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SESAR Solution PJ.02-W2-21.4 SPR-INTEROP/OSED for V3 - Part II - Safety Assessment Report

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AART

PJ.02 AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

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Abstract

This document is Part II of the SPR-INTEROP/OSED related to the SESAR Project ***PJ.02-W2-21.4*** - *"Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting"* that have been validated during validation activities at a V3 level. Part II provides the Safety Assessment Report (SAR) describing all the safety assurance activities that are requested to be performed in order to prove that the system investigated in the Solution PJ02-W2-21.4 is acceptably safe. To this end, this SAR contains also the Safety Criteria identified for the Solution PJ02-21.4.

Table of Contents

EUROPEAN PARTNERSHIP
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List of Tables

EUROPEAN PARTNERSHIP

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List of Figures

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1 Executive Summary

This document contains the Specimen Safety Assessment for a typical application of the SolutionPJ.02-W2-21.4 covering airport operations. The Safety Assessment Report (SAR) represents Part II of the SPR-INTEROP/OSED document and presents the assurance that the Safety Requirements for the V1-V3 phases are complete, correct and realistic, thereby providing all material to adequately inform the PJ.02-W2-21.4 Solution SPR-INTEROP/OSED and TS/IRS.

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2 Introduction

2.1 Background

This Solution enhances the Release 5 SESAR1 Solution #47 “Guidance assistance through airfield ground lighting”. The SESAR1 Solution #47 is known as OI Step AO-0222-A, and the Solution PJ.02-W2-21.4 is known as OI Step AO-0222-B

This new solution intends to automate the prioritisation of mobiles along their cleared route on the whole movement area. The Guidance Service takes into account other traffic for spacing to guide the mobile as it progresses along its assigned route and at the holding points.

2.2 General Approach to Safety Assessment

This safety assessment is conducted as per the SESAR Safety Reference Material (SRM) which itself is based on a twofold approach:

- a success approach which is concerned with the safety of the Solution operations in the absence of failure within the end-to-end Solution functional system, encompassing both Normal operation and Abnormal conditions,

- a conventional failure approach which is concerned with the safety of the Solution operations in the event of failures within the end-to-end Solution functional system.

These two approaches are applied to the derivation of safety properties at each of the successive lifecycle stages of the Solution development (Safety Requirements at service level and at design level).

2.3 Scope of the Safety Assessment

This document describes the safety assessment of Full Guidance via Follow the Greens.

The solution addressed in this Safety Assessment Report is:

- **Solution PJ.02-W2-21.4 - “Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting”**

The OI step addressed in this Safety Assessment Report is:

- **AO-0222-B:** Full Guidance Assistance to mobiles using "Follow the Greens" procedures based on Airfield Ground Lighting

The main assessment phase covered in the safety assessment report in relation to the maturity level targeted by the Solution (V3) at the end of Wave 2 is the safe refined design (a second iteration of the process conducted at the safe initial design level, mainly deriving Safety Requirements at refined design level – rSRD to be documented as appropriate in SPR-INTEROP/OSED and TS/IRS).

2.4 Layout of the Document

The structure of this Safety Assessment Report (SAR) is as follows:

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

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- Section 2 provides an overview of the safety assessment report.
- Section 3 provides an overview of the PJ.02-W2-21.4.
- Section 4 presents the safety specifications at ATS Service level.
- Section 5 presents the Safe Design of the Solution functional system.
- Section 6 presents the Safety Criteria achievability
- Section 7 provides the list of acronyms and terminology.
- Section 8 lists the documents referred to in this document.

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3 Setting the Scene of the safety assessment

The purpose of this section is to provide the main information collected within SAF&HP Scoping and Change assessment and Safety Plan development process in order to set the scene for the safety assessment documented in the SAR.

3.1 Operational concept overview and scope of the change

The solution is intended to optimize airport resources allocation with more efficient A-SMGCS Routing and Planning functions aiming also to avoid potential conflicting situations. That will be particularly true during low visibility conditions. In such conditions low-visibility procedures are in place and mobiles are provided with the Airfield Ground Lighting service switching on / off taxiway centreline lights in accordance with the taxi clearances issued by Tower Controllers.

