-07 OH-10
A-GCOM-001	A-G Comm	A-G communication failure or degradation [1e-4/mov]	OH-12 OH-14 OH-17

			OH-20 OH-21 OH-24 OH-25 OH-26 OH-27 OH-29 OH-30 OH-31 OH-34
MET-001	Local MET system	Incorrect MET/Weather information [1e-4/fh→2e-4/controlh]	OH-02 OH-03
MET-001	Local MET system	Incorrect MET/Weather information [1e-4/mov]	OH-12 OH-31
VNAM-001	Visual Navigation Aids system	Loss or dysfunction of Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	OH-18 OH-22
NVNAM-001	Non Visual Navigation Aids system	Loss or dysfunction of Non Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	OH-33
APERS-001	Airport Personnel	Airport personnel provides incorrect information on runway surface [1e-4/mov]	OH-32
OATSUS-001	Other ATSU unit	Incorrect information is provided by other ATS unit system concerning inbound traffic [1e-4fh]	OH-01
POT.CONFLICT-AIR	Assumptions	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	OH-01 OH-02 OH-03 OH-04 OH-06
CONFLICT-AIR	Assumptions	Conflict in the vicinity of the aerodrome [1e-3]	OH-07 OH-09
AIRSPACE-INF	Assumptions	Airspace infringement in the vicinity of the aerodrome [1e-2]	OH-08 OH-10
POT.CONFLICT-TWY	Assumptions	Probability of an aircraft/vehicle/obstacle in the proximity potentially creating a conflict [1e-1]	OH-14 OH-15
CONFLICT-SURF	Assumptions	Conflict on the manoeuvring area of the aerodrome [1e-2]	OH-16 OH-17

POT.CONFLICT-RWY	Assumptions	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	OH-19 OH-20 OH-21 OH-22 OH-23 OH-24 OH-25
RWY-INC	Assumptions	Potential runway incursion (aircraft / vehicle / animal / person) [1e-1]	OH-26 OH-27
POT.CONFLICT-TERR	Assumptions	Probability of a controlled aircraft flying towards terrain [1e-4]	OH-28 OH-29
CLOSE TRAFFIC AIR	Assumptions	Probability of needing to apply wake turbulence spacing between aircraft [1e-2]	OH-30
AC LANDING	Assumptions	Probability of an aircraft landing [1e-1]	OH-34

Table 16: List of causes leading to operational hazards

4.5.2 Common Cause Analysis

Any common cause introduced by the physical design of the MRTM is to be addressed in the specific safety assessment for the corresponding implementation taking into account acceptable levels of safety as per applicable regulation (V4/V5).

4.5.3 Formalization of Mitigations

In the previous section, different causes leading to the Operational Hazards are identified (**Table 16**). Following the same reasoning as already conducted in SESAR1, **Table 17** shows a list of additional functionality & performance Safety Requirements (success approach) to mitigate System generated Hazards.

SR	SR as a Mitigation to System generated Hazards	Element of the model	Causes of Hazards	of
SR-55	An alert should be provided to the controller in case of failure of the ground-ground communication service.	G-G Comm	G-GCOM-001	
SR-57	An alert should be provided to the controller in case of failure of the communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area.	Surf-G Comm	S-GCOM-001 S-GCOM-002 S-GCOM-003	
SR-61	An alert shall be provided to the controller in case of failure or inappropriate information (delayed, corrupted, frozen, etc.) is provided on the	Visualisation System	VRS-003 VRS-	SR-61

	visualisation system.		001 VRS-007 VRS-009	
SR-62	Data recorder system shall not negatively impact (corrupting data or inducing malfunction) the system from which data is recorded, including the data from the Visualisation system.	Data Recorder	VRS-003 VRS-001 VRS-007 VRS-009	SR-62
SR-64	An alert should be provided to the controller in case of failure of the air-ground communication system.	A-G Comm	A-GCOM-001	
SR-68	In case of loss or degradation of ground-ground communication with adjacent ATSU units in a MRTM position relevant fallback procedures shall be applied.	G-G Comm	G-GCOM-001	
SR-69	In case of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area relevant fallback procedures shall be applied (e.g. use of flash gun lights).	Surf-G Comm	A-GCOM-001	
SR-70	In case surveillance function is available in the MRTM position, but the function is lost or the information provided is inappropriate and detected, relevant fallback procedures shall be applied	Surveillance data	SURV-001 SURV-002 SURV-003	
SR-71	In case of loss of information or detected inappropriate information on a critical view of the visualisation (due to technical failure), a specific procedure shall be applied taking into account the timeframe of the failure mode (e.g. provision of ATC services limiting the simultaneous operations in the area of responsibility, using PTZ camera to get the corresponding lost image, stopping the provision of the service, etc.). Note: critical view is defined in SR-107.	Visualisation System	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012	
SR-72	In case of failure of degradation or air-ground communication with traffic in a MRTM position, relevant procedures from PANS ATM [12] shall be applied (e.g. issuing clearances through the relevant APP controller).	A-G Comm	A-GCOM-001	

SR-73	In case of incorrect MET/Weather information is provided in a MRTM position, or no information at all is provided, controller shall contact relevant airport personnel in the airport in order to obtain this information and any relevant update, if not possible to obtain such information from any other source (e.g. pilots, visual inputs from the visual presentation, MET-office, www/internet).	Local MET system	MET-001
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Table 17: Additional functionality & performance safety requirements and assumptions to mitigate System generated Hazards

4.5.4 Safety Requirements (integrity/reliability)

Considering the aforementioned causes leading to Operational Hazards and the causal analysis in **Appendix D**, the following Safety Requirements for integrity and reliability have been derived (**Table 18**):

SR	Safety Requirement (failure approach)	Element of the model	Derived from (causes)
SR-100	The likelihood of inappropriate flight data information being provided by the Flight Data Processing system in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation	Flight Data Processing System	FDPS-001
SR-101	The likelihood of incorrect or missing arriving/departing procedures publications available to the controller in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation	AI data system	AID-002
SR-102	The likelihood of incorrect or missing information concerning restricted areas in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	AI data system	AID-001
SR-103	The likelihood of failure or degradation of ground-ground communication with adjacent ATSU units in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	G-G Comm	G-GCOM-001
SR-104	The likelihood of failure or degradation of Surface-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area in a MRTM	Surf-G Comm	S-GCOM-001 S-GCOM-002 S-GCOM-003

	position shall be operationally acceptable as per regulation applicable to local implementation.		
SR-105	In case surveillance data is available in the MRTM position, the likelihood that undetected inappropriate surveillance information on a flight is provided shall be operationally acceptable as per regulation applicable to local implementation.	Surveillance data	SURV-001 SURV-002
SR-106	In case surveillance data is available in the MRTM position, the likelihood of complete lack of traffic information shall be operationally acceptable as per regulation applicable to local implementation.	Surveillance data	SURV-003
SR-107	For a local implementation, corresponding assurance level for the software development process of the relevant components of the Visualisation System and its availability shall be defined based on applicable regulation.	Visualisation System	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
SR-108	The likelihood of failure or degradation of air-ground communication with traffic in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	A-G Comm	A-GCOM-001
SR-109	The likelihood of incorrect MET/Weather information provided in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	Local MET system	MET-001
SR-110	The likelihood of loss or dysfunction of Visual Navigation Aids manoeuvred from a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	Visual Navigation Aids system	VNAM-001
SR-111	The likelihood of loss or dysfunction of Non Visual Navigation Aids manoeuvred from a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	Non-Visual Navigation Aids system	NVNAM-001

Table 18: List of safety requirements related to failure conditions

Note: Additional recommendations on the use of advanced visual features for mitigate some of the causes identified here might be included in the final version based on the results from the Validation Report.

4.6 Achievability of the Safety Criteria

The previous section 3.10 studied the achievability of the Safety Criteria through the Safety Objectives that were demonstrated by the means of the Safety Validation Objectives during the Validation Exercises.

This section deals with the Safety Criteria demonstration through the assessment of the Safety Requirements. **Table 19** below links the Safety Criteria with the Safety Requirements that cover them.

Note that the Safety Requirements that are not fully validated are highlighted by an orange colour in the list. All the other Safety Requirements listed here have been validated.

Safety Criteria	Safety Requirements		
SAC#1 There shall be no increase of ATC induced tactical conflict in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-01	SR-20	
	SR-02	SR-21	
	SR-03	SR-22	
	SR-04	SR-23	
	SR-05	SR-31	
	SR-06	SR-32	
	SR-07	SR-33	
	SR-08	SR-38	
	SR-14	SR-40	
	SR-15	SR-45	
	SR-16	SR-46	
	SR-17	SR-47	
	SR-18	SR-48	
	SAC#2 There shall be no increase of Imminent Infringement in each aerodrome for which ATS are remotely provided using Multiple Remote Tower a. as a function of Ineffective ATCO induced conflict management b. as a function of Ineffective externally-induced conflict management c. as a function of Ineffective plan induced conflict management	SR-01	SR-20
		SR-02	SR-21
		SR-03	SR-22
		SR-04	SR-23
		SR-05	SR-31
SR-06		SR-32	
SR-07		SR-33	
SR-08		SR-38	
SR-14		SR-40	
SR-15		SR-45	
SR-16		SR-46	
SR-17		SR-47	
SR-18		SR-48	
SAC#3 There shall be no increase of Imminent Collision in each aerodrome for which ATS are remotely provided using Multiple Remote Tower a. as a function of Ineffective ATCO Collision prevention		SR-01	SR-20
		SR-02	SR-21
		SR-03	SR-22
		SR-04	SR-23
		SR-05	SR-31
	SR-06	SR-32	
	SR-07	SR-33	

	SR-08	SR-38
	SR-14	SR-40
	SR-15	SR-45
	SR-16	SR-46
	SR-17	SR-47
	SR-18	SR-48
SAC#4 There shall be no increase of ATC pre-tactical conflict in each aerodrome for which ATS are remotely provided, using Multiple Remote Tower.	SR-05	SR-23
	SR-06	SR-27
	SR-07	SR-28
	SR-08	SR-29
	SR-14	SR-31
	SR-15	SR-32
	SR-16	SR-33
	SR-17	SR-38
	SR-18	SR-40
	SR-20	SR-45
	SR-21	SR-46
	SR-22	SR-48
SAC#5 There shall be no increase of Flight Towards Terrain commanded by ATC in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-01	SR-27
	SR-05	SR-28
	SR-06	SR-29
	SR-07	SR-31
	SR-08	SR-32
	SR-14	SR-33
	SR-15	SR-38
	SR-16	SR-40
	SR-17	SR-45
	SR-18	SR-46
	SR-20	SR-47
	SR-21	SR-48
	SR-22	
SAC#6 There shall be no increase of Imminent Controlled Flight Into Terrain (CFIT) in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-01	SR-21
	SR-05	SR-22
	SR-06	SR-23
	SR-07	SR-27
	SR-08	SR-28
	SR-09	SR-29
	SR-10	SR-35
	SR-11	SR-36
	SR-12	SR-37
	SR-14	SR-38
	SR-15	SR-40
	SR-16	SR-43
	SR-17	SR-45
	SR-18	SR-46
	SR-20	SR-48
SAC#7 There shall be no increase of unmanaged under-separation	SR-01	SR-21

allowing for Wake Vortex Encounter in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-12 SR-14 SR-15 SR-16 SR-17 SR-18 SR-20	SR-22 SR-23 SR-27 SR-28 SR-29 SR-35 SR-36 SR-37 SR-38 SR-40 SR-43 SR-45 SR-46 SR-48
<p>a. as a function of Inappropriate Separation establishment and management during the final approach interception</p> <p>b. as a function of Inappropriate Separation management of spacing conflicts due to A/C deviation on final approach</p>		
SAC#8 There shall be no increase of Taxiway conflicts in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-01 SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-12 SR-16	SR-17 SR-18 SR-27 SR-28 SR-35 SR-36 SR-37 SR-43 SR-45
<p>a. as a function of ineffective ATCO taxiway planning</p>		
SAC#9 There shall be no increase of Imminent Taxiway Infringement in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-13	SR-16 SR-17 SR-18 SR-35 SR-39 SR-43 SR-44
<p>a. as a function of Inadequate ATCO conflict management</p>		
SAC#10 There shall be no increase of Imminent Taxiway Collision in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11	SR-16 SR-17 SR-18 SR-35 SR-43 SR-44
<p>a. as a function of Ineffective ATCO collision avoidance</p>		
SAC#11 There shall be no increase of pre-Tactical taxiway conflicts in each aerodrome for which ATS are remotely provided, in sequence or in parallel, using Multiple Remote Tower	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-13	SR-16 SR-17 SR-18 SR-35 SR-39 SR-43 SR-44
SAC#12 There shall be no increase of Runway Incursion in each	SR-05	SR-18

aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-13 SR-16 SR-17	SR-31 SR-32 SR-33 SR-35 SR-38 SR-39 SR-44 SR-45
<p>a. as a function of Ineffective ATCO runway entry procedures</p> <p>b. as a function of Ineffective ATCO awareness to recognise pilot/driver entering</p> <p>c. as a function of ineffective ATCO landing management</p> <p>d. as a function of ineffective ATCO take off management</p>		
SAC#13 There shall be no increase of Runway Conflict in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-14 SR-15 SR-16 SR-17 SR-18 SR-20 SR-21 SR-22 SR-23	SR-38 SR-40 SR-45 SR-46 SR-48
<p>a. as a function of Ineffective ATCO awareness to detect Aircraft/Vehicle and Animal/Person runway incursions prior to issuing landing/take-off clearance</p> <p>b. as a function of ATCO providing a clearance inducing a conflict in the runway</p>		
SAC#14 There shall be no increase of Imminent Runway Collision in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-14 SR-15 SR-16 SR-17 SR-18 SR-20 SR-21 SR-22 SR-23	SR-38 SR-40 SR-45 SR-46 SR-48
<p>a. as a function of Ineffective ATCO Runway Collision Avoidance</p>		
SAC#15 There shall be no increase of Inadequate Potential Runway Use in each aerodrome for which ATC services are remotely provided using Multiple Remote Tower	SR-14 SR-15 SR-16 SR-17 SR-18 SR-20 SR-21	SR-22 SR-23 SR-38 SR-40 SR-45 SR-46 SR-48
<p>a. as a function of Ineffective Network Management failure to balance operational airport capacity/demand</p> <p>b. as a function of Ineffective Tower (Runway) Failure to balance arrivals or departures</p>		
SAC#16 There shall be no increase of Runway Excursions in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-14 SR-15 SR-16 SR-17 SR-18 SR-20 SR-21	SR-22 SR-23 SR-38 SR-40 SR-45 SR-46 SR-48
<p>a. as a function of ineffective ATCO weather conditions affecting RWY monitoring affecting arriving aircraft (leading to runway excursion)</p> <p>b. as a function of ineffective check of the runway surface</p>		

(with respect to snow, slush, RWY surface friction, FOD, ...) (leading to runway excursion)		
c. as a function of ineffective ATCO monitoring of AC trajectory on final approach (leading to runway excursion)		
SAC#17 There shall be no increase of other Landing related Accidents in each aerodrome for which ATS are remotely provided using Multiple Remote Tower	SR-14 SR-15 SR-16 SR-17 SR-18 SR-20 SR-21	SR-22 SR-23 SR-38 SR-40 SR-45 SR-46 SR-48
a. as a function of ineffective ATCO weather conditions monitoring affecting arriving aircraft (leading to landing accident)		
b. as a function of ineffective check of the runway surface (with respect to snow, slush, RWY surface friction, FOD, ...) (leading to loss of control on the runway)		
c. as a function of ineffective ATCO monitoring of AC trajectory on final approach (leading to undershoot, AC landing in wrong/closed RWY, AC landing with undercarriage retracted)		
d. as a function of ineffective monitoring of potential intrusions inside the landing-aid protection area (affecting landing AC) as a function of inefficient management of landing-aid light		

Table 19: Achievability of the Safety Criteria

4.7 Realism of the SPR-level Design

To prove that the Safety Requirements in Solution PJ05.02 are achievable and implementable, a complete table of all Safety Requirements is included in **A.4 (B.1 and 0)**. This table contains the evidence that they are achievable – that is, the trial, workshop discussion or expert judgement that validate the concept. It also offers a set of recommendations for future activities, namely for the V4/V5 phase and local implementation.

