OFA06.03.01 Remote Tower - Safety Assessment Report for Single Remote Tower

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Abstract

This document contains the Specimen Safety Assessment for a typical application of the 06.03.01 OFA Remote Tower for Single airport. The report presents the list of Safety Requirements specifying the Remote Tower system at V3 phase level and the collected evidences on their validity thereby providing all material to adequately inform the 06.03.01 OFA OSED (as no SPR is to be developed for this OFA).

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IPR (foreground)

This deliverable consists of SJU foreground.

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Executive summary

This document contains the Specimen Safety Assessment for a typical application of the 06.03.01 OFA Remote Tower for Single airport. The report presents the list of Safety Requirements specifying the Remote Tower system at V3 phase level and the collected evidences on their validity thereby providing all material to adequately inform the 06.03.01 OFA OSED (as no SPR is to be developed for this OFA). The document is an update of the P06.09.03 D14 SAR.

The applied approach within the Safety Assessment Report at hand is based on the specifications formulated in the SESAR Safety Reference Material [1] as well as the Guidance to Apply the SESAR Safety Reference Material [2]. Hence, this document provides a good methodology to be applied as well as a good choice of relevant aspects to be considered when preparing individual safety analysises for Single Remote Tower services. Anyhow, it shall be highlighted that irrespectively of this Safety Assessment Report each ANSP might follow its own individual safety assessment methodology. Consequently, in the individual safety assessments certain aspects might not at all be addressed or as the case may be might be addressed in a modified way.

For instance where this Safety Assessment focusses on the success based approach other methodologies might rest upon already assessed services and only analyse those aspects that are new within Single Remote Tower. Thus, several aspects addressed in this document need not necessarily be addressed in specific safety assessments. Moreover each ANSP might adopt different probability figures – maybe even varying locally. And also certain details like aerodrome characteristics, traffic numbers/constellations, R/T settings etc. might vary.

Having this in mind, the Safety Assessment Report at hand shall be understood as an inspiration for items to be addressed and as a possible approach to apply the internal safety assessment. It shall not be understood as the mandatory and only valid approach though.

1 Introduction

1.1 Background

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

This can be divided into three main application areas:

- Remote and Virtual Tower for Single Aerodrome
- Remote and Virtual Tower for Multiple Aerodrome
- Contingency Tower

The main target for the Single and Multiple RVT Concepts are low to medium density rural airports, which today very much are struggling with low business margins. A very welcome cut in ATS costs for those airports are foreseen by introducing these concepts. The main target for the Contingency Tower solution is medium to high density airports, whereas for most of them no real contingency alternative exists today, if the ordinary tower has to close down for any reason.

For Single and Multiple Remote Tower, the concept will be applied for two different environments:

- Aerodrome Control Service (tower only, tower and approach);
- Aerodrome Flight Information Service (AFIS)

The current document aims at presenting the results of the safety assessment focused on Remote and Virtual Tower for a Single Aerodrome.

1.2 General Approach to Safety Assessment

1.2.1 A Broader approach

This safety assessment is conducted as per the SESAR Safety Reference Material (SRM) [1] which itself is based on a two-fold approach:

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

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

1.3 Scope of the Safety Assessment

L001 This Safety Assessment is focused on the remote provision of ATC and AFIS services using a RVT system. Nevertheless the assessment is mainly done on the ATC services, <u>assuming that this service would allow obtaining the most constraining requirements</u> which will allow as well the provision of AFIS. The assessment of the ATC service is presented in the main body of this report. Some results on the AFIS part are included in Appendix E.

This report is a proposed version for the final SAR, addressing safety related activities. It includes the provision of the following results:

Information defined at "OSED level" which includes:
- the Safety Criteria which determine the expected level of safety for Remote and Virtual Tower
- the Safety Objectives, which specify what the Remote and Virtual Tower has to provide in terms of operational service in order to satisfy the Safety Criteria.

Two types of Safety Objectives are provided: the "Functionality" ones, describing the services required from Remote and Virtual Tower, and the "Integrity" ones, specifying the integrity of the Remote and Virtual Tower system to provide those services.

This document is an update of the P06.09.03 D14 SAR. It should be noted that there is no difference in the safety objectives, recommendations and requirements for single remote tower to medium size aerodromes compared to low density aerodromes. Nevertheless the aspects that were addressed in VP640 are added in Appendix B1 (consolidated List of Safety Requirements) for tracebility reasons. Appendix B2 was also updated. As the objective of single remote tower is to provide a sufficient level of safety, the comparision to current operations ('as in current operations') was deleted thoughout the document. It should be noted that in some areas safety is even increased compared to current operations (e.g. if the infrared sensors are available in low visibility conditions or at night).

These OSED-level outputs are to be included in the OSED.

Information defined at "SPR level" which includes:
- the Safety Requirements specifies how the Remote and Virtual Tower system is to provide the operational services defined by the Safety Objectives mentioned above.

Two types of Safety Requirements are provided as well at this level: the "Functionality" ones and the "Integrity" ones (as for the Safety Objectives).

As no SPR is to be performed in the frame of this OFA, the SPR-level results mentioned above are to be included as well in the OSED.

Evidences on the completeness, correctness and realism of these results are provided in this assessment, either directly included in this report or providing the relevant cross-reference to the concerned project document where evidence can be found for a specific subject.

The intended internal audience for this document are P06.08.04 team members (all other related projects already being closed). External to the SESAR project, other stakeholders are to be found among:

- Appropriate National Safety Authorities (NSA);

- Air Navigation Service Providers (ANSP);

- Airspace users.

1.4 Layout of the Document

Section 1 is the current introduction to the safety assessment report for Remote Tower for Single aerodrome.

Section 2 documents the safety assessment of the Remote Tower system at the service level and provides its specification in terms of Safety Objectives

Section 3 documents the safety assessment of the Remote Tower system at the design level and provides the corresponding specification in terms of Safety Requirements.

Appendix A shows the consolidated list of Safety Objectives specifying the Remote Tower system at service level.

Appendix B presents the consolidated list of Safety Requirements specifying the Remote Tower system at design level.

Appendix C lists the assumptions, issues and limitations identified during the safety assessment.

Appendix D shows the assessment of the abnormal conditions

Appendix E presents some results on the safety assessment of the AFIS

Appendix F includes the Risk Classification Schemes used for the quantification of the Safety objectives derived from the identified operational hazards.

1.5 References

[1]. SESAR P16.06.01, Task T16.06.01-006, SESAR Safety Reference Material, Edition 00.02.02, 10th February 2012

[2]. SESAR P16.06.01, Task T16.06.01-006, Guidance to Apply the SESAR Safety Reference Material, Edition 00.01.02, 10th February 2012

[3]. P6.9.3 Remote Tower Safety Plan, Edition 00.01.00, 28th March 2011

[4]. P6.8.4 – D93 OSED for Remote Tower, Edition 00.07.00, 30th May 2016.

[5]. P6.9.3 – D14 SAR for Single Remote Tower, Edition 00.01.03, 8th February 2016

[6]. P6.9.3 – Safety Workshop in Malmö on the 31/01-01/02/2012 – Minutes of meeting, version 1.1

[7]. P6.2 – D122 Airport Detailed Operational Description (DOD) Step1, Edition 00.01.01, 15th January 2015.

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[12]. ICAO Annex 11 – Air Traffic Services, 13th Edition, July 2001

[13]. EUROCONTROL Manual for Aerodrome Flight Information Service (AFIS), Edition 1.0, 17th June 2010

[14]. EUROCONTROL Safety Assessment Methodology – v2.1, 2006.

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[16]. P6.9.3 – D08-02 Remote and Virutal Tower Validation Report, Edition 00.05.02, 1st May 2014

[17]. P6.9.3 – D15 Validation Report Appendix F: HP Assessment report, Edition 00.01.01, December 2013

[18]. EUROCAE ED-153 - Guidelines for ANS Software Safety Assurance, August 2009

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1.6 Acronyms

ADS-B   Automatic Dependent Surveillance - Broadcast

AFIS   Aerodrome Flight Information Service

ATC	Air Traffic Control
ATS	Air Traffic Services
CFIT	Controlled Flight Into Terrain
CNS	Communication Navigation Surveillance
LVC	Low Visual Conditions
OSED	Operational Service and Environment Definition
RTC	Remote Tower Center
RVT	Remote and Virtual Tower
SAC	SAfety Criteria
SAR	Search and Rescue
SPR	Safety and Performance Requirements

2 Safety specifications at the OSED Level

2.1 Scope

Based on safety activities defined in the Safety Plan [1], this section addresses the following activities:

- description of the key properties of the Operational Environment that are relevant to the safety assessment - section 2.2

- derivation of suitable Safety Criteria (from the OFA Safety Plan [1]) – section 2.3 and 2.4.

- identification of the pre-existing hazards that affect traffic on the (small) airport surface and its vicinity and the risks of which services provided by the Single Remote Tower may reasonably be expected to mitigate to some degree and extent - section 2.5.

- description of the ATS services to be provided by Single Remote Tower and the derivation of Functional Safety Objectives in order to mitigate the pre-existing risks under normal operational conditions - section 2.6

- assessment of the adequacy of the services provided by Single Remote Tower under abnormal conditions of the Operational Environment - section 2.7

- assessment of the adequacy of the services provided by Single Remote Tower under internal-failure conditions and mitigation of the system-generated hazards – section 2.8

- assessment of the impacts of the Single Remote Tower operations on adjacent airspace or on neighbouring ATM systems – section 2.9

- achievability of the Safety Criteria – section 2.10

- validation & verification of the safety specification – section 2.11

2.2 Single Remote Tower - Operational Environment and Key Properties

This section describes the key properties of the Operational Environment that are relevant to the safety assessment of the ATC services provided from a Remote Tower. This information is mainly obtained from the OSED [4], sections 4.1.1 and 4.1.2.

2.2.1 Airspace Structure, Boundaries and Types of Airspace

Airspace classification: Class C, Class D

• **Class C**: Operations may be conducted under IFR, SVFR, or VFR. Entering Class C airspace only requires radio contact with the controlling air traffic authority, but an ATC clearance is ultimately required. Aircraft operating under IFR and SVFR are separated from each other and from flights operating under VFR. Flights operating under VFR are given traffic information in respect of other VFR flights. From the primary airport or satellite airport with an operating control tower must establish and maintain two-way radio communications with the control tower. This airspace is managed by the approach/departure control facility linked to the airport with which the airspace is conjoined.

• **Class D**: Operations may be conducted under IFR, SVFR, or VFR. All flights are subject to ATC clearance. Aircraft operating under IFR and SVFR are separated from each other, and are given traffic information in respect of VFR flights. Flights operating under VFR are given traffic information in respect of all other flights. The controlling authority for this airspace is the control tower for the associated airport, and radar may or may not be used.

Control Zone - CTR: 10-16 NM radius/rectangular, vertical extension up to 3600ft MSL.

Terminal Control Area - TMA: 10-30 NM radius/rectangular, from 1000-2000 MSL to FL095. This area is taken into account when providing APP additionally to TWR services.

Procedures: specific IFR routes and approach procedures and established VFR routes

2.2.2 Airspace Users (Flight Rules), Traffic Levels and complexity

Number of movements: 4000-50000 annually

Number of simultaneous movements: Normally 1-2 simultaneous IFR and VFR flights, depending on period of year the number of simultaneous movements might even exceed.

Traffic Type: Mainly scheduled, charter and General Aviation (GA) flights and Business Aviation (BA).

Aircraft Fleet mix:

- Medium Jets (e.g. B737, A320, MD80), Medium Turbo Props (e.g. SB20, FK50, AT72)

- General Aviation light aircraft (e.g. C172, PA28, PA31)

- Business Aviation and Hospital Flights (HOSP): medium jets and turboprops (e.g. Dassault Falcons, Cessna Citations, BE20)

- Helicopters

2.2.3 Aerodrome Layout Characteristics

Number of Runways: usually 1 maximum 2

Taxiway and runway entries: up to 6, at the end or middle of the runway (or both)

Aprons: 1 to 5

2.2.4 CNS Aids

Communication: ATC voice communication, VHF-transmitters/receivers, Ground radio system, Autonomous VHF-radio, Search and Rescue (SAR) radio, UHF transmitters/receivers. Data link could be implemented.

Navigation: Navigation specifications including ILS and RNAV (using NDB, DME).

Surveillance: Surveillance service is provided above specific altitude, typically 1000-2000 ft, mainly radar-based. ADS-B and surface radar could also be available, but this _is out of the scope of the safety assessment._

2.3 Airspace Users Requirements

As explained in the Safety Plan [3] the introduction of Remote and Virtual Tower concept is not safety driven, i.e. the purpose is not to improve safety, but mainly to reduce ATS related costs. Based on that, the safety criteria to be applied has to ensure that the level of safety is sufficient due to introduction of the RVT, so the airspace users are provided with comparable service as in current operations.

For Single Remote and Virtual Tower the aim of the safety assessment is then to show that providing ATC services remotely for one airport assures an acceptable level of safety in low density airports.

2.4 SAfety Criteria

In order to perform the safety assessment of the Remote Tower concept, the level of safety mentioned in previous section is to be defined in terms of risk (per flight or per flight.hour) associated to the hazardous situations (listed in section 2.5), and defining how the system contributes to them. Based on that, the generic criterion is then refined as shown in section from 2.4.1 to 2.4.6.

Quantification of this risk is to be done based on the Accident-Incident Model (AIM) [7] from WP16.1.1 and from historical data as far as possible. This quantification represents an ECAC wide average of the risk associated to the ATM baseline (i.e. current ATM system before SESAR implementation which in the case of Remote Tower means current service provided from the tower located in the premises of the corresponding airport).

The SAfety Criteria (SAC) presented hereafter are expressed with respectg to this baseline. They do not take account of any modification on the capacity, throughput or traffic movements in the airports considered for each application (these parameters are considered to be the same as in today operations). Even if enhanced visualisation features could have an impact on the movement rate during LVC, the safety criteria is considered in equivalent conditions of traffic (in terms of capacity and movements) and operational environment than in current operations. In case there is a change on this traffic related parameters (e.g. based on results obtained during the concept validation process or inputs from others related projects), then the Safety Criteria will be reviewed and adapted to the new situation.

Note: the references included in the SAC are related to specific elements of the Accident Incident Model used for deriving them.

2.4.1 SAfety Criteria related to Mid-Air Collision in TMA

SAC#1   There shall be no increase of ATC induced tactical conflict (MF7.1) when remotely providing ATS using Remote&Virtual Tower

SAC#2   There shall be no increase of Imminent Infringement (MF5-8) when remotely providing ATS using Remote&Virtual Tower

  a. as a function of Ineffective ATCO induced conflict management (MB7)
  b. as a function of Ineffective externally-induced conflict management (MB6)
  c. as a function of Ineffective plan induced conflict management (MB5)

SAC#3   There shall be no increase of Imminent Collision (MF4) when remotely providing ATS using Remote&Virtual Tower

  a. as a function of Ineffective ATCO Collision prevention (MB4)

2.4.2 SAfety Criteria related to Controlled Flight Into Terrain

SAC#4   There shall be no increase of Imminent CFIT (MF3) when remotely providing ATS using Remote&Virtual Tower

  a. as a function of Ineffective ATCO warning (CB3)

2.4.3 SAfety Criteria related to Wake Vortex Induced Accidents

SAC#5   There shall be no increase of under-spacing allowing for WVE (WP4b) when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Insufficient WT approach spacing imposed by ATC (WF4.1.1)
   b.   as a function of Insufficient separation to prevent WVE spacing provided by ATC (WF4.2.1)

2.4.4 SAfety Criteria related to Taxiway Collision

SAC#6   There shall be no increase of Taxiway conflicts (TP3) when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Ineffective ATC taxiway planning (TB4)
   b.   induced by ATCO (TP3A)

SAC#7   There shall be no increase of Imminent Infringement (TP2) when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Inadequate ATC conflict management (TB3.2)

SAC#8   There shall be no increase of Imminent Taxiway Collision (TP1) when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Ineffective ATC collision avoidance (TP1)

2.4.5 SAfety Criteria related to Runway Collision

SAC#9   There shall be no increase of Imminent Runway Incursion remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Ineffective ATC runway entry procedures (RB4.1)

   b.   as a function of Ineffective ATC vigilance to recognise pilot/driver entering

   c.   as a function of ineffective landing management (RP4C)

   d.   as a function of ineffective take off management (RP4D)

SAC#10   There shall be no increase of Runway Conflict (RP2) when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Ineffective ATC vigilance to detect Aircraft/Vehicle and Animal/Person runway incursions prior to issuing landing/take-off clearance (RB3)

SAC#11   There shall be no increase of Imminent Runway Collision (RP1) when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Ineffective Runway Collision Avoidance (RB2)

2.4.6 SAfety Criteria related to "Landing accidents"

SAC#12   There shall be no increase of Landing Accidents when remotely providing ATS using Remote&Virtual Tower

   a.   as a function of Ineffective weather conditions monitoring affecting arriving/departing aircraft (leading to hard landing or runway excursion)
   b.   as a function of Ineffective check or the runway surface (with respect to snow, slush, RWY surface friction, FOD, …) (leading to loss of control on the runway or runway excursion)
   c.   as a function of Ineffective 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)

e. as a function of Inefficient management of landing-aid lights

2.5 Relevant Pre-existing Hazards

The same hazardous situations and risks to be mitigated as in current operations are to be considered for Single Remote Tower. These hazardous situations, called pre-existing hazards, have been identified from the list provided in the guidance for applying SRM [2]. 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 remotely provided using RVT		Leading to (type of accident)	AIM Model Used	SAC
Hp#1	Situation in which AC trajectories can leading to mid-air collision	MAC	MAC-TMA	SAC#1, SAC#2 SAC#3
Hp#2	Situation leading to collision with an obstacle, ground vehicle, another aircraft on apron or TWY	Taxiway Collision	TWC	SAC#6, SAC#7 SAC#8
Hp#3	Situation leading to collision with an obstacle, ground vehicle, another aircraft on RWY	Runway Collision	RWC	SAC#9, SAC#10 SAC#11
Hp#4	Another aircraft or vehicle inside the OFZ	Runway Collision	RWC	SAC#10
Hp#5	Missed approach	MAC	MAC-TMA	SAC#1, SAC#2 SAC#3
Hp#6	Situation leading to Wake vortex encounter	Wake Turbulence Accident	WTA	SAC#5
Hp#7	Situation leading to Controlled Flight Into Terrain	CFIT	CFIT	SAC#4
Hp#8	Bird close to/in path of aircraft or animal on the runway	Bird-strike Animal-strike	RWC	SAC#9 SAC#11
Hp#9	Adverse weather conditions like violent winds or severe crosswind	(hard landing, runway excursion) Landing accident	None	SAC#12
Hp#10	Snow/slush on the runway	(Loss of control on the runway) Landing accident	None	SAC#12
Hp#11	Low runway surface friction	(veer-off, overrun →Runway excursion) Landing accident	None	SAC#12
Hp#12	Runway undershoot	(off-runway touchdown) Landing accident	None	SAC#12
Hp#13	Aircraft using a closed taxiway	Taxiway Collision	TWC	SAC#6, SAC#7
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)	RWC	SAC#9, SAC#12

		Landing accident (closed runway because of maintenance: RWY surface not operational)		
Hp#15	Another aircraft or vehicle inside landing-aid protection area during CATII/III instrument approach	Landing accident	None	SAC#12
Hp#16	Foreign Object Debris within the Runway protected area	(Loss of control on the runway) Landing accident	None	SAC#12
Hp#17	Aircraft attempt to land with undercarriage retracted	(Gears-up landing) Landing accident	None	SAC#12
Hp#18	Loss/interruption of ATC services	All types of accidents	None	All SACs
Hp#19	Aircraft entering a restricted area (airspace)	Airspace infringement	MAC-TMA	SAC#1, SAC#2

Table 1: List of relevant Pre-existing Hazards

2.6 Mitigation of the Pre-existing Risks – Normal Operations

2.6.1 Operational Services to Address the Pre-existing Hazards

This section describes the ATC services that are provided by the Single Remote Tower in the relevant operational environment to address (all/some of) the pre-existing hazards identified above. They have been defined using the following sources:

- AIM from 16.1.1 [7]

- Generic Task analysis for TWR services provided by Human Performance Task in the project

- ICAO Doc 4444 PANS ATM [9]

- Expert judgement

Note that as for the pre-existing hazards, these services are the same as the ATC services provided in current operations.

ID	Service Objective	Pre-existing Hazards
RVT.ATC-01	‣ Traffic planning ‣ Traffic synchronisation	Hp#1 Situation in which AC trajectories can leading to mid-air collision
RVT.ATC-02	‣ Traffic monitoring ‣ Conflict resolution	Hp#1 Situation in which AC trajectories can leading to mid-air collision Hp#5 Missed approach
RVT.ATC-03	‣ Potential collision detection ‣ Collision avoidance	Hp#1 Situation in which AC trajectories can leading to mid-air collision Hp#5 Missed approach
RVT.ATC-04	‣ Start-up	Hp#2 Situation leading to collision with and

	‣ Push-back ‣ Stand/Parking ‣ Taxiway Routing	obstacle, ground vehicle, another aircraft on apron or TWY Hp#13 Aircraft using a closed taxiway
RVT.ATC-05	‣ Traffic Monitoring ‣ Conflict resolution	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY Hp#13 Aircraft using a closed taxiway
RVT.ATC-06	‣ Potential TWY collision detection ‣ TWY Collision avoidance	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY
RVT.ATC-07	‣ Runway Entry/exit management ‣ Take-off Management ‣ Landing Management	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#4 Another aircraft or vehicle inside the OFZ Hp#13 Aircraft using a closed taxiway
RVT.ATC-08	‣ Traffic Monitoring ‣ Conflict resolution	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#8 Bird close to/in path of aircraft or animal on the runway Hp#14 Aircraft landing in/taking off from a wrong/closed runway
RVT.ATC-09	‣ Potential collision detection ‣ Collision avoidance	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#8 Bird close to/in path of aircraft or animal on the runway
RVT.ATC-10	‣ Traffic monitoring	Hp#7 Situation leading to Controlled Flight Into Terrain
RVT.ATC-11	‣ Traffic Separation ‣ Traffic monitoring	Hp#6 Situation leading to Wake vortex encounter
RVT.ATC-12	ATC prevention of/recovery from events potentially leading to landing accident	Hp#9 Adverse weather conditions like violent winds or severe crosswind Hp#10 Snow/slush on the runway Hp#11 Low runway surface friction Hp#16 Foreign Object Debris within the Runway protected area Hp#12 Runway undershoot Hp#14 Aircraft landing in/taking off from a wrong/closed runway Hp#17 Aircraft attempt to land with undercarriage retracted

		Hp#15 Another aircraft or vehicle inside landing-aid protection area during CATII/III instrument approach
RVT.ATC-13	Ensure availability/continuity of the ATC service (listed above) in all nominal conditions and situations [for example during transition from ATS provision from local TWR to Remote TWR, in particular weather conditions as low Visibility, but also in daylight and darkness]	Hp#18 Loss/interruption of ATC services

Table 2: ATC services and Pre-existing Hazards

2.6.2 Derivation of Safety Objectives for Normal Operations

This section provides the functionality Safety Objectives (concerning the success part of the assessment) for Single Remote Tower providing the ATC services listed in 2.5. They have been defined based on the services presented in previous section, using the same sources mentioned in that section.

The Safety Objectives related to AFIS are provided in Appendix E.

These safety objectives describe WHAT the Remote and Virtual Tower (RVT) system has to perform more in detail in order to provide the ATC services. The whole set of safety objectives is aiming to achieve the safety criteria defined in section 2.4.

The HOW this is to be done will be described by the safety requirements, derived from those safety objectives, in terms of requirements on technical equipment (information to be provided and associated performance characteristics), controller competence/training, and procedures.

Note: The complete list of safety objectives (see Appendix A) is to be included in the Remote Tower OSED, and added to /combined with the list of operational requirements already available in section 6 of that document.

Ref	Services provided	Phase of Fight / Operational Service	Related AIM Barrier	Safety Objective [SO xx]
RVT.ATC-01	Traffic planning and synchronisation	Climb Descend	Traffic Planning and synchronisation (MAC)	SO-001 SO-002 SO-003
RVT.ATC-02	Traffic monitoring and Conflict resolution	Climb Descend	ATC Conflict Management (MAC)	SO-004 SO-005 SO-006
RVT.ATC-03	Potential conflict/ collision detection and avoidance	Climb Descend	ATC Recovery (MAC)	SO-007 SO-008 SO-009 SO-010
RVT.ATC-04	Start-up Push-back Stand/Parking Taxiway Routing	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

RVT.ATC-05	Traffic Monitoring Conflict resolution	Surface-in Surface-out (Apron/Taxi-in/Taxi-out)	TWY conflict management (TWY Col)	SO-016 SO-017
RVT.ATC-06	Potential TWY collision detection TWY Collision avoidance	Surface-in Surface-out (Apron/Taxi-in/Taxi-out)	ATC TWY conflict management (TWY Col)	SO-016 SO-017
RVT.ATC-07	Runway Entry/exit management Take-off Management Landing Management	Surface-in Surface-out (Runway)	Runway Incursion Prevention (RWY Col)	SO-019 SO-020 SO-021 SO-022 SO-023 SO-024 SO-025
RVT.ATC-08	Traffic Monitoring Conflict resolution	Surface-in Surface-out (Runway)	Runway Conflict Prevention (RWY Col)	SO-026 SO-027
RVT.ATC-09	Potential collision detection Collision avoidance	Surface-in Surface-out (Runway)	ATC Runway Collision avoidance (RWY Col)	SO-026 SO-027
RVT.ATC-10	Traffic monitoring	Climb Descend	CFIT ATCO warning (CFIT)	SO-028 SO-029
RVT.ATC-11	Traffic Separation Traffic monitoring	Climb Descend	Wake spacing management (WV ind.Acc)	SO-030
RVT.ATC-12	ATC prevention of/recovery from events potentially leading to landing accident	Climb Descend	No associated model	SO-031 SO-032 SO-033 SO-034 SO-035
RVT.ATC-13	Ensure availability/continuity of the ATC service	All	All models affected	SO-036 SO-037 SO-038

Table 3: Remote Tower OFA Operational Services & Safety Objectives (success approach)

The following table describe the Safety Objectives referred above:

Note: RVT referes to Remote and Virtual Tower system (encompassing people, equipment and procedures). RTC referes to Remote Tower Center, in which in this case only one RVT position is considered in the current assessment for Single aerodrome. For the multiple application of Remote Tower several RVT positions are to be located in a same RTC.