This solution intends to automate the prioritisation of mobiles along their cleared route on the whole movement area. The Guidance Service considers other traffic for spacing to guide the mobile as it progresses along its assigned route and at the holding points. It allocates priorities between mobiles based on local operating rules (e.g. runway exit versus parallel taxiways, aircraft versus vehicle, aircraft converging or crossing at intersections and taxiways passing close to push back routes or other taxiways where insufficient wingtip separation exists), as well as known constraints from the surface management system. Automatic Guidance will be provided using “Follow the Greens” concept on the Airfield Ground Lighting infrastructure.

SESAR Solution ID	SESAR Solution Description	Master or Contributing (M or C)	Contribution to the SESAR Solution short description	OI Steps ref. (from EATMA)	Enablers ref. (from EATMA)
PJ.02-W2-21.4	Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting	M	Benefits are foreseen in safety, efficiency and human performance	AO-0222-B Full Guidance Assistance to mobiles using "Follow the Greens" procedures based on Airfield Ground Lighting	AERODROME-ATC-61b AERODROME-ATC-07c

The OI “AO-0222-B”is the actual scope of this solution and, as such, will be fully validated. The list of enablers will be used on the purpose, some developments are expected to be performed for the AERODROME-ATC-61b and AERODROME-ATC-07c.

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Table 1 below summarises the information exchanges for PJ.02-W2-21.4 concepts for routing with AGL described in the following Use Cases:

Use Case 1	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)
Use case 2	[NOV-5] [GUID-02] Guidance of Vehicles – AGL environment
Use case 3	[NOV-5] [CMAC-03] No Taxi / No FtG Alert

Table 1. Use Cases and corresponding NOV-5 comprised by [NOV-2] Routing with AGL

See the detailed Use Cases in OSED Part I Section 3.3.2.5.

3.2 Solution Operational Environment and Key Properties

Individual guidance via AGL may be used on a 24/7 basis in all weather conditions and on the entire movement area. Since the AGL technology is still quite expensive and the change management process accompanying the technical investments is complicated, it can be assumed that individual guidance via AGL could be implemented predominantly on Large and Very Large airports with complex TWY and RWY layouts.

In any case, the implementation of individual guidance via AGL will have an impact on the roles and responsibilities involved in providing guidance as well as on the roles receiving the instructions.

In principle, wherever individual guidance via AGL will be implemented, the standard operational procedures for taxi-in and taxi-out could be based mainly on controlled lighting systems. Therefore, the integrated guidance network needs to be constructed with sufficient technical and procedural redundancy that guarantees high availability and reliability.

In order to avoid operational limitations due to the use of AGL, the selection process of the end devices, e.g. the TCLs, shall always take the climatologic environment and typical lighting conditions of the specific aerodrome into account. It can be assumed that accumulating AGL guidance service degradations will not be acceptable in terms of business case calculation and future resource planning.

In principle, individual guidance via AGL may reduce Tower Controller workload, but increases the dependence of the airport process on the availability of a complex operational and technical system.

3.3 Stakeholders' expected benefits with potential Safety impact

Stakeholder	Involvement	Why it matters to stakeholder
Airspace Users	Main involvement is participation on workshops and meetings	The provision of an enhanced guidance assistance is expected to increase pilots' situational awareness and assurance of correct taxiing, resulting with a positive impact on safety. Expect less workload while taxiing on complex airports, and less chance of making mistakes and misunderstand ATC instructions
ANSP	Contribution to the definition of the operational concept and to preparation	Expect that radio communication as well as the misunderstandings in communication will be significantly reduced between ATCOs and

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	and execution of the concerned validation activities	pilots/drivers by giving a simpler instruction to the aircrafts/vehicles to follow.
Vehicle drivers	Main involvement is participation on workshops and meetings	Vehicles can also benefit from the solution, and reduce misunderstandings and errors when driving on taxiways

Table 2: Stakeholders' expectations

3.4 Safety Criteria

This section reports the Safety Criteria (SAC) derived by analysing the AIM for the Taxiway Collision (TWY Collision risk model – TWY-COL V1.0) and Runway Collision (RWY Collision risk model V2.1.). It is important to highlight that the safety criteria have been assigned on the basis of expert judgment on both safety and operational expertise.