4.8 Validation & Verification of the Safe Design at SPR Level

A safety team encompassing ATCOs, engineers, Safety and Human Performance specialists have supported this safety assessment.

Safety Requirements have been derived in normal, abnormal and failure conditions to satisfy the Safety Objectives derived at OSED level, which are identified in **Appendix A** of this document. In addition to the HP and Safety workshop (April 2019), several meetings were organised to consolidate the list of Safety Requirements. A final workshop to consolidate HP and Safety requirements for the OSED was also conducted (June 2019).

Appendix B provides the consolidated list of Safety Requirements.

Appendix C provides the consolidated list of Safety Assumptions, Issues, Recommendations and Assessment Limitations.



Appendix D provides the causal analysis for each Operational Hazard, performed in SESAR1.

Appendix E provides the results of the aforementioned HP and Safety workshop (April 2019).

5 Acronyms and Terminology

The acronyms below must be updated and completed with the PJ05 OSED/SPR/INTEROP Part I [1] relevant terminology.

Acronym	Definition
ACC	Area Control Centre
AFIS	Aerodrome Flight Information Service
AGL	Aerodrome Ground Lighting
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
ALRS	Alerting Service
APP	Approach Control
ATCC	Air Traffic Control Centre
ATCEUC	Air Traffic ATCOs European Union's Coordination
ATCO	Air Traffic Control Officer
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSEP	Air Traffic Service Electronic Personnel
AVF	Advance Visual Features
CNS	Communication Navigation and Surveillance
CONOPS	Concept of Operations
CR	Change Request
CTR	Control Zone
CWP	ATCO Working Position
EASA	European Aviation Safety Agency
EATMA	European ATM Architecture

E-ATMS	European Air Traffic Management System
FATO	Final approach and take-off area
HPAR	Human Performance Assessment Report
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INTEROP	Interoperability Requirements
KPA	Key Performance Area
LVO	Low Visibility Operations
LVP	Low Visibility Procedures
RTC	Multiple Remote Tower Centre
RTCO	Multiple Remote Tower Control Operator
MRTM	Multiple Remote Tower Module
OFZ	Obstacle Free Zone
OI	Operational Improvement
OPAR	Operational Performance Assessment Report
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PIRM	Programme Information Reference Model
PTZ	Pan-Tilt-Zoom, also named “Binoculars” in OSED and HPAR
QoS	Quality of Service
RPAS	Remotely Piloted Aircraft Systems
RTC	Remote Tower Centre
RTM	Remote Tower Module
RTO	Remote Tower Operations
RVR	Runway Visual Range
RWC	Runway Control
RWS	RTC supervisor

SAC	Safety Criteria
SAR	Safety Assessment Report
SecAR	Security Assessment Report
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPR	Safety and Performance Requirements
SWIM	System Wide Information Model
TS	Technical Specification
TWC	Taxiway Control
VCS	Voice Communications System
VFR	Visual Flight Rules
VP	Visual Presentation; previously called "OTW" as out-the-window view

Table 20 : Acronyms and terminology

6 References

Safety

- [1] SESAR 2020 PJ05.02 SPR-INTEROP/OSED V3 – Part I, 2019
- [2] SESAR, Safety Reference Material, Edition 4.0, April 2016
- [3] SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016
- [4] SESAR 2020 PJ05.02 Validation Plan V3 – Part I, 2018
- [5] SESAR 2020 PJ05.02 Validation Plan V3 – Part II Safety Plan, 2018
- [6] SESAR 2020 PJ05 Project Management Plan, 2017
- [7] SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015
- [8] SESAR, Resilience Engineering Guidance, May 2016
- [9] SESAR 2020 Safety Policy
- [10] European ATM Master Plan
- [11] AIM – Accident Incident Model
- [12] ICAO Doc 4444 PANS ATM
- [13] SESAR 1 for Single Remote Tower
- [14] SESAR 1 for Multiple Remote Tower
- [15] SESAR 2020 PJ05.02 SPR-INTEROP/OSED V3 – Part IV Human Performance Assessment Report, 2019
- [16] SESAR 2020 PJ05.02 SPR-INTEROP/OSED V3 – Part V Performance Assessment Plan, 2019
- [17] SESAR 2020 PJ05.02 Validation Report V3, 2019
- [18] EUROCAE ED-240, 'MINIMUM AVIATION SYSTEM PERFORMANCE SPECIFICATION FOR REMOTE TOWER OPTICAL SYSTEMS', September 2016
- [19] EASA Minimum aviation system performance specification for remote tower optical systems. ED-240.

Appendix A Safety Objectives

A.1 Safety Objectives (Functionality and Performance)

ID	Description
SO-01	MRTM shall enable coordination and transfer procedures with adjacent ATS unit concerning inbound/outbound traffic (including as necessary aircraft identification) for all aerodromes allocated to the same MRTM
SO-02	MRTM shall enable to manage inbound traffic (including as necessary management of the approach, visual acquisition, entry into traffic circuit and landing sequence) for all aerodromes allocated to the same MRTM
SO-03	MRTM shall enable to manage outbound traffic (including as necessary aircraft identification and departure sequence on the runway) for all aerodromes allocated to the same MRTM
SO-04	MRTM shall enable to separate traffic, with respect to other traffic, applying the corresponding separation minima to the airspace under control responsibility (in the vicinity of the aerodrome) or allowing reduction in separation minima in the vicinity of the aerodrome for all aerodromes allocated to the same MRTM
SO-05	MRTM shall enable to separate traffic with respect to restricted areas on the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-06	MRTM shall enable to manage missed approaches situations (including detection of need for go-around, monitoring of involved aircraft and proposal for resolution) for all aerodromes allocated to the same MRTM
SO-07	MRTM shall enable the detection of conflicts or potential collisions between aircraft (within departing, within arriving and between both traffic) on the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-08	MRTM shall enable the detection of restricted areas infringements by aircraft in the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-09	MRTM shall enable the provision of ATC instructions to resolve conflicts/ avoid collisions on the airspace under control responsibility for all aerodromes allocated to the same MRTM
SO-10	MRTM shall enable the provision of ATC instructions to resolve airspace infringements for all aerodromes allocated to the same MRTM
SO-11	MRTM shall enable to identify departing AC on the stand for providing ATC service for all aerodromes allocated to the same MRTM
SO-12	MRTM shall enable start-up procedures for departing aircraft (including as appropriate the provision of necessary aerodrome information - operational and meteorological) for all aerodromes allocated to the same MRTM

SO-13	MRTM shall enable push-back and towing procedures for all aerodromes allocated to the same MRTM
SO-14	MRTM shall enable the provision of conflict-free routing and taxi instructions to aircraft in the manoeuvring area for all aerodromes allocated to the same MRTM
SO-15	MRTM shall enable the provision of taxi instructions to vehicles in the manoeuvring area for all aerodromes allocated to the same MRTM
SO-16	MRTM shall enable the detection of conflicting situations in the manoeuvring area (involving aircraft, vehicles, and obstacles) for all aerodromes allocated to the same MRTM
SO-17	MRTM shall enable the provision of taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions in the manoeuvring area for all aerodromes allocated to the same MRTM
SO-18	MRTM shall enable to support AC and vehicle movements in the manoeuvring area (through visual aids on the airport surface) for all aerodromes allocated to the same MRTM
SO-19	MRTM shall enable to manage runway entry for departing aircraft (this includes RWY status/occupancy/correctness check before issuing line-up clearance) for all aerodromes allocated to the same MRTM
SO-20	MRTM shall enable to manage runway exit for arriving aircraft (this includes exit TWY status/occupancy check) for all aerodromes allocated to the same MRTM
SO-21	MRT shall enable to manage aircraft/vehicles runway crossing (this includes RWY status/occupancy/correctness check before issuing runway crossing clearance) for all aerodromes allocated to the same MRTM
SO-22	MRTM shall enable to support aircraft for take-off and landing operations (though visual-aids on the airport surface) for all aerodromes allocated to the same MRTM
SO-23	MRTM shall enable to carry out vehicle related tasks on the runway (inspections, etc.) for all aerodromes allocated to the same MRTM
SO-24	MRT shall enable to manage aircraft take-off (this includes RWY status/occupancy/correctness check before issuing take-off clearance) for all aerodromes allocated to the same MRTM
SO-25	MRTM shall enable to manage aircraft landing (this includes RWY status/occupancy/correctness check before issuing landing clearance) for all aerodromes allocated to the same MRTM
SO-26	MRTM shall enable ATC detection and resolution of runway incursions (AC, vehicle, animal, person incursions) for all aerodromes allocated to the same MRTM
SO-27	MRTM shall enable ATC detection and instructions provision to prevent or resolve

	runway collisions for all aerodromes allocated to the same MRTM
SO-28	MRTM shall enable the detection of flight towards terrain situations for all aerodromes allocated to the same MRTM
SO-29	MRTM shall enable to warn/support pilot on Controlled Flight Towards Terrain situations for all aerodromes allocated to the same MRTM
SO-30	MRTM shall enable to establish/maintain sufficient wake turbulence spacing between arriving and/or departing aircraft for all aerodromes allocated to the same MRTM
SO-31	MRTM shall enable to support taking off and landing operations taking account of weather conditions affecting arriving / departing aircraft (applying corresponding procedures and informing pilots as necessary) for all aerodromes allocated to the same MRTM
SO-32	MRTM shall enable to support landing and taking off aircraft taking account of runway surface conditions and potential foreign objects debris - FOD (applying corresponding procedures and informing pilots as necessary) for all aerodromes allocated to the same MRTM
SO-33	MRTM shall enable to support arriving aircraft on final approach (providing relevant information and instructions as necessary) for all aerodromes allocated to the same MRTM
SO-34	MRTM shall enable to provide “navigation” support to aircraft during landing operations (using available non-visual navigation aids as necessary) for all aerodromes allocated to the same MRTM
SO-35	MRTM shall enable the detection of potential intrusions inside landing-aid protection area for all aerodromes allocated to the same MRTM
SO-36	MRTM shall enable to assess the operational environmental conditions on each corresponding aerodrome in order to provide appropriate remote ATC service (for example “visualisation” related conditions: daylight, dawn, darkness, dusk, CAVOK and low visual conditions)
SO-37	MRTM shall enable the provision of appropriate ATC services in the several operational environmental conditions on each corresponding aerodrome (e.g. low visual procedures in low visual conditions)
SO-38	MRTM shall enable the provision of seamless ATC service to airspace users in the several operational environment conditions on each corresponding aerodrome (e.g. daylight, dawn, darkness, dusk, CAVOK and low visual conditions)
SO-39	Prior to remotely providing ATC services, MRTM capabilities shall be assessed/verified for all aerodromes allocated to the same MRTM
SO-40	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware / notified when the remote provision

	of ATC service is initiated in each aerodrome (as per planned schedules)
SO-41	Remote provision of ATC service shall appropriately (safely) be stopped for planned terminations for one or more aerodromes while continuing the service provision in the other/s if needed
SO-42	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware / notified when the remote provision of ATC service is terminated in one or more aerodromes (as per planned schedules)
SO-43	The MRTM cluster of aerodromes is planned considering weather forecast, traffic demand and any other factors impacting the capacity of the MRTM to provide relevant ATC/AFIS services to concerned aerodromes
SO-44	MRTM shall enable tactical management of ATC resources (ATCO) ensuring safe service to all aerodromes in charge with respect to weather conditions, traffic overloads/peaks and unexpected events.
SO-47	MRTM shall enable, as in current operations, the detection of unexpected flights in the area of responsibility where ATC services are being provided for all aerodromes allocated to the same MRTM
SO-48	MRTM shall enable to detect emergency situations on an aircraft (gear problems, fire on tyres or aircraft, tail strike, etc.) for all aerodromes allocated to the same MRTM
SO-49	MRTM shall enable to initiate emergency procedures and follow emergency situations affecting aircraft for all aerodromes allocated to the same MRTM
SO-50	MRTM shall enable to detect and manage a crash situation on the aerodrome/s allocated to the same MRTM or in their vicinity
SO-51	MRTM shall enable to have awareness of potential abnormal situations (abnormal weather, fire on terminal or aerodrome building, overload on the apron, etc.) in the aerodrome/s allocated to the same MRTM that could affect or even force the termination (unplanned terminations) of the provision of ATC services
SO-52	In case of abnormal situation in one of the aerodromes (emergency situations, crash, overload, etc.), ATCO has to keep ensuring safe provision of service by: <ul style="list-style-type: none"> - splitting aerodromes (to another MRTM or handover the responsibility to another ATCO in the same MRTM) - terminating the service progressively
SO-53	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware/notified when the remote provision of ATC service is terminated in an unplanned manner in one or more aerodromes
SO-54	ATC service provision shall be safely stopped in case of MRTM inadequate capability, or the concerned aerodromes could be transferred to another working MRTM
SO-55	Airspace users, relevant ATS units (e.g. those in charge of adjacent sectors) and respective airport services units shall be aware/notified when the ATC service

	provision is stopped or transferred to another MRTM (technical system failure, merging of aerodromes, etc.).
SO-57	Contingency procedures are to be in place in case the MRTM fails to provide remote ATC service to one/some/all aerodromes allocated to the same MRTM
SO-58	Contingency procedures are to be in place in case the MRTM fails to communicate with a/c and/or vehicles in one/some/all aerodromes allocated to the same MRTM
SO-59	Contingency procedures are to be in place in case the MRTM presents a failure on the screens which prevents ATCO from visually assessing traffic in one/some/all aerodromes allocated to the same MRTM
SO-60	Split of aerodromes is to be available to ATCO in the case a partial failure can be dealt with this way

A.2 Safety Objectives (Integrity and availability)