Description
ATC Service Provision from a RVT position
SO-001. RVT shall enable coordination and transfer procedures with adjacent ATS unit concerning arriving and departing traffic (including as necessary aircraft identification)
SO-002. RVT shall enable to manage arrival aircraft (including as necessary management of the approach, visual acquisition, entry into traffic circuit and landing sequence)
SO-003. RVT shall enable to manage departure aircraft (including as necessary aircraft identification and departure sequence on the runway)
SO-004. RVT shall enable to separate traffic, with respect to other traffic, applying the corresponding separation minima to the airspace under control responsibility (on the TMA and in the vicinity of the aerodrome) or allowing reduction in separation minima in the vicinity of the aerodrome.   *See Note 1.*
SO-005. RVT shall enable to separate traffic with respect to restricted areas on the airspace under control responsibility
SO-006. RVT shall enable to manage missed approaches situations (including detection of need for go-around, monitoring of involved aircraft and proposal for resolution)
SO-007. RVT 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
SO-008. RVT shall enable the detection of restricted areas infringements by aircraft in the airspace under control responsibility
SO-009. RVT shall enable the provision of ATC instructions to resolve conflicts/ avoid collisions on the airspace under control responsibility
SO-010. RVT shall enable the provision of ATC instructions to resolve airspace infringements
SO-011. RVT shall enable to identify departing AC on the stand for providing ATC service
SO-012. RVT shall enable start-up procedures for departing aircraft (including as appropriate the provision of necessary aerodrome information - operational and meteorological)
SO-013. RVT shall enable push-back and towing procedures
SO-014. RVT shall enable the provision of taxi instructions to aircraft in the manoeuvring area
SO-015. RVT shall enable the provision of taxi instructions to vehicles in the manoeuvring area
SO-016. RVT shall enable the detection of hazardous situations on the manoeuvring area (involving aircraft, vehicles, and obstacles).
SO-017. RVT shall enable the provision of taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on the manoeuvring area
SO-018. RVT shall enable to support AC and vehicle movements on the manoeuvring area (through visual aids on the airport surface)
SO-019. RVT shall enable to manage runway entry for departure aircraft (this includes RWY status/occupancy check before issuing line-up clearance)
SO-020. RVT shall enable to manage runway exit for landing aircraft (this includes exiting TWY status/occupancy check)
SO-021. RVT shall enable to manage aircraft/vehicles runway crossing (this includes RWY status/occupancy/correctness check before issuing runway crossing clearance)
SO-022. RVT shall enable to support aircraft for take-off and landing operations (though visual-aids on the airport surface)
SO-023. RVT shall enable to carry-out vehicle related tasks on the runway

SO-024.	RVT shall enable to manage aircraft take-off (this includes RWY status/occupancy/correctness check before issuing take-off clearance)
SO-025.	RVT shall enable to manage aircraft landing (this includes RWY status/occupancy/correctness check before issuing landing clearance)
SO-026.	RVT shall enable ATC detection of runway incursions (AC, vehicle, animal, person incursions) and potential collisions on the runway (involving AC, vehicle, animal, obstacles)
SO-027.	RVT shall enable to provide instructions to resolve runway incursions and prevent collisions on the runway
SO-028.	RVT shall enable the detection of flight towards terrain situations
SO-029.	RVT shall enable to warn/support pilot on Controlled Flight Towards Terrain situations
SO-030.	RVT shall enable to establish/maintain sufficient wake turbulence spacing between landing/departing aircraft
SO-031.	RVT 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)
SO-032.	RVT 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)
SO-033.	RVT shall enable to support landing aircraft on final approach (providing relevant information and instructions as necessary)
SO-034.	RVT shall enable to provide "navigation" support to aircraft during landing operations (using available non-visual navigation aids as necessary)
SO-035.	RVT shall enable the detection of potential intrusions inside landing-aid protection area
SO-036.	RVT shall enable to assess the operational environmental conditions on the 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-037.	RVT shall enable the provision of appropriate ATC services in the several operational environmental conditions (e.g. low visual procedures in low visual conditions)
SO-038.	RVT shall enable the provision of seamless ATC service to airspace users in the several operational environment conditions (e.g. daylight, dawn, darkness, dusk, CAVOK and low visual conditions)

Table 4: List of Safety Objectives (success approach) for ATC services in Normal Operations

Note 1: According to PANS ATM (ICAO Doc 4444) §6.1 it may be possible to reduce the separation minima in the vicinity of aerodromes' if:

1. adequate separation can be provided by the aerodrome controller when each aircraft is continuously visible to this controller; or

2. each aircraft is continuously visible to flight crews of the other aircraft concerned and the pilots thereof report that they can maintain their own separation; or

3. in the case of one aircraft following another, the flight crew of the succeeding aircraft reports that the other aircraft is in sight and separation can be maintained.

In this safety assessment "reduction in separation minima" is to be understood as the first way listed here above.

Apart from the safety objectives listed above, the following assumptions are also to be considered in order to ensure the appropriate provision of the services described in previous Table 2: ATC services and Pre-existing HazardsTable 2 and Table 3 and to be able to achieve the safety criteria defined in section 2.4.

While there is no requirement to follow operations as in current operations, the implementation of Safety Requirements shall of course be based on applicable regulations (e.g. ICAO specifications). So far no need for new regulations was identified.

Description
AO-01. The rules of the air (as per Annex 2 [8]) are applied
AO-02. Flight crew apply the same procedures as in current operations (as per PANS-OPS Doc 8168 [10])

Table 5: List of operational assumptions concerning the provision of ATC services in normal conditions

2.6.3 Analysis of the Concept for typical RVT position in a RTC

The 3 main phases considered on a one-day service provision basis for a Remote and Virtual Tower position in charge of one aerodrome are: Initiation phase, service provision, and termination. There are as well some ATFCM related tasks at RTC level ensuring that the traffic and capacity conditions are the ones enabling the remote provision of ATC services to a single airport from a RVT position.

It is then necessary to derive Safety Objectives for the other two phases (initiation and termination), and for those ATFCM related tasks as well.

Note that these tasks would be significantly important when providing remote ATC services to multiple airports.

Description
ATFCM tasks at RTC level
SO-039. RTC shall enable (pre-tactical and tactical) management of ATC resources in terms of staffing for each RVT position taking into account weather conditions, traffic overload/peaks and unexpected events.
Initiation of the ATC service provision from a RVT position
SO-040. Prior to remotely providing ATC services, RVT capabilities shall be assessed / verified
SO-041. 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 is starting to be provided (planned schedules and/or exceptional provision of the ATC service).
Termination of the ATC service provision from a RVT position
SO-042. Remote provision of ATC service shall appropriately (safely) be stopped for planned terminations
SO-043. 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 terminated (as per planned schedules).

Table 6: Additional Safety Objectives for the remote provision of ATC services in normal conditions

2.7 Single Remote Tower Operations under Abnormal Conditions

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

2.7.1 Identification of Abnormal Conditions

The following abnormal condition scenarios have been identified. This list includes those abnormal conditions identified in the HP assessment and those identified during the safety workshop [5].

- Loss of communication (one way or two way) with an aircraft
- Unexpected / unplanned flight in airspace
- Aircraft with emergency
- Crash on airport on its vicinity
- Fire on the aerodrome
- Animal on the aerodrome
- Closing ATC service in the aerodrome
- (Unplanned) ATCO Overload
- Abnormal weather (for example fog, CB, wind shear).

2.7.2 Potential Mitigations of Abnormal Conditions

The abnormal conditions listed above are assessed in this section with the exception of the following cases:

▸ Loss of communication is to be addressed as a degraded mode, assessed in section 2.8.

▸ Animal on the aerodrome is considered to be a "nominal" situation and it has already been addressed in section 2.6.

▸ Abnormal weather: this is partly addressed as nominal situation in section 2.6; the impossibility of providing ATC services is considered as a cause of abnormal condition 5.

While there is no requirement to follow operations as in current operations, the implementation of Safety Requirements shall of course be based on applicable regulations (e.g. ICAO specifications). So far no need for new regulations was identified.

The potential operational effects of the abnormal conditions and the potential mitigation of these effects are presented in the following table:

Ref	Abnormal Conditions	Operational Effect	Mitigation of Effects
1	Unexpected / unplanned flight in airspace (this case does not include the case of loss of communication, which is addressed in a separated case as mentioned above)	This can induce conflict with other traffic in the same area, as it overload controller and/or unexpectedly change his way of managing traffic	Controller has to be able, and depending on the weather/visibility conditions, to remotely identify an unexpected flight in the airspace where ATC services are being provided [SO-044] Once identified, the relevant flight has to be managed (from SO-002 to SO-050)
2	Aircraft with emergency (gear problem, brakes overheating - fire on the tyres, tail strike, bird strike,	All this emergencies can induce landing or taking off accidents.	Remote controller has to be able to potentially detect those situations [SO-045] and provide appropriate support for solving

	etc.).		them [SO-046] It is assumed than, as in current operations, flight crew detects airborne system failures and inform the controller about it [AO-03]
3	Crash on airport on its vicinity	In this case the objective is to trigger the corresponding services for rescue as quick as possible	Remote controller has to be able to detect the loss of an aircraft on the vicinity of the aerodrome. Then he/she has to be able to trigger appropriate rescue procedure, contacting relevant personnel and units and providing available information [SO-047]
4	Fire on the aerodrome	Operations on the aerodrome may probably have to be stopped as the conditions may not be safe for aircraft, passengers and airport personnel.	Remote controller has to be informed about the situation and as necessary interrupt landing and departure operations or even terminate the provision of the ATC service in that area [SO-048, SO-049] Airspace users are to be informed about it as well [SO-050]
5	Closing ATC service in the aerodrome	In case there is a situation significantly affecting the safety of the operations in the corresponding aerodrome, the airport operations manager may decide to close the aerodrome and so stopping ATC services.	Remote controller has to be informed about the situation in the aerodrome in order to apply appropriate termination procedure [SO-048, SO-049]. Airspace users are to be informed about it as well [SO-050]
6	(Unplanned) ATCO Overload	Remote controller could potentially induced or not detect conflicts (on the air but also on the airport surface) due to this overload.	Similar as in today's operations the ATC resources in RVT are to be managed in such way that controller overload is avoided [SO-039]

Table 7: Additional Safety Objectives for Abnormal Conditions

Description
SO-044. RVT shall enable the detection of unexpected flights in the area of responsibility where ATC services are being provided
SO-045. RVT shall enable to detect emergency situations on the aircraft (gear problems, fire on tyres or aircraft, tail strike, etc.)
SO-046. RVT shall enable to initiate emergency procedures and follow emergency situations affecting aircraft

SO-047.	RVT shall enable to detect and manage a crash situation on the aerodrome or in its vicinity
SO-048.	RVT shall be aware of potential abnormal situations (abnormal weather, fire on terminal or aerodrome building, overload on the apron, etc.) in the airport that could affect or even force the termination (unplanned terminations) of the provision of ATC services
SO-049.	Remote provision of ATC service shall appropriately (safely) be stopped for unplanned terminations
SO-050.	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 terminated (as per unplanned terminations).

Table 8: List of Safety Objectives for Abnormal Operations

Description
AO-03. Flight crew detects airborne system failures and informs ATC as in current operations

Table 9: List of Assumptions concerning abnormal operations

2.8 Mitigation of System-generated Risks (failure approach)

This section concerns Single Remote Tower operations under internal failure conditions. Before any conclusion can be reached concerning the adequacy of the safety specification of Single Remote Tower operations, at the service level, it is necessary to assess the possible adverse effects that failures internal to the end-to-end RVT System might have upon the provision of the relevant ATM services described in section 2.6.1 and to derive additional functional and performance safety objectives and integrity safety objectives to mitigate against these effects.

2.8.1 Identification and Analysis of System-generated Hazards

The hazards presented in the following table have mainly been identified based on the functional and performance safety objective until now (what happens if they are not satisfied). Some of them however have been identified based on the initial failure mode assessment done at the level of the logical model elements.

The following table shows for each hazard:

- the corresponding hazard described at operational level

- the related safety objective from which the hazard is derived

- the assessed operational effects of the hazard accounting for the mitigation means identified

- the possible mitigations of the hazard consequences with a reference to existing functional and performance safety objectives (or assumptions) or to new ones.

- the assessed severity of the mitigated consequence determined used the risk classification schemes provided in Appendix I (derived from the Accident Incident Model (AIM)).

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity
OH-01	Remote ATC incorrectly coordinates with other ATSU with respect to inbound / outbound traffic	SO-001	A potential conflict can be induced Imminent Infringement	SO-004 SO-007 SO-009 AO-04 AO-05	MAC-SC3
OH-02	Remote ATC incorrectly	SO-002	A potential conflict	SO-004	MAC-SC3

	manage the entry of a flight into traffic circuit		can be induced

Imminent Infringement | SO-007
SO-009
AO-04 | |
| **OH-03** | Remote ATC incorrectly manages arriving aircraft | SO-002 | A potential conflict can be induced

Imminent Infringement | SO-004
SO-007
SO-009
AO-04
AO-05 | MAC-SC3 |
| **OH-04** | Remote ATC incorrectly manages departing aircraft | SO-003 | A potential conflict can be induced

Imminent Infringement | SO-004
SO-007
SO-009
AO-04
AO-05 | MAC-SC3 |
| **OH-05** | Remote ATC fails to provide appropriate separation to traffic in the vicinity of the aerodrome | SO-004 | Imminent Infringement | SO-007
SO-009
AO-04
AO-05 | MAC-SC3 |
| **OH-06** | Remote ATC fails to provide appropriate separation of traffic with respect to restricted areas | SO-005 | Tactical Conflict | SO-008
SO-010 | MAC-SC4a |
| **OH-07** | Remote ATC incorrectly manages missed approach situation | SO-006 | Imminent Infringement | SO-004
SO-025
AO-04
AO-05 | MAC-SC3 |
| **OH-08** | Remote ATC does not detect in time conflicts / potential collision between aircraft in the vicinity of the aerodrome | SO-007 | Imminent Collision | AO-04
AO-05 | MAC-SC2b |
| **OH-09** | Remote ATC does not detect in time restricted area infringements | SO-008 | Tactical Conflict | AO-04
AO-05
AO-06 | MAC-SC4a |
| **OH-10** | Remote ATC fails to provide appropriate instruction to solve a conflict between traffic on the vicinity of the aerodrome | SO-009 | Imminent Collision | AO-04
AO-05 | MAC-SC2b |
| **OH-11** | Remote ATC fails to provide appropriate instruction to solve an airspace infringement | SO-010 | Tactical Conflict | AO-04
AO-05
AO-06 | MAC-SC4a |
| **OH-12** | Remote ATC fails to provide appropriate information to departing | SO-011
SO-012 | Tactical Taxiway conflict generated | SO-016
SO-017
SO-018 | TInc-SC5 |

	aircraft for the start-up			AO-07	
OH-13	Remote ATC fails to enable push-back-towing operations to appropriate aircraft	SO-013	Tactical Taxiway conflict generated	SO-016 SO-017 SO-018 AO-07	TInc-SC5
OH-14	Remote ATC provides inadequate taxi instruction to aircraft on the manoeuvring area	SO-014	Encounter with aircraft, vehicle or obstacle	SO-016 SO-017 SO-018 AO-07	TInc-SC4
OH-15	Remote ATC provides inadequate taxi instruction to vehicle on the manoeuvring area	SO-015	Encounter with aircraft, vehicle or obstacle	SO-016 SO-017 SO-018 AO-07	TInc-SC4
OH-16	Remote ATC does not detect in time potential conflict on the manoeuvring area	SO-016	Imminent collision	AO-07	TInc-SC3
OH-17	Remote ATC fails to provide appropriate instruction to solve conflicts on the manoeuvring area	SO-017	Imminent collision	AO-07	TInc-SC3
OH-18	Remote ATC fails to provide (appropriate) navigation support to AC and vehicle on the manoeuvring area	SO-018	Tactical Taxiway conflict generated	SO-016 SO-017 AO-07	TInc-SC5
OH-19	Remote ATC incorrectly manage runway entry for a departure aircraft (occupied runway)	SO-019	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
OH-20	Remote ATC incorrectly manage runway exit for a landing aircraft	SO-020	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
OH-21	Remote ATC incorrectly manage runway crossing (occupied runway) for a vehicle or an aircraft	SO-021	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
OH-22	Remote ATC fails to properly support departing and landing aircraft (with respect to visual aids)	SO-022	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
OH-23	Remote ATC incorrectly manage vehicle related	SO-023	Runway conflict	SO-026 SO-027	RInc-SC3

	tasks on the runway			AO-08	
OH-24	Remote ATC incorrectly manage aircraft take-off (occupied runway)	SO-024	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
OH-25	Remote ATC incorrectly manage aircraft landing (occupied runway)	SO-025	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
OH-26	Remote ATC fails to detect in time runway incursions (aircraft or vehicles)	SO-026	Runway penetration	AO-08	RInc-SC4
OH-27	Remote ATC fails to provide appropriate instruction to solve runway incursion and prevent potential collision on the runway	SO-027	Runway penetration	AO-08	RInc-SC4
OH-28	Remote ATC fails to detect in time a flight towards terrain in the vicinity of the aerodrome	SO-028	Imminent CFIT	AO-09	CFIT-SC2b
OH-29	Remote ATC fails to provide appropriate support to pilot on a CFIT situation	SO-029	Imminent CFIT	AO-09	CFIT-SC2b
OH-30	Remote ATC fails to establish sufficient wake turbulence spacing between aircraft	SO-030	Turbulence in front of the aircraft at a distance less than the separation minima	AO-10	Wake-SC3
OH-31	Remote ATC fails to properly support landing / taking off operations with respect to weather conditions	SO-031	Potentially to a Landing accident	AO-11 AO-12	No severity allocated[1]
OH-32	Remote ATC fails to properly support landing / taking off operations with respect to runway conditions and potential foreign objective debris	SO-032	Potentially to a Landing accident	AO-12	No severity allocated[1]
OH-33	Remote ATC fails to properly support departing and arriving AC	SO-033 SO-034	Potentially to a Landing accident	AO-12	No severity allocated[1]

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[1] The risk classification schemes included in Appendix I (derived from AIM – Accident Incident Model from WP16.1.1) do not provide yet severities associated to landing related accidents.

	on the runway with respect to non-visual aids				
OH-34	Remote ATC fails to detect in time an intrusion inside landing-air protection area	SO-035	Potentially to a Landing accident	AO-12	No severity allocated[1]
OH-35	Remote ATC fails to provide appropriate ATC services with respect to operational environment conditions on the aerodrome and its vicinity	SO-036 SO-037 SO-038	This hazard is already covered by more detailed hazards already identified above, potentially inducing conflicts in the vicinity of the aerodrome or on the manoeuvre area due to inappropriate understanding of the operational environment conditions.

This hazard is related to all other hazards EXCEPT:

OH-01, OH-08, OH-09, OH-13, OH-16, OH-26, OH-28, OH-34 | n/a | n/a |
| **OH-36** | ATC resources are incorrectly managed in the RTC for the remote provision of ATC services from a RTV position | SO-039 | In case controller has to manage more traffic than expected, the controller workload could be negatively impacted and so the capability to provide ATC services.

This hazard is to be considered then as part of ALL the other hazards in which controller errors are a potential cause. | n/a | n/a |
| **OH-37** | Remote ATC fails to provide appropriate ATC services due to inappropriate capability of the RVT system | SO-040 | This hazard is already considered as part of ALL other hazards already identified above in which equipment failure/errors are potential causes, potentially inducing | SO-051 SO-052 | n/a |

			conflicts in the vicinity of the aerodrome or on the manoeuvre area.		

Table 10: System-Generated Hazards and Analysis

Description

SO-051. ATC service provision shall appropriately be stopped in case of inadequate capability of the RVT system elements to provide the service Note: inappropriate capability is defined in section 3 on the corresponding safety requirements.
SO-052. 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 cannot be provided anymore (unplanned termination of the ATC service provision due to system failures).

Table 11: Additional Safety Objectives in the case of internal failures

Description
AO-04. VFRs apply see and avoid with respect to other traffic as in current operations
AO-05. Airborne mid-air collision prevention is unchanged with respect to current operations (airborne safety net and see&avoid)
AO-06. Adjacent unit responsible of concerned restricted area provides separation service and collision avoidance
AO-07. Airborne taxiway collision avoidance is unchanged with respect to current operations (see&avoid)
AO-08. Airborne runway collision prevention is unchanged with respect to current operations (see&avoid)
AO-09. Airborne CFIT prevention is unchanged with respect to current operations (airborne safety net and see&avoid)
AO-10. Aircraft maintains visual separation / wake turbulence spacing as in current operations
AO-11. Weather information is obtained onboard from several sources (ATC, ATIS, AO, visualisation of wind-cones, etc.) as in current operations
AO-12. Airborne landing accident prevention is unchanged with respect to current operations

Table 12: List of Assumptions concerning system-generated hazards

2.8.2 Derivation of Safety Objectives (integrity/reliability)

The safety objectives presented here provides the reliability/integrity characteristics of the Safety Objectives presented in section 2. Only the ones related to the second phase 'Service provision' are listed here for the moment (list to be completed).

As explained in section 2.4 the overall safety target for remote tower is to provide a sufficient level of safety. The figures presented in the several SO have been derived from the Risk Classification Scheme defined in the frame of WP16.6.1 (see Guidance E in the document "16.06.01-D06-Guidance to Apply the SESAR Safety Reference Material-00-01-02.doc"). They represent the current ECAC wide average risk, not local levels of risk for specific aerodromes.

<u>Note</u>: for local implementation, these figures need to be checked and updated to reflect the local associated risk.

As in previous section, these Safety Objectives expresses WHAT we expect, in terms of integrity, from the entire Remote & Virtual Tower system as a whole. The safety requirements that will be derived from them will cover the HOW this Safety Objectives are to be satisfied, in terms of technical equipment, controller tasks and procedures.

Safety Objectives		ID
SO-101.	The likelihood that Remote ATC incorrectly coordinates with other ATSU with respect to inbound / outbound traffic shall be no more than 1e-5 per flight.hour	OH-01
SO-102.	The likelihood that Remote ATC incorrectly manage the entry of a flight intro traffic circuit shall be no more than 1e-5 per flight.hour	OH-02
SO-103.	The likelihood that Remote ATC incorrectly manage arriving aircraft shall be no more than 1e-5 per flight.hour	OH-03
SO-104.	The likelihood that Remote ATC incorrectly manage departing aircraft shall be no more than 1e-5 per flight.hour	OH-04
SO-105.	The likelihood that Remote ATC fails to provide appropriate separation to traffic in the vicinity of the aerodrome shall be no more than 1e-5 per flight.hour	OH-05
SO-106.	The likelihood that Remote ATC fails to provide appropriate separation of traffic with respect to restricted areas shall be no more than 1e-4 per flight.hour	OH-06
SO-107.	The likelihood that Remote ATC incorrectly manage missed approach situation shall be no more than 1e-5 per flight.hour	OH-07
SO-108.	The likelihood that Remote ATC does not detect in time conflicts / potential collision between aircraft on the vicinity of the aerodrome shall be no more than 1e-6 per flight.hour	OH-08
SO-109.	The likelihood that Remote ATC does not detect in time restricted area infringements shall be no more than 1e-4 per flight.hour	OH-09
SO-110.	The likelihood that Remote ATC fails to provide appropriate instruction to solve conflict between traffic on the vicinity of the aerodrome shall be no more than 1e-6 per flight.hour	OH-10
SO-111.	The likelihood that Remote ATC fails to provide appropriate instruction to solve airspace infringement shall be no more than 1e-4 per flight.hour	OH-11
SO-112.	The likelihood that Remote ATC fails to provide appropriate information to departing aircraft during the start-up shall be no more than 1e-1 per movement	OH-12
SO-113.	The likelihood that Remote ATC fails to enable push-back/towing operations to appropriate aircraft shall be no more than 1e-1 per movement	OH-13
SO-114.	The likelihood that Remote ATC provides inadequate taxi instruction to aircraft on the manoeuvring area shall be no more than 1e-2 per movement	OH-14
SO-115.	The likelihood that Remote ATC provides inadequate taxi instruction to vehicle in the manoeuvring area shall be no more than 1e-2 per movement	OH-15
SO-116.	The likelihood that Remote ATC does not remotely detect in time conflicts on the manoeuvring area shall be no more than 1e-3 per movement	OH-16
SO-117.	The likelihood that Remote ATC fails to provide appropriate instruction to solve conflicts on the manoeuvring area shall be no more than 1e-3 per movement	OH-17
SO-118.	The likelihood that Remote ATC fails to provide (appropriate) navigation support to AC and vehicle on the manoeuvring area shall be no more than 1e-1 per movement	OH-18
SO-119.	The likelihood that Remote ATC incorrectly manage runway entry for a departure aircraft (occupied runway) shall be no more than 1e-6 per movement	OH-19
SO-120.	The likelihood that Remote ATC incorrectly manage runway exit for a landing aircraft shall be no more than 1e-6 per movement	OH-20
SO-121.	The likelihood that Remote ATC incorrectly manage runway crossing (occupied runway) for a vehicle or an aircraft shall be no more than 1e-6 per movement	OH-21

SO-122.	The likelihood that Remote ATC fails to properly support departing and landing aircraft (wrt visual-aids) shall be no more than 1e-6 per movement	OH-22
SO-123.	The likelihood that Remote ATC incorrectly manage vehicle related tasks on the runway shall be no more than 1e-6 per movement	OH-23
SO-124.	The likelihood that Remote ATC incorrectly manage aircraft take-off (occupied runway) shall be no more than 1e-6 per movement	OH-24
SO-125.	The likelihood that Remote ATC incorrectly manage aircraft landing (occupied runway) shall be no more than 1e-6 per movement	OH-25
SO-126.	The likelihood that Remote ATC fails to detect in time runway incursions shall be no more than 1e-5 per movement	OH-26
SO-127.	The likelihood that Remote ATC fails to provide appropriate instruction to solve runway incursion and prevent potential collision on the runway shall be no more than 1e-5 per movement	OH-27
SO-128.	The likelihood that Remote ATC fails to detect in time a flight towards terrain shall be no more than 1e-7 per movement	OH-28
SO-129.	The likelihood that Remote ATC fails to provide appropriate support to pilot on a CFIT situation shall be no more than 1e-7 per movement	OH-29
SO-130.	The likelihood that Remote ATC fails to establish sufficient wake turbulence spacing between landing/departing aircraft shall be no more than 1e-5 per movement	OH-30
SO-131.	The likelihood that Remote ATC fails to properly support landing / taking off operations with respect to weather conditions shall be no more than in current operations[2]	OH-31
SO-132.	The likelihood that Remote ATC fails to properly support landing / taking off operations with respect to runway conditions and potential foreign objective debris shall be no more than in current operations[2]	OH-32
SO-133.	The likelihood that Remote ATC fails to properly support departing and arriving AC on the runway with respect to non-visual aids shall be no more than in current operations[2]	OH-33
SO-134.	The likelihood that Remote ATC fails to detect in time an intrusion inside landing-air protection area shall be no more than in current operations[2]	OH-34

Table 13: Safety Objectives on system-generated hazards

2.9 Impacts of Remote Tower operations for a Single aerodrome on adjacent airspace or on neighbouring ATM Systems

Any potential interaction with adjacent airspace and impact on neighbouring ATM system are already addressed in previous sections.

No additional safety objectives have been identified on that subject a part from the ones already derived from the assessment of the operations at normal conditions.

2.10 Achievability of the SAfety Criteria

No quantitative evidence on the achievability of the safety criteria through the specification of the safety objectives have been collected for Single Remote Tower.

