



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 V2 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.

Table of Contents

EXECUTIVE SUMMARY	7
1 INTRODUCTION	8
1.1 BACKGROUND	8
1.2 GENERAL APPROACH TO SAFETY ASSESSMENT	8
1.2.1 A Broader approach	8
1.3 SCOPE OF THE SAFETY ASSESSMENT	8
1.4 LAYOUT OF THE DOCUMENT	9
1.5 REFERENCES	9
1.6 ACRONYMS	10
2 SAFETY SPECIFICATIONS AT THE OSED LEVEL	10
2.1 SCOPE	10
2.2 SINGLE REMOTE TOWER - OPERATIONAL ENVIRONMENT AND KEY PROPERTIES	11
2.2.1 Airspace Structure, Boundaries and Types of Airspace	11
2.2.2 Airspace Users (Flight Rules), Traffic Levels and complexity	11
2.2.3 Aerodrome Layout Characteristics	12
2.2.4 CNS Aids	12
2.3 AIRSPACE USERS REQUIREMENTS	12
2.4 SAFETY CRITERIA	12
2.4.1 Safety Criteria related to Mid-Air Collision in TMA	13
2.4.2 Safety Criteria related to Controlled Flight Into Terrain	13
2.4.3 Safety Criteria related to Wake Vortex Induced Accidents	13
2.4.4 Safety Criteria related to Taxiway Collision	13
2.4.5 Safety Criteria related to Runway Collision	13
2.4.6 Safety Criteria related to "Landing accidents"	14
2.5 RELEVANT PRE-EXISTING HAZARDS	14
2.6 MITIGATION OF THE PRE-EXISTING RISKS – NORMAL OPERATIONS	15
2.6.1 Operational Services to Address the Pre-existing Hazards	15
2.6.2 Derivation of Safety Objectives for Normal Operations	17
2.6.3 Analysis of the Concept for typical RVT position in a RTC	21
2.7 SINGLE REMOTE TOWER OPERATIONS UNDER ABNORMAL CONDITIONS	22
2.7.1 Identification of Abnormal Conditions	22
2.7.2 Potential Mitigations of Abnormal Conditions	22
2.8 MITIGATION OF SYSTEM-GENERATED RISKS (FAILURE APPROACH)	24
2.8.1 Identification and Analysis of System-generated Hazards	24
2.8.2 Derivation of Safety Objectives (integrity/reliability)	29
2.9 IMPACTS OF REMOTE TOWER OPERATIONS FOR A SINGLE AERODROME ON ADJACENT AIRSPACE OR ON NEIGHBOURING ATM SYSTEMS	31
2.10 ACHIEVABILITY OF THE SAFETY CRITERIA	31
2.11 VALIDATION & VERIFICATION OF THE SAFETY SPECIFICATION	31
3 SAFE DESIGN AT SPR LEVEL	32
3.1 SCOPE	32
3.2 THE SPR-LEVEL MODEL FOR SINGLE REMOTE TOWER	32
3.2.1 Description of SPR-level Model	33
3.2.2 Task Analysis	38
3.2.3 Derivation of Safety Requirements (Functionality and Performance – success approach)	38
3.3 ANALYSIS OF THE SPR-LEVEL MODEL – NORMAL OPERATIONAL AND ABNORMAL CONDITIONS	57
3.3.1 Scenarios for Normal Operations	57
3.3.2 Analysis of the SPR-level Model – Normal Operations	58
3.3.3 Scenarios for Abnormal Conditions	58
3.3.4 Thread Analysis of the SPR-level Model - Abnormal Conditions	58
3.3.5 Effects on Safety Nets – Normal Operational and Abnormal Conditions	58
3.3.6 Dynamic Analysis of the SPR-level Model – Normal Operational and Abnormal Conditions	58

3.3.7	Additional Safety Requirements (functionality and performance) – Normal Operational Conditions.....	58
3.3.8	Additional Safety Requirements – Abnormal Operational Conditions	59
3.4	DESIGN ANALYSIS – CASE OF INTERNAL SYSTEM FAILURES.....	59
3.4.1	Causal Analysis.....	59
3.4.2	Safety Requirements concerning system failure conditions.....	65
3.5	VALIDATION & VERIFICATION OF THE SAFE DESIGN AT SPR LEVEL	69
APPENDIX A	CONSOLIDATED LIST OF SAFETY OBJECTIVES.....	70
A.1	SAFETY OBJECTIVES (FUNCTIONALITY AND PERFORMANCE).....	70
A.2	SAFETY OBJECTIVES (INTEGRITY)	72
APPENDIX B	CONSOLIDATED LIST OF SAFETY REQUIREMENTS	75
B.1	SAFETY REQUIREMENTS (FUNCTIONALITY AND PERFORMANCE)	75
B.2	SAFETY REQUIREMENTS (INTEGRITY)	93
APPENDIX C	ASSUMPTIONS, SAFETY ISSUES & LIMITATIONS.....	107
C.1	ASSUMPTIONS LOG.....	107
C.2	SAFETY ISSUES LOG.....	108
C.3	OPERATIONAL LIMITATIONS LOG.....	108
APPENDIX D	SAFETY WORKSHOP ON SINGLE REMOTE TOWER.....	109
APPENDIX E	ASSESSMENT OF AFIS PROVIDED FROM A REMOTE TOWER.	110
APPENDIX F	SAFETY RELATED VALIDATION RESULTS FROM ATC TRIAL.....	114
APPENDIX G	ASSESSMENT OF THE COMPLETENESS OF THE SAFETY REQUIREMENTS FOR NORMAL OPERATIONS	115
G.1	UC-1: ARRIVING AIRCRAFT HANDLED BY REMOTELY PROVIDED ATC	115
G.2	UC-2: LARGE ANIMAL ON MANOEUVRING AREA WHILE ARRIVING AIRCRAFT HANDLED BY REMOTELY PROVIDED ATC	116
G.3	UC-3: VFR FLIGHT IN THE TRAFFIC CIRCUIT IS CONFLICTING WITH AN ARRIVING IFR FLIGHT	117
G.4	UC-4: TWO DEPARTING IFR FLIGHTS DURING LOW VISIBILITY.....	117
G.5	UC-5: ARRIVAL AIRCRAFT WITH COMBINED REMOTE TWR/APP.....	119
G.6	UC-6: TRANSITION OF ATS PROVISION FROM LOCAL TWR TO REMOTE TWR.....	120
G.7	UC-7: ARRIVING AIRCRAFT WITH LANDING GEAR NOT LOCKED HANDLED BY REMOTELY PROVIDED ATC	121
APPENDIX H	CAUSAL ANALYSIS FOR IDENTIFIED HAZARDS	123
H.1	CAUSAL ANALYSIS FOR SO-101	123
H.2	CAUSAL ANALYSIS FOR SO-102.....	123
H.3	CAUSAL ANALYSIS FOR SO-103.....	123
H.4	CAUSAL ANALYSIS FOR SO-104.....	124
H.5	CAUSAL ANALYSIS FOR SO-105.....	125
H.6	CAUSAL ANALYSIS FOR SO-106.....	125
H.7	CAUSAL ANALYSIS FOR SO-107.....	125
H.8	CAUSAL ANALYSIS FOR SO-108.....	126
H.9	CAUSAL ANALYSIS FOR SO-109.....	126
H.10	CAUSAL ANALYSIS FOR SO-110	127
H.11	CAUSAL ANALYSIS FOR SO-111	127
H.12	CAUSAL ANALYSIS FOR SO-112.....	127
H.13	CAUSAL ANALYSIS FOR SO-113.....	128
H.14	CAUSAL ANALYSIS FOR SO-114.....	128
H.15	CAUSAL ANALYSIS FOR SO-115.....	129
H.16	CAUSAL ANALYSIS FOR SO-116.....	129
H.17	CAUSAL ANALYSIS FOR SO-117.....	129
H.18	CAUSAL ANALYSIS FOR SO-118.....	130
H.19	CAUSAL ANALYSIS FOR SO-119.....	130
H.20	CAUSAL ANALYSIS FOR SO-120.....	130
H.21	CAUSAL ANALYSIS FOR SO-121	131

H.22	CAUSAL ANALYSIS FOR SO-122	131
H.23	CAUSAL ANALYSIS FOR SO-123	131
H.24	CAUSAL ANALYSIS FOR SO-124	132
H.25	CAUSAL ANALYSIS FOR SO-125	132
H.26	CAUSAL ANALYSIS FOR SO-126	133
H.27	CAUSAL ANALYSIS FOR SO-127	133
H.28	CAUSAL ANALYSIS FOR SO-128	133
H.29	CAUSAL ANALYSIS FOR SO-129	134
H.30	CAUSAL ANALYSIS FOR SO-130	134
H.31	CAUSAL ANALYSIS FOR SO-131	135
H.32	CAUSAL ANALYSIS FOR SO-132	135
H.33	CAUSAL ANALYSIS FOR SO-133	136
H.34	CAUSAL ANALYSIS FOR SO-134	136
APPENDIX I	RISK CLASSIFICATION SCHEMES	137
APPENDIX J	SOFTWARE SAFETY REQUIREMENTS ALLOCATION	142
J.1	SWAL MATRIX.....	142
J.2	SOFTWARE SAFETY REQUIREMENT FOR THE VISUALISATION SYSTEM.....	142
APPENDIX K	HUMAN CONTRIBUTION TO ATC RISK IN RVT SYSTEM.....	145

List of tables

Table 1: List of relevant Pre-existing Hazards	15
Table 2: ATC services and Pre-existing Hazards	17
Table 3: Remote Tower OFA Operational Services & Safety Objectives (success approach).....	19
Table 4: List of Safety Objectives (success approach) for ATC services in Normal Operations	20
Table 5: List of operational assumptions concerning the provision of ATC services in normal conditions	21
Table 6: Additional Safety Objectives for the remote provision of ATC services in normal conditions.....	22
Table 7: Additional Safety Objectives for Abnormal Conditions.....	23
Table 8: List of Safety Objectives for Abnormal Operations	24
Table 9: List of Assumptions concerning abnormal operations.....	24
Table 10: System-Generated Hazards and Analysis	29
Table 11: Additional Safety Objectives in the case of internal failures	29
Table 12: List of Assumptions concerning system-generated hazards.....	29
Table 13: Safety Objectives on system-generated hazards.....	31
Table 14: Mapping of Safety Objectives to SPR-level Model Elements	51
Table 15: Derivation of Safety Requirements from normal and abnormal conditions SO	56
Table 16: Assumptions made in deriving the above Safety Requirements.....	57
Table 17: Operational Scenarios – Normal Conditions	57
Table 18: Additional Safety Requirements for Normal Conditions	59
Table 19: List of causes leading to operational hazards	65
Table 20: List of safety requirements related to failure conditions	69

List of figures

Figure 1: SPR-level Model for Single Remote Tower	34
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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 V2 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).