ID	Description
SOf-01	The likelihood that MRTM fails to coordinate and/or transfer with adjacent ATSU concerning inbound/outbound traffic shall be no more than 3.33e-4 per flight.hour
SOf-02	The likelihood that MRTM fails to manage inbound traffic shall be no more than 4e-6 per flight.hour
SOf-03	The likelihood that MRTM fails to manage outbound traffic shall be no more than 4e-6 per flight.hour
SOf-04	The likelihood that MRTM fails to separate traffic shall be no more than 4e-6 per flight.hour
SOf-05	The likelihood that MRTM fails to separate traffic with respect to restricted areas on the airspace under control responsibility shall be no more than 3.33e-5 per flight.hour
SOf-06	The likelihood that MRTM fails to manage missed approach situations shall be no more than 4e-6 per flight.hour
SOf-07	The likelihood that MRTM fails to detect conflicts or potential collisions between aircraft on the airspace under control responsibility shall be no more than 1e-6 per flight.hour
SOf-08	The likelihood that MRTM fails to timely detect restricted areas infringements shall be no more than 3.33e-5 per flight.hour
SOf-09	The likelihood that MRTM fails to provide ATC instructions to resolve conflicts/avoid collisions on the airspace under control responsibility shall be no more than 1e-6 per flight.hour
SOf-10	The likelihood that MRTM fails to provide appropriate instructions to resolve airspace

	infringements shall be no more than 3.33e-5 per flight.hour
Sof-11	The likelihood that MRTM fails to identify departing aircraft on the stand for providing ATC service shall be no more than 0.01 per movement
Sof-12	The likelihood that MRTM fails to provide appropriate information to departing aircraft for the start-up shall be no more than 0.01 per movement
Sof-13	The likelihood that MRTM fails to apply push-back-towing procedures shall be no more than 0.01 per movement
Sof-14	The likelihood that MRTM fails to provide conflict-free routing and taxi instructions to aircraft in the manoeuvring area shall be no more than 3.33e-03 per movement
Sof-15	The likelihood that MRTM fails to provide taxi instructions to vehicles in the manoeuvring area shall be no more than 3.33e-03 per movement
Sof-16	The likelihood that MRTM fails to detect conflicting situations in the manoeuvring area shall be no more than 5e-04 per movement
Sof-17	The likelihood that MRTM fails to provide taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions in the manoeuvring area shall be no more than 5e-04 per movement
Sof-18	The likelihood that MRT fails to support aircraft and vehicle movements on the manoeuvring area shall be no more than 0.01 per movement
Sof-19	The likelihood that MRTM fails to manage runway entry for departing aircraft shall be no more than 5e-7 per movement
Sof-20	The likelihood that MRTM fails to manage runway exit for landing aircraft shall be no more than 5e-7 per movement
Sof-21	The likelihood that MRTM fails to manage aircraft/vehicle runway crossing shall be no more than 5e-7 per movement
Sof-22	The likelihood that MRTM fails to support aircraft for take-off and landing operations shall be no more than 5e-7 per movement
Sof-23	The likelihood that MRTM fails to carry out vehicle related tasks on the runway shall be no more than 5e-7 per movement
Sof-24	The likelihood that MRTM fails to manage aircraft take-off shall be no more than 5e-7 per movement
Sof-25	The likelihood that MRTM fails to manage aircraft landing shall be no more than 5e-7 per movement
Sof-26	The likelihood that MRTM fails to detect runway incursions and potential collisions on the runway shall be no more than 3.33e-6 per movement

Sof-27	The likelihood that MRTM fails to provide instructions to resolve runway incursions and prevent collisions on the runway shall be no more than 3.33e-6 per movement
Sof-28	The likelihood that MRTM fails to detect flight towards terrain situations shall be no more than 1e-7 per flight
Sof-29	The likelihood that MRTM fails to warn/support pilot on CFIT situations shall be no more than 1e-7 per flight
Sof-30	The likelihood that MRTM fails to establish/maintain sufficient wake turbulence spacing between landing/departing aircraft shall be no more than 4e-5 per flight

A.3 Mapping of Safety Objectives to SPR-level Model Elements and Safety Requirements

Safety Objectives (Functionality and Performance from success approach)	Requirement (forward reference)	Maps on to
SO-01	SR-01 SR-02 SR-03 SR-04 SR-16 SR-17 SR-18 SR-31	Flight Plan system Flight Plan system G-G Comm G-G Comm ATCO ATCO ATCO Surveillance data
SO-02	SR-01 SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-31 SR-32 SR-33 SR-45 SR-47	Flight Plan system A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Surveillance data Visualisation system Visualisation system Local MET system AI data system
SO-03	SR-01 SR-16 SR-17 SR-18	Flight Plan system ATCO ATCO ATCO

	SR-05 SR-06 SR-07 SR-08 SR-31 SR-32 SR-33 SR-45 SR-47	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surveillance data Visualisation system Visualisation system Local MET system AI data system
SO-04	SR-16 SR-17 SR-18 SR-05 SR-06 SR-07 SR-08 SR-31 SR-32 SR-33	ATCO ATCO ATCO A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surveillance data Visualisation system Visualisation system
SO-05	SR-16 SR-17 SR-18 SR-05 SR-06 SR-07 SR-08 SR-31 SR-32 SR-33 SR-47	ATCO ATCO ATCO A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surveillance data Visualisation system Visualisation system AI data system
SO-06	SR-16 SR-17 SR-18 SR-31 SR-32 SR-33	ATCO ATCO ATCO Surveillance data Visualisation system Visualisation system
SO-07	SR-16 SR-17 SR-18 SR-31 SR-32 SR-33	ATCO ATCO ATCO Surveillance data Visualisation system Visualisation system
SO-08	SR-16 SR-17	ATCO ATCO

	SR-18 SR-31 SR-32 SR-33 SR-47	ATCO Surveillance data Visualisation system Visualisation system AI data system
SO-09	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-31 SR-32 SR-33	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Surveillance data Visualisation system Visualisation system
SO-10	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-31 SR-32 SR-33	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Surveillance data Visualisation system Visualisation system
SO-11	SR-01 SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-35	Flight Plan system A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-12	SR-05 SR-06 SR-07 SR-08 SR-12 SR-16 SR-17 SR-18 SR-35 SR-45	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Airport Personnel) ATCO ATCO ATCO Visualisation system Local MET system

SO-13	SR-05	A-G Comm
	SR-06	A-G Comm
	SR-07	A-G Comm
	SR-08	A-G Comm, Surf-G COMM (Vehicles)
	SR-12	Surf-G COMM (Airport Personnel)
	SR-16	ATCO
	SR-17	ATCO
	SR-18	ATCO
	SR-35	Visualisation system
SO-14	SR-05	A-G Comm
	SR-06	A-G Comm
	SR-07	A-G Comm
	SR-08	A-G Comm, Surf-G COMM (Vehicles)
	SR-16	ATCO
	SR-17	ATCO
	SR-18	ATCO
	SR-35	Visualisation system
	SR-36	Visualisation system
SR-37	Visualisation system	
SO-15	SR-09	Surf-G COMM (Vehicles)
	SR-10	Surf-G COMM (Vehicles)
	SR-11	Surf-G COMM (Vehicles)
	SR-16	ATCO
	SR-17	ATCO
	SR-18	ATCO
	SR-35	Visualisation system
	SR-36	Visualisation system
SR-37	Visualisation system	
SO-16	SR-16	ATCO
	SR-17	ATCO
	SR-18	ATCO
	SR-35	Visualisation system
	SR-36	Visualisation system
	SR-37	Visualisation system
SO-17	SR-05	A-G Comm
	SR-06	A-G Comm
	SR-07	A-G Comm
	SR-08	A-G Comm, Surf-G COMM (Vehicles)
	SR-09	Surf-G COMM (Vehicles)
	SR-10	Surf-G COMM (Vehicles)
	SR-11	Surf-G COMM (Vehicles)
	SR-16	ATCO
	SR-17	ATCO
	SR-18	ATCO
	SR-35	Visualisation system

	SR-36 SR-37	Visualisation system Visualisation system
SO-18	SR-16 SR-17 SR-18 SR-43	ATCO ATCO ATCO Visual Navigation Aids system
SO-19	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-20	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-21	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-22	SR-16 SR-17 SR-18 SR-43	ATCO ATCO ATCO Visual Navigation Aids system
SO-23	SR-09 SR-10 SR-11 SR-16 SR-17	Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) ATCO ATCO

	SR-18	ATCO
SO-24	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-25	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-26	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-27	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-16 SR-17 SR-18 SR-35	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system
SO-28	SR-16 SR-17 SR-18 SR-31 SR-32	ATCO ATCO ATCO Surveillance data Visualisation system

	SR-33 SR-34	Visualisation system Visualisation system
SO-29	SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-31 SR-32 SR-33	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Surveillance data Visualisation system Visualisation system
SO-30	SR-01 SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-32 SR-33	Flight Plan system A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Visualisation system Visualisation system
SO-31	SR-05 SR-06 SR-07 SR-08 SR-38 SR-45 SR-16 SR-17 SR-18	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Visualisation system Local MET system ATCO ATCO ATCO
SO-32	SR-13 SR-35 SR-39 SR-16 SR-17 SR-18	Surf-G COMM (Airport Personnel) Visualisation system Visualisation system ATCO ATCO ATCO
SO-33	SR-35 SR-16 SR-17 SR-18	Visualisation system ATCO ATCO ATCO
SO-34	SR-44 SR-16	Non-Visual Navigation Aids system ATCO

	SR-17 SR-18	ATCO ATCO
SO-35	SR-05 SR-06 SR-07 SR-08 SR-09 SR-10 SR-11 SR-35 SR-16 SR-17 SR-18	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Surf-G COMM (Vehicles) Visualisation system ATCO ATCO ATCO
SO-36	SR-38 SR-45 SR-16 SR-17 SR-18	Visualisation system Local MET system ATCO ATCO ATCO
SO-37	SR-16 SR-17 SR-18	ATCO ATCO ATCO
SO-38	SR-40 SR-19 SR-20	Visualisation system ATCO ATCO
SO-39	SR-27 SR-28 SR-29 SR-46	Supervisor Supervisor Supervisor Local NET/DCB Tools
SO-40	SR-21	ATCO
SO-41	SR-14 SR-15 SR-22 SR-48	Surf-G COMM (Airport Personnel) Surf-G COMM (Airport Personnel) ATCO AI data system
SO-42	SR-23	ATCO
SO-43	SR-14 SR-15 SR-26	Surf-G COMM (Airport Personnel) Surf-G COMM (Airport Personnel) RTC unit
SO-44	SR-14 SR-15 SR-22	Surf-G COMM (Airport Personnel) Surf-G COMM (Airport Personnel) ATCO

	SR-48	AI data system
SO-45	SR-20	ATCO
SO-46	SR-20	ATCO
SO-47	SR-16 SR-17 SR-18 SR-32 SR-33	ATCO ATCO ATCO Visualisation system Visualisation system
SO-48	SR-16 SR-17 SR-18 SR-32 SR-33 SR-35 SR-36 SR-37 SR-41 SR-42	ATCO ATCO ATCO Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system
SO-49	SR-03 SR-04 SR-05 SR-06 SR-07 SR-08 SR-16 SR-17 SR-18 SR-30 SR-31 SR-32 SR-33 SR-35 SR-36 SR-37 SR-41 SR-42 SR-49 SR-50 SR-51	G-G Comm G-G Comm A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) ATCO ATCO ATCO Airport Personnel Surveillance data Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Signalling Lamps System Accident, incident and distress alarms Accident, incident and distress alarms
SO-50	SR-03 SR-04 SR-12 SR-16	G-G Comm G-G Comm Surf-G COMM (Airport Personnel) ATCO

	SR-17 SR-18 SR-31 SR-32 SR-33 SR-35 SR-36 SR-37 SR-41 SR-42 SR-50 SR-51	ATCO ATCO Surveillance data Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Visualisation system Accident, incident and distress alarms Accident, incident and distress alarms
SO-51	SR-12 SR-30	Surf-G COMM (Airport Personnel) Airport Personnel
SO-52	SR-14 SR-15 SR-20 SR-22 SR-23 SR-48 SR-24	Surf-G COMM (Airport Personnel) Surf-G COMM (Airport Personnel) ATCO ATCO ATCO AI data system ATCO
SO-53	SR-05 SR-06 SR-07 SR-08 SR-15	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Airport Personnel)
SO-54	SR-23 SR-24	ATCO ATCO
SO-55	SR-05 SR-06 SR-07 SR-08 SR-14 SR-22	A-G Comm A-G Comm A-G Comm A-G Comm, Surf-G COMM (Vehicles) Surf-G COMM (Airport Personnel) ATCO
SO-57	SR-17	ATCO
SO-58	SR-17 SR-69 SR-72	ATCO Surf-G Comm A-G Comm
SO-59	SR-17 SR-71	ATCO Visualisation System

SO-60	SR-17	ATCO
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A.4 Safety Validation Objectives (traceability)

Obj. ID	Validation Objective	Criteria ID	Validation Criteria	Status V3	SOs
OBJ-PJ05.03-V2-VALP-S01	Assess whether the levels of safety are maintained or improved under all normal conditions when ATS are remotely provided to multiple airports	CRT-PJ05.03-V2-VALP-S01.010	The Safety Acceptance Criteria are satisfied (i.e. no increase of risk with respect to a situation in which ATC services are remotely provided by a controller to a single remote tower). Note: A risk assessment is performed.	Fully covered	SO-36 SO-37 SO-38 SO-39 SO-40 SO-41 SO-42
OBJ-PJ05.03-V2-VALP-S02	Assess whether the ATS can safely continue to be remotely provided to multiple aerodromes under external abnormal conditions.	CRT-PJ05.03-V2-VALP-S02.010	The Safety Acceptance Criteria are satisfied. Note: A risk assessment is performed.	Partially covered	SO-47 SO-48 SO-49 SO-50 SO-51 SO-52 SO-53 SO-54 SO-55
OBJ-PJ05.03-V2-VALP-S03	Assess whether the ATS can safely be remotely provided to multiple aerodromes during degraded modes of operation	CRT-PJ05.03-V2-VALP-S03.010	The Safety Acceptance Criteria are satisfied. Note: A risk assessment is performed.	Partially covered	SO-57 SO-58 SO-59 SO-60
OBJ-PJ05.03-	Assess ATCO capability to provide ATC services in a	CRT-PJ05.03-	ATCO is able to identify and solve potential conflicts in a timely	Fully covered	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10

V2-VALP-S04	safe manner to multiple aerodromes under all normal conditions	V2-VALP-S04.010	manner: · In the vicinity of the aerodrome · In the runway area · On the manoeuvring area		SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35
		CRT-PJ05.03-V2-VALP-S04.020	ATCO is able to identify and solve hazardous situations in a timely manner (e.g.): · Unstable approaches · Bird strikes · Aircraft not vacating RWY as expected	Fully covered	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35 SO-45 SO-46
		CRT-PJ05.03-V2-VALP-S04.030	ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with	Fully covered	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35
		CRT-PJ05.03-V2-VALP-S04.040	ATCO is be able to distinguish with which sector the ATCO is communicating with	Fully covered	SO-04 SO-06 SO-07 SO-09 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35

		CRT- PJ05.03- V2- VALP- S04.050	ATCO is not inducing more conflicting situations than in the baseline	Fully covered (workshop, no need for simulation)	SO-45
OBJ- PJ05.03- V2-VALP- S05	Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner	CRT- PJ05.03- V2- VALP- S05.010	ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads	Fully covered (questionnaire s)	
OBJ- PJ05.03- V2-VALP- S06	Assess ATCO capability to cope with / manage abnormal situation in a safe manner	CRT- PJ05.03- V2- VALP- S06.010	ATCO is able to identify and manage abnormal situations (e.g.): · Unknown flight · Aircraft emergency · Crash on an airport or its vicinity · Fire on an airport · Unplanned closure of an airport	Fully covered	SO-47 SO-48 SO-49 SO-50 SO-51 SO-52 SO-53 SO-54 SO-55
OBJ- PJ05.03- V2-VALP- S07	Assess ATCO capability to cope with / manage degraded modes them in a safe manner	CRT- PJ05.03- V2- VALP- S07.010	ATCO is able to detect and recover from a failure occurring at one of the airports affecting (e.g.): · Communication · Visualisation system · Other airport systems / infrastructure	Partially covered	SO-57 SO-58 SO-59 SO-60
		CRT- PJ05.03- V2-	ATCO is able to detect and recover from a failure occurring in several airport (e.g.):		SO-57 SO-58 SO-59

		VALP-S07.020	<ul style="list-style-type: none"> · Communication · Visualisation system · Other airport systems / infrastructure 		SO-60
		CRT-PJ05.03-V2-VALP-S07.030	<p>ATCO is able to detect and recover from a failure in the MRTM affecting (e.g) :</p> <ul style="list-style-type: none"> · Communication · Visualisation system 	Partially covered	SO-57 SO-58 SO-59 SO-60

Appendix B Consolidated List of Safety Requirements

Note 1: All Safety Requirements have been **validated** in the Requirement consolidation workshop that took place in Brussels 4th-5th June 2019. These Safety Requirements **must be included** in the OSED and TS unless they are fully covered by existing OSED and TS Requirements.