2.11 Validation & Verification of the Safety Specification

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

- VP-056: shadow passive mode trial on ATC tower and APP services

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[2] The Risk Classification Schemes presented in Appendix I (provided in Guidance to Apply Safety Reference Material [2]) does not provide for the moment any value for the maximum frequency of occurrence concerning landing accidents.

- VP-057: shadow passive mode trial on ATC tower and APP services, for basic and advances RVT position

- VP-058: shadow passive and active mode trial on AFIS services

- VP-639: shadow passive mode trial on ATC tower services (small aerodromes)

- VP-640: shadow passive mode trial on ATC tower services (medium aerodromes)

L002 The results from these trials have allow to obtain some evidence on the validity of the results obtained for normal operations conditions, but limited evidence concerning abnormal conditions operations and degraded modes (related to internal system failure) have been obtained as only passive shadow mode trials have been done concerning ATC services.

The evidence obtained for the normal conditions show that some ATC tasks were identified as being more challenging in the single remote tower environment than in current operations (i.e. provision of ATC services from a tower located in the premises of the corresponding aerodromes), needing in particular further assessment for the local implementation of the concept. These tasks were 'Identification of an aircraft in the vicinity of the aerodrome' and 'Application of reduced separation in the vicinity of the aerodrome.

This is afterwards captured in the corresponding safety requirements derived in section 3 for each corresponding safety objective.

The safety related results on VP-057 are presented in Appendix F. The complete set of results from the five trials mentioned above is provided in the Validation Reports [15] and [18].

L003 The validity of the evidences collected from the trials is dependent on the characteristics of the aerodrome / operational environment used in those trials (described in the Validation Reports [15] and [18]), which are a sub-set of the operational environment in which remote tower is aimed to operate (as described in section 2.2). This is particularly true for the traffic density and the number of simultaneous movements.

Apart from the trials results, expert judgement has also been used for validating some results through working meetings, workshops and document reviews.

3 Safe Design at SPR Level

3.1 Scope

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

- description of the Logical Model of the Single Remote Tower system – section 3.2

- derivation, from the Functional and Performance Safety objectives of section 2, of the Functional Safety Requirements for the Single Remote Tower system previously described – section 3.3

- analysis of the operation of the Single Remote Tower system described above under normal operational conditions – section 3.4

- analysis of the operation of the Single Remote Tower as described above under abnormal conditions of the operational environment – section 3.5

- assessment of the adequacy of the Single Remote Tower as described above under internal-failure conditions and mitigation of the system generated hazards – section 3.6

- satisfaction fo the Safety Criteria by the Single Remote Tower system– section 3.7

- realism of the Single Remote Tower system – section 3.8

- validation and verification of the Single Remote Tower system specification – section 3.9

3.2 The SPR-level Model for Single Remote Tower

The SPR-level Model in this context is a high-level architectural representation of the Single Remote Tower system design that is entirely independent of the eventual physical implementation of the design in section 4. The SPR-level Model describes the main human tasks, machine functions and airspace design. In order to avoid unnecessary complexity, human-machine interfaces are not shown explicitly on the model – rather they are implicit between human actors and machine-based functions.

Note that two configurations of the Remote Tower system have been considered in the project:

- The Basic configuration, as presented in section 3.2.1 in which, using the visualisation system, visual information is provided to the controller in the same way as it would be from a local tower located in the aerodrome.

- The Advanced configuration, in which besides all the elements provided in section 3.2.1, additional enhanced visual features are also available on the visualisation system, providing additional information to the controller in order to support him/her to perform the corresponding ATS tasks. These enhanced features are listed in section 3.2.1.2 below, and further described in the OSED [REF].

Note that in the safety assessment has mainly focused on the basic configuration. Reference to any of these advanced visual features is only made in this report in case there may be an operational need for them to be put in place. Additional assessment of these specific enhanced visual features needs to be performed.

3.2.1 Description of SPR-level Model

The following figure shows the several elements componing the Remote and Virtual Tower (RVT) system, located in a Remote Tower Center (RTC) providing ATS services. For completeness reasons, external elements interacting with RVT are also showed in this model in order to derive relevant requirements and/or assumptions for the specification of the RVT system.
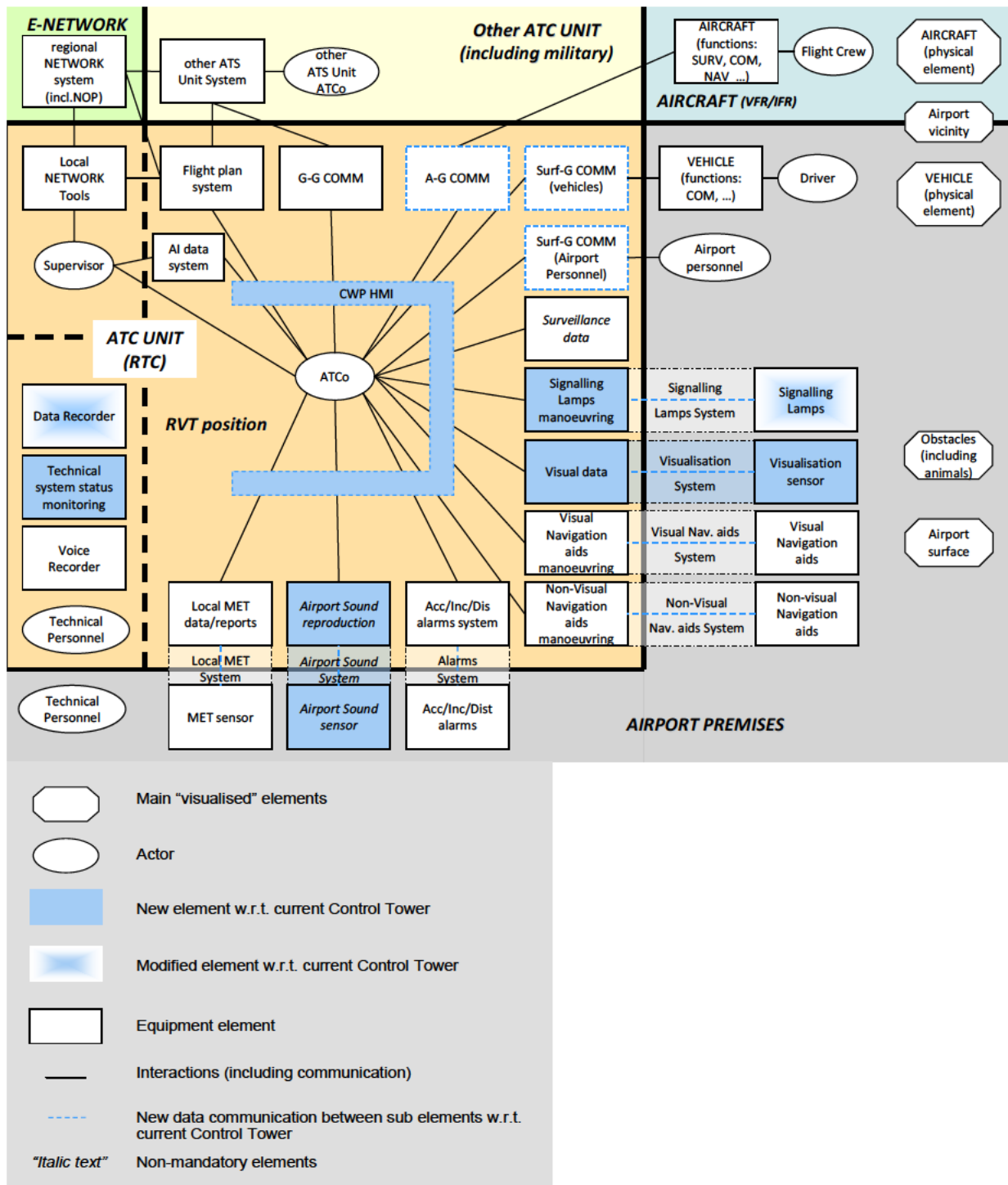
Figure 1: SPR-level Model for Single Remote Tower

The description of the several elements componing this model is provided in next sections.

3.2.1.1 Aircraft Elements

"Aircraft" elements:

Flight Crew	Pilots the aircraft using airborne information/systems and ATC instructions/clearances. They apply the corresponding rules and procedures as per ICAO Annex 2 and PANS OPS.
Aircraft (functions: SURV, COM, NAV, etc.)	Encompasses all the onboard information/systems needed for the flight.
Aircraft (physical element)	The aircraft are captured by the Visualisation system in order to be remotely provided to ATCO

3.2.1.2 Ground Elements

Remote Tower System – ATC Unit

"Strategic-services" related elements:

Local Network Tools	Provides relevant information and tools for supporting the supervisor's (if deployed) tasks as managing the airport re-staffing resources.
Supervisor (optional)	Manages the airport/ATC unit resources/capacity in order to cope with the foreseen traffic (staffing, re-sectorisation, closure of the airport, …).

"Pre-tactical/Tactical-services" related elements:

AI data system	Provides Aeronautical Information to the ATCO (AIP, NOTAMs, SNOWTAMs) to be used by supervisor (if deployed) and/or ATCO as necessary.
Flight plan system	Provides flight plan information to the ATCO for the aircraft flying/operating in the area of responsibility of the ATCO (TMA/Tower or Tower only) in form of paper strips or eventually electronic strips.
G-G COMM	Allows voice/data communication between ATCO and "other ATS unit ATCO". This supports the aeronautical fixed service AFS as defined in ICAO Doc4444 [9].
A-G COMM	Allows voice (VHF) / data (CPDLC) communication between ATCO and flight crew. This support the aeronautical mobile service as defined in ICAO Doc4444 [9].
Surf-G COMM (vehicles)	Allows voice communication (VHF) between ATCO and vehicles drivers on the airport surface
Surf-G COMM (Airport personnel)	Allows voice/data communication between ATCO and airport personnel
Surveillance Data System	When available, it provides "real-time" surveillance data for the (equipped) aircraft flying/operating in a delimited (from x feet to FLxxx) area of responsibility of the ATCO.

Signalling Lamps System	Allows the ATCO to remotely manoeuvre the Signalling Lamps located in the airport premises.
Visualisation System	Provides "real-time" images of the aerodrome*, the aerodrome traffic*, as well as any obstacle* in this area. A specific function allows a binocular view of particular element/objects. Additional advanced features may also be available on the visualisation system: - Infrared view - fixed cameras views - visual tracking - radar tracking - objects highlighting function
Visual Nav. aids System	Allows the ATCO to remotely manoeuvre the different "lighting" systems to support aircraft in "finding their way" to the airport, on the vicinity of the runway and on the airport surface (approach lighting, PAPI, threshold lights, airport beacon, runway and taxiway lighting, etc.)
Non-Visual Nav. Aids System	Allows the ATCO to remotely manoeuvre the different "non-lighting" systems to support aircraft in "finding their way" to the airport/runway (ILS, VOR, DME, …)
Accident, incident and distress alarms	Allows the ATCO to monitor and trigger accident, incident and distress alarms as applicable to the aerodrome.
Airport Sound System	When available, it provides "real-time" noise from the airport (aircraft engines, wind sound, …)
Local MET system	Provides to ATCO the relevant weather information on the airport (temperature, pressure/QNH, snow on the runway (?), wind direction/strength,…).
CWP HMI	Allows to ATCO to get information from all previous systems and to interact with them as necessary
ATCO	Provides ATC services (described in section 2.6) by using the information provided in the CWP HMI. The related ATCO tasks are described through the Task Analysis activity carried out in the frame of the HP assessment, included in section 3.2.2.

(*) as defined in ICAO Annex 11 [11]:
<u>aerodrome</u>: A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.
<u>aerodrome traffic</u>: All traffic on the manoeuvring area of an aerodrome and all aircraft flying in the vicinity of an aerodrome.
Note.— An aircraft is in the vicinity of an aerodrome when it is in, entering or leaving an aerodrome traffic circuit.
<u>obstacle</u>: All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:
a) are located on an area intended for the surface movement of aircraft; or
b) extend above a defined surface intended to protect aircraft in flight; or

c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.

"Technical supervision" related elements:

Data Recorder	Allows to record operational data (ICAO requirement) including visualisation information.
Technical System status monitoring	Allows to monitor and detect any technical failure mode / degraded mode of the system
Voice Recorder	Allows to record voice communication on the applicable radio channels (ICAO requirement)
Technical personnel	In charge of the maintenance of the "Technical supervision" elements

Airport Premises

Signalling Lamps System	Signalling Lamp is located in the airport premises, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
Visualisation System	Captures "real-time" images on the airport premises to be provided to the ATCO in the remote ATC unit (RTC)
Visual Nav. aids System	Visual Navigation aids are located in the airport premises, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
Non-Visual Nav. Aids System	Non-Visual Navigation aids are located in the airport premises, and remotely manoeuvred by ATCO from the remote ATC unit (RTC)
Airport Sound System	Captures "real-time" noise from the airport to be provided to the ATCO in the remote ATC unit (RTC)
Local MET system	Captures the relevant weather information on the airport to be provided to the ATCO in the remote ATC unit (RTC)

Limitation of the assessment: basic RVT has mainly addressed in the assessment. Recommendations on the enhanced visual features are provided, but any detailed assessment on their real impact on safety (benefice or degradation) has been provided in the frame of this assessment.

3.2.1.3 External Entities

"Other ATC Unit" elements:

Other ATS Unit ATCO	ATCO coordinates with other ATS Unit ATCO for transferring departing/arriving aircraft, (with military)

	for activating / deactivating restricted areas, …
Other ATS Unit System	Needed?

"E-Network" elements:

Regional NETWORK system	Provides Regional flight plans for the day of operations (CFMU) to local Network

"Airport premises" elements:

Driver	Drives the vehicle in the manoeuvring area as instructed by the ATCO
Vehicle (functions: COM, …)	Encompasses all the information/systems needed for driving it and communicate with ATCO and other airport personnel
Vehicle (physical element)	The vehicles are captured by the Visualisation system in order to be remotely provided to ATCO
Airport Personnel	Management of the airport stands, pushback services, runway inspections, …
Technical Personnel	Is in charge of the maintenance of the "remote" equipment located in the airport premises
Airport Surface	The airport surface is captured by the Visualisation system in order to be remotely provided to ATCO
Obstacles	Fixed (temporary or permanent) and mobile objects (including animals) that are captured by the Visualisation system in order to be remotely provided to ATCO
Airport Vicinity	Area close to the aerodrome (it includes aircraft which are in, entering or leaving an aerodrome traffic circuit) that is captured by the Visualisation system in order to be remotely provided to ATCO.

3.2.2 Task Analysis

A task analysis has been developed in the framework of the HP assessment. This task analysis provides the detail of the tasks done by the controller for the provision of the ATC services described in section 2.6.1.

The task analysis is available in the Appendix D of the HP assessment [16].

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

This section provides the safety requirements satisfying the safety objectives (functionality and performance) presented in section 2 for both normal and abnormal conditions. These safety requirements are defined at the level of the relevant elements of the SPR-level model shown above.

The following table shows how each mentioned safety objectives is decomposed and mapped on to the corresponding elements of the SPR-level model. The corresponding safety requirement reference is included into brackets.

While there is no requirement to follow operations as in current operations, the implementation of Safety Requirements shall of course be based on applicable regulations (e.g. ICAO specifications). So far no need for new regulations was identified.

SO	Requirement (forward reference)	Maps on to
ATC service provision from a RVT position		
SO-001	Flight plan information related to inbound and outbound traffic is to be provided to the controller for coordination and transfer purposes [SR-05]	Flight Plan system
	Controller has to be able to communicate with adjacent ATSU units in order to coordinate and transfer relevant arriving and departing traffic [SR-06]	G-G Comm
	When available, surveillance data is to be provided to the controller for supporting coordination and transfer procedures [SR-13]	Surveillance data
	Controller has to apply current coordination and transfer procedures on inbound and outbound traffic as relevant [SR-26]	ATCO
SO-002	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	When available, surveillance data is to be provided to the controller for managing arriving traffic [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support arriving traffic [SR-14]	Visualisation system
	Local meteorological information shall be available to the controller in order to support arriving traffic [SR-24]	Local MET system
	Flight plan information related to inbound traffic is to be provided to the controller [SR-05]	Flight Plan System
	Published arriving procedures have to be available to the controller in order to support arriving traffic [SR-01]	AI data system
	Controller has to manage arriving traffic [SR-26]	ATCO
SO-003	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	When available, surveillance data is to be provided to the controller for managing departing traffic [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support	Visualisation system

SO	Requirement *(forward reference)*	Maps on to
	departing traffic [SR-14]	
	Local meteorological information shall be available to the controller in order to support departing traffic [SR-24]	Local MET system
	Flight plan information related to outbound traffic is to be provided to the controller [SR-05]	Flight Plan System
	Published departing procedures have to be available to the controller in order to support departing traffic [SR-02]	AI data system
	Controller has to manage departing traffic [SR-26]	ATCO
SO-004	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	When available, surveillance data is to be provided to the controller for providing traffic separation [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support separation provision to traffic [SR-14]	Visualisation system
	The several types of traffic separation in use today are to be applied and handled by controller [SR-26]	ATCO
SO-005	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	When available, surveillance data is to be provided to the controller for ensuring separation with restricted areas [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support separation with restricted areas [SR-14]	Visualisation system
	Information on active/non-active restricted areas is to be available to the controller in the (or close to) area of responsibility [SR-03]	AI data system
	Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [SR-26]	ATCO
	Controller has to ensure separation with active restricted areas [SR-26]	ATCO
SO-006	When available, surveillance data is to be provided to the controller for managing missed approaches situations [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to manage missed approaches situations [SR-14]	Visualisation system
	Controller has to manage missed approaches situations [SR-26]	ATCO

SO	Requirement (forward reference)	Maps on to
SO-007	When available, surveillance data is to be provided to the controller for detecting conflicts or potential collisions between aircraft [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support detection of conflicts or potential collisions between aircraft [SR-14]	Visualisation system
	Controller within the RTC has to be able to detect conflicts and potential collisions [SR-26]	ATCO
SO-008	When available, surveillance data is to be provided to the controller for ensuring separation with restricted areas [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support separation with restricted areas [SR-14]	Visualisation system
	Information on active/non-active restricted areas is to be available to the controller in the (or close to) area of responsibility [SR-03]	AI data system
	Controller has to be able to detect potential conflicts with restricted areas [SR-26]	ATCO
SO-009	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	When available, surveillance data is to be provided to the controller for supporting the controller on the resolution of conflicts or avoiding potential collisions between aircraft [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support the resolution of conflicts or avoidance of potential collision between aircraft [SR-14]	Visualisation system
	Controller has to provide instructions to solve conflicts and potential collisions [SR-26]	ATCO
SO-010	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	When available, surveillance data is to be provided to the controller for supporting the controller on the resolution of airspace infringements [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support resolution of airspace infringements [SR-14]	Visualisation system
	Controller has to provide instructions to solve conflicts with restricted areas [SR-26]	ATCO

SO	Requirement *(forward reference)*	Maps on to
SO-011	Visual information on the apron and the traffic on this area is potentially to be provided to the controller in order to facilitate the identification of the departing aircraft [SR-15]	Visualisation system
	Flight plan information related to outbound traffic is to be provided to the controller aircraft identification purposes [SR-05]	Flight Plan system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to identify aircraft before providing ATC services [SR-26]	ATCO
SO-012	Visual information on the apron and the traffic on this area is potentially to be provided to the controller in order to facilitate the start-up procedures [SR-15]	Visualisation system
	Controller has to be able to communicate to the personnel in the airport the start-up procedures [SR-09]	Surf-G COMM (Airport personnel)
	Local meteorological information shall be available to the controller in order to support start-up procedures [SR-23] [SR-24]	Local MET system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to provide start-up instructions [SR-26]	ATCO
SO-013	Visual information on the apron and the traffic/vehicles/obstacles on this area is potentially to be provided to the controller in order to support the push-back/towing procedures [SR-15]	Visualisation system
	Controller has to be able to communicate to the personnel in the airport the push-back/towing procedures [SR-09]	Surf-G COMM (Airport personnel)
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to provide push-back/towing instructions [SR-26]	ATCO
SO-014	Visual information on the manoeuvring area and the traffic/vehicles/obstacles on this area is to be provided to the controller in order to provide routing instructions to aircraft [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to provide routing instructions to aircraft on the manoeuvring area [SR-26]	ATCO
SO-015	Visual information on the manoeuvring area and the traffic/vehicles/obstacles on this area is to be provided to the controller in order to provide routing instructions to aircraft aircraft	Visualisation system

SO	Requirement *(forward reference)*	Maps on to
	[SR-16]	
	Controller has to be able to communicate routing instructions to the vehicles in the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to provide routing instructions to vehicles on the manoeuvring area [SR-26]	ATCO
SO-016	Visual information on the manoeuvring area and the traffic/vehicles/obstacles on it is to be provided to the controller in order to detect hazardous situations aircraft [SR-16]	Visualisation system
	Controller has to be able to detect hazardous situations on the manoeuvring area (involving aircraft, vehicles and obstacles) [SR-26]	ATCO
SO-017	Visual information on the manoeuvring area and the traffic/vehicles/obstacles on it is to be provided to the controller in order to provide instructions to solve hazardous situations aircraft [SR-16]	Visualisation system
	Controller has to be able to communicate instructions to solve a hazardous situation to the vehicles on the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to provide taxing instruction in order to solve hazardous situations on the manoeuvring area [SR-26]	ATCO
SO-018	Controller has to be able to manoeuvring visual navigation aids in order to support AC and vehicle movements on the manoeuvring area [SR-21]	Visual Navigation Aids system
	Controller has to use visual navigation aids to support AC and vehicle movements on the manoeuvring area [SR-26]	ATCO
SO-019	Visual information on the take-off/landing area and the traffic/vehicles/obstacles on it (or close to) is to be provided to the controller in order to manage runway entry [] [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to check runway occupancy before providing line-up clearance, managing runway entry [SR-26]	ATCO
SO-020	Visual information on the taxiways close to runway area and the traffic/vehicles/obstacles on them (or close to) is to be provided to the controller in order to manage runway exit [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm

SO	Requirement (forward reference)	Maps on to
	Controller has to check taxiway occupancy before providing runway exit clearance, managing runway exit [SR-26]	ATCO
SO-021	Visual information on the take-off/landing area and the traffic/vehicles/obstacles on it (or close to) is to be provided to the controller in order to manage runway crossing [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to be able to communicate instructions on runway crossing to the vehicles on the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to check runway occupancy before providing runway crossing clearance, managing runway crossing [SR-26]	ATCO
SO-022	Controller has to be able to manoeuvring visual navigation aids in order to support take-off and landing operations [SR-21]	Visual Navigation Aids system
	Controller has to use visual navigation aids to support taking-off and landing operations [SR-26]	ATCO
SO-023	Controller has to be able to communicate with vehicles operating on the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to use manage vehicle related operations on the runway [SR-26]	ATCO
SO-024	Visual information on the take-off/landing area and the traffic/vehicles/obstacles on it (or close to) is to be provided to the controller in order to manage take-off operations [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to check runway occupancy before providing take-off clearance, managing take off operations [SR-26]	ATCO
SO-025	Visual information on the take-off/landing area and the traffic/vehicles/obstacles on it (or close to) is to be provided to the controller in order to manage landing operations [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to check runway occupancy before providing landing clearance, managing landing operations [SR-26]	ATCO
SO-026	Visual information on the take-off/landing area and the potential traffic/vehicles/obstacles present on it (or close to) is to be provided to the controller in order to detect runway incursions [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC	A-G Comm

SO	Requirement *(forward reference)*	Maps on to
	service is being provided [SR-07]	
	Controller has to be able to communicate with vehicles operating on the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to be able to detect runway incursions (AC, vehicles, animals, persons) [SR-26]	ATCO
SO-027	Visual information on the take-off/landing area and the potential traffic/vehicles/obstacles present on it (or close to) is to be provided to the controller in order to solve runway incursions situations[SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to be able to communicate with vehicles operating on the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to provide instructions to solve runway incursions (due to AC, vehicles, animals, persons) [SR-26]	ATCO
SO-028	When available, surveillance data is to be provided to the controller for detecting potential flight towards terrain situations [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support detection potential flight towards terrain situations [SR-14]	Visualisation system
	Controller has to be able to detect potential flight towards terrain situations [SR-26]	ATCO
SO-029	When available, surveillance data is to be provided to the controller for supporting resolution of potential flight towards terrain situations [SR-13]	Surveillance data
	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to support resolution of potential flight towards terrain situations [SR-14]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to provide appropriate instructions, information to support the resolution of potential flight towards terrain situations [SR-26]	ATCO
SO-030	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to establish/maintain sufficient wake turbulence spacing between aircraft [SR-14]	Visualisation system
	Flight plan information (in particular wake turbulence category) related to relevant traffic is to be provided to the controller in order	Flight Plan system

SO	Requirement *(forward reference)*	Maps on to
	to establish/maintain appropriate wake turbulence separation [SR-05]	
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to apply appropriate wake turbulence separation between aircraft [SR-26]	ATCO
SO-031	Visual information of the vicinity of the aerodrome is to be provided to the controller in order to be aware of the weather conditions [SR-18]	Visualisation system
	Local meteorological information shall be available to the controller in order to provide appropriate ATC services and provide necessary information to pilots in particular concerning landing and taking-off operations [SR-23] [SR-24]	Local MET system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to provide appropriate ATC services taking into account the weather conditions on his area of responsibility, as is done in current operations [SR-26]	ATCO
	Controller has to provide appropriate weather information to landing / taking off [SR-26]	ATCO
SO-032	Visual information of the runway area is to be provided to the controller in order check runway conditions for taking off and landing operations [SR-16]	Visualisation system
	Visual information of the runway area is to be provided to the controller in order to potentially identify FODs. A specific binocular-like functions is to be available in order to have a more detailed view of the runway [SR-19]	Visualisation system
	Controller has to be able to communicate with the personnel in the airport in order to coordinate runway inspections to determine runway conditions and detect potential FODs [SR-10]	Surf-G COMM (Airport personnel)
	Controller has to request to the corresponding airport personnel for runway inspections as necessary (under pilot request or when based on visual acquisition) [SR-26]	ATCO
	Controller has to provide relevant information to pilots on runway conditions [SR-26]	ATCO
SO-033	Visual information of the final approach area is to be provided to the controller in support landing operations [SR-16]	Visualisation system
	Controller has to provide relevant information to pilots on runway conditions [SR-26]	ATCO
SO-034	Controller has to be able to manoeuvring non-visual navigation	Non-Visual