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 R&VT 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, 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.

This report is a proposed version for the final SAR, addressing safety related activities for V1 and V2. 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 specifies 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.

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.

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 (at V2 phase in the life cycle) 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 (V2) 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

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1.6 Acronyms

AFIS	Aerodrome Flight Information Service
ATC	Air Traffic Control
ATS	Air Traffic Services
CFIT	Controlled Flight Into Terrain
LVC	Low Visual Conditions
OSD	Operational Service and Environment Definition
RTC	Remote Tower Center
RVT	Remote and Virtual Tower
SAC	SAfety Criteria
SPR	Safety and Performance Requirements

2 Safety specifications at the OSD 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 in the (small) airport surface and vicinity in 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: 10-15 NM radius/rectangular, vertical extension up to 3000ft 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, during summer period it can up to maximum 3, additionally VFR movements.

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

Aircraft Fleet mix:

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

- General Aviation light aircraft (C172, PA28, PA31)
- Business Aviation and Hospital Flights (HOSP): medium jets and turboprops (Dassault Falcons, Cessna Citations, BE20)
- Helicopters

2.2.3 Aerodrome Layout Characteristics

Number of Runways: usually 1, maximum 2

Taxiway and runway entries: 1 to 3, at the end or middle of the runway (or both)

Aprons: 1 to 4

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 at least not reduced due to introduction of the R&VT, so the airspace users are provided with the same 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 is as safe as current locally provided ATS services 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 for 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 of 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 and 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 and 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) Landing accident (closed runway because of maintenance: RWY surface not operational)	RWC	SAC#9, SAC#12
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	<ul style="list-style-type: none"> ▶ Traffic planning ▶ Traffic synchronisation 	Hp#1 Situation in which AC trajectories can leading to mid-air collision
RVT.ATC-02	<ul style="list-style-type: none"> ▶ Traffic monitoring ▶ Conflict resolution 	<p>Hp#1 Situation in which AC trajectories can leading to mid-air collision</p> <p>Hp#5 Missed approach</p>
RVT.ATC-03	<ul style="list-style-type: none"> ▶ Potential collision detection ▶ Collision avoidance 	<p>Hp#1 Situation in which AC trajectories can leading to mid-air collision</p> <p>Hp#5 Missed approach</p>
RVT.ATC-04	<ul style="list-style-type: none"> ▶ Start-up ▶ Push-back ▶ Stand/Parking ▶ Taxiway Routing 	<p>Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY</p> <p>Hp#13 Aircraft using a closed taxiway</p>
RVT.ATC-05	<ul style="list-style-type: none"> ▶ Traffic Monitoring ▶ Conflict resolution 	<p>Hp#2 Situation leading to collision with and obstacle, ground vehicle, another aircraft on apron or TWY</p> <p>Hp#13 Aircraft using a closed taxiway</p>
RVT.ATC-06	<ul style="list-style-type: none"> ▶ 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	<ul style="list-style-type: none"> ▶ Runway Entry/exit management ▶ Take-off Management ▶ Landing Management 	<p>Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY</p> <p>Hp#4 Another aircraft or vehicle inside the OFZ</p> <p>Hp#13 Aircraft using a closed taxiway</p>
RVT.ATC-08	<ul style="list-style-type: none"> ▶ Traffic Monitoring ▶ Conflict resolution 	<p>Hp#3 Situation leading to collision with and obstacle, ground vehicle, another aircraft on RWY</p> <p>Hp#8 Bird close to/in path of aircraft or animal on the runway</p> <p>Hp#14 Aircraft landing in/taking off from a wrong/closed runway</p>
RVT.ATC-09	<ul style="list-style-type: none"> ▶ 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	<p>Hp#9 Adverse weather conditions like violent winds or severe crosswind</p> <p>Hp#10 Snow/slush on the runway</p> <p>Hp#11 Low runway surface friction</p> <p>Hp#16 Foreign Object Debris within the Runway protected area</p> <p>Hp#12 Runway undershoot</p> <p>Hp#14 Aircraft landing in/taking off from a wrong/closed runway</p> <p>Hp#17 Aircraft attempt to land with undercarriage retracted</p> <p>Hp#15 Another aircraft or vehicle inside landing-aid protection area during CATII/III instrument approach</p>
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 Flight / Operational Service	Related AIM Barrier	Safety Objective [SO xx]
0	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 refers to Remote and Virtual Tower system (encompassing people, equipment and procedures). RTC refers 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 RCT.

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. <i>See Note 1.</i>
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.

A part 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 Hazards Table 2 and Table 3 and to be able to achieve the safety criteria defined in section 2.4.

Description
AO-01. The rules of the air (as per Annex 2 [8]) are applied as in current operations
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 also derive Safety Objectives for the other two phases (initiation and termination), as well as for those ATFCM related tasks.

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 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).

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 conditions scenarios have been identified. This list includes those abnormal conditions identified in the HP assessment and those identified during the safety workshop [5]. More details are provided in .

- 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 low pressure, strong winds).

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:

- ▶ Lost 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 is has already been addressed in section 2.6.
- ▶ Abnormal weather: this is partly addressed already as nominal situation in section 2.6; when this implies the impossibility of providing ATC services, then it is considered as a cause of abnormal condition 5.

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 lost 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, as in current operations and depending on the weather/visibility conditions, to remotely identify an unexpected flight in the airspace were ATC services are being provided [SO-044] Once identified, the relevant

			flight has to be managed as in current operations (from SO-002 to SO-050)
2	Aircraft with emergency (gear problem, brakes overheating - fire on the tyres, tail strike, bird strike, etc.).	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 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.	The ATC resources in RVT are to be managed in the same way as in current operations in order to avoid controller overload [SO-039]

Table 7: Additional Safety Objectives for Abnormal Conditions

Description
SO-044. RVT shall enable, as in current operations, 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. FC 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 identified 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
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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 manage the entry of a flight into traffic circuit	SO-002	A potential conflict can be induced Imminent Infringement	SO-004 SO-007 SO-009 AO-04	MAC-SC3
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	SO-010	Tactical Conflict	AO-04 AO-05	MAC-SC4a

	instruction to solve an airspace infringement			AO-06	
OH-12	Remote ATC fails to provide appropriate information to departing aircraft for the start-up	SO-011 SO-012	Tactical Taxiway conflict generated	SO-016 SO-017 SO-018 AO-07	TInc-SC5
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	RIInc-SC3
OH-20	Remote ATC incorrectly manage runway exit for a landing aircraft	SO-020	Runway conflict	SO-026 SO-027 AO-08	RIInc-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	RIInc-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	RIInc-SC3

OH-23	Remote ATC incorrectly manage vehicle related tasks on the runway	SO-023	Runway conflict	SO-026 SO-027 AO-08	RInc-SC3
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

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	<p>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.</p> <p>This hazard is related to all other hazards EXCEPT:</p> <p>OH-01, OH-08, OH-09, OH-13, OH-16, OH-26, OH-28, OH-34</p>	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	<p>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.</p> <p>This hazard is to be considered then as part of ALL the other hazards in which controller errors are a potential cause.</p>	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 conflicts in the vicinity of the	0 SO-052	n/a

			aerodrome or on the manoeuvre area.		
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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 if 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 as in current operations
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 maintain at least the same level of safety as in current operations. 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.

Note: 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:

- Trial 1: shadow passive mode trial on ATC tower and APP services
- Trail 2: shadow passive mode trial on ATC tower and APP services, for basic and advances RVT position
- Trial 3: shadow passive and active mode trial on AFIS services

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

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.

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 remote tower for a single aerodrome can be performed as today, with the **EXCEPTION** of (see Appendix F for more details):

- Application of reduced separation in the vicinity of the aerodrome and
- Aircraft identification.

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

The safety related results on trial 2 are presented in Appendix F. The complete set of results from the 3 trials mentioned above is provided in the Validation Report [15].

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]), 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 to 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 real 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 composing 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.

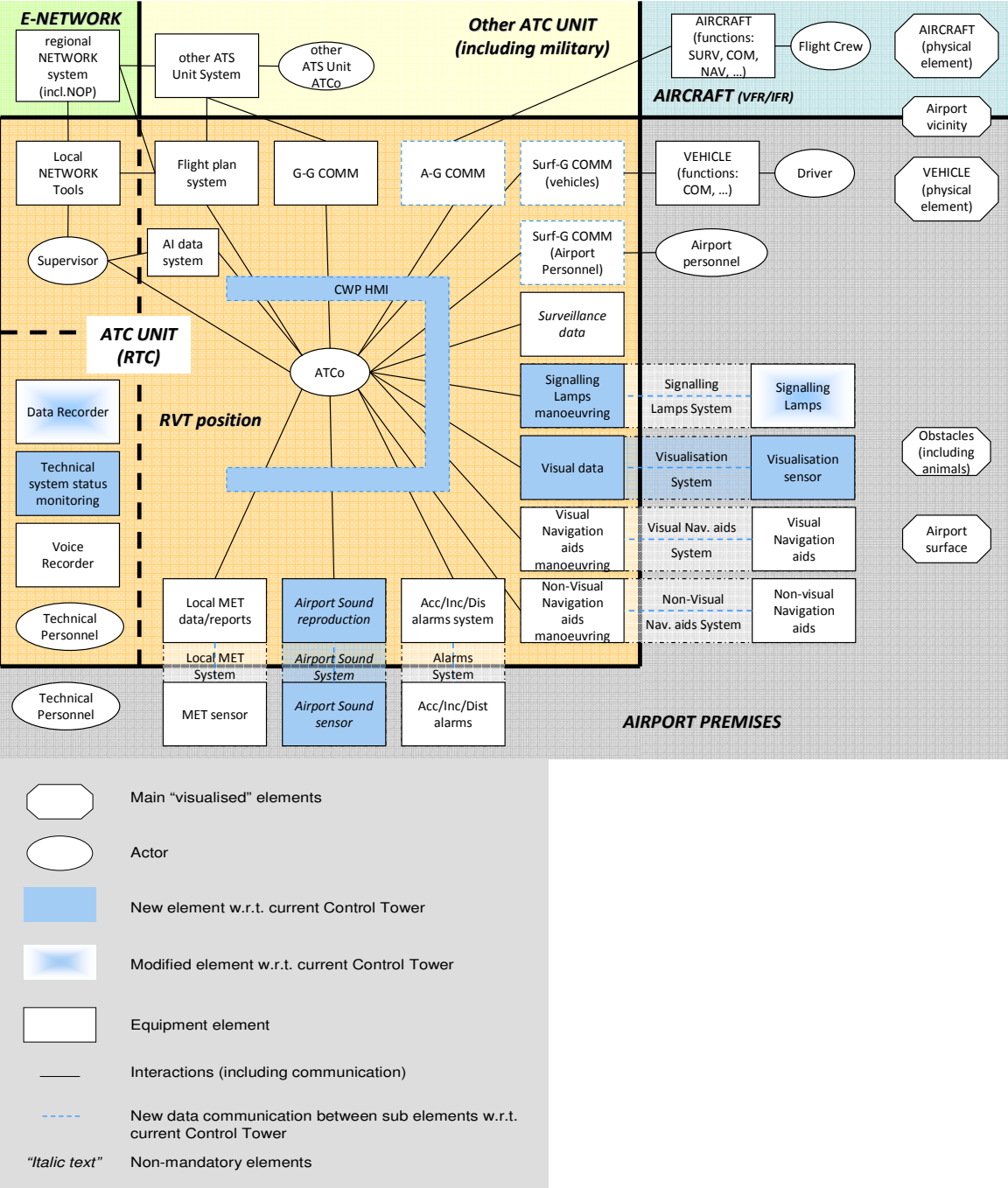


Figure 1: SPR-level Model for Single Remote Tower

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
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	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 tasks as managing the airport re-staffing resources.
Supervisor	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 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

	<p>area.</p> <p>A specific function allows a binocular view of particular element/objects.</p> <p>Additional advanced features may also be available on the visualisation system:</p> <ul style="list-style-type: none"> - 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]:

aerodrome: 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.

aerodrome traffic: 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.

obstacle: 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
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“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.