Note 2: In the Safety Assessment Report, the PTZ (pan-tilt-zoom) function is named “PTZ” while in the OSED and HP this is called “binocular function”. This does not change the meaning of the function that has been simulated and validated.

B.1 Safety Requirements (Functionality and Performance)

As explained in sections 2.2 and 4.2.3, we use two denominations for the type of Safety Requirement, depending on them being part of the Single Remote Tower requirements package (“**pack**”) or being a new requirement specific to the multiple towers setting (“**multiple**”).

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
SR-01	Flight plan information shall be provided to ATCO for each aerodrome allocated to the MRTM	Pack	Flight plan information was available during the VAL EXE on the e-strip system and properly used by the controllers, but some HMI issues still need to be solved.	Closed	Further investigate the HMI properties for the e-strip system as per HP requirements	SO-01 SO-02 SO-03 SO-11 SO-30
SR-02	ATCO shall be able to distinguish between aerodromes in the MRTM from which flight plan information is provided	Multiple	In the VAL EXE Flight plan information was properly associated to the corresponding aerodrome (via the e-strip system), but some HMI issues still need to be	Closed	Further investigate the HMI properties for the e-strip system as per HP requirements	SO-01

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
			solved.			
SR-03	ATCO shall be able to communicate with adjacent ATS units for each aerodrome allocated to the MRTM	Pack	Not tested during the VAL EXE. Discussed during the SAF-HP WSP only. No changes to procedures were identified, and no possible issues: ATCO initiates the communication with ATSU by phone as today.	Closed	ATCO would communicate with adjacent ATS units as today, by phone, and would not need any new tool or implementation to do so	SO-01 SO-49 SO-50
SR-04	ATCO shall be able to distinguish between ATSUs (APP units) from different aerodromes in the MRTM that communication is established with	Multiple	Not tested during the VAL EXE. Discussed during the SAF-HP WSP only. No changes to procedures were identified, and no possible issues: ATCO initiates the communication with ATSU, therefore distinction is not necessary through other means.	Closed	See above SR-03; today ATSUs are contacted by the ATCO, so distinction would not be an issue as ATCO would initiate the communication (information on ATSUs for each airport will have to be listed with clear identifiers); standard procedures	SO-01 SO-49 SO-50
SR-05	ATCO shall be able to communicate with A/C in all aerodromes to which ATC is being provided	Pack	In the VAL EXE communication with A/C in each aerodrome was possible and working properly, even if different solutions were tested.	Closed	Although pilots have not been involved in determining phraseology, SRT are already implemented and pilots will be notified through the normal means (NOTAM, etc.) to know that there	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
					are multiple airports coupled in the same frequency	SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31 SO-35 SO-49 SO-53 SO-55
SR-06	ATCO shall be able to distinguish between aerodromes in the MRTM that communication with A/C is established with	Multiple	No issues were identified with respect to that during the VAL EXEs. AD designator is used in phraseology (during the workshop ATCOs agree that this is the best practice).	Closed	<p>1) AD name is included in phraseology; further definition would be up to local implementation</p> <p>2) To investigate minimum system functionalities supporting this requirement: different prototypes used different HMI options to support this distinction to the ATCO</p> <p>3) Degraded situations have not been widely simulated and it is advised to test the phraseology and functionalities in these cases before implementation</p>	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19 SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31 SO-35 SO-49 SO-53 SO-55



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
SR-07	A-G Comm in the MRTM shall allow to receive communication from all traffic in all aerodromes allocated to the MRTM and to communicate with A/C	Multiple	Agreement that frequencies must be coupled for A/C; other discussions on vehicles hearing A/C to increase safety in the RWY.	Closed	In emergency situations some ATCOs report high communication workload; to investigate further if silent communication can be increased for regular movements (not emergencies).	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19 SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31 SO-35 SO-49 SO-53 SO-55
SR-08	MRTM shall allow to communicate with A/C and Vehicles : - coupling A/C frequencies from all aerodromes allocated to the same MRTM and keeping vehicles in separate frequencies for each aerodrome	Multiple	Agreement that frequencies must be coupled for A/C, and independent for each AD for vehicles; common agreement is that an option to request communication from vehicles would be best, in order not to congest the communication for the ATCO; other discussions on vehicles hearing A/C to increase safety	Closed	To evaluate if vehicles using the RWY need to be coupled with aircraft; this has been discussed in the Workshop and could improve safety, although it would add ground personnel training; we recommend to investigate this possibility. Vehicles to request communication with ATCO is also recommended.	SO-02 SO-03 SO-04 SO-05 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-17 SO-19 SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-29 SO-30 SO-31 SO-35 SO-49 SO-53

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
			in the RWY.			SO-55
SR-09	ATCO shall be able to communicate with and give control instructions to Vehicles in manoeuvring areas at each aerodrome under control responsibility in the MRTM	Pack	In the VAL EXE communication with vehicles in each aerodrome was possible and working properly.	Closed		SO-15 SO-17 SO-21 SO-23 SO-26 SO-27 SO-35
SR-10	ATCO shall be able to distinguish between aerodromes in the MRTM that communication with Vehicles is established with	Multiple	During VAL EXE, ATCO needed to prioritise calls (between A/G and G/G and between aerodromes) when workload was high. There were no concluding evidences on the phraseology to be used for G/G (local implementations).	Closed	1) Further investigation on the HMI part of the COM system is also needed 2) To be further evaluated if G-G communication can demand less ATCO workload during emergency/high traffic situations (silent communication, vehicle requesting information, etc.)	SO-15 SO-17 SO-21 SO-23 SO-26 SO-27 SO-35
SR-11	Communication function in the MRTM shall allow to transmit communication to Vehicles independently (not combined with A/C) for each aerodrome	Multiple	This SR is redundant as it has been further defined before that A/C are coupled in the same frequency while vehicles are not coupled; this SR remains covered by all means.	Closed		SO-15 SO-17 SO-21 SO-23 SO-26 SO-27 SO-35

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	allocated to the MRTM					
SR-12	ATCO shall be able to communicate with Airport Personnel at each aerodrome under control responsibility (start-up, push-back, other services)	Pack	Not addressed during VAL EXE and only discussed during the SAF-HP WS, but it should be the same as for Single Remote Tower.	Closed	In local implementation, to evaluate the way(s) this communication system is to be put in place and implemented for a MRTM	SO-12 SO-13 SO-50 SO-51
SR-13	ATCO shall be able to communicate with Airport Personnel in order to coordinate runway inspections to determine runway conditions and detect potential FODs/animals at each aerodrome allocated to the MRTM	Pack	Partly addressed during VAL EXE, discussed during the SAF-HP WS; it should be the same as for Single Remote Tower.	Closed	In local implementation, to evaluate the way(s) this communication system is to be put in place and implemented for a MRTM	SO-32
SR-14	ATCO shall be able to communicate with Airport Personnel (in the different services present there) at each aerodrome under control responsibility	Pack	Not addressed during VAL EXE and only discussed during the SAF-HP WS, but it should be the same as for Single Remote Tower.	Closed	In local implementation, to evaluate the way(s) this communication system is to be put in place and implemented for a MRTM	SO-41 SO-43 SO-44 SO-52 SO-55

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	(service initiation, termination)					
SR-15	ATCO shall be able to distinguish between aerodromes in the MRTM that communication with Airport Personnel is established with	Multiple	<u>Not addressed during the VAL EXE nor the SAF-HP WSP but should be the same as for Single Remote Tower.</u>	Closed	Not critical; to be defined in V4/V5 for local implementation.	SO-41 SO-43 SO-44 SO-52 SO-53
SR-16	ATCO shall perform all tasks (procedures) to provide ATC Tower service to all aerodromes allocated to the MRTM	Pack	From the VAL EXE no main issues were identified with respect to that; scenarios tested were nominal, with some emergency situations and abnormal/degraded modes. Split&Merge was also tested in some cases (relevant to PJ05.03).	Closed	For PJ05.02, if a split is not an option, investigate if an additional controller is then needed to support ATCO in the tasks in case of emergency (local implementation).	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
						SO-33 SO-34 SO-35 SO-36 SO-37 SO-47 SO-48 SO-49 SO-50
SR-17	ATCO shall be able to prevent overload and manage workload by - giving the responsibility of one or several ADs to an additional ATCO (or assistant) in the same MRTM or - reducing capacity by slowing traffic down - terminating ATC service for one or several aerodromes if no other option is possible. In PJ05.03, ATCO can also prevent overload and manage workload by - transferring it/them to another MRTM	Multiple	Although some VAL EXE have covered the split functionality in PJ05.02, this is a feature of PJ05.03. In PJ05.02 the mitigation to an overload or a degraded mode is support from an additional ATCO or delaying traffic (termination if it cannot be solved). For PJ05.03, there is the additional mitigation means of splitting one or several aerodromes to an available MRTM where an available ATCO can take control of them. In simulations this shows that it does have an initial increase of workload for the transfer, and therefore the ATCO must decide (with the support of a Supervisor) when	Closed	To further investigate the situations in which each solution would be suitable (traffic and complexity) in order to support the definition of clusters for local implementation	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35 SO-36 SO-37 SO-47 SO-48 SO-49



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
			is the right time to split. This has also been extensively discussed during the SAF-HP workshop. This SR applies to both Solutions with different nuances.			SO-50
SR-18	In case a spare controller takes responsibility of one or several aerodromes from the same MRTM, handover/coordination procedures between both controllers shall be applied	Multiple	See validation activity for SR-17. Handover was done via communication between ATCOs and a checklist.	Closed		SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-18 SO-19 SO-20 SO-21 SO-22 SO-23 SO-24 SO-25 SO-26 SO-27 SO-28 SO-29 SO-30 SO-31 SO-32 SO-33 SO-34 SO-35 SO-36 SO-37 SO-47



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
						SO-48 SO-49 SO-50
SR-20	In case a split is needed and one or several aerodromes have to be transferred to another MRTM, transfer handover procedures between different MRTMs shall be applied	Multiple	See validation activity for SR-18. Sharing the view for a while until the handover is complete is advised for as long as necessary.	Closed	It is already a REQ in the OSED (double check) -	SO-38 SO-45 SO-46 SO-52
SR-21	ATCO allocated to an MRTM position shall apply the relevant MRT start-up procedure for each aerodrome before providing ATC service from that MRTM position (this start-up procedure includes check of the MRT capability)	Pack	Procedure should be similar to the one for SRT but it has not been addressed during the VAL EXE nor the SAF-HP WSP.	Closed	Not critical; to be defined in V4/V5 for local implementation.	SO-40
SR-22	ATCO shall inform Airport Personnel at each aerodrome allocated to the	Pack	Procedure should be similar to the one for SRT but it has not been addressed during the	Closed	Not critical; to be defined in V4/V5 for local implementation.	SO-41 SO-44 SO-52 SO-55

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	MRTM about the remote provision of ATC service (initiation, termination)		VAL EXE nor the SAF-HP WSP			
SR-23	ATCO shall ensure that ATC services can be appropriately (safely) stopped at each aerodrome allocated to the MRTM in case the service has to be terminated	Pack	Procedure should be similar to the one for SRT but it has not been addressed during the VAL EXE nor the SAF-HP WSP.	Closed	Not critical; to be defined in V4/V5 for local implementation.	SO-42 SO-52 SO-54
SR-24	ATCO shall inform Airspace Users at each aerodrome allocated to the MRTM about the unplanned termination of the ATC service provision.	Pack	Procedure should be similar to the one for SRT but it has not been addressed during the VAL EXE nor the SAF-HP WSP.	Closed	Not critical; to be defined in V4/V5 for local implementation.	SO-52 SO-54
SR-26	Clusters of aerodromes allocated to an MRTM shall be defined at local level in order to ensure that traffic levels and complexity do not exceed limitations so the ATCO can safely	Multiple	<u>Not addressed during the validation activities.</u>	Closed	For local implementation, define in V4/V5 how to ensure that controller will be delivered a total amount of traffic to which in principle he/she can safely provide ATS. Elements to be potentially taken	SO-43

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	provide ATS services in nominal, abnormal and degraded conditions				into account for clustering aerodromes, among others: <ul style="list-style-type: none"> - total number of movements, and simultaneous movements, - traffic complexity - aerodromes layout complexity, and runways and taxiways names - similarity of procedures - available controllers endorsements - surveillance data availability (air and or surface) 	
SR-30	Airport Personnel shall inform RTC about emergency or abnormal situation in the aerodrome premises that may affect the safe provision of ATC service	Pack	Not addressed during the VAL EXE nor the SAF-HP WSP but should be the same as for Single Remote Tower.	Closed	This presents no issues (same as for SRT) and is therefore considered closed provided that a clear definition of procedures and documentations is performed for local implementation.	SO-49 SO-51
SR-31	Surveillance data shall be provided to ATCO to support tasks for all aerodromes. Air surveillance data is	Pack	Surveillance data was available in all the VAL EXE and it was very useful for controllers in order to foresee the incoming traffic, together	Closed	To evaluate if radar coverage for all aerodromes is necessary if it is not available today for one or several particular aerodromes; this would need to be done in V4/V5 and local	SO-01 SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	mandatory while ground surveillance is optional		with the flight plans. During the workshop ATCOs mentioned that some of the smaller aerodromes might not have radar coverage today, although it was simulated in the VAL EXE.		<p>implementation.</p> <p>Evaluate the need of radar tracking displayed on the visual presentation system in order to support ATCO in performing ATS tasks (AC identification, monitoring incoming traffic, etc.)</p> <p>1) Ensure HMI features concerning radar information take into account current standards, and at the same time coherency with the other systems (visual presentation, flight plan system, etc.).</p> <p><i>Note: Air surveillance was available in all validations. Workshop showed that the lack of Air surveillance has an impact on capacity wherefore evaluation of capacity is needed during local implementation.</i></p>	SO-28 SO-29 SO-49 SO-50
SR-32	Visual information on the vicinity of each aerodrome	Pack	In VAL EXE Visual information for each aerodrome was	Closed	To explore further in V4/V5 weather and visibility conditions,	SO-02 SO-03 SO-04 SO-05

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	and the traffic in those areas shall be provided to ATCO to support tasks as in single remote tower operations		available and working properly.		not only during nominal situations but also when managing abnormal and degraded situations	SO-06 SO-07 SO-08 SO-09 SO-10 SO-28 SO-29 SO-30 SO-47 SO-48 SO-49 SO-50
SR-33	Visual indication supporting A/C identification in the vicinity of each aerodrome allocated to the MRTM should be provided to the ATCO	Pack	Only in some VAL EXE this visual support information was available, and was mainly tested in nominal conditions.	Partially	This was considered nice-to-have, and it is considered important that this is a feature that the ATCO can toggle on and off in order to avoid clutter on the visual representation. Because the VAL EXEs have not tested this in abnormal and degraded modes conditions when ATCO's attention is focused on other things, this REQ is considered partially covered (non-blocking, as it is not critical).	SO-02 SO-03 SO-04 SO-05 SO-06 SO-07 SO-08 SO-09 SO-10 SO-28 SO-29 SO-30 SO-47 SO-48 SO-49 SO-50
SR-35	Visual information on the apron of each aerodrome allocated to the MRTM and traffic in those areas may	Pack	In most of the VAL EXE Visual information for each aerodrome was available and	Closed	The positioning of the cameras needs to consider the airport layout as in SRT.	SO-11 SO-12 SO-13 SO-14 SO-15 SO-16 SO-17 SO-19