SO	Requirement (forward reference)	Maps on to
	aids in order to support AC on landing operations [SR-22]	Navigation Aids system
	Controller has to use non-visual navigation aids to support AC on landing operations [SR-26]	ATCO
SO-035	Visual information on the runway area and the potential traffic/vehicles present on it (or close to) is to be provided to the controller in order to detect potential intrusions inside landing aid protection area [SR-16]	Visualisation system
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to be able to communicate with vehicles operating on the manoeuvring area [SR-08]	Surf-G COMM (Vehicles)
	Controller has to be able to detect potential intrusions inside landing aids protections area (AC, vehicles, animals, persons) [SR-26]	ATCO
SO-036	Visual information on the vicinity and the manoeuvring area of the aerodrome is to be provided to the controller, in particular concerning the visibility conditions in that area in order to apply relevant procedures to provide ATC service [SR-18]	Visualisation system
	Local meteorological information shall be available to the controller in order to determine the current visibility conditions and being able to apply relevant procedures to provide ATC service [SR-23] [SR-24]	Local MET system
	Controller has to be able to determine visibility and meteorological conditions in his area of responsibility (as for example low visual conditions) [SR-26]	ATCO
SO-037	Controller has to apply appropriate procedures to provide ATC service with respect to visibility and meteorological conditions (for example low visual procedures) [SR-26]	ATCO
SO-038	Handover procedures are to be applied. Any additional information concerning RVT position is to be also transferred from one controller to the other [SR-27]	ATCO
	Visual information mentioned in requirements Xs is to be provided in the several visibility conditions (CAVOK, darkness, …) [SR-20]	Visualisation system
ATFCM tasks at RTC level		
SO-039	The aerodrome capacity as per the operational environment defined in section 2.2 has to be provided to the Network Manager and relevant bodies in charge of Demand & Capacity Balancing activities (locally, regionally) in order to ensure that the traffic on an aerodrome to be controller from a RVT position is not exceeding those limits [SR-33]	RTC unit

SO	Requirement (forward reference)	Maps on to
	RTC Supervisor (if deployed) has to manage ATC resources (staffing) for a specific RVT position taking into account aerodrome capacities [SR-34]	Supervisor
	Information on foreseen and real traffic, as well as real time airport capacity and conditions is to be provided to the supervisor (if deployed) in order to be able to manage ATC resources adequately for a specific RVT positions [SR-35]	Local NETWORK tools
Initiation of ATC service provision from a RVT position		
SO-040	Controller allocated to a RVT position has to apply the relevant RVT position start-up procedure before providing ATC service from that RVT position (this start-up procedure includes check of the RVT capability) [SR-28]	ATCO
SO-041	Airspace used are to be informed about the (planned) provision of remote ATC services though AIP or NOTAMs [SR-04]	AI data system
	Controller has to be able to inform the airport personnel when the remote provision of ATC service is to be initiated [SR-11]	Surf-G COMM (Airport personnel)
	Personnel in the airport is to be informed when the remote provision of ATC service is to be initiated [SR-29]	ATCO
Termination of the ATC service provision from a RVT position		
SO-042	Controller has to ensure that ATC services can be appropriately (safely) stopped [SR-30]	ATCO
SO-043	Airspace used are to be informed about the (planned) provision of remote ATC services though AIP or NOTAMs [SR-04]	AI data system
	Controller has to be able to inform the airport personnel when the remote provision of ATC service is to be terminated [SR-11]	Surf-G COMM (Airport personnel)
	Personnel in the airport is to be informed when the remote provision of ATC service is to be terminated [SR-29]	ATCO
Abnormal conditions		
SO-044	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to eventually detect unexpected flights in the area of responsibility where ATC services are being provided [SR-14]	Visualisation system
	Controller has to monitor the area of responsibility in which ATC services area provided in order to eventually detect unexpected flights [SR-26]	ATCO
SO-045	Visual information of the vicinity of the aerodrome and the traffic on this area is to be provided to the controller in order to eventually detect emergency situations on the aircraft [SR-14]	Visualisation system

SO	Requirement *(forward reference)*	Maps on to
	A specific binocular-like function is to be available in order to have a more detailed view of traffic in case of emergency situation [SR-19]	Visualisation system
	Visual information of the final approach area is to be provided to the controller in order to eventually detect emergency situations on the aircraft [SR-16]	Visualisation system
	Visual information on the manoeuvring area and the traffic on it is to be provided to the controller in order to eventually detect emergency situations on the aircraft [SR-16]	Visualisation system
	Visual information on the take-off/landing area and the traffic on it (or close to) is to be provided to the controller in order to eventually detect emergency situations on the aircraft [SR-16]	Visualisation system
	Controller has to monitor the area of responsibility in which ATC services area provided in order to eventually detect emergency on aircraft [SR-26]	ATCO
SO-046	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to be able to communicate with adjacent ATSU units in case coordination is needed for solving an emergency situation [SR-06]	G-G Comm
	Visual information of the vicinity of the aerodrome, of the final approach area, of the landing and take-off areas, and of the manoeuvring and apron areas, as well as the concerned traffic on these areas is to be provided to the controller in order to initiate and support the resolution of emergency situations [SR-14] [SR-15] [SR-16]	Visualisation system
	A specific binocular-like functions is to be available in order to have a more detailed view of the aircraft in a situation emergency [SR-19]	Visualisation system
	When available, surveillance data is to be provided to the controller for supporting the controller on the emergency situation resolution [SR-13]	Surveillance data
	Controller has to be able to communicate with the rescue service people in the airport in order to provide relevant information for solving the emergency situation [SR-26]	Surf-G COMM (Airport personnel)
	In case of loss of radio communication with an aircraft, controller has to be able to remotely use signalling lamps to communicate with this concerned traffic [SR-39]	Signalling Lamps system
	Controller has to be able to activate accident/incident/distress alarms in order to prevent relevant services in the airport and to launch corresponding emergency procedures [SR-39]	Accident / incident / distress alarms system

SO	Requirement *(forward reference)*	Maps on to
	Controller has to apply corresponding emergency procedures in order to support on the resolution of the situation [SR-26]	ATCO
	In case of an emergency in the aerodrome premises that may affect the safe provision of ATC service from the RVT position, the corresponding airport personnel has to contact the RCT to inform about the situation [SR-39]	Airport personnel
SO-047	Controller has to be able to communicate with adjacent ATSU units in case coordination is needed for solving an emergency situation [SR-06]	G-G Comm
	Visual information of the vicinity of the aerodrome, of the final approach area, of the landing and take-off areas, and of the manoeuvring and apron areas, as well as the concerned traffic on these areas is to be provided to the controller in order to initiate and support the resolution of emergency situations [SR-14] [SR-15] [SR-16]	Visualisation system
	A specific binocular-like functions is to be available in order to have a more detailed view of the situation [SR-19]	Visualisation system
	When available, surveillance data is to be provided to the controller for supporting the controller on the emergency situation resolution [SR-13]	Surveillance data
	Controller has to be able to communicate with the rescue service people in the airport in order to provide relevant information for solving the emergency situation [SR-12]	Surf-G COMM (Airport personnel)
	Controller has to be able to activate accident/incident/distress alarms in order to prevent relevant services in the airport and to launch corresponding rescue procedures [SR-39]	Accident / incident / distress alarms system
	Controller has to apply corresponding procedures for the management of a crash situation [SR-26]	ATCO
SO-048	In case of an emergency or abnormal situation in the aerodrome premises that may affect the safe provision of ATC service from the remote tower, the corresponding airport personnel has to contact the RCT to inform about the situation [SR-39]	Airport personnel
	Communicate between remote controller and the relevant airport personnel has to be available [SR-12]	Surf-G COMM (Airport personnel)
SO-049	Controller has to ensure that ATC services are appropriately (safely) stopped in case of abnormal situation forcing the termination of the ATC service provision [SR-31]	ATCO
SO-050	Airspace users are to be informed about the unplanned termination of the ATC service provision [SR-32]	ATCO
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm

SO	Requirement (forward reference)	Maps on to
	Controller has to be able to inform the airport personnel when the remote provision of ATC service is to be unplanned stopped [SR-11]	Surf-G COMM (airport personnel)
	Relevant personnel in the airport is to be informed when the remote provision of ATC service is to be stopped for an unexpected reason [SR-29]	ATCO
SO-051	Controller has to ensure that ATC services are appropriately (safely) stopped in case of inadequate capability of the RVT system to provide the service [SR-61] [SR-62] [SR-63] [SR-65] [SR-66]	ATCO
SO-052	Airspace users are to be informed about the unplanned termination of the ATC service provision [SR-32]	ATCO
	Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]	A-G Comm
	Controller has to be able to inform the airport personnel when the remote provision of ATC service is to be unplanned stopped [SR-11]	Surf-G COMM (airport personnel)
	Relevant personnel in the airport is to be informed when the remote provision of ATC service is to be stopped for an unexpected reason as inappropriate capability of the RVT system to provide the service [SR-29]	ATCO

Table 14: Mapping of Safety Objectives to SPR-level Model Elements

The following table lists the safety requirements and recomendations derived from previous table. They are presented per SPR-model elements. A reference to the corresponding Safety objective(s) is also provided. The reference of the corresponding OSED requirement related to each safety requirement is shown as within "[REF]". Note that the complet reference of those requirements is [REQ-06.09.03-OSED-REF].

Information concerning the validation of each of these safety requirements is provided in Appendix B.

SR#	Safety Requirement	Derived from
AI data system		
SR-01 [FN02.5007]	Published arriving procedures shall be available to the controller	SO-002
SR-02 [FN02.5007]	Published departing procedures shall be available to the controller	SO-003
SR-03 [FN02.5007]	Information on active/non-active restricted areas shall be available to the controller in the (or close to) area of responsibility	SO-005 SO-008
SR-04 [RTC3.0015]	Airspace users should be informed about the (planned) provision of remote ATC services though AIP or NOTAMs	SO-041 SO-043

SR#	Safety Requirement	Derived from
	(starting and ending times).	
Flight Plan Data system		
SR-05 [FN02.5003]	Flight plan information related to relevant traffic shall be provided to the controller in RVT position for providing ATC services	SO-001 SO-002 SO-003 SO-011 SO-030
G-G COMM		
SR-06 [CO02.1002]	Ground-ground communication with relevant adjacent units shall be available to the controller in a RVT position Note: as per the aeronautical fixed service in accordance with ICAO Annex 11, Chapter 6.2.	SO-001 SO-046 SO-047
A-G COMM		
SR-07 [CO02.1001]	Air-ground communication with relevant traffic shall be available to the controller in a RVT position. Note: as per the aeronautical mobile service in accordance with ICAO Annex 11, Chapter 6.1	SO-002 SO-003 SO-004 SO-005 SO-009 SO-010 SO-011 SO-012 SO-013 SO-014 SO-017 SO-019 SO-020 SO-021 SO-024 SO-025 SO-026 SO-027 SO-029 SO-030 SO-031 SO-035 SO-046 SO-050 SO-052
Surf-G COMM (airport personnel/vehicles inside manoeuvring area)		
SR-08 [CO02.1003]	Communications for the control of relevant vehicles, other than aircraft, on manourvring areas shall be available to the controller in a RTV position. Note: as per the Surface movement control service in accordance with ICAO Annex 11, Chapter 6.3	SO-015 SO-017 SO-021 SO-023 SO-026 SO-027 SO-035
Surf-G COMM (airport personnel/vehicles outside manoeuvring area)		

SR#	Safety Requirement	Derived from
SR-09 [CO02.1002]	Communication with airport personnel operating on the apron should be available to controller in RVT position	SO-012 SO-013
SR-10 [CO02.1003]	Communication with airport personnel in charge of runway inspections shall be available to controller in RVT position for the coordination of runway inspections	SO-032
SR-11 [CO02.1002]	Communication with airport personnel in charge of local airport services shall be available to controller in RVT position	SO-041 SO-043 SO-050 SO-052
SR-12 [CO02.1002]	Communication with airport personnel in charge of rescue service in the aerodrome shall be available to controller in RVT position	SO-046 SO-047 SO-048
Surveillance data		
SR-13 [FN02.5001]	When providing Air Traffic Services, surveillance data should be provided to the controller in RVT position	SO-001 SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028 SO-029 SO-046 SO-047
Visualisation system		
SR-14 [VG03.1001]	Visual presentation of traffic in the vicinity of the aerodrome shall be provided to the controller in RVT position Note: this includes final approach and initial climb areas, and it has to take into account specific traffic evolution for landing and taking off as it is the case for helicopters.	SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-019 SO-020 SO-021 SO-024 SO-025 SO-026 SO-027SO-028 SO-029 SO-030 SO-032

SR#	Safety Requirement	Derived from
		SO-033 SO-035 SO-044 SO-045 SO-046 SO-047
SR-15 [VG03.1001]	Visual presentation of the apron and the traffic/vehicles/obstacles/personnel on this area should be provided to the controller in RVT position	SO-011 SO-012 SO-013 SO-046 SO-047
SR-16 [VG03.1001]	Visual presentation of the manoeuvring area and the traffic/vehicles/personnel on this area shall be provided to controller in RVT position Note: this includes runway(s) and the traffic/vehicles/personnel on or close to it.	SO-014 SO-015 SO-016 SO-017 SO-045 SO-046 SO-047
SR-18 [VQ03.1206] [VG03.1001] [VC03.1106]	Visual presentation of the vicinity of the aerodrome and of the aerodrome surface allowing to be aware of the local weather conditions (including visibility conditions) shall be provided to the controller in RVT position	SO-031 SO-036
SR-19 [VS02.3004]	A specific binocular-like function (with equivalent usability and quality performance) shall be available to the controller in RVT position, giving the possibility to zoom/enlarge areas and objects in the visual presentation	SO-032 SO-045 SO-046 SO-047
SR-20 [VC03.1106]	If there is a difference in the perception of daylight/darkness conditions between the visual presentation and the reality, the controller shall have access to information about the current daylight /dusk / darkness / dawn conficiton at the remote aerodrome as well as the expected time for the transitioning between these phases.	SO-038
Visual Navigation aids system		
SR-21 [NV02.4001]	Visual navigation aids on the concerned aerodrome (runway and field lighting system as applicable) shall be manageable and adjustable by controller in RVT position	SO-018 SO-022
Non-Visual Navigation aids system		
SR-22 [NV02.4002]	Non-visual navigation aids on the concerned aerodrome (as applicable) shall be manageable and adjustable by controller in RVT position	SO-034
Local MET system		
SR-23 [MT02.2001]	Controller in a RVT position shall be supplied with meteorological information in accordance with ICO Annex	SO-002 SO-003SO-012

SR#	Safety Requirement	Derived from
	11 Chapter 7.1 and national regulations.	SO-031 SO-036
SR-24 [MT02-2002]	The current MET report, actual wind information, actual QNH and, if measured for the particular airport, RVR values shall continuosly be presented to the controlle in the RVT position.	SO-003 SO-012SO-031 SO-036
ATCO – ATC service provision		
SR-26 [CS03.0001] [CS03.0002] [MT02.2003]	Controller shall apply relevant current procedures (as per ICAO PANS ATM [9]) to provide corresponding ATC service (Tower only or Tower and APP) to a single aerodrome from a RVT position. Note: This concerns procedures in terms of (mainly and as example): * Coordination and transfer for inbound and outbound traffic * Coordination with military and other units concerning restricted areas * Identification of the aircraft to which the ATC service is to be provided * Manage arriving and departing traffic * Ensuring appropriate separation between traffic and with restricted areas * Manage missed approaches * Detection and resolution of hazardous situations (between aircraft, with vehicles, with obstacles) * Support to pilots on the detection and resolution of hazardous situations with terrain * Start-up and push-back/towing procedures * Managing aircraft and vehicle on the manoeuvring area * Detecting and solving hazardous situations (including runway incursions an intrusions inside landing aids protections area) on the manoeuvring area * Managing taking off and landing operations (including the use of visual and non-visual navigation aids) * Detecting and solving hazardous situations related to taking off and landing operations * Providing appropriate ATC services taking into account visual, meteorological and airport conditions (including runway status) * Providing appropriate weather and aerodrome conditions information * Managing emergency situations	SO-001 SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-011 SO-012 SO-013 SO-014 SO-015 SO-016 SO-017 SO-018 SO-019 SO-020 SO-021 SO-022 SO-023 SO-024 SO-025 SO-026 SO-027 SO-028 SO-029 SO-030 SO-031 SO-032 SO-033 SO-034 SO-035 SO-036 SO-037 SO-044 SO-045 SO-046 SO-047

SR#	Safety Requirement	Derived from
SR-27 [CS03.0001] [CS03.0002]	Handover procedures shall be applied in a RVT position. Additional information concerning RVT equipment status shall also be transferred from one controller to the other during this procedure	SO-038
SR-28 [RTC3.0008]	Controller/Supervisor (if implemented) shall verify the status of an aerodrome, in terms of traffic, weather, etc. and the related systems before providing ATC service to the aerodrome. The verification shall also include checking the RVT capability for the provision of the service. Note: this procedure has to include at least the checking of the following elements: - MET system - Ground-ground (with other ATS units), air-ground, and ground- ground (with airport services and personnel) communication system - Visualisation system - Visual and non visual navigation aids	SO-040
SR-29 [RTC3.0016]	Personnel in charge of local airport services shall be aware of when the ATC service is provided in the corresponding airport.	SO-041 SO-043 SO-050 SO-052
SR-30 [CS03.0001] [CS03.0002]	Prior to a planned termination, controller shall ensure that ATC services can be safely stopped.	SO-042
SR-31 [CS03.0001] [CS03.0002]	Prior to an unplanned termination of the service, controller should ensure that ATC services are safely stopped.	SO-049
SR-32 [CS03.0001] [CS03.0002]	Controller should inform all traffic under his/her responsibility in case the provision of the ATC services is unplannedly stopped.	SO-050 SO-052
RTC level		
SR-33 [CS03.0001] [CS03.0002]	Aerodrome capacity shall be defined not only based on the aerodrome characteristics but also taking account the fact that ATC service is remotely provided. Note: For relevant aerodromes (mainly based on their size) capacity is to be provided to the Network Manager and relevant bodies in charge of demand & Capacity Balancing activities (locally, regionally) in order to ensure that the traffic on those aerodromes to be controller from a RVT position is not exceeding those limits.	SO-039
SR-34 [SUP3.0010]	If a RTC Supervisor role is implemented, supervisor in a RTC shall access functions for the planning, coordination and monitoring of the upcoming and present traffic flow in the purpose of tactical opening and closure of RVTs	SO-039

SR#	Safety Requirement	Derived from
	positions and allocation of airports to them	
SR-35 [SUP3.0013]	If a RTC Supervisor role is implemented, supervisor shall access functions for the monitoring of weather for all the aerodromes.	SO-039
Signalling Lamps system		
SR-37 [CM02.1004]	Signalling Lamps on the concerned aerodrome shall be manageable and adjustable by controller in RVT position in order to support AC and vehicle movements in case of loss of communication	SO-046
Accident / incident / distress alarms system		
SR-38 [FN02.5004]	Activation of accident / incident / distress alarms and corresponding coordination shall be available to controller in RVT position	SO-046 SO-047
Airport services / relevant personnel		
SR-39 [RTC3.0016]	Relevant airport service / personnel shall contact the RTC / controller in RVT position in order to inform about any situation or condition on the aerodrome that might affect the safe provision of ATC services	SO-046 SO-048

Table 15: Derivation of Safety Requirements from normal and abnormal conditions SO

ID	Assumptions
Other ATS units	
AO-13.	Other ATC units adjacent to the RTC (including military) operate and provide the relevant ATS service as per PANS ATM [9]
Services at the airport	
AO-14.	Services at the airport concerning apron operations, runway inspections, technical support, etc., are provided.
Equipment at the airport	
AO-15.	Relevant Visual and Non visual navigation aids are available in the airport premises

Table 16: Assumptions made in deriving the above Safety Requirements

3.3 Analysis of the SPR-level Model – Normal Operational and Abnormal Conditions

This section aims at ensuring that the SPR-level design is complete, correct and internally coherent with respect to the safety requirements derived for the normal operating conditions that were used to develop the corresponding safety objectives in section 2.6.2.

The analysis necessarily depends on proving the Safety Requirements (Functionality and Performance) from three perspectives:

- a static view of the system behaviour using scenarios for normal operations described in section the OSED

- check that the system design operates in a way that does not have a negative effect on the operation of related ground-based and airborne safety nets

- a dynamic view of the system behaviour using validation exercises.

3.3.1 Scenarios for Normal Operations

The use cases proposed in the OSED to be used as scenarios for Normal operations for assessing the completeness of the safety requirements obtained until now are the following ones:

ID	Scenario	Rationale for the Choice
UC-1	Arriving aircraft handled by remotely provided ATS	Use case in OSED §5.1.1.4
UC-2	Large Animal on Manoeuvring area while arriving aircraft handled by remotely provided ATC	Use case in OSED §5.1.1.4b
UC-3	VFR flight in the traffic circuit is conflicting with an arriving IFR flight	Use case in OSED §5.1.2
UC-4	Two departing IFR flights during Low Visibility	Use case in OSED §5.1.3
UC-5	Arrival aircraft with combined Remote TWR/APP	Use case in OSED §5.1.4
UC-6	Transition of ATS provision from local TWR to Remote TWR	Use case in OSED §5.1.5

Table 17: Operational Scenarios – Normal Conditions

3.3.2 Analysis of the SPR-level Model – Normal Operations

The analysis of the several scenarios for normal operations listed in previous section is presented in Appendix G

Only two additional safety requirements have been obtained from the analysis of the operational scenario UC-6 listed in previous section. These requirements are shown in section 3.3.7.

3.3.3 Scenarios for Abnormal Conditions

Only one abnormal scenario has been analysed, the one (proposed in OSED section §5.1.1.4c) concerning "Arriving aircraft with landing gear not locked handled by remotely provided ATC" (UC-7).

3.3.4 Thread Analysis of the SPR-level Model - Abnormal Conditions

The analysis of the several scenarios for normal operations listed in previous section is presented in Appendix G.

Any additional safety requirement has been obtained from the analysis of this abnormal condition.

3.3.5 Effects on Safety Nets – Normal Operational and Abnormal Conditions

The potential ground-based safety nets that could be used in a remote tower are the same as in a current tower providing tower services and potentially APP services. In both cases the fact of remotely providing the ATC services will not have a negative effect on the operation of those related safety nets as they mainly operated based on surveillance data, which remains unchanged in remote tower with respect to current operations.

There is no change on the way flights operate when they are remotely controlled, so a priori there is no impact on the airborne safety net either.

3.3.6 Dynamic Analysis of the SPR-level Model – Normal Operational and Abnormal Conditions

As mentioned before, the validation exercises performed in the frame of Remote Tower OFA have been the following ones:

- VP-056: shadow passive mode trial on ATC tower and APP services
- VP-057: shadow passive mode trial on ATC tower and APP services, for basic and advances RVT position
- VP-058: shadow passive and active mode trial on AFIS services
- VP-639: shadow passive mode trial on ATC tower services (small aerodromes)
- VP-640: shadow passive mode trial on ATC tower services (medium aerodromes)

The results from these trials have allow to obtain some evidence on the validity of the results obtained mainly for normal operations conditions, but limited evidence on the dynamic aspects of the system as only passive shadow mode trials have been done concerning ATC services.

The safety related results on VP-057 are presented in Appendix F. The complete set of results from the five trials mentioned above is provided in the Validation Report [15].

3.3.7 Additional Safety Requirements (functionality and performance) – Normal Operational Conditions

The following safety requirements have been identified from the assessment of the SPR-design (from the static view of the system) with respect to normal operational conditions.

SR#	Safety Requirement
SR-40 [RTC3.0017]	Coordination and transfer of control of operational systems between local and RVT shall take place prior to transfer ATS provision from one to the other (in terms of sharing operational conditions and information)

Table 18: Additional Safety Requirements for Normal Conditions

3.3.8 Additional Safety Requirements – Abnormal Operational Conditions

No additional safety requirements have been identified from the assessment of the SPR-design with respect to abnormal operational conditions (the static view, the dynamic view, and the potential impact on safety nets).

3.4 Design Analysis – Case of Internal System Failures

This part of the safety assessment focuses on the causes of the hazards identified in section 2.8. The steps concerning this assessment are the following ones:

- for each system-generated hazard, top-down identification of internal system failures that could cause the hazard
- 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)
- setting of Safety Requirements to limit the frequency with which each identified system failure could be allowed to occur, taking account of the above mitigations.

- show that the Safety Requirements are achievable - i.e. can be satisfied in a typical physical implementation

3.4.1 Causal Analysis

This section provides a list of causes, per SPR-model level element, leading to the hazards listed in section 2.8. The link with the related operational hazards is show in the table.

The specific list of causes for each operational hazard is provided in Appendix H.

Note: the causes related to human error in performing specific tasks have also been taken into account in the causal analysis for each hazard. The corresponding quantification of these errors is provided only in order to show traceability and transparency on the process. But no quantitative safety requirement has been directly derived from them. Based on these results the purpose is to provide an indication of the associated risk to the identified human related errors. This list is potentially to be addressed in future activities of the human performance assessment for remote tower (see the list in Appendix K).