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	Flight Plan system

SO	Requirement <i>(forward reference)</i>	Maps on to
	<p>purposes [SR-05]</p> <p>Controller has to be able to communicate with adjacent ATSU units in order to coordinate and transfer relevant arriving and departing traffic [SR-06]</p> <p>When available, surveillance data is to be provided to the controller for supporting coordination and transfer procedures [SR-13]</p> <p>Controller has to apply current coordination and transfer procedures on inbound and outbound traffic as relevant [SR-26]</p>	<p>G-G Comm</p> <p>Surveillance data</p> <p>ATCo</p>
SO-002	<p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>When available, surveillance data is to be provided to the controller for managing arriving traffic [SR-13]</p> <p>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]</p> <p>Local meteorological information shall be available to the controller in order to support arriving traffic [SR-24]</p> <p>Flight plan information related to inbound traffic is to be provided to the controller [SR-05]</p> <p>Published arriving procedures have to be available to the controller in order to support arriving traffic [SR-01]</p> <p>Controller has to manage arriving traffic as in current operations [SR-26]</p>	<p>A-G Comm</p> <p>Surveillance data</p> <p>Visualisation system</p> <p>Local MET system</p> <p>Flight Plan System</p> <p>AI data system</p> <p>ATCo</p>
SO-003	<p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>When available, surveillance data is to be provided to the controller for managing departing traffic [SR-13]</p> <p>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 departing traffic [SR-14]</p> <p>Local meteorological information shall be available to the controller in order to support departing traffic [SR-24]</p> <p>Flight plan information related to outbound traffic is to be provided to the controller [SR-05]</p> <p>Published departing procedures have to be available to the controller in order to support departing traffic [SR-02]</p> <p>Controller has to manage departing traffic as in current operations [SR-26]</p>	<p>A-G Comm</p> <p>Surveillance data</p> <p>Visualisation system</p> <p>Local MET system</p> <p>Flight Plan System</p> <p>AI data system</p> <p>ATCo</p>

SO	Requirement (forward reference)	Maps on to
SO-004	<p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>When available, surveillance data is to be provided to the controller for providing traffic separation [SR-13]</p> <p>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]</p> <p>The several types of traffic separation in use today are to be applied and handled by controller [SR-26]</p>	<p>A-G Comm</p> <p>Surveillance data</p> <p>Visualisation system</p> <p>ATCo</p>
SO-005	<p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>When available, surveillance data is to be provided to the controller for ensuring separation with restricted areas [SR-13]</p> <p>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]</p> <p>Information on active/non-active restricted areas is to be available to the controller in the (or close to) area of responsibility [SR-03]</p> <p>Incorrect coordination with adjacent unit (civil or military) responsible of the corresponding restricted area [SR-26]</p> <p>Controller has to ensure separation with active restricted areas as in current operations [SR-26]</p>	<p>A-G Comm</p> <p>Surveillance data</p> <p>Visualisation system</p> <p>AI data system</p> <p>ATCo</p> <p>ATCo</p>
SO-006	<p>When available, surveillance data is to be provided to the controller for managing missed approaches situations [SR-13]</p> <p>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]</p> <p>Controller has to manage missed approaches situations as in current operations [SR-26]</p>	<p>Surveillance data</p> <p>Visualisation system</p> <p>ATCo</p>
SO-007	<p>When available, surveillance data is to be provided to the controller for detecting conflicts or potential collisions between aircraft [SR-13]</p> <p>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]</p> <p>Controller has to detect conflicts and potential collisions as in current operations [SR-26]</p>	<p>Surveillance data</p> <p>Visualisation system</p> <p>ATCo</p>
SO-008	<p>When available, surveillance data is to be provided to the controller for ensuring separation with restricted areas [SR-13]</p>	<p>Surveillance data</p>

SO	Requirement (forward reference)	Maps on to
	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 detect potential conflicts with restricted areas as in current operations [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 as in current operations [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 as in current operations [SR-26]	ATCo
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 as in current operations [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

SO	Requirement <i>(forward reference)</i>	Maps on to
	<p>Controller has to be able to communicate to the personnel in the airport the start-up procedures [SR-09]</p> <p>Local meteorological information shall be available to the controller in order to support start-up procedures [SR-25]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to provide start-up instructions as in current operations [SR-26]</p>	<p>Surf-G COMM (Airport personnel)</p> <p>Local MET system</p> <p>A-G Comm</p> <p>ATCo</p>
SO-013	<p>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]</p> <p>Controller has to be able to communicate to the personnel in the airport the push-back/towing procedures [SR-09]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to provide push-back/towing instructions as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>Surf-G COMM (Airport personnel)</p> <p>A-G Comm</p> <p>ATCo</p>
SO-014	<p>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]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to provide routing instructions to aircraft on the manoeuvring area as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>A-G Comm</p> <p>ATCo</p>
SO-015	<p>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 [SR-16]</p> <p>Controller has to be able to communicate routing instructions to the vehicles in the manoeuvring area [SR-08]</p> <p>Controller has to provide routing instructions to vehicles on the manoeuvring area as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>Surf-G COMM (Vehicles)</p> <p>ATCo</p>
SO-016	<p>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]</p> <p>Controller has to detect hazardous situations on the manoeuvring area (involving aircraft, vehicles and obstacles) as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>ATCo</p>
SO-017	<p>Visual information on the manoeuvring area and the traffic/vehicles/obstacles on it is to be provided to the controller in</p>	<p>Visualisation system</p>

SO	Requirement (<i>forward reference</i>)	Maps on to
	<p>order to provide instructions to solve hazardous situations aircraft [SR-16]</p> <p>Controller has to be able to communicate instructions to solve a hazardous situation to the vehicles on the manoeuvring area [SR-08]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to provide taxiing instruction in order to solve hazardous situations on the manoeuvring area as in current operations [SR-26]</p>	<p>Surf-G COMM (Vehicles)</p> <p>A-G Comm</p> <p>ATCo</p>
SO-018	<p>Controller has to be able to manoeuvring visual navigation aids in order to support AC and vehicle movements on the manoeuvring area [SR-21]</p> <p>Controller has to use visual navigation aids to support AC and vehicle movements on the manoeuvring area as in current operations [SR-26]</p>	<p>Visual Navigation Aids system</p> <p>ATCo</p>
SO-019	<p>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-17]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to check runway occupancy before providing line-up clearance, managing runway entry as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>A-G Comm</p> <p>ATCo</p>
SO-020	<p>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-17]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to check taxiway occupancy before providing runway exit clearance, managing runway exit as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>A-G Comm</p> <p>ATCo</p>
SO-021	<p>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-17]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to be able to communicate instructions on runway crossing to the vehicles on the manoeuvring area [SR-08]</p> <p>Controller has to check runway occupancy before providing runway crossing clearance, managing runway crossing as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>A-G Comm</p> <p>Surf-G COMM (Vehicles)</p> <p>ATCo</p>

SO	Requirement (<i>forward reference</i>)	Maps on to
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 as in current operations [SR-26]	ATCo
SO-023	Controller has to be able to communicate with vehicles operating on the runway or on the vicinity [SR-08]	Surf-G COMM (Vehicles)
	Controller has to use manage vehicle related operations on the runway as in current operations [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-17]	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 as in current 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-17]	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 as in current 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-17]	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 runway or on the vicinity [SR-08]	Surf-G COMM (Vehicles)
	Controller has to detect runway incursions (AC, vehicles, animals, persons) as in current operations [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-17]	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 be able to communicate with vehicles operating on the runway or on the vicinity [SR-08]	Surf-G COMM (Vehicles)
	Controller has to provide instructions to solve runway incursions (due to AC, vehicles, animals, persons) as in current operations [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 detect potential flight towards terrain situations as in current operations [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 as in current operations [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 to establish/maintain appropriate wake turbulence separation [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 apply appropriate wake turbulence separation between aircraft as in current operations [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	Local MET system

SO	Requirement (<i>forward reference</i>)	Maps on to
	<p>landing and taking-off operations [SR-23] [SR-24] [SR-25]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>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]</p> <p>Controller has to provide appropriate weather information to landing / taking off traffic as in current operations [SR-26]</p>	<p>A-G Comm</p> <p>ATCo</p> <p>ATCo</p>
SO-032	<p>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-17]</p> <p>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]</p> <p>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]</p> <p>Controller has to request to the corresponding airport personnel for runway inspections as necessary (under pilot request or when based on visual acquisition) as in current operations [SR-26]</p> <p>Controller has to provide relevant information to pilots on runway conditions as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>Visualisation system</p> <p>Surf-G COMM (Airport personnel)</p> <p>ATCo</p> <p>ATCo</p>
SO-033	<p>Visual information of the final approach area is to be provided to the controller in support landing operations [SR-17]</p> <p>Controller has to provide relevant information to pilots on runway conditions as in current operations [SR-26]</p>	<p>Visualisation system</p> <p>ATCo</p>
SO-034	<p>Controller has to be able to manoeuvring non-visual navigation aids in order to support AC on landing operations [SR-22]</p> <p>Controller has to use non-visual navigation aids to support AC on landing operations as in current operations [SR-26]</p>	<p>Non-Visual Navigation Aids system</p> <p>ATCo</p>
SO-035	<p>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-17]</p> <p>Controller has to be able to communicate with traffic to which ATC service is being provided [SR-07]</p> <p>Controller has to be able to communicate with vehicles operating on the runway or on the vicinity [SR-08]</p> <p>Controller has to detect potential intrusions inside landing aids</p>	<p>Visualisation system</p> <p>A-G Comm</p> <p>Surf-G COMM (Vehicles)</p> <p>ATCo</p>