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	be provided to ATCO to support tasks as in single remote tower operations		working properly.			SO-20 SO-21 SO-24 SO-25 SO-26 SO-27 SO-32 SO-33 SO-35 SO-48 SO-49 SO-50
SR-36	Visual indication supporting A/C and Vehicle detection (i.e. object bounding) in the manoeuvring area of each aerodrome allocated to the MRTM should be provided to the ATCO	Pack	Only in some VAL EXE this visual support information was available, and was mainly tested in nominal conditions.	Partially	This was considered nice-to-have, and it is considered important that this is a feature that the ATCO can toggle on and off in order to avoid clutter on the visual representation. Because the VAL EXEs have not tested this in abnormal and degraded modes conditions when ATCO's attention is focused on other things, this REQ is considered partially covered (non-blocking, as it is not critical).	SO-14 SO-15 SO-16 SO-17 SO-48 SO-49 SO-50
SR-37	Visual indication supporting detection of A/C, Vehicle, Personnel and Obstacle entering/being	Pack	Only in some VAL EXE this visual support information was available, and was mainly	Partially	This requirement is considered important for multiple remote towers while it was only nice-to-have in single remote tower.	SO-14 SO-15 SO-16 SO-17 SO-48 SO-49

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	close to a runway of each aerodrome allocated to the MRTM should be provided to the ATCO		tested in nominal conditions.		Because the VAL EXEs have not tested this feature, this could be investigated further from V3.	SO-50
SR-38	Visual presentation (VP) on the manoeuvring area and the vicinity of each aerodrome shall be provided to ATCO to support tasks as in single remote tower operations	Pack	In VAL EXE Visual information for each aerodrome was available and working properly.	Closed		SO-31 SO-36
SR-39	Visual presentation (VP) of the runway area for each aerodrome shall be provided to ATCO to support tasks as in single remote tower operations	Pack	In VAL EXE Visual information for each aerodrome was available and working properly.	Closed		SO-32
SR-40	Visual information available in the Visualisation System shall be provided in the several visibility conditions (CAVOK, darkness,...) for all	Pack	In VAL EXE Visual information for each aerodrome was available and working properly, taking into account there were simulated.	Closed	To investigate the filtering function on the visualisation system in order to ensure information provided to the controller is as close as possible from reality (for example, to define the visibility in one aerodrome).	SO-38

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	aerodromes allocated to the MRTM					
SR-41	The PTZ shall be available for each aerodrome allocated to the MRTM in order to support ATC tasks as for Single Remote Tower	Pack	PTZ functionality was available during the VAL EXE and it was useful for controller but it was not specifically used during abnormal situations as emergency ones for example.	Closed	To be tested during deployment.	SO-48 SO-49 SO-50
SR-42	Time, compass rose and aerodromes names should be provided on the visual presentation for each aerodrome allocated to the same MRTM	Pack	Different solutions were tested in the several VAL EXE. Still not agreed if those solution work in the same way. To be further investigated.	Closed	To further investigate the information to be displayed on the visualisation system and where it needs to be located.	SO-48 SO-49 SO-50
SR-43	Managing visual navigation aids shall be provided to ATCO to support tasks for each aerodrome allocated to the MRTM	Pack	Tested during some VAL EXE: ATCO can control lights and beams from the HMI. This is the same requirement as for Single Remote Tower.	Closed	To be tested during deployment.	SO-18 SO-22
SR-44	ATCO shall be able to manoeuvre non-visual navigation aids in order to support AC on landing	Pack	Not tested during the VAL EXE but should be the same as for Single Remote Tower.	Closed	To be tested during deployment.	SO-34

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	operations for each aerodrome allocated to the MRTM					
SR-45	Local MET information shall be provided to ATCO to support tasks for all aerodromes	Pack	In VAL EXE Local MET information for each aerodrome was available and working properly.	Closed	To be tested during deployment.	SO-02 SO-03 SO-12 SO-31 SO-36
SR-46	Information on present and incoming traffic (as well as real time airport capacity if applicable) and weather forecast shall be provided to the ATCO in order to be able to plan and manage ATCO resources adequately for a specific MRTM position.	Multiple	Different solutions were tested in the several VAL EXE. To be further investigated.	Closed	This could be a tool but doesn't need to, and is therefore validated in V3. This relates to an OSED requirement.	SO-39
SR-47	Published AIP information for each aerodrome allocated to the same MRTM shall be provided to ATCO	Pack	Not addressed during the VAL EXE nor the SAF-HP WSP but should be the same as for Single Remote Tower.	Closed	To be checked during deployment.	SO-02 SO-03 SO-05 SO-08



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
SR-48	Airspace users shall be informed about the (planned) provision of remote ATC services though AIP	Pack	Not addressed during the VAL EXE nor the SAF-HP WSP but should be the same as for Single Remote Tower.	Closed	To be checked during deployment.	SO-41 SO-44 SO-52
SR-49	ATCO shall be able to remotely use signalling lamps to communicate with concerned traffic in each aerodrome allocated to the same MRTM	Pack	Addressed during some VAL EXE and discussed during SAF-HP WSP. This is the same as for Single Remote Tower. The display of the lights settings for 3 aerodromes has been discussed in order for the ATCO to be able to turn them on/off easily.	Closed	To investigate in V4/V5 how to implement it in the HMI for 3 aerodromes in terms of space, differentiation and user experience (HP).	SO-49
SR-50	ATCO shall be able to activate accident/incident/distress alarms in order to alert relevant services in the correspondent aerodrome of the MRTM and to launch corresponding emergency procedures for that	Pack	Not addressed during the VAL EXE only during the SAF-HP WSP; should be the same as for Single Remote Tower.	Closed	To be checked during deployment.	SO-49 SO-50



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	aerodrome					
SR-51	ATCO shall be able to activate accident/incident/distress alarms from one or more aerodromes allocated to the MRTM with relevant information	Multiple	Not addressed during the VAL EXE nor the SAF-HP WSP (only light discussions) but should be the same as for Single Remote Tower.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes.	SO-49 SO-50
SR-52	ATCO shall be able to recognise alarms, and distinguish to which aerodrome the alarm is related, in order to prioritise and solve the possible situations	Multiple	Not addressed during the VAL EXE nor the SAF-HP WSP (only light discussions) but should be the same as for Single Remote Tower.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes.	SO-49 SO-50
SR-55	An alert should be provided to the controller in case of failure of the ground-ground communication service.	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
SR-57	An alert should be provided to the controller in case of failure of the communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area.	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	
SR-61	An alert shall be provided to the controller in case of failure or inappropriate information (delayed, corrupted, frozen, etc.) is provided on the visualisation system.	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	
SR-62	Data recorder system shall not negatively impact (corrupting data or inducing malfunction) the system from which data is recorded, including the data from the Visualisation	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for	

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	system.				inspections.	
SR-64	An alert should be provided to the controller in case of failure of the air-ground communication system.	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	
SR-68	In case of loss or degradation of ground-ground communication with adjacent ATSU units in a MRTM position relevant fallback procedures shall be applied.	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	
SR-69	In case of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the	SO-58

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	operating on the manoeuvring area relevant fallback procedures shall be applied (e.g. use of flash gun lights).				runway, for example for inspections.	
SR-70	In case surveillance function is available in the MRTM position, but the function is lost or the information provided is inappropriate and detected, relevant fallback procedures shall be applied	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	
SR-71	In case of loss of information or detected inappropriate information on a critical view of the visualisation (due to technical failure), a specific procedure shall be applied taking into account the timeframe of the failure mode (e.g. provision of ATC services limiting the	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	SO-59

SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	simultaneous operations in the area of responsibility, using PTZ camera to get the corresponding lost image, stopping the provision of the service, etc.). Note: critical view is defined in SR-107.					
SR-72	In case of failure of degradation or air-ground communication with traffic in a MRTM position, relevant procedures from PANS ATM [12] shall be applied (e.g. issuing clearances through the relevant APP controller).	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the runway, for example for inspections.	SO-58
SR-73	In case of incorrect MET/Weather information is provided in a MRTM position, or no information at all is provided, controller shall contact relevant	Pack	Mitigation mean identified from the hazard assessment. Not addressed during the validation activities.	Open	To be checked in V4/V5 to see how the alerts can help the ATCO in a display of 2 or 3 aerodromes. Same procedure as for SRT should apply, including communication with personnel operating in the	



SR#	Safety Requirement (functionality & performance)	Type	Validation Activity	V3 Status	Next activities / recommendations	Derived from SO / OH
	airport personnel in the airport in order to obtain this information and any relevant update, if not possible to obtain such information from any other source (e.g. pilots, visual inputs from the visual presentation, MET-office, www/internet).				runway, for example for inspections.	



B.2 Safety Requirements (Integrity and availability)

All Safety Requirements for integrity (failures) are to be assessed during V4/V5; hence they are all considered “open” at this stage.

SR#	Safety Requirement (integrity)	Validation Activity and Next activities/recommendations	V3 Status	Derived from OH
SR-100	The likelihood of inappropriate fight data information being provided by the Flight Data Processing system in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH1, OH2, OH3, OH30, OH33, OH60
SR-101	The likelihood of incorrect or missing arriving/departing procedures publications available to the controller in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH1, OH2, OH3, OH24, OH25, OH29, OH31, OH33
SR-102	The likelihood of incorrect or missing information concerning restricted areas in a	No higher performance is requested than for existing systems.	Open	OH5, OH8



SR#	Safety Requirement (integrity)	Validation Activity and Next activities/recommendations	V3 Status	Derived from OH
	MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	
SR-103	The likelihood of failure or degradation of ground-ground communication with adjacent ATSU units in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).		OH1
SR-104	The likelihood of failure or degradation of Surface-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area in a MRTM position shall be operationally acceptable as per regulation applicable to local	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an		OH12, OH13, OH17, OH18, OH21, OH27, OH58, OH60



SR#	Safety Requirement (integrity)	Validation Activity and Next activities/recommendations	V3 Status	Derived from OH	
	implementation.	acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).			
SR-105	In case surveillance data is available in the MRTM position, the likelihood that undetected inappropriate surveillance information on a flight is provided shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH02, OH04, OH06, OH08, OH22, OH29, OH33, OH44, OH60	OH03, OH05, OH07, OH09, OH25, OH30, OH43, OH57,
SR-106	In case surveillance data is available in the MRTM position, the likelihood of complete lack of traffic information shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH02, OH04, OH06, OH08, OH22, OH29, OH33, OH44, OH60	OH03, OH05, OH07, OH09, OH25, OH30, OH43, OH57,
SR-107	For a local implementation, corresponding	Specific SWAL level shall defined for the new Visualisation	Open	OH6,	OH7,



SR#	Safety Requirement (integrity)	Validation Activity and Next activities/recommendations	V3 Status	Derived from OH
	assurance level for the software development process of the relevant components of the Visualisation System and its availability shall be defined based on applicable regulation.	System based on the potential associated risk in case of failure of this equipment.		OH11, OH14, OH16, OH18, OH19, OH20, OH21, OH22, OH23, OH24, OH25, OH26, OH27, OH28, OH30, OH31, OH32, OH33, OH35, OH36, OH37, OH38, OH57, OH59, OH60
SR-108	The likelihood of failure or degradation of air-ground communication with traffic in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH2, OH3, OH4, OH5, OH6, OH9, OH10, OH12, OH14, OH17, OH18, OH19, OH20, OH21, OH22, OH24, OH25, OH25, OH26, OH27, OH29, OH31, OH32, OH33, OH40, OH42,



SR#	Safety Requirement (integrity)	Validation Activity and Next activities/recommendations	V3 Status	Derived from OH
				OH58, OH60
SR-109	The likelihood of incorrect MET/Weather information provided in a MRTM position shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH24, OH25, OH30, OH31, OH33, OH36, OH37
SR-110	The likelihood of loss or dysfunction of Visual Navigation Aids manoeuvred from a MRTM position shall be operationally acceptable as per regulation applicable to local implementation. Note: as per the results from this safety assessment the likelihood is to be no more than 5 times per year.	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).	Open	OH31, OH32, OH33, OH34
SR-111	The likelihood of loss or dysfunction of Non Visual Navigation Aids manoeuvred from a MRTM position shall be operationally	No higher performance is requested than for existing systems. In V3 no assessment on the failure cases for the system	Open	OH28, OH31, OH32, OH33, OH34



SR#	Safety Requirement (integrity)	Validation Activity and Next activities/recommendations	V3 Status	Derived from OH
	<p>acceptable as per regulation applicable to local implementation.</p> <p>Note: as per the results from this safety assessment the likelihood is to be no more than 5 times per year.</p>	<p>has been performed, and neither a SWAL. This can be based on the SESAR1 conclusions on Single Remote Tower but we strongly recommend to do an in-depth assessment before deployment so the system failure rate is at an acceptable level (e.g. average value derived from risk analysis in SESAR1 was no more than 5 times every 2 years).</p>		



Appendix C Assumptions, Safety Issues & Limitations

C.1 Assumptions log

The following Assumptions were necessarily raised in deriving the above Functional and Performance Safety Requirements:

Ref	Assumption	Validation
A-01	ATC resources (modules and cluster of aerodromes, planning, staff allocation and rostering, etc.) is strategically and pre-tactically managed in a way that allows the concept of the MRTM	

Table 21: Assumptions log

C.2 Operational Limitations log

The following Operational Limitations were necessarily raised during the safety assessment:

Ref	Operational Limitations	Resolution
L-01	RPAS were planned in the OSED/SPR/INTEROP but the SAR does not evaluate or validate if any differences would arise from the introduction of co-operative RPAS in the environment	
L-02	The OSED/SPR/INETROP Part I [1] described a layout with one or two runways and/or with a FATO; however this SAR does not cover these options as they have not been validated; some helicopter movements were tried during some of the validations but not in a specific FATO designated for it.	
L-03	The number of simultaneous movements depends on the traffic complexity	To be done in future steps

Table 22: Operational Limitations log

Appendix D Causal analysis for identified hazards

This appendix provides the several causes for each of the identified hazards in section 3.

Note that for the quantitative requirements the following unit conversion has been used (based on the operational environment description presented in section 3.2).

Also note that this is based in SESAR 1 work and that all data is not presented here.