Cause ID	Cause description	Related OH
Flight Data Processing System		
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4fh]	OH-01 OH-03 OH-04
FDPS-001	Inappropriate information is provided by the Flight Data Processing System [1e-4/mov]	OH-12 OH-13 OH-30
AI data system		
AID-002	Incorrect arriving/departing procedures are available or are not provided to the controller [1e-3/fh]	OH-03 OH-04
AID-001	Information concerning restricted areas use is incorrect or missing [1e-4/fh]	OH-05 OH-09 OH-11
G-G Comm		
G-GCOM-001	G-G communication failure or degradation [1e-4fh].	OH-01
Surf-G Comm		
S-GCOM-002	Failure or degradation of the S-G communication with personnel in charge of the apron [1e-4/mov]	OH-13
S-GCOM-001	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	Failure or degradation of voice communication with personnel responsible of RWY inspections [1e-4/mov]	OH-32

Surveillance data		
SURV-001	(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 OH-11
SURV-002	Inappropriate Surveillance information concerning restricted areas in the vicinity of the aerodrome [1e-4/fh]	OH-06
SURV-003	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/fh]	OH-09
SURV-001	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	Lack of surveillance for traffic on the vicinity of the aerodrome [1e-4/mov]	OH-28 OH-29

Visualisation System		
VRS-003	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 OH-11
VRS-001	Loss of information on the vicinity of the aerodrome provided by VRS [1e-4/fh]	OH-09 OH-28
VRS-005	Inappropriate information on APRON area is provided on VRS using binoculars-like function [1e-4/mov]	OH-12 OH-13
VRS-007	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	Loss of information on manoeuvring area on the VRS [1e-4/mov]	OH-16 OH-26

VRS-008	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	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	Loss of information on final approach on the VRS [1e-4/mov]	OH-26 OH-28
VRS-003	Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome [1e-4/mov]	OH-28 OH-29 OH-31
ATCO		
ATCO-008	ATCO incorrectly coordinates with other ATSU for inbound/outbound traffic transfer [1e-3fh]	OH-01
ATCO-013	ATCO fails to identify and aircraft near the traffic circuit [1e-3fh]	OH-02
ATCO-002	ATCO fails to provide appropriate instruction for AC to entry into traffic circuit [1e-3/fh]	OH-02
ATCO-001	ATCO fails to manage arriving traffic in the vicinity of the aerodrome [1e-3/fh]	OH-03
ATCO-038	ATCO fails to manage departing traffic in the vicinity of the aerodrome [1e-3/fh]	OH-04
ATCO-003	ATCO fails to apply appropriate separation between aircraft on the vicinity of the aerodrome[1e-3/fh]	OH-05
ATCO-014	ATCO fails to appropriately separate aircraft from restricted areas on the vicinity of the aerodrome [1e-4fh]	OH-06
ATCO-011	Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [1e-4/fh]	OH-06 OH-11
ATCO-006	ATCO fails to manage go-around situations [1e-3/fh]	OH-07

ATCO-004	ATCO fails to detect in time conflicts and potential collisions on the vicinity of the aerodrome [1e-3/fh]	OH-08
ATCO-009	ATCO fails to detect in time restricted area infringement [1e-2/fh]	OH-09
ATCO-005	ATCO fails to provide appropriate instruction to solve conflict on the aerodrome vicinity [1e-3/fh]	OH-10
ATCO-007	ATCO fails to provide appropriate instruction to solve airspace infringement [1e-2/fh]	OH-11
ATCO-010	ATCO identifies an incorrect departing AC for initiating the remote ATC service [1e-2/mov]	OH-12 OH-13
ATCO-039	ATCO incorrectly provides information to departing aircraft during the start-up [1e-1/mov]	OH-12
ATCO-040	ATCO incorrectly coordinated with airport personnel in charge of the apron for push-back/towing procedures [1e-2]	OH-13
ATCO-016	ATCO identifies incorrect aircraft on the manoeuvring area (taxiways) [1e-2/mov]	OH-14
ATCO-015	ATCO fails to provide appropriate route instruction to aircraft on the manoeuvring area [1e-2/mov]	OH-14
ATCO-017	ATCO identifies incorrect vehicle on the manoeuvring area (taxiway) [1e-3]	OH-15
ATCO-018	ATCO provides inappropriate route instruction to vehicle on the manoeuvring area (taxiway) [1e-3/mov]	OH-15
ATCO-019	ATCO fails to detect in time conflict on the manoeuvring area [1e-1/mov]	OH-16
ATCO-020	ATCO fails to provide appropriate instruction to solve conflicts on the manoeuvring area [1e-1/mov]	OH-17
ATCO-021	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 fails to correctly identify next aircraft in the departing sequence [1e-4/mov]	OH-19
ATCO-022	ATCO allows aircraft to line-up in a runway already being used [1e-4/mov]	OH-19
ATCO-023	Remote ATCO fails to provide appropriate runway exit instruction to landing aircraft [1e-4/mov]	OH-20
ATCO-025	ATCO identifies an incorrect aircraft or vehicle for crossing the runway [1e-4/mov]	OH-21
ATCO-026	ATCO fails to provide appropriate navigation support to departing/arriving AC on the runway using Visual Navigation Aids	OH-22

	[1e-4/mov]	
ATCO-031	ATCO allows vehicle to enter/operate in a runway which is being used [1e-4/mov]	OH-23
ATCO-027	ATCO provides take-off clearance for departing AC in a runway already being used [1e-4/mov]	OH-24
ATCO-028	ATCO provide landing clearance for a runway already being used [1e-4/mov]	OH-25
ATCO-029	ATCO fails to detect in time a runway incursion [1e-4/mov]	OH-26
ATCO-032	ATCO fails to provide appropriate instruction to solve runway incursion and prevent potential collision [1e-4/mov]	OH-27
ATCO-033	ATCO fails to detect in time a flight towards terrain [1e-3/mov]	OH-28
ATCO-034	ATCO fails to provide appropriate instructions and information for solving CFTT situation [1e-3/mov]	OH-29
ATCO-035	ATCO fails to create sufficient WT spacing between landing/departing aircraft [1e-3/mov]	OH-30
ATCO-036	ATCO fails to appropriately assess weather conditions [1e-3/mov]	OH-31
ATCO-041	ATCO fails to appropriately provide weather related information to pilot for supporting landing/departing operations [1e-3/mov]	OH-31
ATCO-037	ATCO fails to visually assess runway surface conditions [1e-3/mov]	OH-32
ATCO-042	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 fails to detect an intrusion inside landing-air protection area [1e-3/mov]	OH-34
A-G Comm		
A-GCOM-001	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 OH-11
A-GCOM-001	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
Local MET system		
MET-001	Incorrect MET/Weather information [1e-4/fh→2e-4/controlh]	OH-03
		OH-04
MET-001	Incorrect MET/Weather information [1e-4/mov]	OH-12
		OH-31
Visual Navigation Aids system		
VNAM-001	Loss or dysfunction of Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	OH-18
		OH-22
Non Visual Navigation Aids system		
NVNAM-001	Loss or dysfunction of Non Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	OH-33
Airport Personnel		
APERS-001	Airport personnel provides incorrect information on runway surface [1e-4/mov]	OH-32
Other ATSU unit		
OATSUS-001	Incorrect information is provided by other ATS unit system concerning inbound traffic [1e-4fh]	OH-01
Assumptions		
POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	OH-01
		OH-02
		OH-03
		OH-04
		OH-05
		OH-07
CONFLICT-AIR	Conflict in the vicinity of the aerodrome [1e-3]	OH-08
		OH-10
AIRSPACE-INF	Airspace infringement in the vicinity of the aerodrome [1e-2]	OH-09
		OH-11
POT.CONFLICT-TWY	Probability of an aircraft/vehicle/obstacle in the proximity potentially creating a conflict [1e-1]	OH-14
		OH-15
CONFLICT-SURF	Conflict on the manoeuvring area of the aerodrome [1e-2]	OH-16
		OH-17
POT.CONFLICT-RWY	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	Potential runway incursion (aircraft / vehicle / animal / person) [1e-1]	OH-26
		OH-27
POT.CONFLICT-TERR	Probability of a controlled aircraft flying towards terrain [1e-4]	OH-28
		OH-29
CLOSE TRAFFIC AIR	Probability of needing to apply wake turbulence spacing between aircraft [1e-2]	OH-30
AC LANDING	Probability of an aircraft landing [1e-1]	OH-34

Table 19: List of causes leading to operational hazards

3.4.2 Safety Requirements concerning system failure conditions

From the causes identified for each hazard and listed in previous section, the following safety requirements have been derived.

Note that for the quantitative requirements the following unit conversion has been used (based on the operational environment description presented in section 2.2.

Unit conversion *for the maximum tolerable values:*

Assuming:

* a traffic volume of 50.000 movements per year in the concerned aerodrome, with an average of 30 minutes for each movement in the area remotely controlled from a RVT position → 2.5e4 fh /year

* remote control to this aerodrome is provided 10 hour per day, 360 days per year → 3600 control.h/year

That represents about 14 movements per controlled hour (i.e. 140 movements per day).

SR#	Safety Requirement	Derived from
Flight Data Processing System		
SR-42 [RI03.6001]	The likelihood of inappropriate fight data information being provided by the Flight Data Processing system in a RVT position shall be operationally acceptable as per regulation acpplicable to local implementation	FDPS-001
AI data system		
SR-43 [RI03.6001]	The likelihood of incorrect or missing arriving/departing procedures publications available to the controller in a RVT position shall be operationally acceptable as per regulation applicable to local implementation	AID-002
SR-44 [RI03.6001]	The likelihood of incorrect or missing information concerning restricted areas in a RVT position shall be operationally acceptable as per regulation applicable to local implementation	AID-001

SR#	Safety Requirement	Derived from
G-G Comm		
SR-45 [RI03.6001]	The likelihood of failure or degradation of ground-ground communication with adjacent ATSU units in a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	G-GCOM-001
SR-46 [FN02.5006]	An alert should be provided to the controller in case of failure of the ground-ground communication service.	G-GCOM-001
Surf-G Comm		
SR-47 [RI03.6001]	The likelihood of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area in a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	S-GCOM-001 S-GCOM-002 S-GCOM-003
SR-48 [FN02.5006]	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.	S-GCOM-001 S-GCOM-002 S-GCOM-003
Surveillance data		
SR-49 [RI03.6001]	In case surveillance data is available in the RVT position, the likelihood that undetected inappropriate surveillance information on a flight is provided shall be operationally acceptable as per regulation applicable to local implementation.	SURV-001 SURV-002
SR-51 [RI03.6001]	In case surveillance data is available in the RVT position, the likelihood of complete lack of traffic information shall be operationally acceptable as per regulation applicable to local implementation.	SURV-003
Visualisation System		
SR-52 [RI03.6002]	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. Note: as per the results from this safety assessment a SWAL 3 for the critical aerodrome view (including the sensors in the airport premises, the link between them and the RTM and the displays on which the visual presentation is provided to the ATCO) is porposed. Note: as per the results from this safety assessment the likelihood of loss of a critical aerodrome view on the visualisation system is to be no more than 7e-4 per	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012

SR#	Safety Requirement	Derived from
	operational hour. Note: critical view refers to parts of the visualisation system providing visual presentation of the runway, the initial climb out and final approach areas.	
SR-54 [VC03.1007]	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-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
Data recorder		
SR-55 [DR02.6002]	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.	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
A-G Comm		
SR-56 [RI03.6001]	The likelihood of failure or degradation of air-ground communication with traffic in a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	A-GCOM-001
SR-57 [FN02.5006]	An alert should be provided to the controller in case of failure of the air-ground communication system.	A-GCOM-001
Local MET system		
SR-58 [RI03.6001]	The likelihood of incorrect MET/Weather information provided in a RVT position shall be operationally acceptable as per regulation applicable to local implementation	MET-001
Visual Navigation Aids system		
SR-59 [RI03.6001]	The likelihood of loss or dysfunction of Visual Navigation Aids manoeuvred from a RVT position shall be operationally acceptable as per regulation applicable to local implementation. <u>Note</u>: as per the results from this safety assessment the likelihood is to be no more than 5 times per year.	VNAM-001
Non-Visual Navigation Aids system		
SR-60 [RI03.6001]	The likelihood of loss or dysfunction of Non Visual Navigation Aids manoeuvred from a RVT position shall be operationally acceptable as per regulation applicable to	NVNAM-001

SR#	Safety Requirement	Derived from
	local implementation. Note: as per the results from this safety assessment, the likelihood is to be no more than 5 times per year.	
ATCO		
SR-61 [CS03.0001] [CS03.0002]	In case of loss or degradation of ground-ground communication with adjacent ATSU units in a RVT position relevant fallback procedures shall be applied.	G-GCOM-001 SO-051
SR-62 [CS03.0001] [CS03.0002]	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).	S-GCOM-001 S-GCOM-002 S-GCOM-003
SR-63 [CS03.0001] [CS03.0002]	In case surveillance function is available in the RVT position, but the function is lost or the information provided is inappropriate and detected, relevant fallback procedures shall be applied.	SURV-001 SURV-002 SURV-003
SR-64 [RTC3.0019]	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 camero to het the corresponding lost image, stopping the provision of the service, etc.). Note: critical view is defined in SR-52.	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
SR-66 [CS03.0001] [CS03.0002]	In case of failure or degradation or air-ground communication with traffic in a RVT position, relevant procedures from PANS ATM [9] shall be applied (e.g. issuing clearances through the relevant APP controller).	A-GCOM-001
SR-67 [RTC3.0019]	In case of incorrect MET/Weather information is provided in a RVT position, or not 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. piltos, visual unpits from the visual presentation, MET-office, internet, etc.).	MET-001

Table 20: List of safety requirements related to failure conditions

Note: Safety requirements related to the controller performing the corresponding ATC tasks from a RVT position are to be included as relevant based on the results from the Human Performance Assessment (REF).

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.

3.5 Validation & Verification of the Safe Design at SPR Level

As explained in section 2.11, a certain number of validation exercises were ferformed in the frame of Remote Tower OFA for single aerodrome. The results from these trials have allow to obtain some evidence on the validity of certain safety requirements concerning normal operations conditions, but limited ones concerning abnormal conditions operations. The main reason is that only passive shadow mode trials have been done concerning ATC services (see L001).

They have not allowed collecting enough evidence on the achievability of safety requirements concerning the degraded mode conditions. Only some expert feed back on some fall back procedures in case of internal system failure were collected during the trials.

The corresponding evidence for each safety requirement identified in this section 3 is provided in Appendix B (see L002 on the evidence validity). Specific results on proposed procedures for degraded mode conditions are presented in the Rules and Regulation report [14]. The overall results from the trials are provided in the P06.09.03 Validation Report [15] and P06.08.04 Validation Report [18].

Appendix A   Consolidated List of Safety Objectives

A.1   Safety Objectives (Functionality and Performance)

Description
ATC Service Provision from a RVT position
SO-001 RVT shall enable coordination and transfer procedures with adjacent ATS unit concerning arriving and departing traffic (including as necessary aircraft identification)
SO-002 RVT shall enable to manage arrival aircraft (including as necessary management of the approach, visual acquisition, entry into traffic circuit and landing sequence)
SO-003 RVT shall enable to manage departure aircraft (including as necessary aircraft identification and departure sequence on the runway)
SO-004 RVT shall enable to separate traffic, with respect to other traffic, applying the corresponding separation minima to the airspace under control responsibility (on the TMA and in the vicinity of the aerodrome) or allowing reduction in separation minima in the vicinity of the aerodrome.
SO-005 RVT shall enable to separate traffic with respect to restricted areas on the airspace under control responsibility
SO-006 RVT shall enable to manage missed approaches situations (including detection of need for go-around, monitoring of involved aircraft and proposal for resolution)
SO-007 RVT 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
SO-008 RVT shall enable the detection of restricted areas infringements by aircraft in the airspace under control responsibility
SO-009 RVT shall enable the provision of ATC instructions to resolve conflicts/ avoid collisions on the airspace under control responsibility
SO-010 RVT shall enable the provision of ATC instructions to resolve airspace infringements
SO-011 RVT shall enable to identify departing AC on the stand for providing ATC service
SO-012 RVT shall enable start-up procedures for departing aircraft (including as appropriate the provision of necessary aerodrome information - operational and meteorological)
SO-013 RVT shall enable push-back and towing procedures
SO-014 RVT shall enable the provision of taxi instructions to aircraft in the manoeuvring area
SO-015 RVT shall enable the provision of taxi instructions to vehicles in the manoeuvring area
SO-016 RVT shall enable the detection of hazardous situations on the manoeuvring area (involving aircraft, vehicles, and obstacles).
SO-017 RVT shall enable the provision of taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on the manoeuvring area
SO-018 RVT shall enable to support AC and vehicle movements on the manoeuvring area (through visual aids on the airport surface)
SO-019 RVT shall enable to manage runway entry for departure aircraft (this includes RWY status/occupancy check before issuing line-up clearance)
SO-020 RVT shall enable to manage runway exit for landing aircraft (this includes exiting TWY status/occupancy check)
SO-021 RVT shall enable to manage aircraft/vehicles runway crossing (this includes RWY status/occupancy/correctness check before issuing runway crossing clearance)

SO-022 RVT shall enable to support aircraft for take-off and landing operations (though visual-aids on the airport surface)
SO-023 RVT shall enable to carry-out vehicle related tasks on the runway
SO-024 RVT shall enable to manage aircraft take-off (this includes RWY status/occupancy/correctness check before issuing take-off clearance)
SO-025 RVT shall enable to manage aircraft landing (this includes RWY status/occupancy/correctness check before issuing landing clearance)
SO-026 RVT shall enable ATC detection of runway incursions (AC, vehicle, animal, person incursions) and potential collisions on the runway (involving AC, vehicle, animal, obstacles)
SO-027 RVT shall enable to provide instructions to resolve runway incursions and prevent collisions on the runway
SO-028 RVT shall enable the detection of flight towards terrain situations
SO-029 RVT shall enable to warn/support pilot on Controlled Flight Towards Terrain situations
SO-030 RVT shall enable to establish/maintain sufficient wake turbulence spacing between landing/departing aircraft
SO-031 RVT 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)
SO-032 RVT 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)
SO-033 RVT shall enable to support landing aircraft on final approach (providing relevant information and instructions as necessary)
SO-034 RVT shall enable to provide "navigation" support to aircraft during landing operations (using available non-visual navigation aids as necessary)
SO-035 RVT shall enable the detection of potential intrusions inside landing-aid protection area
SO-036 RVT shall enable to assess the operational environmental conditions on the 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-037 RVT shall enable the provision of appropriate ATC services in the several operational environmental conditions (e.g. low visual procedures in low visual conditions)
SO-038 RVT shall enable the provision of seamless ATC service to airspace users in the several operational environment conditions (e.g. daylight, dawn, darkness, dusk, CAVOK and low visual conditions)
ATFCM tasks at RTC level
SO-039 RTC shall enable (pre-tactical and tactical) management of ATC resources in terms of staffing for each RVT position taking account for weather conditions, traffic overload/peaks and unexpected events.
Initiation of the ATC service provision from a RVT position
SO-040 Prior to remotely providing ATC services, RVT capabilities shall be assessed / verified
SO-041 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 is starting to be provided (planned schedules and/or exceptional provision of the ATC service).
Termination of the ATC service provision from a RVT position
SO-042 Remote provision of ATC service shall appropriately (safely) be stopped for planned

terminations
SO-043 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 terminated (as per planned schedules).
ATC service provision tasks in abnormal conditions
SO-044 RVT shall enable the detection of unexpected flights in the area of responsibility where ATC services are being provided
SO-045 RVT shall enable to detect emergency situations on the aircraft (gear problems, fire on tyres or aircraft, tail strike, etc.)
SO-046 RVT shall enable to initiate emergency procedures and follow emergency situations affecting aircraft
SO-047 RVT shall enable to detect and manage a crash situation on the aerodrome or in its vicinity
SO-048 RVT shall be aware of potential abnormal situations (abnormal weather, fire on terminal or aerodrome building, overload on the apron, etc.) in the airport that could affect or even force the termination (unplanned terminations) of the provision of ATC services
SO-049 Remote provision of ATC service shall appropriately (safely) be stopped for unplanned terminations
SO-050 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 terminated (as per unplanned terminations).
ATC service provision tasks in degraded mode conditions
SO-051 ATC service provision shall appropriately be stopped in case of inadequate capability of the RVT system elements to provide the service
SO-052 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 cannot be provided anymore (unplanned termination of the ATC service provision due to system failures).

Table 21: Consolidated list of Functionality Safety Objectives

A.2   Safety Objectives (Integrity)

Description
SO-101 The likelihood that Remote ATC incorrectly coordinates with other ATSU with respect to inbound / outbound traffic shall be no more than 1e-5 per flight.hour
SO-102 The likelihood that Remote ATC incorrectly manage the entry of a flight intro traffic circuit shall be no more than 1e-5 per flight.hour
SO-103 The likelihood that Remote ATC incorrectly manage arriving aircraft shall be no more than 1e-5 per flight.hour
SO-104 The likelihood that Remote ATC incorrectly manage departing aircraft shall be no more than 1e-5 per flight.hour
SO-105 The likelihood that Remote ATC fails to provide appropriate separation to traffic in the vicinity of the aerodrome shall be no more than 1e-5 per flight.hour
SO-106 The likelihood that Remote ATC fails to provide appropriate separation of traffic with respect to restricted areas shall be no more than 1e-4 per flight.hour
SO-107 The likelihood that Remote ATC incorrectly manage missed approach situation shall be no more than 1e-5 per flight.hour
SO-108 The likelihood that Remote ATC does not detect in time conflicts / potential collision between

aircraft on the vicinity of the aerodrome shall be no more than 1e-6 per flight.hour

SO-109 The likelihood that Remote ATC does not detect in time restricted area infringements shall be no more than 1e-4 per flight.hour

SO-110 The likelihood that Remote ATC fails to provide appropriate instruction to solve conflict between traffic on the vicinity of the aerodrome shall be no more than 1e-6 per flight.hour

SO-111 The likelihood that Remote ATC fails to provide appropriate instruction to solve airspace infringement shall be no more than 1e-4 per flight.hour

SO-112 The likelihood that Remote ATC fails to provide appropriate information to departing aircraft during the start-up shall be no more than 1e-1 per movement

SO-113 The likelihood that Remote ATC fails to enable push-back/towing operations to appropriate aircraft shall be no more than 1e-1 per movement

SO-114 The likelihood that Remote ATC provides inadequate taxi instruction to aircraft on the manoeuvring area shall be no more than 1e-2 per movement

SO-115 The likelihood that Remote ATC provides inadequate taxi instruction to vehicle in the manoeuvring area shall be no more than 1e-2 per movement

SO-116 The likelihood that Remote ATC does not remotely detect in time conflicts on the manoeuvring area shall be no more than 1e-3 per movement

SO-117 The likelihood that Remote ATC fails to provide appropriate instruction to solve conflicts on the manoeuvring area shall be no more than 1e-3 per movement

SO-118 The likelihood that Remote ATC fails to provide (appropriate) navigation support to AC and vehicle on the manoeuvring area shall be no more than 1e-1 per movement

SO-119 The likelihood that Remote ATC incorrectly manage runway entry for a departure aircraft (occupied runway) shall be no more than 1e-6 per movement

SO-120 The likelihood that Remote ATC incorrectly manage runway exit for a landing aircraft shall be no more than 1e-6 per movement

SO-121 The likelihood that Remote ATC incorrectly manage runway crossing (occupied runway) for a vehicle or an aircraft shall be no more than 1e-6 per movement

SO-122 The likelihood that Remote ATC fails to properly support departing and landing aircraft (wrt visual-aids) shall be no more than 1e-6 per movement

SO-123 The likelihood that Remote ATC incorrectly manage vehicle related tasks on the runway shall be no more than 1e-6 per movement

SO-124 The likelihood that Remote ATC incorrectly manage aircraft take-off (occupied runway) shall be no more than 1e-6 per movement

SO-125 The likelihood that Remote ATC incorrectly manage aircraft landing (occupied runway) shall be no more than 1e-6 per movement

SO-126 The likelihood that Remote ATC fails to detect in time runway incursions shall be no more than 1e-5 per movement

SO-127 The likelihood that Remote ATC fails to provide appropriate instruction to solve runway incursion and prevent potential collision on the runway shall be no more than 1e-5 per movement

SO-128 The likelihood that Remote ATC fails to detect in time a flight towards terrain shall be no more than 1e-7 per movement

SO-129 The likelihood that Remote ATC fails to provide appropriate support to pilot on a CFIT situation shall be no more than 1e-7 per movement

SO-130 The likelihood that Remote ATC fails to establish sufficient wake turbulence spacing between landing/departing aircraft shall be no more than 1e-5 per movement

SO-131 The likelihood that Remote ATC fails to properly support landing / taking off operations with respect to weather conditions shall be no more than in current operations
SO-132 The likelihood that Remote ATC fails to properly support landing / taking off operations with respect to runway conditions and potential foreign objective debris shall be no more than in current operations[2]
SO-133 The likelihood that Remote ATC fails to properly support departing and arriving AC on the runway with respect to non-visual aids shall be no more than in current operations[2]
SO-134 The likelihood that Remote ATC fails to detect in time an intrusion inside landing-air protection area shall be no more than in current operations[2]

Table 22: Consolidated list of Integrity Safety Objectives

Appendix B   Consolidated List of Safety Requirements

This appendix presents the complete list of safety requirements obtained from the safety assessment presented in this report. Some additional explanation on each requirement as well as evidence (or reference to detailed evidence) on their validity obtained from the validation exercises and other project activities are also provided. In addition and based on those evidence, the corresponding maturity level is defined and some activities are recommended to be done (for the corresponding V phase).

The reference of the corresponding OSED requirement related to each safety requirement is shown as within "[REF]" (under the name of each safety requirement). Note that the complete reference of those requirements is [REQ-06.09.03-OSED-REF].