SO	Requirement (<i>forward reference</i>)	Maps on to
	protections area (AC, vehicles, animals, persons) as in current operations [SR-26]	
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] 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-25] Controller has to be able to determine visibility and meteorological conditions in his area of responsibility (as for example low visual conditions) [SR-26]	Visualisation system Local MET system 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 as in current operations. Any additional information concerning RVT position is to be also transferred from one controller to the other [SR-27] Visual information mentioned in requirements Xs is to be provided in the several visibility conditions (CAVOK, darkness, ...) as in current operations [SR-20]	ATCo 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 Supervisor has to manage ATC resources (staffing) for a specific RVT position taking into account aerodrome capacities as in current operations [SR-34] Information on foreseen and real traffic, as well as real time airport capacity and conditions is to be provided to the supervisor in order to be able to manage ATC resources adequately for a specific RVT positions [SR-35]	RTC unit Supervisor 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

SO	Requirement (<i>forward reference</i>)	Maps on to
	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, as in current operations, 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
	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-17]	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-17]	Visualisation system
	Controller has to monitor, as in current operations, 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	A-G Comm

SO	Requirement (forward reference)	Maps on to
	<p>service is being provided [SR-07]</p> <p>Controller has to be able to communicate with adjacent ATSU units in case coordination is needed for solving an emergency situation [SR-06]</p> <p>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] [SR-17]</p> <p>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]</p> <p>When available, surveillance data is to be provided to the controller for supporting the controller on the emergency situation resolution [SR-13]</p> <p>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]</p> <p>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]</p> <p>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]</p> <p>Controller has to apply corresponding emergency procedures in order to support on the resolution of the situation [SR-26]</p> <p>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]</p>	<p>G-G Comm</p> <p>Visualisation system</p> <p>Visualisation system</p> <p>Surveillance data</p> <p>Surf-G COMM (Airport personnel)</p> <p>Signalling Lamps system</p> <p>Accident / incident / distress alarms system</p> <p>ATCo</p> <p>Airport personnel</p>
SO-047	<p>Controller has to be able to communicate with adjacent ATSU units in case coordination is needed for solving an emergency situation [SR-06]</p> <p>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] [SR-17]</p> <p>A specific binocular-like functions is to be available in order to have a more detailed view of the situation [SR-19]</p> <p>When available, surveillance data is to be provided to the controller for supporting the controller on the emergency situation</p>	<p>G-G Comm</p> <p>Visualisation system</p> <p>Visualisation system</p> <p>Surveillance data</p>

SO	Requirement (<i>forward reference</i>)	Maps on to
	<p>resolution [SR-13]</p> <p>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]</p> <p>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]</p> <p>Controller has to apply corresponding procedures for the management of a crash situation [SR-26]</p>	<p>Surf-G COMM (Airport personnel)</p> <p>Accident / incident / distress alarms system</p> <p>ATCo</p>
SO-048	<p>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]</p> <p>Communicate between remote controller and the relevant airport personnel has to be available [SR-12]</p>	<p>Airport personnel</p> <p>Surf-G COMM (Airport personnel)</p>
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
	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
0	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	ATCo

SO	Requirement (<i>forward reference</i>)	Maps on to
	to provide the service [SR-29]	

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

The following table lists the safety requirements derived from previous table. They are presented per SPR-model elements. A reference to the corresponding Safety objective(s) is also provided. In case an equivalent or similar requirement is already provided in the OSED [REF] the corresponding reference has also been provided.

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	Published arriving procedures shall be available to the controller in order to support arriving traffic	SO-002
SR-02	Published departing procedures shall be available to the controller in order to support departing traffic	SO-003
SR-03	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	Airspace users shall be informed about the (planned) provision of remote ATC services through AIP or NOTAMs (starting and ending times).	SO-041 SO-043
Flight Plan Data system		
SR-05 [FN02.5002]	Flight plan information related to relevant traffic shall to 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 [CM02.1002]	Aeronautical fixed service (ground-ground communications) with relevant adjacent units (in accordance with ICAO Annex 11, Chapter 6.2) is to be available to controller in a RVT position for ground-ground communications	SO-001 SO-046 SO-047
A-G COMM		
SR-07 [CM02.1001]	Aeronautical mobile service (air-ground communications) in the area of responsibility (in accordance with ICAO Annex 11, Chapter 6.1) is to be available to controller in a RVT position for providing instructions/clearances and for receiving pilots' responses/requests.	SO-002 SO-003 SO-004 SO-005 SO-009 SO-010 SO-011 SO-012 SO-013 SO-014 SO-017 SO-019

SR#	Safety Requirement	Derived from
		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 [CM02.1003]	Surface movement control service (communications for the control of vehicles other than aircraft on manoeuvring areas) at controlled aerodrome (in accordance with ICAO Annex 11 Chapter 6.3) shall be available to controller in a RVT position for providing instructions and clearances to vehicles and for receiving drivers responses/requests.	SO-015 SO-017 SO-021 SO-023 SO-026 SO-027 SO-035
Surf-G COMM (airport personnel/vehicles outside manoeuvring area)		
SR-09	Ground-ground communication with airport personnel operating on the apron should be available to controller in RVT position for supporting apron related operations	SO-012 SO-013
SR-10	Ground-ground communication with airport personnel in charge of runway inspections shall be available to controller in RVT position for the coordination of runway inspections in order to determine runway conditions and detect potential FODs/animals	SO-032
SR-11	Ground-ground communication with airport personnel in charge of local airport services shall be available to controller in RVT position to inform them when the remote provision of ATC service is to be initiated and terminated	SO-041 SO-043 SO-050 SO-052
SR-12	Ground-ground communication with airport personnel in charge of rescue service in the aerodrome shall be available to controller in RVT position to provide relevant information for solving all relevant emergency situations	SO-046 SO-047 SO-048
Surveillance data		
SR-13 [FN02.5001]	When providing APP and Tower control services, surveillance data shall be provided to the controller in RVT position for the provision of APP service	SO-001 SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028

SR#	Safety Requirement	Derived from
		SO-029 SO-046 SO-047
Visualisation system		
SR-14 [VS02.3001] [VG03.1001]	Visual information on the vicinity of the aerodrome and the traffic on this area shall be provided to the controller in RVT position in order to allow their identification and location for remotely providing ATC service	SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028 SO-029 SO-030 SO-044 SO-045 SO-046 SO-047
SR-15	Visual information on the apron and the traffic/vehicles/obstacles/personnel on this area should be provided to the controller in RVT position in order to allow their identification and location for supporting operations in that area	SO-011 SO-012 SO-013 SO-046 SO-047
SR-16 [VS02.3001] [VG03.1001] [VG03.1205]	Visual information on the manoeuvring area and the traffic/vehicles/obstacles/personnel on this area shall be provided to controller in RVT position in order to allow their identification and location for the remote provision of ATC service on the aerodrome surface	SO-014 SO-015 SO-016 SO-017 SO-045 SO-046 SO-047
SR-17 [VS02.3001] [VG03.1001]	Visual information on the take-off and landing area (including runways(s), final approach and initial climb areas) and the traffic/vehicles/obstacles/personnel on (or close to) it shall be provided to the controller in RVT position to allow their identification and location for remotely managing take-off and landing operations <u>Note:</u> that has to take into account specific traffic evolution for landing and taking off as it is the case for helicopters.	SO-019 SO-020 SO-021 SO-024 SO-025 SO-026 SO-027 SO-032 SO-033 SO-035 SO-045 SO-046 SO-047
SR-18	Visual information on the vicinity of the aerodrome and on 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	SO-032 SO-045 SO-046

SR#	Safety Requirement	Derived from
	position, giving the possibility to zoom/enlarge areas and objects in the visual presentation	SO-047
SR-20 [VC03.1104] [VQ03.1201] [VQ03.1202]	All visual information to be presented on the visualisation system, in the several visibility conditions (CAVOK, darkness, dawn, LVC, etc...), shall be provided (in terms of ability to identify and locate areas, aircraft, vehicles, obstacles, personnel and obstacles) as in current operations in the same visibility conditions.	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 in order to support AC and vehicle movements on the manoeuvring area for example and support take-off and landing operations	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 in order to support aircraft on landing operations and navigation on the area of responsibility	SO-034
Local MET system		
SR-23 [MT02-2001]	Meteorological information (as per ICAO PANS-ATM chapter 6.6 and Chapter 4.10) shall be available to the controller in a RVT position for supporting arriving traffic in case APP service is also provided	SO-002 SO-031
SR-24 [MT02-2001]	Meteorological information (as per ICAO PANS-ATM chapter 6.4 and Chapter 4.10) shall be available to the controller in RVT position for supporting departing traffic in case APP service is also provided	SO-003 SO-031
SR-25 [MT02-2001]	Local meteorological information (as per ICAO PANS-ATM chapter 7.4.1.2) shall be available to the controller in RVT for providing aerodrome tower control	SO-012 SO-031 SO-036
ATCo – ATC service provision		
SR-26	<p>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.</p> <p><u>Note:</u> This concerns procedures in terms of (mainly and as example):</p> <ul style="list-style-type: none"> * 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 	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

SR#	Safety Requirement	Derived from
	<ul style="list-style-type: none"> * 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-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-27	Handover procedures shall be applied in a RVT position as in current operations. Additional information concerning RVT equipment status shall also be transferred from one controller to the other during this procedure	SO-038
SR-28	<p>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 shall include the checking of the RVT capability for the provision of the service.</p> <p>Note: this procedure has to include at least the checking of the following elements:</p> <ul style="list-style-type: none"> - 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	Personnel in the airport shall be informed by the controller when the remote provision of ATC service is to be initiated and terminated	SO-041 SO-043 SO-050 SO-052
SR-30	Prior to a planned termination, controller shall to ensure that ATC services can be appropriately (safely) stopped.	SO-042
SR-31	Prior to an unplanned termination, controller shall to ensure that	SO-049

SR#	Safety Requirement	Derived from
	ATC services are appropriately (safely) stopped.	
SR-32	Controller shall to 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	The aerodrome capacity shall 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 controlled from a RVT position is not exceeding those limits <u>Note:</u> that this aerodrome capacity is not only to be defined based on the aerodrome characteristics but also taking into account the fact that ATC service is remotely provided.	SO-039
Supervisor		
SR-34	Supervisor in a RTC shall manage ATC resources (staffing) for a specific RVT position taking into account aerodrome capacities as it is done in current operations	SO-039
Local Network tools		
SR-35	Demand traffic information (foreseen and real one), as well as real time airport capacity and conditions shall be provided to the RTC supervisor in order to be able to manage ATC resources adequately for a specific RVT position	SO-039
Services at the airport		
SR-36	In case MET information is not directly/automatically provided to the corresponding RVT position in the RTC, specific aerodrome personnel (local MET service) shall collect and provide this information to the corresponding RTC/RVT position.	SO-002 SO-003 SO-012 SO-031 SO-036
Signalling Lamps system		
SR-37	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	Accident / incident / distress alarms shall be available to controller in RVT position in order to launch relevant emergency procedures	SO-046 SO-047
Airport services / relevant personnel		
SR-39	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
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Other ATS units
AO-13. Other ATC units adjacent to the RTC (including military) operates and provide the relevant ATS service as per PANS ATM [9] as in current operations
Services at the airport
AO-14. Services at the airport concerning apron operations, runway inspections, technical support, etc., are provided as in current operations.
Equipment at the airport
AO-15. Relevant Visual and Non visual navigation aids are available in the airport premises as in current operations

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:

- Trial 1: shadow passive mode trial on ATC tower and APP services
- Trail 2: shadow passive mode trial on ATC tower and APP services, for basic and advances RVT position
- Trial 3: shadow passive and active mode trial on AFIS services

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 trial 2 are presented in Appendix F. The complete set of results from the 3 trials mentioned above is provided in the Validation Report [REF].