D.1 Causal analysis for SOf-01

The likelihood that MRTM fails to coordinate and/or transfer with adjacent ATSU concerning inbound/outbound traffic shall be no more than 3.33e-4 per flight.hour (1e-5 per controlled hour)

FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4fh]	Flight Plan system
G-GCOM-001	G-G communication failure or degradation [1e-4fh].	G-G Comm
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4fh]	Surveillance data
ATCO-008	ATCo incorrectly coordinates with other ATSU for inbound/outbound traffic transfer [1e-3fh]	ATCo
POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	EXT
OATSUS-001	Incorrect information is provided by other ATS unit system concerning inbound traffic [1e-4fh]	Other ATSU unit

D.2 Causal analysis for SOf-02

The likelihood that MRTM fails to manage inbound traffic shall be no more than 4e-6 per flight.hour (1e-5 per controlled hour)

POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	EXT
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system

MET-001	Incorrect MET/Weather information [1e-4/fh]	Local MET system
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/fh]	Flight Plan system
AID-002	Incorrect arriving procedures are available or are not provided to the controller [1e-3/fh]	AI data system
ATCO-001	ATCo fails to manage arriving traffic in the vicinity of the aerodrome [1e-3/fh]	ATCo

D.3 Causal analysis for SOf-03

The likelihood that MRTM fails to manage outbound traffic shall be no more than 4e-6 per flight.hour (1e-5 per controlled hour)

POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	EXT
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm
ATCO-038	ATCo fails to manage departing traffic in the vicinity of the aerodrome [1e-3/fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
MET-001	Incorrect MET/Weather information [1e-4/fh]	Local MET system
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/fh]	Flight Plan system
AID-002	Incorrect arriving/departing procedures are available or are not provided to the controller [1e-3/fh]	AI data system

D.4 Causal analysis for SOf-04

The likelihood that MRTM fails to separate traffic shall be no more than 4e-6 per flight.hour (1e-5 per controlled hour)

POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	EXT
ATCO-003	ATCO fails to apply appropriate separation between aircraft on the vicinity of the aerodrome[1e-3/fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance	Surveillance

	information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm

D.5 Causal analysis for SOf-05

The likelihood that MRTM fails to separate traffic with respect to restricted areas on the airspace under control responsibility shall be no more than 3.33e-5 per flight.hour (1e-4 per controlled hour)

ATCO-014	ATCO fails to appropriately separate aircraft from restricted areas on the vicinity of the aerodrome [1e-4fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
AID-001	Information concerning restricted areas use is incorrect or missing [1e-4/fh]	AI data system
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm
SURV-002	Inappropriate Surveillance information concerning restricted areas in the vicinity of the aerodrome [1e-4/fh→]	Surveillance data
ATCO-011	Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [1e-4/fh]	ATCo

D.6 Causal analysis for SOf-06

The likelihood that MRTM fails to manage missed approach situations shall be no more than 4e-6 per flight.hour (1e-5 per controlled hour)

POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	EXT
ATCO-006	ATCo fails to manage go-around situations [1e-3/fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm

D.7 Causal analysis for SOf-07

The likelihood that MRTM fails to detect conflicts or potential collisions between aircraft on the airspace under control responsibility shall be no more than 1e-6 per flight.hour (1e-5 per controlled hour)

CONFLICT-AIR	Conflict in the vicinity of the aerodrome [1e-3]	EXT
ATCO-004	ATCO fails to detect in time conflicts and potential collisions on the vicinity of the aerodrome [1e-3/fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system

D.8 Causal analysis for SOf-08

The likelihood that MRTM fails to timely detect restricted areas infringements shall be no more than 3.33e-5 per flight.hour (1e-4 per controlled hour)

AIRSPACE-INF	Airspace infringement in the vicinity of the aerodrome [1e-2]	EXT
ATCO-009	ATCO fails to detect in time restricted area infringement [1e-2/fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
SURV-003	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-001	Loss of information on the vicinity of the aerodrome provided by VRS [1e-4/fh]	Visualisation system
AID-001	Information concerning restricted areas use is incorrect or missing [1e-4/fh]	AI data system

D.9 Causal analysis for SOf-09

The likelihood that MRTM fails to provide ATC instructions to resolve conflicts/avoid collisions on the airspace under control responsibility shall be no more than 1e-6 per flight.hour (1e-5 per controlled hour)

CONFLICT-AIR	Conflict in the vicinity of the aerodrome [1e-3]	EXT
ATCO-005	ATCo fails to provide appropriate instruction to solve conflict on	ATCo

	the aerodrome vicinity [1e-3/fh]	
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm

D.10 Causal analysis for SOf-10

The likelihood that MRTM fails to provide appropriate instructions to resolve airspace infringements shall be no more than 3.33e-5 per flight.hour (1e-4 per controlled hour)

AIRSPACE-INF	Airspace infringement in the vicinity of the aerodrome [1e-2]	EXT
ATCO-007	ATCo fails to provide appropriate instruction to solve airspace infringement [1e-2/fh]	ATCo
SURV-001	(In case this function is available) Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/fh]	Surveillance data
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/fh]	Visualisation system
AID-001	Information concerning restricted areas use is incorrect or missing [1e-4/fh]	AI data system
ATCO-011	Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [1e-4/fh]	ATCo
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm

D.11 Causal analysis for SOf-11

The likelihood that MRTM fails to identify departing aircraft on the stand for providing ATC service shall be no more than 0.01 per movement (or controlled flight)

ATCO-024	ATCo fails to correctly identify next aircraft in the departing sequence [1e-4/mov]	ATCo
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/mov]	Flight Plan system
VRS-005	Inappropriate information on APRON area is provided on VRS using binoculars-like function [1e-4/mov]	Visualisation system
ATCO-039	ATCO incorrectly provides information to departing aircraft during the start-up [1e-1/mov]	ATCo

A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm
MET-001	Incorrect MET/Weather information [1e-4/mov]	Local MET system

D.12 Causal analysis for SOF-12

The likelihood that MRTM fails to provide appropriate information to departing aircraft for the start-up shall be no more than 0.01 per movement (or controlled flight)

ATCO-010	ATCo identifies an incorrect departing AC for initiating the MRTM service [1e-3/mov]	ATCo
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/mov]	Flight Plan system
VRS-005	Inappropriate information on APRON area is provided on VRS using binoculars-like function [1e-4/mov]	Visualisation system
ATCO-039	ATCo incorrectly provides information to departing aircraft during the start-up [1e-1/mov]	ATCo
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm
MET-001	Incorrect MET/Weather information [1e-4/mov]	Local MET system

D.13 Causal analysis for SOF-13

The likelihood that MRTM fails to apply push-back-towing procedures shall be no more than 0.01 per movement (or controlled flight)

ATCO-010	ATCo identifies an incorrect departing AC for initiating the MRTM service [1e-2/mov]	ATCo
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/h/mov]	Flight Plan system
VRS-005	Inappropriate information on APRON area is provided on VRS using binoculars-like function [1e-4/mov]	Visualisation system
ATCO-040	ATCO incorrectly coordinated with airport personnel in charge of the apron for push-back/towing procedures [1e-2/mov]	ATCo
S-GCOM-002	Failure or degradation of the S-G communication with personnel in charge of the apron [1e-4/mov]	Surf-G Comm

D.14 Causal analysis for SOF-14

The likelihood that MRTM fails to provide conflict-free routing and taxi instructions to aircraft in the manoeuvring area shall be no more than 3.33e-03 per movement (1e-2 per controlled flight)

POT.CONFLICT-TWY	Probability of an aircraft/vehicle/obstacle in the proximity potentially creating a conflict [1e-1]	EXT
ATCO-016	ATCO identifies incorrect aircraft on the manoeuvring area (taxiways) [1e-2/mov]	ATCo
ATCO-015	ATCo fails to provide appropriate route instruction to aircraft on the manoeuvring area [1e-2/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

D.15 Causal analysis for SOf-15

The likelihood that MRTM fails to provide taxi instructions to vehicles in the manoeuvring area shall be no more than 3.33e-03 per movement (1e-2 per controlled flight)

POT.CONFLICT-TWY	Probability of an aircraft/vehicle/obstacle in the proximity potentially creating a conflict [1e-1]	EXT
ATCO-017	ATCO identifies incorrect vehicle on the manoeuvring area (taxiway) [1e-3/mov]	ATCo
ATCO-018	ATCO provides inappropriate route instruction to vehicle on the manoeuvring area (taxiway) [1e-3/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
S-GCOM-001	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	Surf-G Comm

D.16 Causal analysis for SOf-16

The likelihood that MRTM fails to detect conflicting situations in the manoeuvring area shall be no more than 5e-04 per movement (1e-3 per controlled flight)

CONFLICT-SURF	Conflict on the manoeuvring area of the aerodrome [1e-2]	EXT
ATCO-019	ATCo fails to detect in time conflict on the manoeuvring area [1e-1/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
VRS-009	Loss of information on manoeuvring area on the VRS [1e-4/mov]	Visualisation system

D.17 Causal analysis for SOF-17

The likelihood that MRTM fails to provide taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions in the manoeuvring area shall be no more than 5e-04 per movement (1e-3 per controlled flight)

CONFLICT-SURF	Conflict on the manoeuvring area of the aerodrome [1e-2]	EXT
ATCO-020	ATCo fails to provide appropriate instruction to solve conflicts on the manoeuvring area [1e-1/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm
S-GCOM-001	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	Surf-G Comm

D.18 Causal analysis for SOF-18

The likelihood that MRT fails to support aircraft and vehicle movements on the manoeuvring area shall be no more than 0.01 per movement (or controlled flight)

ATCO-021	ATCo fails to provide appropriate navigation support to AC and vehicle on the taxiway using Visual Navigation Aids [1e-1/mov]	ATCo
VNAM-001	Loss or dysfunction of Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	Visual Navigation Aids system

D.19 Causal analysis for SOF-19

The likelihood that MRTM fails to manage runway entry for departing aircraft shall be no more than 5e-7 per movement (1e-6 per controlled flight)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-024	ATCO fails to correctly identify next aircraft in the departing sequence [1e-4/mov]	ATCo
ATCO-022	ATCO allows aircraft to line-up in a runway already being used [1e-4/mov]	ATCo
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system

D.20 Causal analysis for SOF-20

The likelihood that MRTM fails to manage runway exit for landing aircraft shall be no more than 5e-7 per movement (1e-6 per controlled flight)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-023	MRTMo fails to provide appropriate runway exit instruction to landing aircraft [1e-4/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm
S-GCOM-001	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	Surf-G Comm

D.21 Causal analysis for SOF-21

The likelihood that MRTM fails to manage aircraft/vehicle runway crossing shall be no more than 5e-7 per movement (1e-6 per controlled flight)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-025	ATCO identifies an incorrect aircraft or vehicle for crossing the runway [1e-4/mov]	ATCo
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm
S-GCOM-001	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	Surf-G Comm

D.22 Causal analysis for SOF-22

The likelihood that MRTM fails to support aircraft for take-off and landing operations shall be no more than 5e-7 per movement (1e-6 per controlled flight)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-026	ATCo fails to provide appropriate navigation support to departing/arriving AC on the runway using Visual Navigation	ATCo

	Aids [1e-4/mov]	
VNAM-001	Loss or dysfunction of Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	Visual Navigation Aids system

D.23 Causal analysis for SOf-23

The likelihood that MRTM fails to carry out vehicle related tasks on the runway shall be no more than 5e-7 per movement (1e-6 per controlled flight)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-031	ATCo allows vehicle to enter/operate in a runway which is being used [1e-4/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
S-GCOM-001	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	Surf-G Comm

D.24 Causal analysis for SOf-24

The likelihood that MRTM fails to manage aircraft take-off shall be no more than 5e-7 per movement (1e-6 per controlled flight)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-027	ATCo provides take-off clearance for departing AC in a runway already being used [1e-4/mov]	ATCo
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

D.25 Causal analysis for SOf-25

The likelihood that MRTM fails to manage aircraft landing shall be no more than 5e-7 per movement (1e-6 per controlled hour)

POT.CONFLICT-RWY	Probability of an aircraft/vehicle/obstacle on (or close to) the runway potentially creating a conflict [1e-2]	EXT
ATCO-028	ATCO provide landing clearance for a runway already being used [1e-4/mov]	ATCo
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

D.26 Causal analysis for SOf-26

The likelihood that MRTM fails to detect runway incursions and potential collisions on the runway shall be no more than 3.33e-6 per movement (1e-5 per controlled flight)

RWY-INC	Potential runway incursion (aircraft / vehicle / animal / person) [1e-1]	EXT
ATCO-029	ATCO fails to detect in time a runway incursion [1e-4/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is provided on VRS [1e-4/mov]	Visualisation system
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
VRS-009	Loss of information on manoeuvring area on the VRS [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
VRS-012	Loss of information on final approach on the VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

D.27 Causal analysis for SOf-27

The likelihood that MRTM fails to provide instructions to resolve runway incursions and prevent collisions on the runway shall be no more than 3.33e-6 per movement (1e-5 per controlled flight)

RWY-INC	Potential runway incursion (aircraft / vehicle / animal / person) [1e-1]	EXT
ATCO-032	ATCo fails to provide appropriate instruction to solve runway incursion and prevent potential collision [1e-4/mov]	ATCo
VRS-007	Inappropriate information on manoeuvring area (taxiways) is	Visualisation

	provided on VRS [1e-4/mov]	system
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm
S-GCOM-001	Failure or degradation of voice communication with vehicles on the manoeuvring area [1e-4/mov]	Surf-G Comm

D.28 Causal analysis for SOf-28

The likelihood that MRTM fails to detect flight towards terrain situations shall be no more than 1e-7 per controlled flight

POT.CONFLICT-TERR	Probability of a controlled aircraft flying towards terrain [1e-4]	EXT
ATCO-033	ATCO fails to detect in time a flight towards terrain [1e-3/mov]	ATCo
VRS-001	Loss of information on the vicinity of the aerodrome provided by VRS [1e-4/mov]	Visualisation system
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
VRS-012	Loss of information on final approach on the VRS [1e-4/mov]	Visualisation system
SURV-001	Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/mov]	Surveillance data
SURV-003	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/mov]	Surveillance data

D.29 Causal analysis for SOf-29

The likelihood that MRTM fails to warn/support pilot on CFIT situations shall be no more than 1e-7 per controlled flight

POT.CONFLICT-TERR	Probability of a controlled aircraft flying towards terrain [1e-4]	EXT
ATCO-034	ATCO fails to provide appropriate instructions and information for solving CFTT situation [1e-3/mov]	ATCo
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/mov]	Visualisation system
VRS-010	Inappropriate information on final approach area is provided on	Visualisation

	VRS [1e-4/mov]	system
SURV-001	Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/mov]	Surveillance data
SURV-003	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/mov]	Surveillance data
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

D.30 Causal analysis for SOf-30

The likelihood that MRTM fails to establish/maintain sufficient wake turbulence spacing between landing/departing aircraft shall be no more than 4e-5 per flight (1e-5 per controlled flight)

CLOSE TRAFFIC AIR	Probability of needing to apply wake turbulence spacing between aircraft [1e-2]	EXT
ATCO-035	ATCo fails to create sufficient WT spacing between landing/departing aircraft [1e-3/mov]	ATCo
VRS-010	Inappropriate information on final approach area is provided on VRS [1e-4/mov]	Visualisation system
SURV-001	Inappropriate Surveillance information concerning AC ID and position in the vicinity of the aerodrome [1e-4/mov]	Surveillance data
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/mov]	Flight Plan system
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

Appendix E HP and Safety Workshop

Considering the low amount of data received in terms of Safety Questionnaires, it is not possible to assess with a sufficient level of confidence if Multiple Remote Towers are as safe as Single Remote Towers from the questionnaires alone. The Safety Questionnaires however confirm certain observations and conclusions derived from observation at the Validation Exercises and from the extended discussions with ATCOs at the HP and SAF workshop that took place on the 3rd and 4th April 2019 in Brussels at EUROCONTROL's Headquarters. Assistants to this workshop included ATCOs from AVINOR, COOPANS, DFS and Hungarocontrol, and Solution leaders and contributors from COOPANS, DFS, DLR, ENAV, Indra, Hungarocontrol and EUROCONTROL.

E.1 Results from Safety Questionnaires

As stated above, there was limited feedback from the Safety Questionnaires during the V3 exercises. Subsequently their quantifications will not be presented here.

The questionnaires provide some general representation of the aspects that were simulated and those that were not, and the tools that they found useful. For instance, from the results of the questionnaires we corroborate that most ATCOs feel that their capability to do a task was the same or worse with MRT than with SRT; this might not mean much in itself, as it is something to be expected, but what is interesting is the tools that helped the ATCOs realise the task despite the added complexity of managing more aerodromes. Self-reporting has the caveat that some ATCOs tend to be more confident and assess their capability to perform their tasks as high as with a SRT, while other ATCOs are more self-critical and despite reporting that they could do the job they felt that they couldn't do it with the same capability as with SRT.

The Questionnaires also reveal, as do the results from the Validation Exercises, that no scenarios involving military or restricted areas were in the scope of PJ05. Some scenarios involving communication with ATSUs were very limited as well.