B.1   Safety Requirements (Functionality and Performance)

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	AI data system					
SR-01 [FN02.5007]	Published arriving procedures shall be available to the controller	This information is required to support arriving traffic while provide ATC services.	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-002
SR-02 [FN02.5007]	Published departing procedures shall be available to the controller	This information is required to support departing traffic while provide ATC services.	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-003
SR-03 [FN02.5007]	Information on active/non-active restricted areas shall be available to the controller in the (or close to) area of responsibility	This information is required to provide ATC services.	This has not been tested during the trials. But this kind of information is already needed and used in current operations.	Closed		SO-005 SO-008
SR-04	Airspace users should be informed about the (planned) provision of	Airspace user, as in current operations,	VP-058, VP-640 in particular where the	Closed		SO-041 SO-043

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
[RTC3.0015]	remote ATC services though AIP or NOTAMs (starting and ending times).	need to know when the ATC services are provided in a specific aerodrome. Besides, and for improving the overall awareness of the situation and to avoid confusions, they also need to be informed about the fact that these services are remotely provided.	airspace user was involved in the validation exercice. .			
	Flight Plan data system					
SR-05 [FN02.5003]	Flight plan information related to relevant traffic shall be provided by the flight data processing system to the controller in RVT position for providing ATC services	This information is required to provide ATC services.	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-001 SO-002 SO-003 SO-011 SO-030
	Ground-ground communication					
SR-06 [CO02.1002]	Ground-ground communication with relevant adjacent units shall be available to the controller in a RVT position Note: as per the aeronautical fixed service in accordance with ICAO Annex 11, Chapter 6.2.	This information is required to provide ATC services.	VP-058 in particular as it was an active mode exercice in which AFISO interacted with adjacent sector for the provision of the AFIS service	Closed		SO-001 SO-046 SO-047

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	A-G COMM					
SR-07 [CO02.1001]	Air-ground communication with relevant traffic shall be available to the controller in a RVT position. Note: as per the aeronautical mobile service in accordance with ICAO Annex 11, Chapter 6.1	This service is required to provide ATC services.	VP-058 in particular as it was an active mode exercice in which AFISO interacted with pilots provinding instructions and information.	Closed		SO-002 SO-003 SO-004 SO-005 SO-009 SO-010 SO-011 SO-012 SO-013 SO-014 SO-017 SO-019 SO-020 SO-021 SO-024 SO-025 SO-026 SO-027 SO-029 SO-030 SO-031 SO-035 SO-046 SO-050 SO-052
	Surf-G COMM (airport personnel/vehicles inside manoeuvring area)					

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
SR-08 [CO02.1003]	Communications for the control of relevant vehicles, other than aircraft, on manourvring areas shall be available to the controller in a RTV position. Note: as per the Surface movement control service in accordance with ICAO Annex 11, Chapter 6.3	This service is required to provide ATC services.	VP-056, VP-057, VP-058 There were some technical problems in some of these exercices but enough evidence for closing V2 requirement was collected.	Closed		SO-015 SO-017 SO-021 SO-023 SO-026 SO-027SO-035
	Surf-G COMM (airport personnel/vehicles outside manoeuvring area)					
SR-09 [CO02.1002]	Communication with airport personnel operating on the apron should be available to controller in RVT position	The approval for push-back is provided by ATCO to the pilot. Then pilot communicated with corresponding ground personnel. Nevertheless a direct communication between ATCO and the airport personnel operating in the apron could prevent some hazardous situations to occur.	VP-058 in particular as it was an active mode exercice in which AFISO interacted personel operating in the apron.	Closed		SO-012 SO-013
SR-10 [CO02.1003]	Communication with airport personnel in charge of runway inspections shall be available to	This service is required to determine runway conditions and detect	VP-056, VP-057	Closed		SO-032

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	controller in RVT position for the coordination of runway inspections	potential FODs/animals to provide ATC services.				
SR-11 [CO02.1002]	Communication with airport personnel in charge of local airport services shall be available to controller in RVT position	This service is required to inform airport personnel when the remote provision of ATC service is to be initiated and terminated	Not addressed during the trials	Open	V2: To clearly assess who needs to be contacted and the way to do so (direct line, intercom system, webcam, etc.). Ensure that the communication is available when necessary.	SO-041 SO-043 SO-050 SO-052
SR-12 [CO02.1002]	Communication with airport personnel in charge of rescue service in the aerodrome shall be available to controller in RVT position	This service is required to provide relevant information for solving all relevant emergency situations.	Not addressed during the trials	Open	V2: To clearly assess who needs to be contacted and the way to do so. Ensure that the communication is available when necessary. *(common outcome from SAF and HP assessment)* Potentially investigate the feasibility of an intercom system or webcam between ground staff at airport and staff working in remote tower *(outcome from HP assessment)*	SO-046 SO-047 SO-048

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	Surveillance data					
SR-13 [FN02.5001]	The controller in the RVT position should have access to surveillance data when providing Air Traffic Services.	This service would be required to provide ATC services. *This recommendation is also an output from the HP assessment.*	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-001 SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028 SO-029 SO-046 SO-047
	Visualisation system					
SR-14 [VG03.1001]	The controller in the RVT position shall have access to the visual presentation of traffic in the vicinity of the aerodrome. Note: this includes final approach and initial climb areas and it has to take into account specific traffic evolution for landing and taking off as it is the case for helicopters.	This service is required to provide ATC services. *This requirement is also an output from the HP assessment.*	VP-056, VP-057, VP-058, VP-639, VP-640 Some evidence has been collected on the capability of the visualisation system to provide information to be used for the provision of ATC services. Some items are still to be further assessed as it is explained for SR-26 (in particular for supporting the controller to judge distances and	Open	V3: Specify the technical characteriscs of the Visualisation System in terms of accuracy, resolution, refreshment rate, etc. based on the characteristics of the RVT platform used during the validation exercises.	SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028 SO-029 SO-030

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
			separation betweent traffic, and to identify aircraft on the vicinity of the aerodrome).			SO-044 SO-045 SO-046 SO-047
SR-15 [VG03.1001]	The controller in the RVT position should have access to a visual presentation of the apron and the traffic / vehicles / obstacles / personnel on this area	This is a recommendation in order to improve the situational awareness of the controller even with respect to those areas that are not under his/her responsibility but that may have an impact on the ones in which he/she is responsible.	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-011 SO-012 SO-013 SO-046 SO-047
SR-16 [VG03.1001]	The controller in the RVT position shall have access to a visual presentation of the manoeuvring area and the traffic/vehicles/personnel on this area Note: this includes runway(s) and the traffic/vehicles/personnel on or close to it.	This service is required to provide ATC services. *This requirement is also an output from the HP assessment.*	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-014 SO-015 SO-016 SO-017 SO-045 SO-046 SO-047
SR-18	The controller in the RVT position shall have access to a visual	This service is required to provide ATC services.	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-031 SO-036

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
[VQ03.1206] [VG03.1001] [VC03.1106]	presentation of the vicinity of the aerodrome and on the aerodrome surface allowing to be aware of the local weather conditions (including visibility conditions)	*This requirement is also an output from the HP assessment.*				
SR-19 [VS02.3004]	The controller in the RVT position shall have access to a specific binocular-like function (with equivalent usability and quality performance), giving the possibility to zoom/enlarge areas and objects in the visual presentation	This functionality is required. *This requirement is also an output from the HP assessment.*	VP-056, VP-057, VP-058, VP-639, VP-640 The evidence collected show that this function is needed in a Remote Tower, but the way it needs to be implementation is still to be further assess	Closed		SO-032 SO-045 SO-046 SO-047
SR-20 [VC03.1106]	If there is a difference in the perception of daylight/darkness conditions between the visual presentation and the reality, the controller shall have access to information about the current daylight / dusk / darkness / dawn conditon at the remote aerodrome as well as the expected time for the transitioning between these phases.	The purpose of this requirement is to ensure that controller is able to adequately adapt the provision of ATC service based on the conditions on the aerodrome he/she is provided with on the visualisation system.	VP-056, VP-057, VP-058, VP-639, VP-640 Several weather and visibility conditions have been experienced during the five trials. But as only passive shadow mode was done for the ATC related exercices not enough evidence have been collected on the capability of the controller to adapt the ATC service to be provided with respect to	Open	V4: evaluate the potential impact on the pilots reaction in case controller provides ATC service based on an understanding of the visual conditions on the airport (obtained though the visualisation system) which does not correspond to the one the pilot have. V2: further assess the potential need of	SO-038

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
			the information he / he is provided with by the visualisation system. *The outcome from the HP assessment on that item also requires a further assessment to collect more evidences.*		advanced visual features to support the controller in appropriately provide the ATC service with respect to the real visual conditions on the airport (e.g.infra-red).	
	Visual Navigation aids system					
SR-21 [NV02.4001]	Visual navigation aids on the concerned aerodrome (runway and field lighting system as applicable) shall be manageable and adjustable by controller in RVT	This is also done in current operations position in order to support AC and vehicle movements on the manoeuvring area for example and support take-off and landing operations. What needs to be ensured is that can remotely be done.	VP-056, VP-057, VP-058 In particular for VP-058 as it was an active mode trial.	Closed		SO-018 SO-022
	Non-Visual Navigation aids system					
SR-22 [NV02.4002]	Non-visual navigation aids on the concerned aerodrome (as applicable) shall be manageable and adjustable by controller in	This is also done in current operations in order to support aircraft on landing operations	VP-056, VP-057, VP-058, VP-639, VP-640 In particular for VP-058 as it	Closed		SO-034

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	RVT position	and navigation on the area of responsibility. What needs to be ensured is that can remotely be done.	was an active mode trial.			
	Local MET system					
SR-23 [MT02.2001]	Controller in a RVT position shall have access to meteorological information in accordance with ICO Annex 11 Chapter 7.1 and national regulations.	This information is required to provide ATC services. *This requirement is also an outcome from the HP assessment.*	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-002 SO-003 SO-012 SO-031 SO-036
SR-24 [MT02-2002]	The current MET report, actual wind information, actual QNH and, if measured for the particular airport, RVR values shall continuosly be presented to the controlle in the RVT position.	This information is required to provide ATC services. *This requirement is also an outcome from the HP assessment.*	VP-056, VP-057, VP-058, VP-639, VP-640	Closed		SO-003 SO-012 SO-031 SO-036
	ATCO – ATC service provision					
SR-26 [CS03.0001] [CS03.0002] [MT02.2003]	Controller shall apply relevant current procedures (as per ICAO PANS ATM [9]) to provide corresponding ATC service (Tower only or Tower and APP) to a single aerodrome from a RVT position. Note: This concerns procedures in	This requirement encompasses the procedures to be applied for the provision of ATC service as per PANS ATM as it is done in current operations when	Efficiency of some of the tasks (see below) depend on visibility conditions and on the aircraft size (which is a matter of capacity/delay but not a matter of safety). Visual aircraft identification has sometimes to be	Open	Items to be further evaluated in V3 for medium size aerodromes: - Further assess the capability of evaluation distances / judge separation for the	SO-001 SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	terms of (mainly and as exmaple): * Coordination and transfer for inbound and outbound traffic * Coordination with military and other units concerning restricted areas * Identification of the aircraft to which the ATC service is to be provided * Manage arriving and departing traffic * Ensuring appropriate separation between traffic and with restricted areas * Manage missed approaches * Detection and resolution of hazardous situations (between aircraft, with vehicles, with obstacles) * Support to pilots on the detection and resolution of hazardous situations with terrain * Start-up and push-back/towing procedures * Managing aircraft and vehicle on the manoeuvring area * Detecting and solving hazardous	providing Tower or Tower + APP controller services. Any additional procedures related to the fact that the ATC service is provided from a Remote location have been captured in separated requirements (see below).	supported by PTZ-camera. PTZ-map helped to do that with very little more effort for the ATCO compared to just using the visual presentation. Sequencing VFR traffic applying visual separation needs to be supported by object bounding and automatic PTZ-Tracking for medium size aerodromes in order to be able to apply it in a variety of visibility condidtions. ATCO can always use other means of separation (e.g. height, or pilot sees and follows) as in a local tower Low density aerodromes do not depend on a high frequency of applying visual separation as the traffic demand does not require it. ATCO can still apply visual separation when needed and certain of visual view. For some other ATC tasks no evidence was collected as they were not addressed during the trials (for		provision of reduced separation (and the potential need for enhanced visual features or for changing procedures). V4: Further assess capability of ATC provision under degraded modes of operations.	SO-009 SO-010 SO-011 SO-012 SO-013 SO-014 SO-015 SO-016 SO-017 SO-018 SO-019 SO-020 SO-021 SO-022 SO-023 SO-024 SO-025 SO-026 SO-027 SO-028 SO-029 SO-030 SO-031 SO-032 SO-033 SO-034 SO-035 SO-036 SO-037 SO-044

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	situations (including runway incursions an intrusions inside landing aids protections area) on the manoeuvring area * Managing taking off and landing operations (including the use of visual and non-visual navigation aids) * Detecting and solving hazardous situations related to taking off and landing operations * Providing appropriate ATC services taking into account visual, meteorological and airport conditions (including runway status) * Providing appropriate weather and aerodrome conditions information * Managing emergency situations		example ensuring appropriate separation with restricted areas which usually is made with support from radar view).			SO-045 SO-046 SO-047
SR-27 [CS03.0001] [CS03.0002]	Handover procedures shall be applied in a RVT position. Additional information concerning RVT equipment status shall also be transferred from one controller to the other during this procedure	Handover procedures are currently applied. They need to take into account the several equipement in the RVT.	Not addressed during the trials	Open	V4: to define the type of information concerning the RVT equipement (in particular Visualisation System) to be included in the handover procedures.	SO-038

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
SR-28 [RTC3.0008]	Controller/Supervisor (if implemented) shall verify the status of an aerodrome, in terms of traffic, weather, etc. and the related systems before providing ATC service to the aerodrome. The verification shall also include checking the RVT capability for the provision of the service. Note: this procedure has to include at least the checking of the following elements: - MET system - Ground-ground (with other ATS units), air-ground, and ground- ground (with airport services and personnel) communication system - Visualisation system - Visual and non visual navigation aids	It is necessary to check the status of the several systems before starting to provide the ATC service from the RVT position.	VP-058 For this trial a specific procedure for starting-up the RVT position prior to providing the AFIS services was developed in order to be able to run the active mode trials. Nevertheless, a more formalised procedure need to be defined in particular when ATC services are provided from the RVT position.	Open	V4: define the system checking that need to be done, how often and by who it needs to be done.	SO-040
SR-29 [RTC3.0016]	Personnel in charge of local airport services shall be aware of when the ATC service is provided in the corresponding airport.	This is done in current operations.	VP-058. But not tested for ATC services	Open	V4: To clearly assess who needs to be contacted and the way to do so. Ensure that the communication is	SO-041 SO-043 SO-050 SO-052

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
					available when necessary.	
SR-30 [CS03.0001] [CS03.0002]	Prior to a planned termination, controller shall ensure that ATC services can be safely stopped.	This is done in current operations.	VP-058. But not tested for ATC services	Open	V4: specific procedures are to be defined.	SO-042
SR-31 [CS03.0001] [CS03.0002]	Prior to an unplanned termination of the service, controller should ensure that ATC services are safely stopped.	This is done in current operations.	Not addressed during the trials	Open	V4: specific procedures are to be defined for this situations	SO-049
SR-32 [CS03.0001] [CS03.0002]	Controller should inform all traffic under his/her responsibility in case the provision of the ATC services is unplannedly stopped.	This is done in current operations.	Not addressed during the trials	Open	V4: specific procedures are to be defined for this situations	SO-050 SO-052
	RTC level					
SR-33 [CS03.0001] [CS03.0002]	Aerodrome capacity shall be defined not only based on the aerodrome characteristics but also taking account the fact that ATC service is remotely provided. Note: For relevant aerodromes (mainly based on their size) capacity is to be provided to the Network Manager and relevant bodies in charge of demand & Capacity Balancing activities (locally, regionally) in order to	Capacity of the aerodrome is done in current operations taking into account the capability to provide ATC services. This capacity needs also to take into account the fact that the services are remotely provided.	Not addressed during the trials	Open	V4: to asses whether the capacity of the aerodrome is impacted by the fact that ATC services are remotely provided.	SO-039

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	ensure that the traffic on those aerodromes to be controller from a RVT position is not exceeding those limits.					
	Supervisor					
SR-34 [SUP3.0010]	If a RTC Supervisor role is implemented, supervisor in a RTC shall access functions for the planning, coordination and monitoring of the upcoming and present traffic flow in the purpose of tactical opening and closure of RVTs positions and allocation of airports to them	This task is done in current operations. Note that this requirement will be significantly important for the Multiple Remote Tower in the frame of a Remote Tower Center.	Not addressed during the trials	Closed	V4: define in detail the technical support, the information needed and the way to perform this task. *Some additional items related to further validation activities for this safety requirement have also been identified in the HP assessment report. The exact reference to them will be included in the final version of this SAR.*	SO-039
SR-35 [SUP3.0013]	If a RTC Supervisor role is implemented, supervisor shall access functions for the monitoring of weather for all the aerodromes.	Capacity of the aerodrome is done in current operations taking into account the capability to provide ATC services. This capacity needs also to take into account the fact that the services	Not addressed during the trials	Open	V4: to asses whether the capacity of the aerodrome is impacted by the fact that ATC services are remotely provided.	SO-039

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
		are remotely provided.				
	Signalling Lamps system					
SR-37 [CM02.1004]	Signalling Lamps on the concerned aerodrome shall be manageable and adjustable by controller in RVT position in order to support AC and vehicle movements in case of loss of communication	This system is already used in current operations. They need to be evaluated in order to ensure that they can be applied from a Remote Tower position.	The signalling lamp system was initially tested during VP-058 as well as VP-639.	Closed		SO-046
	Accident / incident / distress alarms system					
SR-38 [FN02.5004]	The controller in the RVT position shall have access to activation of accident / incident / distress alarms and corresponding coordination	This kind of procedures are already needed and applyed in current operations. They need to be evaluated in order to ensure that they can be applied from a Remote Tower position.	Not addressed during the trials	Open	V4: functionality and capability of launching different emergency procedures from a remote tower position need to be tested	SO-046 SO-047
	Airport services / relevant personnel					
SR-39 [RTC3.0016]	Relevant airport service / personnel shall contact the RTC / controller in RVT position in order to inform about any situation or condition on the aerodrome that might affect the safe provision of ATC services	This kind of procedures are already needed and applyed in current operations. They need to be evaluated in order to ensure that they can be applied from a Remote Tower position.	This has not been tested during the trials.	Open	V4: specific procedures related to situations or conditions on the aerodrome that migh affect the safe provision of ATC service from a remote tower has to be defined and the	SO-046 SO-048

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
					capability to apply them need to be tested.	
	RTC level					
SR-40 [RTC3.0017]	Coordination and transfer of control of operational systems between the local tower and RVT shall take place prior to transfer ATS provision from one to the other (in terms of sharing operational conditions and information)		Not addressed during the trials	Open	V4: To define and assess the specific procedures for the coordination and transfer of the control.	UC-6

B.2   Safety Requirements (Integrity)

Some feedback on procedures to be applied in case of system failure, in particular for the Visualisation System, has been collected during VP-057, VP-639 and VP-640 based on operational expert judgement. The detail of this feedback is included in the Rules and Regulations Assessment report [14] and in the corresponding Validation Reports [15] and [18].

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	Flight Data Processing System					
SR-42 [RI03.6001]	The likelihood of inappropriate fight data information being provided by the Flight Data Processing system in a RVT position shall be operationally acceptable as per regulation applicable to local implementation	No higher performance is requested for existing systems An average value derived from the risk analysis done in section 3.4.1 of this SAR would	Analytical assessment based on expert judgement and project reviews.	Closed		SO-101 SO-103 SO-104 SO-112 SO-113 SO-130

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
		be no more than 5 times every 2 years				
	AI data system					
SR-43 [RI03.6001]	The likelihood of incorrect or missing arriving/departing procedures publications available to the controller in a RVT position shall be operationally acceptable as per regulation applicable to local implementation	No higher performance is requested for existing systems An average value derived from the risk analysis done in section 3.4.1 of this SAR would be no more than 2 times per month	Analytical assessment based on expert judgement and project reviews.	Closed		SO-103 SO-104
SR-44 [RI03.6001]	The likelihood of incorrect or missing information concerning restricted areas in a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested for existing systems An average value derived from the risk analysis done in section 3.4.1 of this SAR would be no more than 5 times every 2 years	Analytical assessment based on expert judgement and project reviews.	Closed		SO-105 SO-109 SO-111
	G-G Comm					
SR-45 [RI03.6001]	The likelihood of failure or degradation of ground-ground communication with adjacent ATSU units in a RVT position shall be operationally acceptable to	No higher performance is requested for existing systems An average value derived from the risk analysis done in section	Analytical assessment based on expert judgement and project reviews.	Closed		SO-101

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	local implementation.	3.4.1 of this SAR would be no more than 5 times every 2 years				
SR-46 [FN02.5006]	An alert should be provided to the controller in case of failure of the ground-ground communication service.	Mitigation mean identified from the hazard assessment. *This recomendation is also an outcome from the HP assessment.*	Analytical assessment based on expert judgement and project reviews. Not tested during simulations	Open	V4: to test the efficiency of the alert during trials together with the corresponding procedure to be applied by the controller.	SO-101
	Surf-G Comm					
SR-47 [RI03.6001]	The likelihood of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area in a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested for existing systems An average value derived from the risk analysis done in section 3.4.1 of this SAR would be no more than 5 times per year	Analytical assessment based on expert judgement and project reviews.	Closed		SO-113 SO-115 SO-117 SO-120 SO-121 SO-123 SO-127 SO-132 SO-134
SR-48 [FN02.5006]	An alert should be provided to the controller in case of failure of the communication with personnel	Mitigation mean identified from the hazard assessment.	Analytical assessment based on expert judgement and project reviews.	Open	V4: to test the efficiency of the alert during trials together with the	SO-113 SO-115 SO-117

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	operating on the apron or vehicles/personnel operating on the manoeuvring area	It should include communication with personnel operating in the runway, for example for inspections. *This recommendation is also an outcome from the HP assessment.*	Not tested during simulations		corresponding procedure to be applied by the controller.	SO-120 SO-121 SO-123 SO-127 SO-132 SO-134
	Surveillance data					
SR-49 [RI03.6001]	In case surveillance data is available in the RVT 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 for existing systems An average value derived from the risk analysis done in section 3.4.1 of this SAR would be no more than 5 times every 2 years	Analytical assessment based on expert judgement and project reviews.	Closed		SO-101 SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111 SO-128 SO-129 SO-130
SR-51 [RI03.6001]	In case surveillance data is available in the RVT position, the likelihood of complete lack of traffic information shall be operationally acceptable as per regulation applicable to local	No higher performance is requested for existing systems An average value derived from the risk analysis done in section	Analytical assessment based on expert judgement and project reviews.	Closed		SO-109 SO-128 SO-129

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	implementation.	3.4.1 of this SAR would be no more than 5 times every 2 years				
	Visualisation System					
SR-52 [RI03.6002]	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. Note: as per the results from this safety assessment a SWAL 3 for the critical aerodrome view (including the sensors in the airport premises, the link between them and the RTM and the displays on which the visual presentation is provided to the ATCO) is porposed. Note: as per the results from this safety assessment the likelihood of loss of a critical aerodrome view on the visualisation system is to be no more than 7e-4 per operational hour. Note: critical view refers to parts of the visualisation system providing visual presentation of the runway, the initial climb out	Specific SWAL level is defined for the new Visualisation System based on the potential associated risk in case of failure of this equipment. See detail of the SWAL allocation in Appendix J	Analytical assessment based on expert judgement and project reviews.	Closed	V4: apply corresponding assurance activities in order to satify SWAL 3	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111 SO-114 SO-115 SO-116 SO-117 SO-119 SO-120 SO-121 SO-123 SO-124 SO-125 SO-126 SO-127 SO-128 SO-129 SO-130 SO-131 SO-132

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	and final approach areas. -					SO-134
SR-54 [VC03.1007]	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.	Mitigation mean identified from the hazard assessment. *This requirement is also an outcome from the HP assessment.*	Analytical assessment based on expert judgement and project reviews. Not tested during simulations	Open	V4: to test the efficiency of the alert during trials together with the corresponding procedure to be applied by the controller.	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111 SO-114 SO-115 SO-116 SO-117 SO-119 SO-120 SO-121 SO-123 SO-124 SO-125 SO-126 SO-127 SO-128 SO-129 SO-130 SO-131 SO-132 SO-134

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	Data recorder					
SR-55 [DR02.6002]	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.	Similar requirement already existing for current operations with respect to surveillance and communication systems.	Analytical assessment based on expert judgement and project reviews. Not tested during simulations	Open	V4: to be tested during trials and/or analytical assessment to be provided	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111 SO-114 SO-115 SO-116 SO-117 SO-119 SO-120 SO-121 SO-123 SO-124 SO-125 SO-126 SO-127 SO-128 SO-129 SO-130 SO-131 SO-132 SO-134
	A-G Comm					

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
SR-56 [RI03.6001]	The likelihood of failure or degradation of air-ground communication with traffic in a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	No higher performance is requested for existing systems An average value derived from the risk analysis done in section 3.4.1 of this SAR would be no more than 5 times every 2 years	Analytical assessment based on expert judgement and project reviews.	Closed		SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-110 SO-111 SO-112 SO-114 SO-117 SO-120 SO-121 SO-124 SO-125 SO-126 SO-127 SO-129 SO-130 SO-131 SO-134
SR-57 [FN02.5006]	An alert should be provided to the controller in case of failure of the air-ground communication system.	Mitigation mean identified from the hazard assessment. *This recommendation is also an outcome from the HP assessment.*	Analytical assessment based on expert judgement and project reviews. Not tested during simulations	Open	V4: to test the efficiency of the alert during trials together with the corresponding procedure to be applied by the controller.	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-110 SO-111 SO-112 SO-114 SO-117

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
						SO-120 SO-121 SO-124 SO-125 SO-126 SO-127 SO-129 SO-130 SO-131 SO-134
	Local MET system					
SR-58 [RI03.6001]	The likelihood of incorrect MET/Weather information provided in a RVT position shall be operationally acceptable as per regulation applicable to local implementation	No higher performance is requested for existing systems An average value derived from the risk analysis done in section 3.4.1 would be no more than 5 time every 2 years	Analytical assessment based on expert judgement and project reviews.	Closed		SO-103 SO-104 SO-112 SO-131
	Visual Navigation Aids system					
SR-59 [RI03.6001]	The likelihood of loss or dysfunction of Visual Navigation Aids manoeuvred from a RVT position shall be operationally acceptable as per regulation applicable to local implementation.	Integrity level fixed based on the associated risk in case of complete loss of the equipement.	Analytical assessment based on expert judgement and project reviews.	Closed		SO-118 SO-122

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	Note: as per the results from this safety assessment the likelihood is to be no more than 5 times per year.					
	Non-Visual Navigation Aids system					
SR-60 [RI03.6001]	The likelihood of loss or dysfunction of Non Visual Navigation Aids manoeuvred from a RVT 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.	Integrity level fixed based on the associated risk in case of complete loss of the equipement.	Analytical assessment based on expert judgement and project reviews.	Closed		SO-133
	ATCO					
SR-61 [CS03.0001] [CS03.0002]	In case of loss or degradation of ground-ground communication with adjacent ATSU units in a RVT position relevant fallback procedures shall be applied	Mitigation mean identified from the hazard assessment. Same procedure as in current operations.	Assessment based on expert judgement and project reviews. Not tested during simulations.	Open	V4: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-101 SO-051
SR-62 [CS03.0001]	In case of failure or degradation of ground-ground communication with personnel operating on the	Mitigation mean identified from the hazard assessment.	Assessment based on expert judgement and	Open	V4: to test the efficiency of the corresponding procedure to be applied	SO-113 SO-115 SO-117

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
[CS03.0002]	apron or vehicles/personnel operating on the manoeuvring area relevant fallback procedures shall be applied (e.g. use of flash gun lights)..	Same procedure as in current operations, including communication with personnel operating in the runway, for example for inspections,	project reviews. Not tested during simulations.		by the controller.	SO-120 SO-121 SO-123 SO-127 SO-132 SO-134
SR-63 [CS03.0001] [CS03.0002]	In case surveillance function is available in the RVT position, but the function is lost or the information provided is inappropriate and detected, relevant fallback procedures shall be applied	Mitigation mean identified from the hazard assessment. Same procedure as in current operations.	Assessment based on expert judgement and project reviews. Not tested during simulations	Open	V4: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-101 SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111 SO-128 SO-129 SO-130
SR-64 [RTC3.0019]	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	Mitigation mean identified from the hazard assessment.	Assessment based on expert judgement and project reviews. Not tested during simulations, only discussed with controllers	Open	V4: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
	operations in the area of responsibility, using PTZ camero to het the corresponding lost image, stopping the provision of the service, etc.). Note: critical view is defined in SR-52.					SO-111 SO-114 SO-115 SO-116 SO-117 SO-119 SO-120 SO-121 SO-123 SO-124 SO-125 SO-126 SO-127 SO-128 SO-129 SO-130 SO-131 SO-132 SO-134
SR-66 [CS03.0001] [CS03.0002]	In case of failure or degradation or air-ground communication with traffic in a RVT position, relevant procedures from PANS ATM [9] shall be applied (e.g. issuing clearances through the relevant APP controller).	Mitigation mean identified from the hazard assessment. Same procedure as in current operations.	Assessment based on expert judgement and project reviews. Not tested during simulations	Open	V4: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111 SO-114 SO-115 SO-116

REQ	Description	Additional Explanation	Validation Activity / Evidence	V3 Status	Next activities / recommendations	Satisfies
						SO-117 SO-119 SO-120 SO-121 SO-123 SO-124 SO-125 SO-126 SO-127 SO-128 SO-129 SO-130 SO-131 SO-132 SO-134
SR-67 [RTC3.0019]	In case of incorrect MET/Weather information is provided in a RVT position, or not 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. piltos, visual inputs from the visual presentation, MET-office, www/internet).	Mitigation mean identified from the hazard assessment.	Assessment based on expert judgement and project reviews. Not tested during simulations.	Open	V4: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-103 SO-104 SO-112 SO-131

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
AO-01	The rules of the air (as per Annex 2 [8]) are applied as in current operations	This is unchanged with respect to current operations.

Nevertheless the way the airspace users will operate knowing that the ATC service is remotely provided ('pilots trying to cheat') still needs to be investigated.