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	Coordination 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)

SR#	Safety Requirement
SR-41	Control shall be transferred from local TWR before initiating remote provision of ATC from RVT

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 shown 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	OH-03

	provided to the controller [1e-3/fh]	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-4/fh]	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 [1e-4/mov]	OH-22
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	The likelihood of inappropriate flight data information being provided by the Flight Data Processing system in a RVT position	FDPS-001

SR#	Safety Requirement	Derived from
	shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	
AI data system		
SR-43	The likelihood of incorrect or missing arriving/departing procedures publications available to the controller in a RVT position shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 2 times per month	AID-002
SR-44	The likelihood of incorrect or missing information concerning restricted areas in a RVT position shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	AID-001
G-G Comm		
SR-45	The likelihood of failure or degradation of ground-ground communication with adjacent ATSU units in a RVT position shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	G-GCOM-001
SR-46	An alert shall be provided to the controller in case of failure of the ground-ground communication service.	G-GCOM-001
Surf-G Comm		
SR-47	The likelihood of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area (including those operating in the runway, for example for inspections), in a RVT position, shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times per year	S-GCOM-001 S-GCOM-002 S-GCOM-003
SR-48	An alert shall be provided to the controller in case of failure of the ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area (including those operating in the runway, for example for inspections).	S-GCOM-001 S-GCOM-002 S-GCOM-003
Surveillance data		
SR-49	In case surveillance data is available in the RVT position, the likelihood that undetected inappropriate surveillance information on a flight is provided shall be no more than in current operations. <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	SURV-001
SR-50	In case surveillance data is available in the RVT position, the likelihood that undetected inappropriate surveillance information on restricted areas is provided shall be no more than in current	SURV-002

SR#	Safety Requirement	Derived from
	operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	
SR-51	In case surveillance data is available in the RVT position, the likelihood of complete lack of traffic information shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	SURV-003
Visualisation System		
SR-52	The Visualisation System software processes shall comply with SWAL 2 for the critical aerodrome view parts. Note: critical view refers to parts of the visualisation system providing visual information on the following areas of the aerodrome: <ul style="list-style-type: none">- manoeuvring area- runway area- initial climbing and final approach areas	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
SR-53	The likelihood of lost of a critical aerodrome view on the visualisation system for more than 30 seconds shall be no more than 7e-4 per operational hour. Note: critical view refers to parts of the visualisation system providing visual information on the following areas of the aerodrome: <ul style="list-style-type: none">- manoeuvring area- runway area- initial climbing and final approach areas	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
SR-54	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	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	The likelihood of failure or degradation of air-ground communication with traffic in a RVT position shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in	A-GCOM-001

SR#	Safety Requirement	Derived from
	section 3.4.1 would be no more than 5 times every 2 years	
SR-57	An alert shall be provided to the controller in case of failure of the air-ground communication system.	A-GCOM-001
Local MET system		
SR-58	The likelihood of incorrect MET/Weather information provided in a RVT position shall be no more than in current operations <u>Note</u> : an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 time every 2 years	MET-001
Visual Navigation Aids system		
SR-59	The likelihood of loss or dysfunction of Visual Navigation Aids manoeuvred from a RVT position shall be no more than 5 times per year.	VNAM-001
Non-Visual Navigation Aids system		
SR-60	The likelihood of loss or dysfunction of Non Visual Navigation Aids manoeuvred from a RVT position shall be no more than 5 times per year.	NVNAM-001
ATCo		
SR-61	In case of loss or degradation of ground-ground communication with adjacent ATSU units in a RVT position current relevant procedures shall be applied as today	G-GCOM-001 SO-051
SR-62	In case of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area (including those operating in the runway, for example for inspections), relevant current procedures shall be applied as today.	S-GCOM-001 S-GCOM-002 S-GCOM-003
SR-63	In case surveillance function is available in the RVT position, but the function is lost or the information provided is inappropriate and detected, relevant current procedures shall be applied as today	SURV-001 SURV-002 SURV-003
SR-64	In case of loss of information or detected inappropriate information on a critical view of the visualisation system for more than 30 seconds, a specific procedure shall be applied for the provision of ATC services limiting the simultaneous operations in the area of responsibility. <u>Note</u> : a procedure of this type (called One Movement Mode) is proposed in D03 – Appendix C [14].	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
SR-65	In case of loss of information or detected inappropriate information on several critical views of the visualisation system for more than 30 seconds the ATC service has to be safely stopped (unplanned termination).	VRS-003 VRS-001 VRS-007 VRS-009 VRS-008 VRS-010 VRS-012
SR-66	In case of failure or degradation or air-ground communication with traffic in a RVT position, relevant procedures from PANS	A-GCOM-001

SR#	Safety Requirement	Derived from
	ATM [9] shall be applied as in current operations	
SR-67	In case of incorrect MET/Weather information is provided in a RVT position, or not information at all is provided, controller has to contact relevant airport personnel in the airport in order to obtain this information and any relevant update. <u>Note:</u> such a procedure is proposed in D03 Appendix C [14].	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 performed 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 L002).

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 L003 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 Validation Report [15].

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, as in current operations, 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
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SO-053. ATC service provision shall appropriately be stopped in case of inadequate capability of the RVT system elements to provide the service Note: inappropriate capability if 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 21: Consolidated list of Functionality Safety Objectives

A.2 Safety Objectives (Integrity)

Description
SO-101 The likelihood that Remote ATC incorrectly coordinates with other ATSUs 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 into 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).

B.1 Safety Requirements (Functionality and Performance)

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	AI data system					
SR-01	Published arriving procedures shall be available to the controller in order to support arriving traffic	This information is required, as in current operations, to provide ATC services.	Trials 1, 2, 3	Closed	V3: define in detail the physical support and the way to provide this information to the controller	SO-002
SR-02	Published departing procedures shall be available to the controller in order to support departing traffic	This information is required, as in current operations, to provide ATC services.	Trials 1, 2, 3	Closed	V3: define in detail the physical support and the way to provide this information to the controller	SO-003
SR-03	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, as in current operations, 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	V3: To investigate if the same procedures as in current operations can be applied to obtain this type of information and if not specify the way to provide this information to the controller	SO-005 SO-008
SR-04	Airspace users shall be informed about the (planned) provision of	Airspace user, as in current operations, need	Trial 3 in particular where the airspace user was involved	Open	V2: assess the several means for informing the	SO-041 SO-043

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	remote ATC services though AIP or NOTAMs (starting and ending times).	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.	in the validation exercise. But this need to be investigated further, in particular to determine if information on the NOTAMs, AIP is enough or specific information has to be provided to the aircraft by radio in the first contact too.		airspace users V3: To investigate if specific phraseology has to be defined when the services are remotely provided, for the first radio contact but also potentially for the other communications with the aircraft (<i>common outcome from SAF and HP assessment</i>)	
	Flight Plan data system					
SR-05	Flight plan information related to relevant traffic shall to be provided to the controller in RVT position for providing ATC services	This information is required, as in current operations, to provide ATC services.	Trials 1, 2, 3	Closed	V3: define in detail the technical support and the way to provide this information to the controller	SO-001 SO-002 SO-003 SO-011 SO-030
	Ground-ground communication					
SR-06	Aeronautical fixed service (ground-ground communications) with relevant adjacent units (in accordance with ICAO Annex 11, Chapter 6.2) is to be available to controller in a RVT position for ground-ground communications	This information is required, as in current operations, to provide ATC services.	Trials 3 in particular as it was an active mode exercise in which AFISO interacted with adjacent sector for the provision of the AFIS service	Closed	V3: define in detail the technical support and the way to provide this information to the controller	SO-001 SO-046 SO-047
	A-G COMM					

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
SR-07	Aeronautical mobile service (air-ground communications) in the area of responsibility (in accordance with ICAO Annex 11, Chapter 6.1) is to be available to controller in a RVT position for providing instructions/clearances and for receiving pilots' responses/requests.	This service is required, as in current operations, to provide ATC services.	Trials 3 in particular as it was an active mode exercise in which AFISO interacted with pilots providing instructions and information.	Closed	V3: define in detail the technical support and the way to make this service available. V3: Assess the impact of RT on communication load (<i>outcome from HP assessment</i>)	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 manoeuvring area) inside					
SR-08	Surface movement control service (communications for the control of vehicles other than aircraft on manoeuvring areas) at controlled	This service is required, as in current operations, to provide ATC services.	Trials 1, 2, 3 There were some technical problems in some of these	Closed	V3: define in detail the technical support and the way to make this	SO-015 SO-017 SO-021 SO-023

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	aerodrome (in accordance with ICAO Annex 11 Chapter 6.3) shall be available to controller in a RVT position for providing instructions and clearances to vehicles and for receiving driver's responses / requests.		exercices but enough evidence for closing V2 requirement was collected.		service available.	SO-026 SO-027 SO-035
	Surf-G COMM (airport personnel/vehicles outside manoeuvring area)					
SR-09	Ground-ground communication with airport personnel operating on the apron should be available to controller in RVT position for supporting apron related operations	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.	Trials 3 in particular as it was an active mode exercise in which AFISO interacted personel operating in the apron.	Closed	V3: define in detail the technical support and the way to make this service available in case the recommendation is retained.	SO-012 SO-013
SR-10	Ground-ground communication with airport personnel in charge of runway inspections shall be available to controller in RVT position for the coordination of runway inspections in order to determine runway conditions and detect potential FODs/animals	This service is required, as in current operations, to provide ATC services.	Trials 1 and 2	Closed	V3: define in detail the technical support and the way to make this service available.	SO-032