Regarding the main elements supporting the tasks, there is in some cases an overwhelming agreement on the tools that were more useful. Here the main elements that were highlighted in the questionnaires (with ">" meaning "more useful than", and ">>" meaning "significantly more useful than"):

- Visual reproduction: Basic image, Object bounding (Labelling)
- Overlays: radar tracking >> AD map overlays /MET overlays
- PTZ: Basic PTZ
- System Support: Planning tool
- ATS systems: electronic flight strips >> ground surveillance >> air surveillance >> communication systems

This has not changed significantly from the results in V2. The questions included in the questionnaire have been implicitly discussed in the HP and SAF workshop as well, and we are satisfied that the results can provide good evidences for the safety assessment on the work that has been done. We also notice that some Validation Exercises lacked scenarios on abnormal conditions, and more specifically in degraded modes.

In the sections below, the different Safety Validation Objectives are assessed in order to ensure that they are covered by the workshop and other validation activities.

E.2 Notes from Safety and Human Performance workshop

E.2.1 Nominal Cases

ROLES AND RESPONSIBILITIES

Additional 'ATCO': Options depending on the traffic situation in other:

To temporarily delay / stop / suspend traffic – coordination with APP controller is needed.

Termination of service (longer term)

Requirement: not to request an additional controller for all cases; e.g. in case that the traffic amount/complexity, operational environment (weather, day/night, etc.) allows for only one (ex: night with low complexity).

For 3 airports: everybody seem to agree on the need for an additional controller, or someone else to take over some tasks (e.g. coordination tasks, communication).

The requirement needs to state that this other ATCO or support person must be available when needed (to detail locally, considering rostering and breaks).

The requirement is to be a "SHALL" in case 'termination' is not an option. We need to reword it properly.

HC: they had a situation with emergency and the controller managed the situation but with a lot of delay, and the blocking point was the communication; having a planning controller taking on the coordination would be enough.

Coordination task:

Workload was manageable in simulations but in some cases it was not part of the exercises.

HC: they included coordination tasks with APP*. So the conclusion was that sometimes there was too much communication, but mainly during emergency situation (in nominal situations it was OK).

**Later in the workshop it turned out that HC has to record the ATIS manually at Debrecen and PAPA which would as well increase the communication load.*

There were other tasks that have not been tested, and some of them were simplified (e.g. military activities and coordination, etc.). The purpose was to harmonised procedures for all aerodromes, maybe including silence coordination.

Supervisor

They are responsible for planning resources. This is new for the supervisor (planning allocation).

In different airports/countries supervisors have very different tasks. E.g. in HUNGAROCNTROL they handle all emergencies, rather than the ATCOs. Following an emergency situation the ATCO would normally be required to leave the working position. Perhaps just delaying traffic after an emergency would be a possibility to "recover" after intense traffic situations, not just emergencies.

Any other additional tasks: additional coordination in case of failure situations. In fact the tasks might be the same as currently but more complex.

ON feedback: supervisor to identify when a new position needs to be open (split an AD, transferring from one Module to another than can take it), but the controller should be able to decide the best moment for the transfer, even if the responsibility remains on the supervisor.

Workload tool is a requirement for the SUP position and a recommendation for the ATCOs in a Remote Centre. The ATCO might not know the workload that they create for another colleague when asking for a transfer or might not be aware how the aggregated traffic would impact their workload following a merge.

OPERATING METHODS:**Clustering:**

- Same RWY direction (geographical specificities), have been considered and tested by COOPANS; inconclusive if this would be a problem long-term.
- HUNGAROCNTROL: Aerodrome local procedures - e.g. for emergency - need to be harmonised among the aerodromes in the same cluster/module. COOPANS considers this unlikely as all aerodromes have different needs. Requirement can be to harmonise as much as possible considering local particularities.
- The ATCOs perceive a risk in making errors related to mixing local procedures. They consider they might not be so vigilant in assessing situations involving local procedures (hence losing more time in providing answers to pilots) as they would if controlling only one AD. The more ADs one has to provide control to, the higher the risk. There is not only a risk of mixing procedures, but a benefit in terms of time efficiency, as when procedures are harmonised the ATCO does not need to mentally swap between them when applying them.
- Training is a requirement for enhancing ATCOs' familiarity with all local procedures (currently up to 3 ADs and always the same ADs for one ATCO)
- It was observed in simulations with 3 ADs that under high workload, ATCOs would go back to using the local procedures they were used to from the AD they normally work for in real operations – this could be a matter of training, in the long term.
- The clustering option of ADs based on local procedures should be evaluated.
- Having the same systems for all aerodromes would enhance the possibility for silent communication (less workload, more time to manage traffic and detect conflicts, potentially safer).

PJ05.02 V3 Procedures:

- Harmonised procedures: need to be more detailed, type of procedures, etc. Renée will come back with a proposal in the report (after coordination with HC). The purpose would be to save time for the ATCO e.g. procedures on coordination, frequencies to contact, altitudes in AIP/ initial altitude included in the clearance, etc. The harmonisation of e.g. emergency procedures was already simulated; all 3 airports had the same emergency procedure (sequence whom and how to contact etc.).
- Traffic level: 20 movement per hour (30 for HC) for the module

PJ05.02 V3 Procedures:

- Clustering AD: should be done considering avoiding confusions and to limit workload
 - taking into account geographical specificities
 - Runway directions should be ok.
 - Harmonised procedures: this can be difficult as there would also be differences.
 - Traffic type as well (maybe)
 - Weather
- For the split and merge, other things need to be considered too:
 - The endorsements of the controller to which a cluster is assigned has to be taken into account as well. There is no max number of endorsed AD for the moment for a controller.
- Traffic level : 30 movements per hour for the module

HUMAN AND THE SYSTEM

Direction finger:

This requirement has disappeared.

E-strips:

- Different implementations have been tested.
- This is not a specific requirement for multiple, as it was already for Single. The only thing with multiple is to ensure its usability (have enough space, being properly located, etc.) which has to be stated for multiple (see later) as the space is limited and the requirement is to see the information at all times and to be able to distinguish information easily.

Display:

- Greyed out information should be for non-active aerodromes. Non-active runways are indicated as well, usually in red.

VISUALISATION

Visual and non-visual: ILS and lights: not all tested in all the validation exercises, mainly for technical constraints.

- Information on the status of the lights and no-visual aids should be always and easily visible for the ATCO, and it has to be easy to identify to which aerodrome they correspond.

Minimum information to be displayed:

- as defined for Single; non-mandatory information should be hidden as selected by the ATCO in order not to clutter the view and to make it easy to find important information.
- Dark time was not tested in V3.

Weather information: same requirement as per Single.

- The only additional thing should be to decide if the MET information should always be displayed or not.
- Supervisor should have a weather forecast (constant MET briefing for all the aerodromes in the RTC) in order to plan better. A tool should be needed for that.
- ATIS information includes weather but it was not simulated, and that would mean more use of frequency, and potentially more time for the ATCO to record them if it's not automated or semi-automated ATIS, as it has to be recorded every hour.
- If there is no ATIS or no automatic one, then capacity needs to be reduced in Solution 02 (to allow the ATCO to record it). The way it's done should be defined in the implementation phases.

Camera positions:

- Blindspots: not all the areas are visible. Manoeuvring area is visible, apron might not be visible, but should be visible if the ATCO has any responsibility in the apron too (agreement with the local aerodrome). Even if not having a responsibility, it is worth seeing the apron for planning reasons as they can anticipate who will be entering the manoeuvring area, when and where.
- In HC: The problem is not just to find the optimal position for cameras, but to be able to install them in the aerodrome as there are regulations limiting the installation of those cameras (in high for example).
- Marcus: we need to make the difference between Budapest airport (large airport) and the other mediums ones for which Remote Tower is to be applied. Do not generalise too much, otherwise there will be too many constraints and the CBA will just not work.

- This requirement is the same already for Single, so no need for a new one. The only additional thing to take into account is:
 - when two aerodromes have the same runway direction but for which the cameras are in the opposite side; this can be disturbing in particular to control VFRs. HC and DFS tested similar scenarios but they were not confused (they adapted easily, making a clear distinction between the aerodromes).

Information displayed in the label:

The label should be adjustable if used (based on radar information)

PTZ:

- for Avinor it was not used in the validation for technical constraints.
- PTZ is a requirement as for single, and Automatic PTZ is not a requirement.

Current tasks (SR-16):

Less able to perform some tasks, namely monitoring other AD while doing something in one AD.

Sound could help to keep a better situational awareness – but could be confusing from 3 aerodromes. If not, some other ways should be put in place to indicate what is happening in the other ADs while not monitoring them (based on surveillance for example, but ground surveillance one not available everywhere).

In Multiple Remote tower the way of managing the traffic might change with respect to current situation, as things can be missed (late detections, etc.). Maybe delaying traffic or working more conservatively.

Landing and take-off: critical phase, the ATCO needs to monitor them closely. A tool could help the ATCO to tell them that there is an aircraft on short final for example.

Very unusual feeling described by the ATCOs from Avinor as they were not able to watch the landing and departing A/C at all times, given the simultaneous movements. Additional alerts shall be considered in order to enhance the awareness in the absence of sound. E.g. rimcas (currently only in big aerodromes).

AI DATA, ALERTS, ETC.

In AIP should be indicated if an airport is part of a cluster so service is Provided from a Multiple Remote Tower (even if sometimes is provided as Single).

Alerts needs to be provided for each airport in a clear and easy way.

COMMUNICATION

Airport Name:

AD name: true for everybody except for Avinor (they used “Remote”). They used the name from time to time also because that is what they do today, but it would be a matter of training.

Rather than “Remote”, if anything, they should use “Multiple Remote”, because the fact that the ATCO controls more than one AD and that there are other AD on frequency is what makes it different for pilots too.

APP ATCO could add information in one simple command when transferring A/C to TWR, informing it is Multiple Remote Tower; this could be an extra barrier in enhancing the awareness of pilots.

Once communication is established, it is still not clear if the ATCO and pilot need to keep adding the name of the AD at every communication or clearance (maybe for clearances). This would be the closest to today.

In LFV they always use the AD name with the RWY, every time. It's easier than having to think in which situation use it or not.

Potential problem of similar call sign needs to be considered for communications with pilots from different ADs.

No pilots have been truly involved in the discussions, so in the scope of PJ05 it is not responsible to state that changing the procedure for pilots would be possible.

More discussions with airlines on phraseology and potential frequency congestion should take place.

Information campaigns - HP requirement for flight crew to read NOTAM and other documents pointing out they are communicating with a Multiple Remote Tower to enhance awareness about coupled frequencies. If pilots are required to read back the airport for multiple remote towers only, this might be dismissed as they are not in the habit of always doing so in conventional aerodromes. Currently in the Jeppesen charts there is an indication of « remote », perhaps with the introduction of multiple remote towers there shall be an indication on « multiple remote ».

Note: Concerning the GM from EASA, the proposal was not to use Remote as it was not seen as necessary, but based on the experience on Single only, not Multiple. As mentioned before, it could be worthwhile to use the denomination of Multiple.

Communication with vehicles:

System that allow a request of communication from the vehicle (push to talk) so the ATCO is aware a vehicle wants to talk with them but can choose the moment that suits them. This functionality comes from military. DFS has something like that. ATCOs are very keen on this as the sufficient training of vehicle drivers is not guaranteed, from their experience.

A way to implement it would be displaying on the panorama that a vehicle is calling from a specific aerodrome (no need to change the comm system like that).

You can have an indication as well on in which frequency a call has been received.

Avinor uses 2 frequencies, one for ground-ground, another for ground-tower. So the frequency is not too busy for the ATCO. HC have the same but because of lack of training ground vehicles were using the frequency for the tower for communications ground-ground.

Ground frequencies should not be coupled between aerodromes. So ATCO have to select the right frequency to talk with each aerodrome vehicles.

As per DLR, there was no main problem on identifying who was calling each time.

LFV tested a scenario where many vehicles/aircraft called at the same time. They have an indication on the frame of the screens about who is calling. There was no main problem, ATCOs managed the situation (asking com again, etc.).

Nevertheless Ground communications are the most disturbing ones, one may miss call from an A/C because a vehicle is calling at the same time (they don't know ATCO is busy). So a system to 'hold on' those comms could help, in particular in Multiple RT.

HC uses some procedures for vehicles in order to reduce the number of ground-tower communication.

As per RWY Incursion prevention plan, one recommendation is to have the vehicles in the air frequency when they are in the runway, in order to have a common situational awareness. This implies a transfer of frequency between ground and air for vehicles. This is done in most of the German and French airports.

This has not been tested in any validation. More training for ground drivers might be necessary; many of them do not speak English but being in the frequency might nevertheless give them awareness of the line being busy or other movements i.e. aircraft being on the RWY. Vehicles on the runway will be in the same frequency as all aircraft/vehicles in the runway for all the aerodromes. To be included as recommendation.

E.g. In Italy they have a coordinator that manages the ground frequency and the call and who coordinates with the tower ATCO for the use of the runway.

Contacting airport personnel:

- HC simulated emergency situation. The first thing was to harmonise the emergency procedure for the 3 aerodromes. While dealing with the emergency (coordinating, etc.), there was few time to communicate and take care of the other aerodromes. And this was in a simulation, so in real life the overload would be much higher. The procedure should be to split the other two aerodromes as soon as possible. This is where you need someone else for manage the other 2 aerodromes (Solution 02).

E.2.2 Abnormal

Unexpected flights:

- VFR may be unexpected but this is not abnormal.
- The real issue is A/C not contacting the controller:
 - It can take longer to detect depending on the direction A/C comes from.
 - Sound may help, as well as radar (if the traffic has a transponder). Radar presentation is a requirement, but radar coverage depends on the aerodromes.
 - The possibility of detecting unexpected flight visually might be lower without 360° view.
 - Detecting drones might be complicated as well.
 - Managing the situation: might take time and resources.

In those abnormal situations a solution would be to split (Solution 02: having someone helping, Solution 03: transfer to another module). But the time it takes to do the split is to be taken into account as during the split one cannot be managing an emergency situation. Splitting two AD will take even longer. Controllers prefer to keep the airport with abnormal situation.

In some cases a situation is so unexpected that the ATCO doesn't even have time to split. The ATCO has to manage the situation with all the ADs: this reinforces the idea that when providing multiple remote tower service traffic has to be managed in a more conservative way in order to be able to cope with these unexpected situations.

E.2.3 Splitting and transferring

Planning tool:

- for the ATCOs this was a “nice to have” tool; it makes things easier –improving efficiency- as ATCOs don’t need to check FLP for each AD and they can foresee peaks and lows. It can be a “SHOULD” requirement.
- For the supervisor it would be mandatory, as they have the view of the entire centre that might be 15, 20 aerodromes. ATCO has the view of up to 3 aerodromes, the ones in the module.
- The timeframe they will need and use might be different (e.g. 30min for ATCO and hours for the Supervisor).
- Nice to have a representation of all aerodromes separately as well as coupled, otherwise mental calculation is required.
- To be noted, though, that the planning tool can only take into account planned events (traffic with FPL) but not all the unexpected flights (e.g. VFR without FPL). A possibility would be to make mandatory FPL even for VFR in AD remotely controlled. Or make assumptions on the Planning Tool to account for that (extra buffer?). The planning tool shall eventually account for the available endorsements as well (to clarify how many - up to 4?).
- Indra: in the tool for the ATCOs they also displayed the callsigns so they could expect who was to call for example.
- Split: they all used a checklist for the split which is based on current checklists for other situations at aerodromes.