Workshop with corresponding stakeholders is to be conducted in order to assess potential consequences of this issue as well as possible mitigations (*outcome from HP assessment*). |
AO-02	Flight crew apply the same procedures as in current operations (as per PANS-OPS Doc 8168 [10])	
AO-03	Flight crew detects airborne system failures and informs ATC as in current operations	
AO-04	VFRs apply see and avoid with respect to other traffic as in current operations	
AO-05	Airborne mid-air collision prevention is unchanged with respect to current operations (airborne safety net and see&avoid)	
AO-06	Adjacent unit responsible of concerned restricted area provides separation service and collision avoidance	
AO-07	Airborne taxiway collision avoidance is unchanged with respect to current operations (see&avoid)	
AO-08	Airborne runway collision prevention is unchanged with respect to current operations (see&avoid)	
AO-09	Airborne CFIT prevention is unchanged with respect to current operations (airborne safety net and see&avoid)	
AO-10	Aircraft maintains visual separation / wake turbulence spacing as in current operations	
AO-11	Weather information is obtained onboard from several sources (ATC, ATIS, AO, visualisation of wind-cones, etc.) as in current operations	
AO-12	Airborne landing accident prevention is unchanged with respect to current operations	
AO-13	Other ATC units adjacent to the RTC (including military) operates and provide the relevant ATS service as per PANS ATM [9]	
AO-14	Services at the airport concerning apron operations, runway inspections, technical support, etc., are provided.	
AO-15	Relevant Visual and Non visual navigation aids are available in the airport premises	

C.2   Safety Issues log

The several safety issues raised during the safety assessment have been identified at the level of each safety requirement. They are mainly related to elements to be further assessed in order to get the corresponding maturity level. They are described in Appendix B for each safety requirement.

C.3   Operational Limitations log

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

Ref	Operational Limitations	Resolution
L001	This Safety Assessment is focused on the remote provision of ATC and AFIS services using a RVT system. Nevertheless the assessment is mainly done on the ATC services, assuming that this service would allow obtaining the most constraining requirements which will allow as well the provision of AFIS. The assessment of the ATC service is presented in the main body of this report. Some results on the AFIS part are included in Appendix E.	A complete assessment of the use of Remote Tower for the provision of AFIS service needs to be done. This assessment can be done based on the results obtained from the assessment of ATC services (in particular concerning the information to be provided to the AFISo) but the specific AFIS procedures needs to be specifically addressed.
L002	The results from these trials have allow to obtain some evidence on the validity of the results obtained for normal operations conditions, but limited evidence concerning abnormal conditions operations and degraded modes (related to internal system failure) have been obtained as only passive shadow mode trials have been done concerning ATC services.	Additional trials (active ones) are to be performed in active mode or even in simulations in order to better assess the abnormal situations and potentially the procedures and means defined to mitigate the degraded modes of operations.
L003	The validity of the evidences collected from the trials is dependent on the characteristics of the aerodrome / operational environment used in those trials (described in the Validation Report [15] and [18]), which are a sub-set of the operational environment in which remote tower is aimed to operate (as described in section 2.2). This is particularly true for the traffic density and the number of simultaneous movements.	Other types of airport should be used for additional trials in order to obtain evidences covering a larger range of operational environment characteristics.

Appendix D   Safety Workshop on Single Remote Tower

The information provided in this appendix is part of the results from the Safety Workshop held in Malmö on the 31rst of January and the 1rst of February 2012 [5].

The following items were addressed during this workshop:

- Item 1 – Weather related aspects
- Item 2 – Visual separation aspects
- Item 3 – Visual reproduction failure aspects
- Item 4 – Air-Ground communication failure aspects
- Item 5 – Abnormal conditions aspects
- Item 6 – Hazards and Human Errors aspects
- Item 7 – AFIS service versus ATC service

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Appendix E   Assessment of AFIS provided from a Remote Tower.

As mentioned in section 1.3, even if Remote Tower for Single Airport is to be used for remotely providing ATS services, the safety assessment documented in this safety assessment report is mainly focused on the ATC service. This strategy was applied assuming that the most constraining results specifying Remote Tower system would be derived from ATC services.

This appendix aims at providing an initial insight on how the results obtained from the assessment of Remote Tower for the ATC service also allow to satisfy the corresponding operational requirements for the provision of AFIS. But it needs to be noted that the assessment for AFIS is still to be completed.

Safety Objectives for AFIS – Normal Conditions	Related Pre-Existing Hazards
SO.AFIS-01 : RVT shall enable selecting runway-in-use	Hp#14 Aircraft landing in/taking off from a wrong/closed runway
SO.AFIS-02 : RVT shall enable the identification of potential "conflicts" in the vicinity of the airport	Hp#1 Situation in which AC trajectories can leading to mid-air collision Hp#5 Missed approach
SO.AFIS-03 : RVT shall enable the provision of traffic information (including local traffic) to relevant traffic ▸ direction of flight or traffic concerned ▸ type of wake turbulence category ▸ level of traffic and potential changes ▸ relative bearing (12-h clock indication) ▸ other relevant information	Hp#1 Situation in which AC trajectories can leading to mid-air collision Hp#6 Situation leading to Wake vortex encounter Hp#5 Missed approach
SO.AFIS-04 : RVT shall enable the provision of information concerning the availability of the runway for departing / arriving traffic	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#4 Another aircraft or vehicle inside the OFZ Hp#5 Missed approach
SO.AFIS-05: RVT shall enable the provision of appropriate traffic position information on the manoeuvring area	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY Hp#4 Another aircraft or vehicle inside the OFZ
SO.AFIS-06 : RVT shall enable the provision of wake turbulence and jet blast related information	Hp#6 Situation leading to Wake vortex encounter
SO.AFIS-07 : RVT shall enable the provision of essential information on airport conditions to departing and arriving traffic (surface conditions, maintenance works, obstacles, birds, lighting system failure, etc.) ▸ conditions on the manoeuvring area ▸ conditions on the parking area	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#2 Situation leading to collision with and obstacle, ground vehicle, another

	aircraft on apron or TWY
	Hp#8 Bird close to/in path of aircraft or animal on the runway
	Hp#12 Runway undershoot
SO.AFIS-08 : RVT shall enable the provision of start-up instructions to departing traffic	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY
SO.AFIS-09 : RVT shall enable the provision to meteorological information to departing and arriving traffic	Hp#7 Situation leading to Controlled Flight Into Terrain
	Hp#9 Adverse weather conditions like violent winds or severe crosswind
	Hp#10 Snow/slush on the runway
SO.AFIS-10 : RVT shall enable the usage of visual signals to indicate to traffic that airport is not safe	Hp#9 Adverse weather conditions like violent winds or severe crosswind
	Hp#10 Snow/slush on the runway
	Hp#16 Foreign Object Debris within the Runway protected area
	Hp#18 Loss/interruption of ATC services
SO.AFIS-11 : RVT shall enable coordinating with ATC for arriving traffic	Hp#1 Situation in which AC trajectories can leading to mid-air collision
SO.AFIS-12 : RVT shall enable coordinating with ATC for departing traffic	Hp#1 Situation in which AC trajectories can leading to mid-air collision
SO.AFIS-13 : RVT shall enable the provision of information on local traffic to assist taxiing operations	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY
SO.AFIS-14 : RVT shall enable to provide authorisation to persons/vehicles to entry to the manoeuvring area	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY
	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY
SO.AFIS-15 : RVT shall enable the provision of light signals to ground vehicles and personnel on the manoeuvring area (when adequate or in case of radio-communication failure)	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY
	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY
SO.AFIS-16 : RVT shall enable the provision of relevant information on local traffic and airport conditions to assist the flight crew to decide when to take-off	Hp#8 Bird close to/in path of aircraft or animal on the runway
	Hp#9 Adverse weather conditions like violent winds or severe crosswind

	Hp#10 Snow/slush on the runway
	Hp#11 Low runway surface friction
	Hp#13 Aircraft using a closed taxiway
	Hp#14 Aircraft landing in/taking off from a wrong/closed runway
	Hp#16 Foreign Object Debris within the Runway protected area
SO.AFIS-17 : RVT shall enable the provision of relevant information on local traffic and airport conditions to assist the flight crew in deciding whether to land or go-around.	Hp#5 Missed approach Hp#12 Runway undershoot
SO.AFIS-18 : RVT shall enable to be aware of a runway incursion or the existence of any obstruction (including animals) on or in close proximity to the take-off/landing area	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#8 Bird close to/in path of aircraft or animal on the runway Hp#15 Another aircraft or vehicle inside landing-aid protection area during CATII/III instrument approach
SO.AFIS-19 : RVT shall enable to operate aeronautical ground lights ‣ manoeuvring lighting ‣ Taxiway area lighting	Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY
SO.AFIS-20 : RVT shall enable to monitor visual aids status	Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY Hp#13 Aircraft using a closed taxiway Hp#14 Aircraft landing in/taking off from a wrong/closed runway

Results from VP-058 show that Remote Tower system enables the remote provision of AFIS in the normal operational environment conditions.

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This appendix also aims at providing an initial insight on how the results obtained from the assessment of Remote Tower for the ATC service also would allow to satisfy the corresponding operational requirements for the provision of AFIS. Nevertheless the assessment for AFIS is to be

<u>completed</u> and the corresponding requirements need to be expressed with respect to the AFIS service (in particular with respect to the procedures to be applied as per AFIS Manual [12]).

Safety Objectives for AFIS – Normal Conditions	Safety Requirements
SO.AFIS-01 : RVT shall enable selecting runway-in-use	SR-23 SR-24
SO.AFIS-02 : RVT shall enable the identification of potential "conflicts" in the vicinity of the airport	SR-13 SR-14 SR-18 SR-20
SO.AFIS-03 : RVT shall enable the provision of traffic information (including local traffic) to relevant traffic	SR-07 SR-13 SR-14 SR-18 SR-20
SO.AFIS-04 : RVT shall enable the provision of information concerning the availability of the runway for departing / arriving traffic	SR-07 SR-16 SR-18 SR-20
SO.AFIS-05 : RVT shall enable the provision of appropriate traffic position information on the manoeuvring area	SR-16 SR-18 SR-20 SR-07 SR-08
SO.AFIS-06 : RVT shall enable the provision of wake turbulence and jet blast related information	SR-05
SO.AFIS-07 : RVT shall enable the provision of essential information on airport conditions to departing and arriving traffic (surface conditions, maintenance works, obstacles, birds, lighting system failure, etc.)	SR-06 SR-07 SR-08 SR-09 SR-10 SR-19
SO.AFIS-08 : RVT shall enable the provision of start-up instructions to departing traffic	SR-07 SR-09 SR-15
SO.AFIS-09 : RVT shall enable the provision to meteorological information to departing and arriving traffic	SR-23 SR-24 SR-07
SO.AFIS-10 : RVT shall enable the usage of visual signals to indicate to traffic that airport is not safe	SR-21 SR-37
SO.AFIS-11 : RVT shall enable coordinating with ATC for arriving traffic	SR-05 SR-06 SR-13
SO.AFIS-12 : RVT shall enable coordinating with ATC for departing traffic	SR-05 SR-06 SR-13
SO.AFIS-13 : RVT shall enable the provision of information on local traffic to assist taxiing operations	SR-07 SR-16 SR-18 SR-19 SR-20
SO.AFIS-14 : RVT shall enable to provide authorisation to persons/vehicles to entry to the manoeuvring area	SR-15 SR-16 SR-18 SR-19 SR-20 SR-08
SO.AFIS-15 : RVT shall enable the provision of light signals to ground vehicles and personnel on the manoeuvring area (when adequate or in case of radio-communication failure)	SR-21 SR-37
SO.AFIS-16 : RVT shall enable the provision of relevant information on local traffic and airport conditions to assist the flight crew to decide when to take-off	SR-07 SR-10 SR-11 SR-13 SR-16 SR-18 SR-19 SR-20 SR-23 SR-24
SO.AFIS-17 : RVT shall enable the provision of relevant information on local traffic and airport conditions to assist the flight crew in deciding whether to land or go-around.	SR-07 SR-10 SR-11 SR-13 SR-16 SR-18 SR-19 SR-20 SR-22 SR-23 SR-24

SO.AFIS-18 : RVT shall enable to be aware of a runway incursion or the existence of any obstruction (including animals) on or in close proximity to the take-off/landing area	SR-08 SR-10 SR-16 SR-18 SR-19 SR-20
SO.AFIS-19 : RVT shall enable to operate aeronautical ground lights	SR-21
SO.AFIS-20 : RVT shall enable to monitor visual aids status	SR-21

Appendix F   Safety related validation results from ATC trial

"6.9.3_Results from Safety Questionnaire_Trial 2_20120831.doc"

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The complete set of results from all the trials is provided in the P06.09.03 Validation Report [15] and P06.08.04 Validation Report [18].

Appendix G   Assessment of the completeness of the Safety Requirements for Normal Operations

This appendix uses the Use Case in the OSED Part 3 (section 5.1) applicable to Single Remote Tower in order to assess the completeness of the Safety Requirements for nominal and abnormal conditions identified in section 2. The tables presented here are only part of the information included in the OSED. For more detail, in particular all the conditions related to each use case (general, pre and post conditions) please refer directly to the OSED Part 3 sections from 5.1.1 to 5.1.5.

ID	Scenario	Rationale for the Choice
Normal Conditions		
UC-1	Arriving aircraft handled by remotely provided ATS	Use case in OSED §5.1.1.4
UC-2	Large Animal on Manoeuvring area while arriving aircraft handled by remotely provided ATC	Use case in OSED §5.1.1.4b
UC-3	VFR flight in the traffic circuit is conflicting with an arriving IFR flight	Use case in OSED §5.1.2
UC-4	Two departing IFR flights during Low Visibility	Use case in OSED §5.1.3
UC-5	Arrival aircraft with combined Remote TWR/APP	Use case in OSED §5.1.4
UC-6	Transition of ATS provision from local TWR to Remote TWR	Use case in OSED §5.1.5
Abnormal Conditions		
UC-7	Arriving aircraft with landing gear not locked handled by remotely provided ATC	Use case in OSED §5.1.5

Prior to enter into the detail of each UC, 2 assumptions which apply to all the use cases below are presented here:

A.O-01 The rules of the air (as per Annex 2 [8]) are applied as in current operations

A.O-02 Flight crew apply the same procedures as in current operations (as per PANS-OPS Doc 8168 [10])

More detailed assumptions are identified through the different use cases as relevant.

G.1 UC-1: Arriving aircraft handled by remotely provided ATC

Condition (general, pre or post)

GC1 - The Remote TWR ATCO is located in a RTM, located away from the aerodrome and/or local Tower.

GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual reproduction of the aerodrome view

GC3 - The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.

PreC1 - An inbound estimate is delivered from ACC

PostC1 - Safe and efficient provision of ATS for arrival aircraft, with the same or better levels of service as if the ATS had been provided locally

Step	Remote TWR ATCO	Flight Crew	Corresponding SR#
1.	Establishes contact (R/T) with the inbound IFR flight crew when the aircraft is established on final approach.	Acknowledges contact.	SR-05 SR-07 SR-26 SR-16
2.	Verifies that the runway is free of obstacles for the landing of the aircraft and issues the landing clearance to the flight crew using R/T.	Acknowledges the landing clearance.	SR-16 SR-18 SR-20 SR-26 SR-07
3.	Monitors the aircraft's final approach and landing to ensure safety and intervenes if required.	Proceeds with the approach and lands the aircraft.	SR-13 SR-16 SR-18 SR-20 SR-26 AO-02
4.	Issue a clearance where to exit the runway. Verifies that the aircraft has vacated the runway via the planned exit Issues a taxi clearance via appropriate taxiway(s) to the allocated stand on apron.	Executes the clearance and vacates runway Acknowledges the taxi clearance.	SR-07 SR-26 SR-16 AO-02
5.	Monitors the traffic situation for the detection of potential hazardous situations (e.g. converging airport traffic, temporary obstructions and debris). If the Taxi Clearance Limit is an active runway, the Remote TWR ATCO verifies that the runway is clear and the aircraft can cross, and issues taxi route clearance(s) to the stand.	Acknowledges and accepts the route clearance, updating the aircraft system. Manoeuvre the aircraft assisted by the routing displayed onboard the aircraft and/or using visual navigation aids (e.g. taxiway markings and lighting).	SR-26 SR-16

G.2 UC-2: Large Animal on Manoeuvring Area while arriving aircraft handled by remotely provided ATC

Step 1 and 2 are the same as per UC-1.

Step	Remote TWR ATCO	Flight Crew	Corresponding SR#
3.	Is made aware of a large animal moving on the manoeuvring area towards the RWY and immediately tells the aircraft to go-around and follow the go-around procedure	Acknowledges and immediately initiate the go-around procedure.	SR-26 SR-16 SR-20 SR-07 SR-10 AO-02
4.	Instructs ground personnel (Using a communications link between the Remote Tower facility and the		SR-10 SR-16 SR-19 SR-26

	aerodrome) to immediately to go to the given position of the animal and commence methods to remove or scare off the animal.		
5.	Updates flight crew on on-going situation and approximate time frame for being given a new approach and landing clearance	The flight crew will consider this in their planning for alternative aerodromes to land if necessary.	SR-07 SR-13 SR-16 SR-26 AO-02
6.	Receives confirmation from ground personnel (via communications link) that the animal is no longer in the vicinity.		SR-10
7.	Checks the visual reproduction again for their own confirmation and informs the aircraft that it is clear to land again	Acknowledges the landing clearance.	SR-16 SR-19 SR-26
8.	Flow continues from 3 in Use Case UC-1		

G.3 UC-3: VFR flight in the traffic circuit is conflicting with an arriving IFR flight

Condition (general, pre or post)

GC1 - The Remote TWR ATCO is located in a RTM, located away from the aerodrome and/or local Tower.

GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual reproduction of the aerodrome view

GC3 - The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.

PreC1 - The VFR flight in the traffic circuit is conflicting with an arriving IFR flight;

PreC2 - Airspace class C

PreC3 - The ATCO doesn´t have both aircraft in sight

PostC1 - Safe and efficient provision of ATS for the arrival aircraft, with the same or better levels of service as if the ATS had been provided locally.

Step	Remote TWR ATCO	Flight Crew	Corresponding SR#
1.	Contact VFR Flight (R/T) and clears the VFR flight to a published VFR holding point or any suited location.	VFR flight crew acknowledges clearance and proceeds to VFR holding point or any suited location.	SR-07 SR-14 SR-16 SR-26

G.4 UC-4: Two departing IFR flights during Low Visibility

Condition (general, pre or post)

GC1 - The Remote TWR ATCO is located in a remote tower module, located away from the aerodrome and/or local Tower.

GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual

reproduction of the aerodrome view.

GC3 -   The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.

PreC1 - In this scenario there are two departing IFR flights.

PreC2 - Visibility is poor and Low visibility Procedures are in place.

PreC3 - En-route clearance is issued by ATCO before start-up upon flight crew request, by use of R/T or Datalink.

PostC1 -Safe and efficient provision of ATS for the departing aircraft, with the same or better levels of service as if the ATS had been provided locally. The Advanced Visual Features enable simultaneous movements during LVP.

Step	Remote TWR ATCO	Flight Crew	Corresponding SR#
1.	Initiates Low Visibility Procedures locally at the airport, and informs the airport authority and departing aircraft.	Acknowledges LVP in operation	SR-20 SR-07 SR-11 SR-26
2.	Clears departing aircraft No.1 for engine start-up when ready	Departing aircraft No.1 confirms engine start-up	SR-07
3.	Verifies that the runway (and manoeuvring areas if applicable) is free of obstructions (i.e. vehicles, people, animals) and approve departing aircraft No.1 to push back.	Aircraft No.1 executes push back.	SR-16 SR-16 SR-09 SR-20 SR-26 SR-07
4.	Clears the first departing aircraft (No.1 for departure) to taxi to the holding point of the runway-in-use and when approaching the holding clears departing aircraft No.1 to line up on the runway.	Acknowledges taxi and runway clearances	SR-26 SR-07
5.	Clears departing aircraft No.2 for engine start-up when ready	Departing aircraft No.2 confirms engine start-up	SR-26 SR-07
6.	Verifies that the runway (and manoeuvring areas if applicable) is free of obstructions (i.e. vehicles, people, animals) and approve departing aircraft No.2 to push back.	Aircraft No.2 s execute push back	SR-16 SR-16 SR-09 SR-20 SR-26 SR-07
7.	Clears the second departing aircraft (No.2 for departure) to taxi to the holding point of the runway-in-use.	Departing aircraft No.2 acknowledges taxi clearance	SR-26 SR-07
8.	Verifies that the runway (and manoeuvring areas if applicable) is free of obstructions Clears No.1 for take-off	No.1 acknowledges clearance and departs on runway-in-use	SR-16 SR-16 SR-09 SR-20 SR-26 SR-07
9.	Clears the second departing aircraft (No.2 for departure) to line up on the	Acknowledges clearance	SR-26 SR-07

	runway.		
10.	Verifies that the runway (and manoeuvring areas if applicable) is free of obstructions Clears departing aircraft No.2 for take-off	Departing aircraft No.2 acknowledges clearance and departs on runway-in-use	SR-16 SR-16 SR-09 SR-20 SR-26 SR-07

G.5 UC-5: Arrival aircraft with combined Remote TWR/APP

Condition (general, pre or post)

GC1 - The Remote TWR ATCO is located in a remote tower module, located away from the aerodrome and/or local Tower.

GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual reproduction of the aerodrome view.

GC3 - The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.

PreC1 - A combined Remote APP/TWR ATCO is responsible for ATS in the CTR around a remotely serviced aerodrome and TMA FL95 and below.

PreC2 - Arriving aircraft are given inbound clearances direct to the Initial Approach Fix (IAF) for the runway-in-use.

PreC3 - No ATS surveillance service is provided by TWR/APP ATCO.

PreC4 - Two IFR flights are arriving at approximately the same time into the aerodrome.

PostC1 - Safe and efficient provision of ATS for the arrival aircraft, with the same or better levels of service as if the ATS had been provided locally.

Step	Remote APP/TWR ATCO	Flight Crew	Corresponding SR#
1.	Issues an approach clearance to Aircraft No. 1 full procedure (VOR)/ILS on VHF omnidirectional radio.	Arriving aircraft No.1 acknowledges clearance	SR-13 SR-07 SR-14 SR-16 SR-18 SR-20 SR-26
2.	Issues a clearance for Aircraft No. 2 to a published holding, with vertical separation to Aircraft No. 1 and with expected approach time given.	Arrival aircraft No.2 acknowledges clearance.	SR-13 SR-07 SR-14 SR-18 SR-20 SR-26
3.	Verifies that the runway is free of obstacles for the landing of the aircraft and clears the aircraft for a visual approach.	Acknowledges the landing clearance and runway in sight and performs VFR approach.	SR-16 SR-16 SR-18 SR-20 SR-26 SR-07 SR-09
4.	Issues arrival aircraft No.2 with an approach clearance	Aircraft No.2 acknowledges clearance	SR-07 SR-01 SR-13 SR-14 SR-18 SR-20 SR-26
5.	Monitors aircraft No.1's final approach and landing to ensure safety and intervenes if required.	Proceeds with the approach and lands the aircraft.	SR-13 SR-16 SR-18 SR-20 SR-26 AO-02

6.	Issues a taxi clearance via appropriate taxiway(s) to the allocated stand on apron. Verifies that the aircraft has vacated the runway via the planned exit.	Acknowledges the taxi clearance. Executes the clearance and vacates runway.	SR-07 SR-15 SR-16 SR-18 SR-20 SR-26
7.	Clears No.2 for landing and monitors aircraft No.2's final approach and landing to ensure safety and intervenes if required.	Proceeds with the approach and lands the aircraft.	SR-07 SR-01 SR-13 SR-16 SR-18 SR-20 SR-26
8.	The visual reproduction will then be used to monitor and control both aircraft		SR-16 SR-18 SR-20 SR-26

G.6 UC-6: Transition of ATS provision from local TWR to Remote TWR

Condition (general, pre or post)

GC1 - The Remote TWR ATCO is located in a remote tower module, located away from the aerodrome and/or local Tower.

GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual reproduction of the aerodrome view.

GC3 - The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.

PreC1 - The local TWR ATCO is ready to hand over to the Remote TWR ATCO.

PostC1 - Safe and efficient provision of ATS for the arrival aircraft, with the same or better levels of service as if the ATS had been provided locally.

Step	Remote TWR ATCO	Local TWR ATCO	Corresponding SO#
1	Prior to the nominated time of transfer, the Remote TWR ATCO coordinates with the Local TWR ATCO to see if conditions are sufficient to begin remote provision of ATS.	The Local TWR ATCO has the final decision.	New: SR-27 SR-28 SR-29
2	Once satisfied that a transfer can take place, the Remote TWR ATCO performs various checks in the remote facility		New: SR-28
3	Once all checks have been complete to the satisfaction of the Remote TWR ATCO, the Remote TWR ATCO takes control of the relevant equipment from the Local TWR ATCO. The Remote TWR ATCO informs the Local TWR ATCO that they are ready to begin remote provision of ATS services. .	This is confirmed by the Local TWR ATCO	SR-29

4	The Remote TWR ATCO then calls the Local TWR ATCO by telephone to transfer information on: • General information including deviations from normal procedures; • Work in Progress on or close to manoeuvring area that could have an influence; • AWOS – Check date and "letter" for current Met. Info; • RDP Settings – range, centre settings, additional maps; • Traffic situation – actual air traffic, vehicles on manoeuvring area, issued clearances; • If available RDP settings – tange, centre settings, additional maps • Any other pertinent information.		SR-27 SR-28
5	After transfer of relevant information, transfer of control is performed with the Remote TWR ATCO taking control. The Remote TWR ATCO performs final essential checks on radio and telephone functions and volume by conducting final transmissions to the Local TWR ATCO and ACC.		SR-27 SR-28
6	The Remote TWR ATCO then requests control by using the supervisor telephone (if deployed) and initiating "Remote Provision of ATS". The Remote TWR ATCO accepts and states "Remote facility takes control".	The Local TWR ATCO then states "You take control" and acknowledges the initiation.	SR-27 SR-28 SR-29
7		The Local TWR ATCO informs the airport agents, officers and ACC that the remote facility is now providing ATS	SR-29

G.7 UC-7: Arriving aircraft with landing gear not locked handled by remotely provided ATC

Steps 1 and 2 are the same as per UC-1.

Step	Remote TWR ATCO	Flight Crew	Corresponding SO#
3.		Flight crew observes an indication in the cockpit that the landing gear not is down and locked and request to make a low pass above the aerodrome. The flight crew request the Remote Tower ATCO to observe	AO-03 SR-07 SR-14 SR-18 SR-20 SR-19 SR-26

		if the landing gear seems to be down	
4.	Informs the flight crew that gear seems to be down using a zoom view to focus on the aircraft.	Acknowledges response and decide to land	SR-07 SR-26 SR-19
5.	Informs emergency unit and initiates emergency procedures to be followed		SR-12 SR-26
6.	Monitors the aircraft's final approach and landing to ensure safety and intervenes if required.	Proceeds with the approach and lands the aircraft.	SR-26 SR-16 SR-18 SR-20 AO-02
7.	Flow continues from 4 in UC-1a		

Appendix H   Causal analysis for identified hazards

This appendix provides the several causes for each of the identified hazards in section 2.