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
SR-11	Ground-ground communication with airport personnel in charge of local airport services shall be available to controller in RVT position to inform them when the remote provision of ATC service is to be initiated and terminated	This service is required, as in current operations, to provide ATC services	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	Ground-ground communication with airport personnel in charge of rescue service in the aerodrome shall be available to controller in RVT position to provide relevant information for solving all relevant emergency situations	This service is required, as in current operations, to provide ATC services.	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. <i>(common outcome from SAF and HP assessment)</i> Potentially investigate the feasibility of an intercom system or webcam between ground staff at airport and staff working in remote tower <i>(outcome from HP assessment)</i>	SO-046 SO-047 SO-048
	Surveillance data					
SR-13	When providing APP and Tower control services, surveillance data shall be provided to the controller in RVT position for the provision of	This service is required, as in current operations, to provide ATC services. <i>This requirement is also</i>	Trials 1, 2, 3	Closed	V3: define in detail the technical support and the way to provide this information to the	SO-001 SO-002 SO-003 SO-004

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	APP service	<i>an output from the HP assessment.</i>			controller Potentially, investigate the feasibility and benefits of establishing a link between PTZ and the Air Situation Display (<i>outcome from HP assessment</i>).	SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028 SO-029 SO-046 SO-047
	Visualisation system					
SR-14	Visual information on the vicinity of the aerodrome and the traffic on this area shall be provided to the controller in RVT position in order to allow their identification and location for remotely providing ATC service	This service is required, as in current operations, to provide ATC services. <i>This requirement is also an output from the HP assessment.</i>	Trials 1, 2, 3 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 separation between traffic, and to identify aircraft on the vicinity of the aerodrome).	Open	V2: to evaluate more in detail the quality of the video reproduction in order to ensure that relevant objects can be better detected and continuously monitored (<i>common outcome from SAF and HP assessment</i>). V3: Specify the technical characteristics 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. V2: assess more in	SO-002 SO-003 SO-004 SO-005 SO-006 SO-007 SO-008 SO-009 SO-010 SO-028 SO-029 SO-030 SO-044 SO-045 SO-046 SO-047

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
					detail the video tracking function <i>(common outcome from SAF and HP assessment)</i> .	
SR-15	Visual information on the apron and the traffic / vehicles / obstacles / personnel on this area should be provided to the controller in RVT position in order to allow their identification and location for supporting operations in that 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.	Trials 1, 2, 3	Closed	V3: assess the need of having a dedicated fixed view of specific areas of the apron of a global view potentially improved with the PTZ camera.	SO-011 SO-012 SO-013 SO-046 SO-047
SR-16	Visual information on the manoeuvring area and the traffic/vehicles/obstacles/personnel on this area shall be provided to controller in RVT position in order to allow their identification and location for the remote provision of ATC service on the aerodrome surface	This service is required, as in current operations, to provide ATC services. <i>This requirement is also an output from the HP assessment.</i>	Trials 1, 2, 3	Closed	V3: Specify the technical characteristics 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 V3: assess more in detail the video tracking function <i>(common outcome from SAF and HP assessment)</i> . V3: assess more in detail the need for fixed cameras providing views	SO-014 SO-015 SO-016 SO-017 SO-045 SO-046 SO-047

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
					of specific areas of the aerodrome, and the way to present this information to the controller.	
SR-17	<p>Visual information on the take-off and landing area (including runways(s), final approach and initial climb areas) and the traffic/vehicles/obstacles/personnel on (or close to) it shall be provided to the controller in RVT position to allow their identification and location for remotely managing take-off and landing operations</p> <p><u>Note:</u> that has to take into account specific traffic evolution for landing and taking as it is the case for helicopters.</p>	<p>This service is required, as in current operations, to provide ATC services.</p> <p><i>This requirement is also an output from the HP assessment.</i></p>	Trials 1, 2, 3	Closed	<p>V3: to evaluate more in detail the quality of the video reproduction in order to ensure that relevant objects can be better detected and continuously monitored.</p> <p>V3: Specify the technical characteristics 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.</p> <p>V3: assess more in detail the video tracking function (<i>common outcome from SAF and HP assessment</i>).</p>	<p>SO-019</p> <p>SO-020</p> <p>SO-021</p> <p>SO-024</p> <p>SO-025</p> <p>SO-026</p> <p>SO-027</p> <p>SO-032</p> <p>SO-033</p> <p>SO-035</p> <p>SO-045</p> <p>SO-046</p> <p>SO-047</p>
SR-18	<p>Visual information on the vicinity of the aerodrome and on the aerodrome surface allowing to be aware of the local weather conditions (including visibility conditions) shall be provided to the</p>	<p>This service is required, as in current operations, to provide ATC services.</p> <p><i>This requirement is also an output from the HP</i></p>	Trials 1, 2, 3	Closed	<p>V3: Further assess the potential used of PTZ or additional fixed cameras to support the controller on this task (for example providing the image of</p>	<p>SO-031</p> <p>SO-036</p>

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	controller in RVT position	<i>assessment.</i>			specific areas or elements on the aerodrome as the windsocks) (<i>common outcome from SAF and HP assessment</i>). V3: evaluate the training for the remote controllers on those aspects as they will not be located in the place they will provide the ATC service.	
SR-19	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	This functionality is required as in current operations. <i>This requirement is also an output from the HP assessment.</i>	Trial 1, 2, 3 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	V3: define in detail the physical implementation and the way to provide this information to the controller as well as the image quality and its usability V3: assess in more detail the possibility of adding some predefined views in the binocular-like function in order to facilitate its use (or alternatively to provide the controller with some specific additional fixed cameras views) <i>Some additional items to be further assessed with respect to the binocular-like function have been</i>	SO-032 SO-045 SO-046 SO-047

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
					<i>identified in the HP assessment report.</i>	
SR-20	All visual information to be presented on the visualisation system, in the several visibility conditions (CAVOK, darkness, dawn, LVC, etc...), shall be provided (in terms of ability to identify and locate areas, aircraft, vehicles, obstacles, personnel and obstacles) as in current operations in the same visibility conditions.	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.	<p>Several weather and visibility conditions have been experienced during the several trials.</p> <p>But as only passive shadow mode was done for the ATC related exercises not enough evidence have been collected on the capability of the controller to adapt the ATC service to be provided with respect to the information he / he is provided with by the visualisation system.</p> <p><i>The outcome from the HP assessment on that item also requires a further assessment to collect more evidences.</i></p>	Open	<p>V2: further assessment of the quality of the image provided is needed, in particular in darkness and down conditions (<i>common outcome from SAF and HP assessments</i>).</p> <p>V2: assess the capability of the controller to adapt the provision of ATC services with respect to the weather and visibility conditions information provided on the visualisation system.</p> <p>V2: 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.</p> <p>V2: further assess the potential need of advanced visual features to support the controller</p>	SO-038

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
					<p>in appropriately provide the ATC service with respect to the real visual conditions on the airport (e.g.infra-red).</p> <p><i>Some additional items to be further assessed with respect to the quality of the image provided on the visualisation reproduction and on potential enhanced visual features have been identified in the HP assessment report:</i></p> <ul style="list-style-type: none"> - automatic contrast control to be implemented. - ensure that joint seam of the visual reproduction screens are not located at hot spot places <p><i>Additional recommendations are listed in the HP assessment with respect to the visualisation system.</i></p>	
	Visual Navigation aids system					
SR-21	Visual navigation aids on the concerned aerodrome (runway)	This is also done in current operations.	Trial 1, 2, 3	Closed	V3: define in detail the technical support and	SO-018

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	and field lighting system as applicable) shall be manageable and adjustable by controller in RVT 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.	In particular for trial 3 as it was an active mode trial.		the way to provide this information / allow this functionality to the controller	SO-022
	Non-Visual Navigation aids system					
SR-22	Non-visual navigation aids on the concerned aerodrome (as applicable) shall be manageable and adjustable by controller in RVT position in order to support aircraft on landing operations and navigation on the area of responsibility	This is also done in current operations. What needs to be ensured is that can remotely be done.	Trial 1, 2, 3 In particular for trial 3 as it was an active mode trial.	Closed	V3: define in detail the technical support and the way to provide this information / allow this functionality to the controller	SO-034
	Local MET system					
SR-23	Meteorological information (as per ICAO PANS-ATM chapter 6.6 and Chapter 4.10) shall be available to the controller in a RVT position for supporting arriving traffic in case APP service is also provided	This information is required, as in current operations, to provide ATC services. <i>This requirement is also an outcome from the HP assessment.</i>	Trial 1, 2, 3	Closed	V3: define in detail the physical support and the way to provide this information to the controller	SO-002 SO-031
SR-24	Meteorological information (as per ICAO PANS-ATM chapter 6.4 and Chapter 4.10) shall be available to the controller in RVT position for supporting departing traffic in case	This information is required, as in current operations, to provide ATC services.	Trial 1, 2, 3	Closed	V3: define in detail the physical support and the way to provide this information to the	SO-003 SO-031

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	APP service is also provided	<i>This requirement is also an outcome from the HP assessment.</i>			controller	
SR-25	Local meteorological information (as per ICAO PANS-ATM chapter 7.4.1.2) shall be available to the controller in RVT for providing aerodrome tower control	<p>This information is required, as in current operations, to provide ATC services.</p> <p><i>This requirement is also an outcome from the HP assessment.</i></p>	Trial 1, 2, 3	Closed	<p>V3: define in detail the physical support and the way to provide this information to the controller</p> <p>V2: in case part of the local meteorological information is to be collected by personnel in the aerodrome, specific procedures are to be defined (see requirement SR-39).</p>	SO-012 SO-031 SO-036
	ATCo – ATC service provision					
SR-26	<p>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.</p> <p><u>Note:</u> This concerns procedures in terms of (mainly and as example):</p> <ul style="list-style-type: none"> * Coordination and transfer for inbound and outbound traffic * Coordination with military and other units concerning restricted areas 	<p>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 providing Tower or Tower + APP controller services.</p> <p>Any additional procedures related to the fact that the ATC service is provided from a Remote location have</p>	<p>As validation exercises where done in passive shadow mode for the ATC services, not enough evidence have been collected with respect to this requirement.</p> <p>Evidence collected for the moment show that the capability of performing the following tasks from a Remote Tower is lower than in current operations :</p> <ul style="list-style-type: none"> * aircraft identification 	Open	<p>Items to be further evaluated in V2:</p> <ul style="list-style-type: none"> - Further evaluate the different enhanced visual features for improving the capability of identifying aircraft. - Further assess the capability of evaluation distances / judge separation for the provision of reduced separation (and the potential need for 	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