SPLIT/MERGE (SR-17)

- Planning tool may help to decide when and which one to transfer.
- Time for split depends on weather, complexity, etc. in the corresponding ADs; the technical transfer was about 10-15 seconds, then some time (some minutes) for the second ATCO to take control and the first one to release it. A handover-like check list was applied for the split.
- Maybe, by default, the same view on the AD transferred that the initial ATCO is using should be provided to the second ATCO in order to quicker understand the situation.
- A fixed position for one/several aerodromes could help reduce confusion.
 - However there was no full agreement on whether the fixed or flexible configurations were more appropriate
 - The advantage of fixed configuration would be to easily take over by another ATCO in case it’s needed. If everything is customised, the next ATCO will find it difficult to understand the situation and the handover will take longer. In case of flexibility in configuration is done, then a “default” configuration should be easily available. And in flexible allocation and configuration some rules need to be established.
- Closing an aerodrome or several has not been simulated/tested. Current procedures should apply, contacting the APP to take traffic away.

Communication failure: lamp signals on the PTZ could be used (tested in Sundsvall and pilots could see it; more on this in Communication and in Degraded).

WORKSHOP Conclusion: The split is supposed to follow a checklist in order to transfer to an available MRTM. The time and focus that it takes to split would be taken into consideration when splitting because of an emergency. In the validation exercises the split was either suggested by the supervisor

or decided by the ATCO because of traffic increase or complexity. The transfer was working in the platforms that were observed, and the ATCOs seemed to be comfortable with the procedure.

E.2.4 Degraded

- In Single and Multiple: same alerts in case of last of communication or other systems.
- Mitigation means are to be applied in case of failure for one AD: e.g. split. If the failure affects all the AD, then termination of the service, but this may take some time. Mitigation needs to be defined for each case, locally.
- It has not been tested in the exercises.
- Screen freezing is a failure that is more complicated to detect than the loss.
- Even applying the same mitigations means for each AD as per Single implementing them will never be as obvious in Multiple, and it can affect the service provided in the other AD.

PJ05.03, loss of Supervisors planning tool:

- Limit the capacity in each AD and also the number of AD in the RTC, or more controllers are needed if possible (if Modules and people allow).
- The plan will take more time as it will be done manually: support without optimising cost-efficiency, split as much as possible.
- The tool helps in making the RTC more efficient, but surely to be able to cope with more AD in the RTC.
- Tasks of Supervisor have not yet been really defined.
- Supervisor is more in the strategic planning (even on the day of operations), so failure of systems is less critical but criticality is still there. Supervisor is doing the role of supervisor and Flow Manager (as analogy with ACC). Mitigation means need to be put in place, maybe similar to ACC.

It is assumed that all the requirements derived for ATC are covering AFIS as well. Unless a different solution is to be used, then new assessment needs to be done.

Screens

COOPANS: In the case of frozen screen/s, there is an indication and an alert.

1 screen failure: using PTZ should solve the situation in the short term, removing traffic and then applying LVC procedures.

All the screens: LVC procedures can be applied.

There is also the possibility of switching to the other screens in the case that there is no traffic in the other aerodrome(s).

HC: The platform is not able to switch screens, but ATCOs would accept to switch screens in case of failure.

COOPANS: There may be legal problems in the case of no longer monitoring an aerodrome because of this switch.

Communication

COOPANS: It's the same as in single remote tower. The main problem would be if common fails for all the aerodromes at the same time. There is an emergency frequency for communicating with pilots, and a dedicated line with aerodromes.

Due to frequencies being coupled, pilots would potentially have less awareness in distinguishing flights from other aerodromes or their own, and having a full picture of the amount of traffic. The phone could be an option as well, and back-up batteries to keep up the system running too.

Radar

COOPANS: The service can still be delivered despite degradation of the radar, with a possible impact on capacity but not on safety. ATCOs would ask pilots to report their position, and this would be a higher workload for both.

Flight Planning

COOPANS: This system is useful for capacity but wouldn't affect safety. In the detection of a failure would be the same as for single remote towers. Once the failure or degradation is detected, ATCO can continue to work by manually writing down the flight plans (as with a pen and paper).

Planning Tool

COOPANS/HC: It is equivalent to the e-strips system. This is a "nice to have" feature. If the planning tool does not work properly (e.g. not forecasting the right information), there are other systems providing the same information. There is no great impact in losing this feature.

Other

HC: ILS, PTZ, etc. – there are other systems that can fail too. It should be taken into account that some systems may be part of the same HMI, and they would fail at the same time.

Combination of failures

The type of traffic can impact on the basic needs to keep providing service – VFR needs radar for example, IFR could be managed without.

In order to provide a full service with peak traffic, the only tool that can fail of the aforementioned is the planning tool.

In order to provide full service with nominal traffic, the planning tool and the radar can fail – but this depends on the type of traffic; VFR needs radar for example, IFR could be managed without.

In order to provide the minimum service needed to deal with the current traffic but rejecting new departures (contingency situation): communication can fail on one aerodrome, and either the radar or the screens can fail, but not both at once.

To sum up, certain circumstances will need to be considered for each case: type of traffic, amount of traffic, airspace classification, etc.

Complexity

A contingency plan needs to be defined on how to deal with each possible situation. There is a discussion on the need of a back-up system (or a more robust system). In a conventional tower there is still the possibility to go outside with the radio and use visual monitoring, but in single or multiple remote towers it is not possible.

These constraints are the same for both single and MRTM.

PJ05.02:

1. Sequencing task: controller providing the sequence for landing at the same time for several aerodromes, for VFRs.

- This could be confusing and controller might mix-up the sequences.
- Mitigations would be to either split or hold traffic.
- It has not been tested as such. But managing VFR has been tested in other stress situations. The tendency is to focus on one AD and to provide a more conservative service to the others. Controllers need to be able to decide when they need to split. So the solution would rather

be on letting the controller decide (to split, to delay, to manage traffic differently) instead of identifying specific situations in which a split is 'mandatory'.

- Training requirements on this should be defined.

2. Design of the tools and systems of the platforms.

- Recommendations should be provided on the best options in terms of design, location of information, colouring, and other HMI and ergonomic factors from a Human Performance perspective. But this is difficult to be done in detail as each validation uses different platforms, and because it was simulations most of the time, and because in SESAR we don't get to a physical level.
- It has not really been done, at least not in detail and exhaustively (could be done comparing errors on different platforms for example).

3. Fatigue:

- the runs during the validation exercises couldn't allow to measure this, as they were too short and not enough runs; also, not everybody experience fatigue in the same way (difficult to simulate, it would need an exhaustive scientific experiment).
- Fatigue studies should be done during ops phase. Nevertheless no fatigue studies have been done for Single Remote Tower and not even for conventional towers.
- National rules/laws/regulations may limit the time a controller is to be sitting and working in front of the screens and how long the breaks need to be.

E.3 Validation Objectives: SAFETY – Nominal

E.3.1 OBJ-PJ05.02-V3-VALP-S01 – Results

OBJ-PJ05.02-V3-VALP-S01	Assess whether the levels of safety are maintained or improved under all normal conditions when ATS are remotely provided to multiple airports	CRT-PJ05.02-V3-VALP-S01.010	The Safety Acceptance Criteria are satisfied (i.e. no increase of risk with respect to a situation in which ATC services are remotely provided by a ATCO to a single remote tower). Note: A risk assessment is performed.
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WORKSHOP Conclusion: ATCOs were able to perform most tasks with the same level of safety as they would in a Single Remote Tower. Depending on the workload, ATCOs might need to prioritise tasks between ADs. In some cases an additional person may support these tasks in order to maintain capacity (e.g. in coordination, weather and runway conditions check-ups, etc.).

E.3.2 OBJ-PJ05.02-V3-VALP-S04 – Results

OBJ-PJ05.02-V3-VALP-S04	Assess ATCO capability to provide ATC services in a safe manner to multiple aerodromes under all normal conditions	CRT-PJ05.02-V3-VALP-S04.010	ATCO is able to identify and solve potential conflicts in a timely manner: · In the vicinity of the aerodrome · In the runway area · On the manoeuvring area
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WORKSHOP Conclusion: ATCOs are able to maintain safety while detecting and managing conflicts. The only difference with respect to SRT discussed with ATCOs was that the monitoring of all aerodromes at all times is not feasible and depending on the complexity of the traffic this might contribute to ATCOs workload. As the ATCO cannot constantly monitoring all the AD, an automated (or even AI) system could do it in their place. This should be part of the training as well, as the ATCO would need to change their tasks and ‘accept’ that they cannot monitor constantly. This has been part of the discussions but would need to be further investigated prior to implementation.

OBJ-PJ05.02-V3-VALP-S04	Assess ATCO capability to provide ATC services in a safe manner to multiple aerodromes under all normal conditions	CRT-PJ05.02-V3-VALP-S04.020	ATCO is able to identify and solve hazardous situations in a timely manner (e.g.): · Unstable approaches · Bird strikes
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			· Aircraft not vacating RWY as expected
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WORKSHOP Conclusion: Supporting tools to identify hazardous situations, e.g. runway incursions, could be helpful to the ATCO. The panorama views don't always allow to see certain things if they are too small.

OBJ- PJ05.02-V3-VALP-S04	Assess ATCO capability to provide ATC services in a safe manner to multiple aerodromes under all normal conditions	CRT- PJ05.02-V3-VALP-S04.030	ATCO is able to distinguish with which aircraft, vehicle at which aerodrome the ATCO is communicating with
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WORKSHOP Conclusion: ATCOs had no apparent issues in distinguishing the caller and the aerodrome they were calling from. Different validation platforms had different ways to support the ATCO (colours, sound, highlights, etc.), which were nice to have. Frequencies were coupled for all aircraft. For vehicles, they agree that they should be separate for each aerodrome. A functionality inspired in the military, the push-to-talk, is desirable by ATCOs in order for vehicles not to congest the frequency. ATCOs can then deal with the vehicle communication once it is suitable for them.

OBJ- PJ05.02-V3-VALP-S04	Assess ATCO capability to provide ATC services in a safe manner to multiple aerodromes under all normal conditions	CRT- PJ05.02-V3-VALP-S04.040	ATCO is be able to distinguish with which sector the ATCO is communicating with
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WORKSHOP Conclusion: This specific criteria has been considered unnecessary by the Solution team as the ATCO shall contact the sector by their own initiative. This means that they would need to have a clear indication of the phone number of each sector in order to distinguishing them – but this is hardly a technological requirement as it could be simple piece of paper and the training necessary would be limited if at all. We are therefore closing this validation criteria as N/A if agreed by the SJU, but could be marked as fully covered as we do not see any safety issue related to this.

OBJ- PJ05.02-V3-VALP-S04	Assess ATCO capability to provide ATC services in a safe manner to multiple	CRT- PJ05.02-V3-VALP-	ATCO is not inducing more conflicting
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	aerodromes under all normal conditions	S04.050	situations than in SRT
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WORKSHOP Conclusion: According to ATCOs self-reporting, results from validation exercises and expert judgement, there is nothing suggesting that ATCOs induce conflicting situations in the MRTM setting more than they would in a SRT. As covered by previous CRT-PJ05.02-V3-VALP-S04.010, they would feel more reassured if they could rely on some tool as a safety net, in order to be alerted if there was a conflicting situation that they missed. They did not induce more conflicts than in SRT and traffic was manageable.

E.3.3 OBJ-PJ05.02-V3-VALP-S05 – Results

OBJ- PJ05.02-V3-VALP-S05	Assess ATCO capability to perform specific procedures related to MRTM capabilities in a safe manner	CRT-PJ05.02-V3-VALP-S05.010	ATCO is able to foresee traffic at his/her MRTM at short term in order to avoid overloads
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WORKSHOP Conclusion: ATCOs were ahead of traffic and were able to monitor and manage movements even in parallel operations. When traffic was too high they felt that communication took a big part of their time and focus. Without being able to split or be supported by an additional ATCO, it was suggested that additional features maximising silent communication would help. A planning tool also helped them during some validation exercises to organise traffic ahead and slow it down if necessary.

More on the planning tool in the specific section dedicated to split&merge, section **E.2.3**.

E.4 Validation Objectives: SAFETY – Abnormal

E.4.1 OBJ- PJ05.02-V3-VALP-S02 Results

OBJ-PJ05.02-V3-VALP-S02	Assess whether the ATS can safely continue to be remotely provided to multiple aerodromes under external abnormal conditions.	CRT-PJ05.02-V3-VALP-S02.010	The Safety Acceptance Criteria are satisfied. Note: A risk assessment is performed.
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WORKSHOP Conclusion: The validation exercises in V3 further showed that abnormal situations were dealt with by ATCOs in a similar manner as in SRT - with the added workload of monitoring in other aerodromes while dealing with the situation. Checklists for emergency situations exist today and they would need to be adapted in order to account for the added complexity of having 2 or 3 aerodromes in the same MRTM. Every specific situation would demand a different kind of management, as well as the traffic, the cluster of aerodromes and the module capabilities. This is to be further defined at local implementation level.

E.4.2 OBJ- PJ05.02-V3-VALP-S06 Results

OBJ-PJ05.02-V3-VALP-S06	Assess ATCO capability to cope with / manage abnormal situation in a safe manner	CRT-PJ05.02-V3-VALP-S06.010	ATCO is able to identify and manage abnormal situations (e.g.): <ul style="list-style-type: none"> · Unknown flight · Aircraft emergency · Crash on an airport or its vicinity · Fire on an airport · Unplanned closure of an airport
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WORKSHOP Conclusion: During the abnormal situations discussed at the workshop, and simulated in some cases as part of the validation exercises, one mitigation was to have a support ATCO/supervisor/other personnel to assist with the situation (Solution 02). The time needed to do a split is to be taken into account as during the split one cannot manage the abnormal situation. In the case of splitting 2 other aerodromes this would be even more cumbersome. ATCOs reported that in case of an emergency they prefer to keep the aerodrome with the emergency at their charge and transfer the other/s. In some cases a situation is so unexpected that the ATCO doesn't even have time to split. The ATCO has to manage the situation with all the ADs: this reinforces the idea that when providing multiple remote tower service traffic has to be managed in a more conservative way in order to be able to cope with these unexpected situations.

E.5 Validation Objectives: SAFETY – Degraded

E.5.1 OBJ- PJ05.02-V3-VALP-S03 Results

OBJ-PJ05.02-V3-VALP-S03	Assess whether the ATS can safely be remotely provided to multiple aerodromes during degraded modes of operation	CRT-PJ05.02-V3-VALP-S03.010	The Safety Acceptance Criteria are satisfied. Note: A risk assessment is performed.
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WORKSHOP Conclusion: Degraded mode was not properly simulated in the V3 validations. Discussions with ATCOs and safety experts suggest that the specific needs for contingency and mitigations for all the possible degraded modes can be validated in V4/V5 and during local implementation. The discussions were fruitful in that they presented different options for delaying and/or terminating traffic in one or several aerodromes but a full analysis to assess the minimum equipment level that would be needed to keep providing service shall be performed before implementation.

E.5.2 OBJ- PJ05.02-V3-VALP-S07 Results

OBJ-PJ05.02-V3-VALP-S07	Assess ATCO capability to cope with / manage degraded modes and recover from them in a safe manner	CRT-PJ05.02-V3-VALP-S07.010	ATCO is able to detect and recover from a failure occurring at one of the airports affecting (e.g.): · Communication · Visualisation system · Other airport systems / infrastructure
		CRT-PJ05.02-V3-VALP-S07.020	ATCO is able to detect and recover from a failure occurring in several airport (e.g): · Communication · Visualisation system · Other airport systems / infrastructure
		CRT-PJ05.02-V3-VALP-S07.030	ATCO is able to detect and recover from a failure in the MRTM affecting (e.g) : · Communication · Visualisation system

WORKSHOP Conclusion: Discussions were extensive on the tools/services that the ATCO absolutely needs in order to perform their tasks. However, we do not have a conclusive list of the minimum services, which would be needed in order to implement this solution. The degraded situations present different outcomes depending if there are 2 or 3 aerodromes, and specific solutions needs to be implemented locally.

-END OF DOCUMENT-