The main safety barriers, analysing the AIM for the Runway Collision, supposed to be impacted by the introduction of the solution are:

- B4: **Runway Incursion Monitoring** aiming to mitigate the "(AC/Vehicle) Induced Incursion"
- B5: **Runway Crossing Management** aiming to mitigate the "(ATC) Induced Incursion"
- B6: **Line-up/Take-off Management** aiming to mitigate the "(ATC) Induced Incursion"

The main safety barriers, analysing the AIM for the Taxiway Collision, supposed to be impacted by the introduction of the solution are:

- B3: **Taxiway Conflict Management**, aiming to prevent the "Imminent Taxiway Infringement"

For each identified barrier, the related integrated risk picture has been analysed to show the ATM contribution to aviation accident risks. The main causes leading to barrier failures and the base events (lowest level risks) in the model for each impacted barrier have been identified as well. That analysis has led to set the following Safety Criteria:

SAC Ref	Suggested SAC	Associated Hazard Ref	Associated Hazard
SAC#1	With Full Guidance Follow the Greens functionalities introduced in the context of the Solution PJ02-21.04, there shall be no increase in the frequency of Induced Incursions (RP3).	**Ha#1:**	A situation leading to collision with another aircraft, ground vehicle or other object on RWY
SAC#2	With Full Guidance Follow the Greens functionalities introduced in the context of the Solution PJ02-21.04, there shall be no increase in the frequency of Imminent Taxiway Infringements (TP2).	**Ha#2**	A situation leading to collision with an obstacle, ground vehicle, another aircraft on the aerodrome manoeuvring area.

Table 3 Safety criteria

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4 Safety specification at ATS service level

The purpose of this section is to derive the Safety Requirements at Service level for the ATS operational Solution.

The Safety Requirements at ATS Service level (SRS) specify the desired safety behaviour of the change at its interface with the ATS operational context considering normal and abnormal conditions of the context (success approach) and the failures of the functional system (failure approach).

The interface of the change with the ATS operational context might be at the level of the ATS service provided by the Solution functional system to an aircraft or a group of aircraft (i.e. the WHAT of the ATS service specification) or at the level of the specification of the ATS service in terms of the ATCOs and Pilots action, mutual interaction and use of functionalities/information/other services (i.e. the HOW of the ATS service specification).

The main safety assurance activities feeding this section are the ones conducted in V2. The documented results might be refined based on outcomes from the safety assurance activities done in V3.

Safety requirements at ATS Service level (SRS) are to be placed on the services of the Solution functional system that are changed or affected by the change (through change in behaviour or through new interactions introduced). The derived SRSs are to be consistent with the set of operational requirements produced by the Solution team in charge of SPR-INTEROP/OSED Part I (Section 4) and completeness and correctness of the full set of SRSs with regards to the satisfaction of the Safety Criteria is to be shown. Any Assumption, Safety Issue or Limitation identified during the service specification process is to be recorded in Appendix I.

4.1 Overview of activities performed

This section addresses the following activities:

- derivation of Safety Requirements at ATS Service level (SRS) in view of mitigating the relevant risks inherent to aviation in normal conditions of operation– section 4.2
- assessment of the adequacy of the ATS operational services provided by the Solution under abnormal conditions of the Operational Environment & derivation of necessary SRSs – section 4.3
- assessment of the adequacy of the ATS operational services provided by the Solution in the case of internal failures and mitigation of the Solution functional system-generated hazards through derivation of SRSs – section 4.4
- verification of the operational safety specification process (mainly about obtaining Backing evidence from the properties of the processes by which Direct Evidence was gleaned) – section 4.5.

4.2 Mitigation of Risks Inherent to Aviation – Normal conditions

The purpose of this section is to determine what operational services are provided to prevent runway incursions and taxiway conflicts, and to derive Safety Requirements at Service Level (success approach) in order to mitigate the Risks Inherent to Aviation under normal operational conditions.

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The set of Safety Requirements at the ATS Service level (SRS) in this section specifies the desired safety behaviour of the change at its interface with the operational context considering normal conditions.

The SRS are derived taking into account:

- All relevant Use Cases
- EATMA Models at operational specification level (NOV-5 diagrams).
- Impact on adjacent airspace or on neighbouring ATM Systems

A complete set of SRS is to be provided in order to ensure satisfaction of the Safety Criteria in Normal conditions of operation. For that, operational requirements produced by the Solution team in charge of SPR-INTEROP/OSED Part I (and documented in Section 4) are to be taken into consideration and to be completed as necessary.