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	<ul style="list-style-type: none"> * 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 	<p>been captured in separated requirements (see below).</p>	<p>* ensuring appropriate separation between traffic (in particular concerning the application of reduced separation).</p> <p><i>HP assessment output on the application of reduced separation:</i></p> <p><i>Reduced visual separation must not be applied in current systems investigated [...].</i></p> <p>For some other ATC tasks any evidence was collected as they were not addressed during the trials (for example ensuring appropriate separation with restricted areas or managing emergency situations).</p> <p>See more detail on the validation results in Appendix F, trial 2.</p> <p><i>The HP assessment also request more assessment on that item as the collected evidences are not considered enough.</i></p>		<p>enhanced visual features or for changing procedures).</p> <p>- Evaluate the capability of the ATCo to perform ATC related tasks in a timely manner (active mode validation exercise).</p> <p>- Assess capability of ATC provision under abnormal and degraded modes of operations.</p> <p>Initial results on these items as well as some other items are included in the validation results report in Appendix F, trial 2.</p> <p><i>Some additional items related to further validation activities for this safety requirement have also been identified in the HP assessment report. Some of them are:</i></p> <ul style="list-style-type: none"> - assess whether controller can perform ATC tasks in normal, abnormal and degraded modes. - workload assessment 	<p>SO-016</p> <p>SO-017</p> <p>SO-018</p> <p>SO-019</p> <p>SO-020</p> <p>SO-021</p> <p>SO-022</p> <p>SO-023</p> <p>SO-024</p> <p>SO-025</p> <p>SO-026</p> <p>SO-027</p> <p>SO-028</p> <p>SO-029</p> <p>SO-030</p> <p>SO-031</p> <p>SO-032</p> <p>SO-033</p> <p>SO-034</p> <p>SO-035</p> <p>SO-036</p> <p>SO-037</p> <p>SO-044</p> <p>SO-045</p> <p>SO-046</p> <p>SO-047</p>

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	<p>landing operations</p> <ul style="list-style-type: none"> * 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 				- assess the impact on of the position of the cameras to assess the distance between objects.	
SR-27	Handover procedures shall be applied in a RVT position as in current operations. 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 equipment in the RVT.	Not addressed during the trials	Open	V2: to define the type of information concerning the RVT equipment (in particular Visualisation System) to be included in the handover procedures.	SO-038
SR-28	<p>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 shall include the checking of the RVT capability for the provision of the service.</p> <p>Note: this procedure has to include at least the checking of the following elements:</p> <ul style="list-style-type: none"> - MET system 		<p>Trial 3.</p> <p>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.</p> <p>Nevertheless, a more formalised procedure need to be defined in particular when ATC services are provided from the RVT</p>	Open	V2: define the system checking that need to be done, how often and by who it needs to be done.	SO-040

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	<ul style="list-style-type: none"> - 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 		position.			
SR-29	Personnel in the airport shall be informed by the controller when the remote provision of ATC service is to be initiated and terminated	This is done in current operations.	Trial 3. But not tested for ATC services	Open	V2: To clearly assess who needs to be contacted and the way to do so. Ensure that the communication is available when necessary.	SO-041 SO-043 SO-050 SO-052
SR-30	Prior to a planned termination, controller shall to ensure that ATC services can be appropriately (safely) stopped.	This is done in current operations.	Trial 3. But not tested for ATC services	Open	V2: specific procedures are to be defined.	SO-042
SR-31	Prior to an unplanned termination, controller shall to ensure that ATC services are appropriately (safely) stopped.	This is done in current operations.	Not addressed during the trials	Open	V2: specific procedures are to be defined for this situations	SO-049
SR-32	Controller shall to 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	V2: specific procedures are to be defined for this situations	SO-050 SO-052
	RTC level					

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
SR-33	<p>The aerodrome capacity shall 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 controlled from a RVT position is not exceeding those limits</p> <p><u>Note:</u> that this aerodrome capacity is not only to be defined based on the aerodrome characteristics but also taking into account the fact that ATC service is remotely provided.</p>	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	V2: to asses whether the capacity of the aerodrome is impacted by the fact that ATC services are remotely provided.	SO-039
	Supervisor					
SR-34	Supervisor in a RTC shall manage ATC resources (staffing) for a specific RVT position taking into account aerodrome capacities as it is done in current operations	<p>This task is done in current operations.</p> <p>Note that this requirement will be significantly important for the Multiple Remote Tower.</p>	Not addressed during the trials	Closed	<p>V3: define in detail the technical support, the information needed and the way to performe this task.</p> <p><i>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.</i></p>	SO-039

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	Local Network tools					
SR-35	Demand traffic information (foreseen and real one), as well as real time airport capacity and conditions shall be provided to the RTC supervisor in order to be able to manage ATC resources adequately for a specific RVT position	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	V2: to asses whether the capacity of the aerodrome is impacted by the fact that ATC services are remotely provided.	SO-039
	Services at the airport					
SR-36	In case MET information is not directly/automatically provided to the corresponding RVT position in the RTC, specific aerodrome personnel (local MET service) shall collect and provide this information to the corresponding RTC/RVT position.	This is related to safety requirement SR-25. <i>This requirement is also an outcome from the HP assessment.</i>	Not addressed during the trials	Open	V2: define the type of information to be collected, and the way to provide this information to the remote controller.	SO-002 SO-003 SO-012 SO-031 SO-036
	Signalling Lamps system					
SR-37	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 tested during the trial 3 but not satisfactory results where obtained (due to technical issues). See Validation Report [15]	Open	V2: functionality and capability of communicating with the aircraft using signalling lamps need to be tested	SO-046

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
			section §6.3.2.3.2			
	Accident / incident / distress alarms system					
SR-38	Accident / incident / distress alarms shall be available to controller in RVT position in order to launch relevant emergency procedures	This kind of procedures are already needed and applied 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	V2: 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	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 applied 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	V3: specific procedures related to situations or conditions on the aerodrome that might affect the safe provision of ATC service from a remote tower has to be defined and the capability to apply them need to be tested.	SO-046 SO-048

B.2 Safety Requirements (Integrity)

Only normal conditions were experienced during the trials. No direct evidence from these validation exercises has then been collected with respect to the safety requirements on degraded and failure modes.

Some feed back on procedures to be applied in case of system failure, in particular for the Visualisation System, has been collected during Trial 2 based on operational expert judgement. The detail of this feed back is included in the Rules and Regulations Assessment report [14] and in the Validation Report [15].

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	Flight Data Processing System					
SR-42	<p>The likelihood of inappropriate flight data information being provided by the Flight Data Processing system in a RVT position shall be no more than in current operations</p> <p><u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years</p>	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-101 SO-103 SO-104 SO-112 SO-113 SO-130
	AI data system					
SR-43	<p>The likelihood of incorrect or missing arriving/departing procedures publications available to the controller in a RVT position shall be no more than in current operations</p> <p><u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 2 times per month</p>	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-103 SO-104
SR-44	<p>The likelihood of incorrect or missing information concerning restricted areas in a RVT position shall be no more than in current operations</p> <p><u>Note:</u> an average value derived from the risk analysis done in</p>	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-105 SO-109 SO-111

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	section 3.4.1 would be no more than 5 times every 2 years					
	G-G Comm					
SR-45	The likelihood of failure or degradation of ground-ground communication with adjacent ATSU units in a RVT position shall be no more than in current operations <u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-101
SR-46	An alert shall be provided to the controller in case of failure of the ground-ground communication service.	Mitigation mean identified from the hazard assessment. <i>This requirement is also an outcome from the HP assessment.</i>	Analytical assessment based on expert judgement and project reviews. Not tested during simulations	Open	V2: 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	The likelihood of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area (including those operating in the runway, for example for inspections), in a RVT	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-113 SO-115 SO-117 SO-120 SO-121 SO-123 SO-127 SO-132

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	position, shall be no more than in current operations <u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times per year					SO-134
SR-48	An alert shall be provided to the controller in case of failure of the ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area (including those operating in the runway, for example for inspections).	Mitigation mean identified from the hazard assessment. <i>This requirement is also an outcome from the HP assessment.</i>	Analytical assessment based on expert judgement and project reviews. Not tested during simulations	Open	V2: to test the efficiency of the alert during trials together with the corresponding procedure to be applied by the controller.	SO-113 SO-115 SO-117 SO-120 SO-121 SO-123 SO-127 SO-132 SO-134
	Surveillance data					
SR-49	In case surveillance data is available in the RVT position, the likelihood that undetected inappropriate surveillance information on a flight is provided shall be no more than in current operations. <u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	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

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
SR-50	In case surveillance data is available in the RVT position, the likelihood that undetected inappropriate surveillance information on restricted areas is provided shall be no more than in current operations <u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-106
SR-51	In case surveillance data is available in the RVT position, the likelihood of complete lack of traffic information shall be no more than in current operations <u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-109 SO-128 SO-129
	Visualisation System					
SR-52	The Visualisation System software processes shall comply with SWAL 2 for the critical aerodrome view parts. <u>Note:</u> critical view refers to parts of the visualisation system providing visual information on the following areas of the aerodrome: - manoeuvring area	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	V3: apply corresponding assurance activities in order to satisfy SWAL 2	SO-102 SO-103 SO-104 SO-105 SO-106 SO-107 SO-108 SO-109 SO-110 SO-111

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	<ul style="list-style-type: none"> - runway area - initial climbing and final approach areas 					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-53	<p>The likelihood of lost of a critical aerodrome view on the visualisation system for more than 30 seconds shall be no more than $7e-4$ per operational hour.</p> <p>Note: critical view refers to parts of the visualisation system providing visual information on the following areas of the aerodrome:</p> <ul style="list-style-type: none"> - manoeuvring area - runway area <p>initial climbing and final approach areas</p>	Integrity level fixed based on the associated risk in case of complete loss of the equipment.	Analytical assessment based on expert judgement and project reviews.	Closed	V3: to perform a detailed analytical assessment based on physical design	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

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
						SO-123 SO-124 SO-125 SO-126 SO-127 SO-128 SO-129 SO-130 SO-131 SO-132 SO-134
SR-54	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.	<p>Mitigation mean identified from the hazard assessment.</p> <p><i>This requirement is also an outcome from the HP assessment.</i></p>	<p>Analytical assessment based on expert judgement and project reviews.</p> <p>Not tested during simulations</p>	Open	V2: 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

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
						SO-130 SO-131 SO-132 SO-134
	Data recorder					
SR-55	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	V2: 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