H.1 Causal analysis for SO-101

The likelihood that Remote ATC incorrectly coordinates with other ATSU with respect to inbound / outbound traffic shall be no more than 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

H.2 Causal analysis for SO-102

The likelihood that Remote ATC incorrectly manages the entry of a flight intro traffic circuit shall be no more than 1e-5 per controlled hour

POT.CONFLICT-AIR	Probability of an aircraft in the proximity potentially creating a conflict [1e-2]	EXT
ATCO-013	ATCO fails to identify and aircraft near the traffic circuit [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
ATCO-002	ATCO fails to provide appropriate instruction for AC to entry into traffic circuit [1e-3/fh]	ATCO
A-GCOM-001	A-G communication failure or degradation [1e-4/fh]	A-G Comm

H.3 Causal analysis for SO-103

The likelihood that Remote ATC incorrectly manages arriving aircraft shall be no more than 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

H.4 Causal analysis for SO-104

The likelihood that Remote ATC incorrectly manages departing aircraft shall be no more than 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

H.5 Causal analysis for SO-105

The likelihood that Remote ATC fails to provide appropriate separation to traffic in the vicinity of the aerodrome shall be no more than 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 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

H.6 Causal analysis for SO-106

The likelihood that Remote ATC fails to provide appropriate separation of traffic with respect to restricted areas shall be no more than 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

H.7 Causal analysis for SO-107

The likelihood that Remote ATC incorrectly manage missed approach situation shall be no more than 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

H.8 Causal analysis for SO-108

The likelihood that Remote ATC does not detect in time conflicts / potential collision between aircraft on the vicinity of the aerodrome shall be no more than 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

H.9 Causal analysis for SO-109

The likelihood that Remote ATC does not detect in time restricted area infringements shall be no more than 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

H.10 Causal analysis for SO-110

The likelihood that Remote ATC fails to provide appropriate instruction to solve conflict between traffic on the vicinity of the aerodrome shall be no more than 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 the aerodrome vicinity [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

H.11 Causal analysis for SO-111

The likelihood that Remote ATC fails to provide appropriate instruction to solve airspace infringement shall be no more than 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

H.12 Causal analysis for SO-112

The likelihood that Remote ATC fails to provide appropriate information to departing aircraft during the start-up shall be no more than 1e-1 per controlled flight

ATCO-010	ATCO identifies an incorrect departing AC for initiating the remote ATC 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

H.13 Causal analysis for SO-113

The likelihood that Remote ATC fails to enable push-back/towing operations to appropriate aircraft shall be no more than 1e-1 per controlled flight

ATCO-010	ATCO identifies an incorrect departing AC for initiating the remote ATC 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

H.14 Causal analysis for SO-114

The likelihood that Remote ATC provides inadequate route instruction to aircraft on the manoeuvring area shall be no more than 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

H.15 Causal analysis for SO-115

The likelihood that Remote ATC provides inadequate route instruction to vehicle in the manoeuvring area shall be no more than 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

H.16 Causal analysis for SO-116

The likelihood that Remote ATC does not remotely detect in time conflicts on the manoeuvring area shall be no more than 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

H.17 Causal analysis for SO-117

The likelihood that Remote ATC fails to provide appropriate instruction to solve conflicts on the manoeuvring area shall be no more than 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

H.18 Causal analysis for SO-118

The likelihood that Remote ATC fails to provide (appropriate) navigation support to AC and vehicle on the manoeuvring area shall be no more than 1e-1 per 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

H.19 Causal analysis for SO-119

The likelihood that Remote ATC incorrectly manages runway entry for a departure aircraft (occupied runway) shall be no more than 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

H.20 Causal analysis for SO-120

The likelihood that Remote ATC incorrectly manage runway exit for a landing aircraft shall be no more than 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	Remote ATCO 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

H.21 Causal analysis for SO-121

The likelihood that Remote ATC incorrectly manage runway crossing (occupied runway) for a vehicle or an aircraft shall be no more than 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

H.22 Causal analysis for SO-122

The likelihood that Remote ATC fails to properly support departing and landing aircraft (wrt visual-aids) shall be no more than 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 Aids [1e-4/mov]	ATCO
VNAM-001	Loss or dysfunction of Visual Navigation Aids system on the manoeuvring area [1e-4/mov]	Visual Navigation Aids system

H.23 Causal analysis for SO-123

The likelihood that Remote ATC incorrectly manages vehicle related tasks on the runway shall be no more than 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 |

H.24 Causal analysis for SO-124

The likelihood that Remote ATC incorrectly manages aircraft take-off (occupied runway) shall be no more than 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

H.25 Causal analysis for SO-125

The likelihood that Remote ATC incorrectly manages aircraft landing (occupied runway) shall be no more than 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-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

H.26 Causal analysis for SO-126

The likelihood that Remote ATC fails to detect in time runway incursions shall be no more than 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

H.27 Causal analysis for SO-127

The likelihood that Remote ATC fails to provide appropriate instruction to solve runway incursion and prevent potential collision on the runway shall be no more than 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 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

H.28 Causal analysis for SO-128

The likelihood that Remote ATC fails to detect in time a flight towards terrain 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

H.29 Causal analysis for SO-129

The likelihood that Remote ATC fails to provide appropriate support to pilot on a CFIT situation 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 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
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

H.30 Causal analysis for SO-130

The likelihood that Remote ATC fails to establish sufficient wake turbulence spacing between landing/departing aircraft shall be no more than 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

H.31 Causal analysis for SO-131

The likelihood that Remote ATC fails to properly support landing /taking off operations with respect to weather conditions shall be no more than in current operations

ATCO-036	ATCO fails to appropriately assess weather conditions [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-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
MET-001	Incorrect MET/Weather information [1e-4/mov]	Local MET system
ATCO-041	ATCO fails to appropriately provide weather related information to pilot for supporting landing/departing operations [1e-3/mov]	ATCO
A-GCOM-001	A-G communication failure or degradation [1e-4/mov]	A-G Comm

H.32 Causal analysis for SO-132

The likelihood that Remote ATC fails to properly support landing /taking off operations with respect to runway conditions and potential foreign objective debris shall be no more than in current operations

ATCO-037	ATCO fails to visually assess runway surface conditions [1e-3/mov]	ATCO
APERS-001	Airport personnel provides incorrect information on runway surface [1e-4/mov]	Airport Personnel
VRS-008	Inappropriate information on manoeuvring area (runway) is provided on VRS [1e-4/mov]	Visualisation system
S-GCOM-003	Failure or degradation of voice communication with personnel responsible of RWY inspections [1e-4/mov]	Surf-G Comm

H.33 Causal analysis for SO-133

The likelihood that Remote ATC fails to properly support departing and arriving AC on the runway with respect to non-visual aids shall be no more than in current operations

ATCO-042	ATCO fails to provide appropriate navigation support to landing AC on the runway using Non Visual Navigation Aids [1e-4/mov]	ATCO

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

H.34 Causal analysis for SO-134

The likelihood that Remote ATC fails to detect in time an intrusion inside landing-air protection area shall be no more than in current operations

AC LANDING	Probability of an aircraft landing [1e-1]	EXT
ATCO-043	ATCO fails to detect an intrusion inside landing-air protection area [1e-3/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

Appendix I   Risk Classification Schemes

This appendix presents the Risk Classification Schemes (RCS) used for defining the Safety Objectives corresponding to the several hazards identified during the safety assessment (in sections 2.8.1 and 2.8.2). They have been derived from the Accident Incident Model (AIM) developed in the frame of WP16.1.1.

These RCS represents the maximum tolerable frequency of occurrence of an event, being this frequency of accurrence an ECAC wide average of the baseline risk (related to current operations – before SESAR) associated to the events of the corresponding severity class.

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt hr)
MAC-SC1	A situation where an aircraft comes into physical contact with another aircraft in the air.	MAC Accident (MF3)	1 e-9
MAC-SC2a	A situation where an imminent collision was not mitigated by an airborne collision avoidance but for which geometry has prevented physical contact	Near collision (MF3a)	1 e-6
MAC-SC2b	A situation where airborne collision avoidance prevents near collision	Imminent collision (MF4)	1 e-5
MAC-SC3	A situation where an imminent collision was prevented by ATC Collision prevention: STCA, expedite, etc. Note: this should encompass an ATC induced tactical conflict (MF7.1) that nearly always lead to imminent infringement	Imminent infringement (MF5-8)	1 e-4
MAC-SC4a	A situation where an imminent infringement coming from a crew/aircraft induced conflict was prevented by tactical conflict management	Tactical Conflict (crew/aircraft induced) (MF6.1)	1 e-3
MAC-SC4b	A situation where an imminent infringement coming from a planned conflict was prevented by tactical conflict management	Tactical Conflict (planned) (MF5.1)	1 e-2
MAC-SC5	A situation where, on the day of operations, a tactical conflict (planned) was prevented by Traffic Planning and Synchronization.	Pre tactical conflict (MF5.2)	1 e-1

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt)
CFIT-SC1	A situation where an aircraft collides with terrain/water/ obstacle	CFIT Accident (CF2)	1 e-8
CFIT-SC2a	A situation where an imminent CFIT was not mitigated by pilot/airborne avoidance (visual terrain warning, TAWS, GPWS) but for which aircraft trajectory geometry has prevented the collision with terrain/water/ obstacle	Near CFIT (CF2a)	1 e-8
CFIT-SC2b	A situation where a near CFIT was prevented by pilot/airborne avoidance (visual terrain warning, TAWS, GPWS)	Imminent CFIT (CF3)	1 e-6
CFIT-SC3a	A situation where an imminent CFIT was prevented by ATC CFIT avoidance (e.g. MSAW)	Controlled flight towards terrain (CF4)	1 e-5
CFIT-SC3b	A situation where Controlled flight towards terrain was prevented by pilot tactical CFIT resolution (flight crew monitoring)	Flight towards terrain commanded (CF5 – 8)	1 e-5
Severity Class	**Hazardous situation**	**Operational Effect of failure**	**Maximum tolerable frequency of occurrence (/flt)**
RInc-SC1	A situation where an aircraft has come into physical contact with another object on the runway	RWY Accident (RF3)	1 e-8
RInc-SC2(a)	A situation where an imminent runway collision was not mitigated by pilot/driver or aircraft system collision avoidance – see and avoid & any pilot assist.	Near collision (RF3a)	1 e-7
RInc-SC2(b)	A situation where a runway conflict was not mitigated by ATC runway collision avoidance eg, Vigilance, RIMCAS, ASMGCS failure etc.	Imminent collision (RP1)	1 e-6
RInc-SC3	Situations where either: • A Runway entry incursion instigated by ATC or a non-ATC runway entry incursion (induced by pilot/vehicle driver) is concurrent with a conflicting aircraft approaching the runway and this has not been mitigated by ATC Runway tactical operations. • a runway incursion due to premature take-off/landing is concurrent with a conflicting aircraft approaching the runway	Encounters between a/c, vehicle or person on the runway and one a/c approaching (one is cleared and one isn't) (RP2)	1 e-5

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt)
	• an animal/person runway incursion is concurrent with a conflicting aircraft approaching the runway		
RInc-SC4	An imminent runway incursion not mitigated by the ATC runway monitoring. Imminent runway incursion are due to: • unauthorized runway entry (ATC and non-ATC) • failure to exit runway • unautorized Take-off or Landing • animal/person approaching the runway	Runway penetration without encounter (RP3)	1 e-4
RInc-SC5	A situation where the runway use (ATC and non-ATC) does not respect procedures for: • runway entry • landing • take-off	Imminent Runway penetration (RP4)	1 e-3

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt)
Wake-SC1	A situation where aircraft loss of control was not mitigated by the wake encounter recovery barrier e.g. ineffective aircraft recovery following a severe wake encounter	Accident- Permanent loss of control (WE1)	1 e-9
Wake-SC2	A situation with separation minima infrigement (SMI) where an aircraft encountered a severe wake turbulence leading to a temporary but significant loss of control (e.g. aircraft stall conditions) and possibly injuries onboard	Significant temporary loss of control with or without injuries onboard (WE2F)	1 e-6
Wake-SC3	A situation without separation minima infrigement (SMI) where an aircraft encountered a severe wake turbulence leading to a temporary loss of control but without injuries onboard	Temporary loss of control without injuries onboard (WE2S)	
	A situation where an aircraft has encountered a non-severe wake turbulence following a Separation Minima Infrigement (SMI) with the leader aircraft	Turbulence affecting the aircraft handling and increasing the loss of separation risk with the leader aircraft (WE3F)	1 e-5

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt)
	A situation with separation minima infrigement (SMI) where the leader aircraft has generated a wake turbulence in front of the follower aircraft. The tactical conflict associated to SMI is coming from planned conflicts (WE9) or induced conflicts (WE6 and WE7) and was not mitigated by the Tactical conflict resolution barrier(B6-B8)	Imminent significant Turbulence

Turbulence in front of the aircraft at a distance less than the separation minima (WE4F[3]) | |
| Wake-SC4 | A situation where an aircraft has encountered a non-severe wake turbulence without separation minima infrigement (SMI) | Turbulence affecting slightly the aircraft handling (WE3S) | |
| | A situation without separation minima infrigement (SMI) where a leader aircraft has generated a wake turbulence in front of the follower aircraft | Imminent non-significant Turbulence

Turbulence in front of the aircraft at a distance greater than the separation minima (WE4S[4]) | 1 e-4 |

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt)
TInc-SC1	A situation where an aircraft has come into physical contact with another object on the runway[(*)]	TWY Accident (TF3)	1 e-7
TInc-SC2	A situation where an imminent taxiway collision was not mitigated by pilot/driver or aircraft system taxiway collision avoidance – see and avoid & any pilot assist.	Near collision (TF3a)	1 e-6
TInc-SC3	A situation where a runway conflict was not mitigated by ATC taxiway collision avoidance eg, Vigilance, ASMGCS failure etc.	Imminent collision (TP1)	1 e-2
TInc-SC4	A situation where a tactical taxiway conflict (coming from planned taxiway conflicts or induced taxiway conflicts) was not mitigated by Taxiway Conflict Management. Neither a crew/driver or the GC detected and resolved the conflict.	Encounters between a taxiing aircraft and another a/c, a vehicle or an obstacle on the taxiway or an obstacle. Safe distance is lost (TP2)	1 e-1

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[3] WE4F severity is SC3 because currently the « Wake avoidance and encounter Management barrier » is ineffective. When this barrier will be effective, it is planned to assign SC4.
[4] WE4S severity is SC4 because currently the « Wake avoidance and encounter Management barrier » is ineffective. When this barrier will be effective, it is planned to assign SC5.

Severity Class	Hazardous situation	Operational Effect of failure	Maximum tolerable frequency of occurrence (/flt)
TInc-SC5	A situation where a conflict free taxi plan has not been provided to an aircraft (planned conflict) or when a conflict free taxiing plan is comprimised by ATC, pilot/driver or by a new obstacle (induced conflcit).	Tactical Taxiway conflict generated (planed or induced) (TP3)	1

Appendix J   Software Safety Requirements allocation

J.1 SWAL matrix

The software safety requirements provided in this document (section 3.4.2) have been defined based on the following matrix:

Likelihood	Severity 1	2	3	4
Very Probable	SWAL 1	SWAL 2	SWAL 3	SWAL 4
Possible	SWAL 2	SWAL 3	SWAL 3	SWAL 4
Very Unlikely	SWAL 3	SWAL 3	SWAL 3	SWAL 4
Extrem Unlikely	SWAL 4	SWAL 4	SWAL 4	SWAL 4

This matrix is based on the one proposed in ED-153 Guidelines for ANS Software Safety Assurance [17].

Each severity class in this matrix encompass the following ones from the Risk Classification Schemes presented in Appendix I (only those assigned to the hazards in section 2.8.1 are shown here):

Severity 2: MAC-SC2b and CFIT-SC2b

Severity 3: MAC-SC3, TInc-SC3, RInc-SC3, WV-SC3

Severity 4: MAC-SC4a, TInc-Sc4, RInc-4

The likelihoods levels in the matrix are the following ones:

	per ops.h	
Very probable	1,00E-01	about 6 times per week
Possible	1,00E-02	about 3 times per month
Very Unlikely	1,00E-03	about 3 times per year
Extrem Unlikely	1,00E-04	about 1 times every 3 years

The conversion from the operational hours (ops.h) to the frequency of occurrence is done based on the unit conversion statement presented in section 3.4.2 (i.e. 3600 operational hours per year).

J.2 Software safety requirement for the Visualisation system

The software safety requirements defined for the Visualisation system is:

The Visualisation System software processes shall comply with SWAL 3.

The tables below show how this software safety requirement for the Visualisation has been determined.

VRS-001 Loss of information on the vicinity of the aerodrome provided by VRS - 1e-4/fh

	Severity	Likelihood (ops.h)	SWAL
OH-28	CFIT-SC2b	7,0E-03	3
OH-09	MAC-SC4a	7,0E-02	4

Software Safety Requirement: **SWAL 3**

| **VRS-003** | Inappropriate information provided in the VSR for aircraft on the vicinity of the aerodrome - 1e-4/fh |

	Severity	Likelihood (ops.h)	SWAL
OH-02	MAC-SC3	7,0E-02	3
OH-03	MAC-SC3	7,0E-02	3
OH-04	MAC-SC3	7,0E-02	3
OH-05	MAC-SC3	7,0E-02	3
OH-06	MAC-SC4a	7,0E+00	4
OH-07	MAC-SC3	7,0E-02	3
OH-08	MAC-SC2b	7,0E-03	3
OH-09	MAC-SC4a	7,0E-02	4
OH-10	MAC-SC2b	7,0E-03	3
OH-28	CFIT-SC2b	7,0E-04	3
OH-29	CFIT-SC2b	7,0E-04	3
OH-31	TBD	7,0E-04	3 or 4

Software Safety Requirement: **SWAL 3**

| **VRS-007** | Inappropriate information on manoeurvring area (taxiways) is provided on VRS - 1e-4/mov |

	Severity	Likelihood (ops.h)	SWAL
OH-14	TInc-SC4	1,4E+00	4
OH-15	TInc-SC4	1,4E+00	4
OH-16	TInc-SC3	1,4E-01	3
OH-17	TInc-SC3	1,4E-01	3
OH-20	RInc-SC3	1,4E-01	3
OH-23	RInc-SC3	1,4E-01	3
OH-26	RInc-SC4	1,4E+00	4
OH-27	RInc-SC4	1,4E+00	4
OH-34	TBD	1,4E-01	2 or 3 or 4

Software Safety Requirement: **SWAL 3**

| **VRS-008** | Inappropriate information on manoeuvirng area (runway) is provided on VRS - 1e-4/mov |

	Severity	Likelihood (ops.h)	SWAL
OH-19	RInc-SC3	1,4E-01	3
OH-20	RInc-SC3	1,4E-01	3
OH-21	RInc-SC3	1,4E-01	3
OH-23	RInc-SC3	1,4E-01	3
OH-24	RInc-SC3	1,4E-01	3
OH-25	RInc-SC3	1,4E-01	3
OH-26	RInc-SC4	1,4E+00	4

OH-27	RInc-SC4	1,4E+00	4
OH-31	TBD	1,4E-03	3 or 4
OH-32	TBD	1,4E-03	3 or 4
OH-34	TBD	1,4E-01	2 or 3 or 4

Software Safety Requirement: **SWAL 3**

VRS-009 Loss of information on manoeuvring area on the VRS - 1e-4/mov

	Severity	*Likelihood (ops.h)*	*SWAL*
OH-16	TInc-SC3	1,4E-01	3
OH-26	RInc-SC4	1,4E+00	4

Software Safety Requirement: **SWAL 3**

VRS-010 Inappropriate information on final approach area is provided on VRS - 1e-4/mov

	Severity	*Likelihood (ops.h)*	*SWAL*
OH-19	RInc-SC3	1,4E-01	3
OH-21	RInc-SC3	1,4E-01	3
OH-23	RInc-SC3	1,4E-01	3
OH-24	RInc-SC3	1,4E-01	3
OH-25	RInc-SC3	1,4E-01	3
OH-26	RInc-SC4	1,4E+00	4
OH-28	CFIT-SC2b	1,4E-03	3
OH-29	CFIT-SC2b	1,4E-03	3
OH-30	WV-SC3	1,4E-01	3
OH-31	TBD	1,4E-03	3 or 4

Software Safety Requirement: **SWAL 3**

VRS-012 Loss of information on final approach on the VRS - 1e-4/mov

	Severity	*Likelihood (ops.h)*	*SWAL*
OH-26	RInc-SC4	1,4E+00	4
OH-28	CFIT-SC2b	1,4E-03	3

Software Safety Requirement: **SWAL 3**

Appendix K   Human Contribution to ATC Risk in RVT system

As mentioned in section 3.4.1 the causes related to human error in performing specific tasks have also been taken into account in the causal analysis for each hazard. The corresponding quantification of these errors is provided only in order to show traceability and transparency on the process. But no quantitative safety requirement has been directly derived from them. Based on these results the purpose is to provide an indication of the associated risk to the identified human related errors. This list is potentially to be addressed in future activities of the human performance assessment for remote tower.

BE#	Basic Event description	Severity of associated effect	Contribution
Contribution to Near Mid Air Collision			
ATCO-004	ATCO fails to detect in time conflicts and potential collisions on the vicinity of the aerodrome [1e-3/fh]	MAC-SC2b	1e-3
Contribution to Inmminent Infringement			
ATCO-013	ATCO fails to identify and aircraft near the traffic circuit [1e-3fh]	MAC-SC3	2e-2
ATCO-002	ATCO fails to provide appropriate instruction for AC to entry into traffic circuit [1e-3/fh]	MAC-SC3	2e-2
ATCO-001	ATCO fails to manage arriving traffic in the vicinity of the aerodrome [1e-3/fh]	MAC-SC3	2e-2
ATCO-038	ATCO fails to manage departing traffic in the vicinity of the aerodrome [1e-3/fh]	MAC-SC3	2e-2
ATCO-008	ATCO incorrectly coordinates with other ATSU for inbound/outbound traffic transfer [1e-3fh]	MAC-SC3	1e-2
ATCO-003	ATCO fails to apply appropriate separation between aircraft on the vicinity of the aerodrome[1e-3/fh]	MAC-SC3	1e-2
ATCO-006	ATCO fails to manage go-around situations [1e-3/fh]	MAC-SC3	1e-2
Contribution to Potential Tactical conflicts in the air			
ATCO-014	ATCO fails to appropriately separate aircraft from restricted areas on the vicinity of the aerodrome [1e-4fh]	MAC-SC4a	1
ATCO-011	Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [1e-4/fh]	MAC-SC4a	1
ATCO-009	ATCO fails to detect in time restricted area infringement [1e-2/fh]	MAC-SC4a	1e-2
Contribution to Controlled Flight towards terrain			

ATCO-033	ATCO fails to detect in time a flight towards terrain [1e-3/mov]	CFIT-SC2b	1e-4
ATCO-034	ATCO fails to provide appropriate instructions and information for solving CFTT situation [1e-3/mov]	CFIT-SC2b	1e-4
ATCO-035	ATCO fails to create sufficient WT spacing between landing/departing aircraft [1e-3/mov]	Wake-SC3	1e-2
Contribution to Runway Conflict			
ATCO-023	Remote ATCO fails to provide appropriate runway exit instruction to landing aircraft [1e-4/mov]	RInc-SC3	5e-2
ATCO-025	ATCO identifies an incorrect aircraft or vehicle for crossing the runway [1e-4/mov]	RInc-SC3	5e-2
ATCO-024	ATCO fails to correctly identify next aircraft in the departing sequence [1e-4/mov]	RInc-SC3	4e-2
ATCO-022	ATCO allows aircraft to line-up in a runway already being used [1e-4/mov]	RInc-SC3	4e-2
ATCO-027	ATCO provides take-off clearance for departing AC in a runway already being used [1e-4/mov]	RInc-SC3	4e-2
ATCO-028	ATCO provide landing clearance for a runway already being used [1e-4/mov]	RInc-SC3	4e-2
ATCO-026	ATCO fails to provide appropriate navigation support to departing/arriving AC on the runway using Visual Navigation Aids [1e-4/mov]	RInc-SC3	2e-2
ATCO-031	ATCO allows vehicle to enter/operate in a runway which is being used [1e-4/mov]	RInc-SC3	1e-2
Contribution to Runway Incursion			
ATCO-029	ATCO fails to detect in time a runway incursion [1e-4/mov]	RInc-SC4	6e-1
ATCO-032	ATCO fails to provide appropriate instruction to solve runway incursion and prevent potential collision [1e-4/mov]	RInc-SC4	5e-1
Contribution to Taxiway Conflict			
ATCO-019	ATCO fails to detect in time conflict on the manoeuvring area [1e-1/mov]	TInc-SC3	1e-2
ATCO-020	ATCO fails to provide appropriate instruction to solve conflicts on the manoeuvring area [1e-1/mov]	TInc-SC3	1e-2
Contribution to Taxiway potential Conflict			

ATCO-016	ATCO identifies incorrect aircraft on the manoeuvring area (taxiways) [1e-2/mov]	TInc-SC4	2e-1
ATCO-015	ATCO fails to provide appropriate route instruction to aircraft on the manoeuvring area [1e-2/mov]	TInc-SC4	2e-1
ATCO-017	ATCO identifies incorrect vehicle on the manoeuvring area (taxiway) [1e-3]	TInc-SC4	2e-1
ATCO-018	ATCO provides inappropriate route instruction to vehicle on the manoeuvring area (taxiway) [1e-3/mov]	TInc-SC4	2e-1
Contribution to inducing taxiway hazardous situations			
ATCO-010	ATCO identifies an incorrect departing AC for initiating the remote ATC service [1e-2/mov]	TInc-SC5	1
ATCO-039	ATCO incorrectly provides information to departing aircraft during the start-up [1e-1/mov]	TInc-SC5	1
ATCO-040	ATCO incorrectly coordinated with airport personnel in charge of the apron for push-back/towing procedures [1e-2]	TInc-SC5	1
ATCO-021	ATCO fails to provide appropriate navigation support to AC and vehicle on the taxiway using Visual Navigation Aids [1e-1/mov]	TInc-SC5	1
Contribution to landing related accidents / incidents			
ATCO-036	ATCO fails to appropriately assess weather conditions [1e-3/mov]	No severity assigned	1
ATCO-041	ATCO fails to appropriately provide weather related information to pilot for supporting landing/departing operations [1e-3/mov]	No severity assigned	1
ATCO-037	ATCO fails to visually assess runway surface conditions [1e-3/mov]	No severity assigned	1
ATCO-042	ATCO fails to provide appropriate navigation support to landing AC on the runway using Non Visual Navigation Aids [1e-4/mov]	No severity assigned	1
ATCO-043	ATCO fails to detect an intrusion inside landing-air protection area [1e-3/mov]	No severity assigned	1e-2

-**END OF DOCUMENT -**