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	A-G Comm					
SR-56	<p>The likelihood of failure or degradation of air-ground communication with traffic in a RVT position shall be no more than in current operations</p> <p><u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 times every 2 years</p>	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	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	An alert shall be provided to the controller in case of failure of the air-ground communication system.	<p>Mitigation mean identified from the hazard assessment.</p> <p><i>This requirement is also an outcome from the HP assessment.</i></p>	<p>Analytical assessment based on expert judgement and project reviews.</p> <p>Not tested during simulations</p>	Open	V2: 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	V2 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	The likelihood of incorrect MET/Weather information provided in a RVT position shall be no more than in current operations <u>Note:</u> an average value derived from the risk analysis done in section 3.4.1 would be no more than 5 time every 2 years	No higher performance is requested for existing systems	Analytical assessment based on expert judgement and project reviews.	Closed	V3: detailed analytical assessment based on physical design and/or provision of evidence from existing system used in current operations	SO-103 SO-104 SO-112 SO-131
	Visual Navigation Aids system					
SR-59	The likelihood of loss or dysfunction of Visual Navigation Aids manoeuvred from a RVT position shall be no more than 5 times per year.	Integrity level fixed based on the associated risk in case of complete loss of the equipment.	Analytical assessment based on expert judgement and project reviews.	Closed	V3: to perform a detailed analytical assessment based on physical design	SO-118 SO-122
	Non-Visual Navigation Aids system					
SR-60	The likelihood of loss or dysfunction of Non Visual	Integrity level fixed based on the associated	Analytical assessment based on expert judgement and	Closed	V3: to perform a detailed analytical assessment	SO-133

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	Navigation Aids manoeuvred from a RVT position shall be no more than 5 times per year.	risk in case of complete loss of the equipment.	project reviews.		based on physical design	
	ATCo					
SR-61	In case of loss or degradation of ground-ground communication with adjacent ATSU units in a RVT position current relevant procedures shall be applied as today	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	V2: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-101
SR-62	In case of failure or degradation of ground-ground communication with personnel operating on the apron or vehicles/personnel operating on the manoeuvring area (including those operating in the runway, for example for inspections), relevant current procedures shall be applied as today.	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	V2: to test the efficiency of the corresponding procedure to be applied by the controller.	SO-113 SO-115 SO-117 SO-120 SO-121 SO-123 SO-127 SO-132 SO-134
SR-63	In case surveillance function is available in the RVT position, but the function is lost or the information provided is inappropriate and detected, relevant current procedures shall be applied as today	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	V2: 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

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
						SO-111 SO-128 SO-129 SO-130
SR-64	<p>In case of loss of information or detected inappropriate information on a critical view of the visualisation system for more than 30 seconds, a specific procedure shall be applied for the provision of ATC services limiting the simultaneous operations in the area of responsibility.</p> <p><u>Note:</u> a procedure of this type (called One Movement Mode) is proposed in D03 – Appendix C [14].</p>	Mitigation identified from the mean hazard assessment.	<p>Assessment based on expert judgement and project reviews.</p> <p>Not tested during simulations, only discussed with controllers</p>	Open	V2: 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 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-65	In case of loss of information or detected inappropriate information	Mitigation identified from the mean	Assessment based on expert judgement and project	Open	V2: to test the efficiency of the corresponding	SO-102 SO-103

REQ	Description	Additional Explanation	Validation Activity / Evidence	V2 Status	Next activities / recommendations	Satisfies
	on several critical views of the visualisation system for more than 30 seconds the ATC service has to be safely stopped (unplanned termination).	hazard assessment.	reviews. Not tested during simulations, only discussed with controllers		procedure to be applied by the controller.	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
SR-66	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 as in current operations	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	V2: 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	V2 Status	Next activities / recommendations	Satisfies
						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-67	<p>In case of incorrect MET/Weather information is provided in a RVT position, or not information at all is provided, controller has to contact relevant airport personnel in the airport in order to obtain this information and any relevant update.</p> <p><u>Note:</u> such a procedure is proposed in D03 Appendix C [14].</p>	Mitigation identified from the mean hazard assessment.	<p>Assessment based on expert judgement and project reviews.</p> <p>Not tested during simulations.</p>	Open	V2: 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	<p>This is unchanged with respect to current operations.</p> <p>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.</p> <p>Workshop with corresponding stakeholders is to be conducted in order to assess potential consequences of this issue as well as possible mitigations (<i>outcome from HP assessment</i>).</p>
AO-02	Flight Crew apply the same procedures as in current operations (as per PANS-OPS Doc 8168 [10])	
AO-03	FC 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 as in current operations	
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] as in current operations	
AO-14	Services at the airport concerning apron operations, runway inspections, technical support, etc., are provided as in current operations.	
AO-15	Relevant Visual and Non visual navigation aids are available in the airport premises as in current operations	

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, <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.	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]), 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 31st of January and the 1st 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 <ul style="list-style-type: none"> ▶ 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.) <ul style="list-style-type: none"> ▶ 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

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

	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 <ul style="list-style-type: none"> ▶ 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 the trial 3 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 completed 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-25

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-17 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-25 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-17 SR-18 SR-19 SR-20 SR-25 SR-36
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-17 SR-18 SR-19 SR-20 SR-22 SR-25 SR-36
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-17 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

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The complete set of results from all the trials is provided in the Validation Report [15].

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-17
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-17 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-17 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-17 SR-20 SR-07 SR-10 AO-02
4.	Instructs ground personnel (Using a communications link between the Remote Tower facility and the aerodrome) to immediately to go to the given position of the animal and		SR-10 SR-16 SR-19 SR-26

	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-17 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)			
<p>GC1 - The Remote TWR ATCO is located in a RTM, located away from the aerodrome and/or local Tower.</p> <p>GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual reproduction of the aerodrome view</p> <p>GC3 - The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.</p> <p>PreC1 - The VFR flight in the traffic circuit is conflicting with an arriving IFR flight;</p> <p>PreC2 - Airspace class C</p> <p>PreC3 - The ATCO doesn't have both aircraft in sight</p> <p>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.</p>			
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-17 SR-26

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

Condition (general, pre or post)			
<p>GC1 - The Remote TWR ATCO is located in a remote tower module, located away from the aerodrome and/or local Tower.</p> <p>GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual</p>			

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-17 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-17 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-17 SR-09 SR-20 SR-26 SR-07
9.	Clears the second departing aircraft (No.2 for departure) to line up on the runway.	Acknowledges clearance	SR-26 SR-07

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-17 SR-09 SR-20 SR-26 SR-07
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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-17 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-17 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-17 SR-18 SR-20 SR-26 AO-02
6.	Issues a taxi clearance via appropriate taxiway(s) to the allocated stand on apron.	Acknowledges the taxi clearance.	SR-07 SR-15 SR-16 SR-18 SR-20 SR-26

	Verifies that the aircraft has vacated the runway via the planned exit.	Executes the clearance and vacates runway.	
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-17 SR-18 SR-20 SR-26
8.	The visual reproduction will then be used to monitor and control both aircraft		SR-17 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)			
<p>GC1 - The Remote TWR ATCO is located in a remote tower module, located away from the aerodrome and/or local Tower.</p> <p>GC2 - The Remote TWR ATCO is situated at a RTM where they are presented with a visual reproduction of the aerodrome view.</p> <p>GC3 - The Remote TWR ATCO is providing ATS to a single Aerodrome/Airport.</p> <p>PreC1 - The local TWR ATCO is ready to hand over to the Remote TWR ATCO.</p> <p>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.</p>			
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: <ul style="list-style-type: none"> General information including deviations from normal procedures; Work in Progress on or close to 		SR-27 SR-28

	<p>manoeuvring area that could have an influence;</p> <ul style="list-style-type: none"> • 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 – range, centre settings, additional maps • Any other pertinent information. 		
5	<p>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.</p>		SR-27 SR-28
6	<p>The Remote TWR ATCO then requests control by using the supervisor telephone and initiating “Remote Provision of ATS”.</p> <p>The Remote TWR ATCO accepts and states “Remote facility takes control”.</p>	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 ATCO	TWR	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 if the landing gear seems to be down	AO-03 SR-07 SR-14 SR-18 SR-20 SR-19 SR-26
4.	Informs the Flight Crew that Gear seems to be down using a zoom view		Acknowledges response and decide to land	SR-07 SR-26 SR-19

	to focus on the aircraft.		
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-17 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 into 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
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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	Surf-G

	the manoeuvring area [1e-4/mov]	Comm
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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
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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	Visualisation

	provided on VRS [1e-4/mov]	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 occurrence 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	<p>Situations where either:</p> <ul style="list-style-type: none"> 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 an animal/person runway incursion 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
RInc-SC4	<p>An imminent runway incursion not mitigated by the ATC runway monitoring.</p> <p>Imminent runway incursion are due to:</p> <ul style="list-style-type: none"> unauthorized runway entry (ATC and non-ATC) failure to exit runway unauthorized Take-off or Landing animal/person approaching the runway 	Runway penetration without encounter (RP3)	1 e-4
RInc-SC5	<p>A situation where the runway use (ATC and non-ATC) does not respect procedures for:</p> <ul style="list-style-type: none"> 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 infringement (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 infringement (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)	1 e-5
	A situation where an aircraft has encountered a non-severe wake turbulence following a Separation Minima Infringement (SMI) with the leader aircraft	Turbulence affecting the aircraft handling and increasing the loss of separation risk with the leader aircraft (WE3F)	
	A situation with separation minima infringement (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 infringement (SMI)	Turbulence affecting slightly the aircraft handling (WE3S)	1 e-4
	A situation without separation minima infringement (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)	

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-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
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 compromised by ATC, pilot/driver or by a new obstacle (induced conflict).	Tactical Taxiway conflict generated (planned 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:

<i>Likelihood</i>	<i>Severity</i>			
	1	2	3	4
Very Probable	SWAL 1	SWAL 2	SWAL 3	SWAL 4
Possible	SWAL 2	SWAL 2	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 the Safety Assessment Methodology [] - PSSA Chapter 3 Guidance Material A.

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 2.

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

	<i>Severity</i>	<i>Likelihood (ops.h)</i>	<i>SWAL</i>
OH-08	MAC-SC2b	7,0E-03	2
OH-09	MAC-SC4a	7,0E-02	4

OH-28	CFIT-SC2b	7,0E-04	3
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Software Safety Requirement: **SWAL 2**

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 manoeuvring 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 manoeuvring 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	RIInc-SC3	1,4E-01	3
OH-26	RIInc-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	RIInc-SC3	1,4E-01	3
OH-21	RIInc-SC3	1,4E-01	3
OH-23	RIInc-SC3	1,4E-01	3
OH-24	RIInc-SC3	1,4E-01	3
OH-25	RIInc-SC3	1,4E-01	3
OH-26	RIInc-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	RIInc-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 Imminent 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	CFIT-SC2b	1e-4

	terrain [1e-3/mov]		
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	TInc-SC4	2e-1

	[1e-2/mov]		
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 -