The design characteristics/items of the Solution functional system should not be considered at this level but at the design level (in section 5.2), when the derived SRSs will enable the derivation of the Safety Requirements at Design level (SRD).

4.2.1 Safety Requirements at ATS Service level (SRS) for Normal conditions of operation

This section defines a sort of traceability among the services expected to be provided by the guidance and the pre-existing hazards. The scope is to allocate each service to the pre-existing hazards.

Table 4 contains the main operational service defined in the OSED document [3]:

ID	ATS Operational Service	Hazards inherent to aviation
ATS-01	Traffic Monitoring on the RWY and RWY Conflict prevention	**Ha#1:** A situation leading to collision with another aircraft, ground vehicle or other object on RWY
ATS-02	Traffic Monitoring on taxiways where taxi clearance is needed and TWY Conflict resolution	**Ha#2:** A situation leading to collision with an obstacle, ground vehicle, another aircraft on the aerodrome manoeuvring area.

Table 4: ATS Operational services potentially impacted and Hazards inherent to aviation

Table 5 presents the consolidated list of the SRS for normal conditions of operation that have been derived in Appendix B.

SRS ID	SRS for Normal conditions of operation	Related SAC
SRS 001	The solution shall guide AC and vehicle movements during runway entry (through visual aids on the airport surface).	SAC #1
SRS 002	The solution shall guide AC movements during runway exit (through visual aids on the airport surface).	SAC #2

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SRS ID	SRS for Normal conditions of operation	Related SAC
SRS 003	The solution shall guide aircraft and vehicle movements during runway crossing (through visual aids on the airport surface).	SAC #1
SRS 004	The solution shall enable ATC detection of imminent runway incursions (AC, vehicle).	SAC #1
SRS 005	The solution shall enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions.	SAC #1
SRS 006	The solution shall enable to guide AC and vehicle movements on taxiways where taxi clearance is needed (through visual aids on the airport surface).	SAC #2
SRS 007	The solution shall enable ATC detection of conflicting situations on taxiways where taxi clearance is needed (involving aircraft, vehicles, and obstacles).	SAC #2
SRS 008	The solution shall enable the provision of guidance (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed.	SAC #2

Table 5: List of SRS (functionality and performance) for normal conditions of operation

4.2.2 Additional SRS related to adjacent airspace or neighbouring ATM Systems

Full guidance function applies to taxiway and runway operations and there is no impact on the adjacent airspace. The impact on neighbouring ATM systems could be evaluated in the next iterations.

4.3 Mitigation of Risks Inherent to Aviation - Abnormal conditions

The purpose of this section is to present the Safety Requirements at ATS Service level (SRS) derived for Abnormal conditions of operation.

The SRS in this section refer to the ability of the Solution to work through (robustness), or at least recover from (resilience) any abnormal conditions, external to the Solution functional system, that might be encountered relatively infrequently (i.e. abnormalities of the context in which the Solution functional system is intended to operate).

4.3.1 Identification of Abnormal Conditions

The following abnormal conditions have been identified.

- ABN 1 Aircraft with emergency (gear problem, brakes overheating - fire on the tires, tail strike, bird strike, etc.).
- ABN 2 Unplanned closure of an airport, closing ATC service
- ABN 3 Fire at airport
- ABN 4 Unplanned runway closure
- ABN 5 Unplanned taxiway closure

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- ABN 6 (Unplanned) ATCO overload
- ABN 7 Extreme sun glare or heavy snow

4.3.2 Safety Requirements at ATS Service level (SRS) for Abnormal conditions of operation

Table 6 provides the consolidated view of the SRS for abnormal conditions of operation derived in Appendix C.

SRS ID	Description	Related SAC
SRS 009	ATCOs shall be able to provide appropriate support for managing aircrafts in abnormal conditions.	SAC #1 SAC #2
SRS 010	The solution shall be able to provide guidance for aircrafts in abnormal conditions.	SAC #1 SAC #2

Table 6: List of additional SRS for Abnormal conditions of operation

4.4 Mitigation of System-generated Risks (failure conditions)

The purpose of this section is to present the Safety Requirements at ATS Service level (SRS) associated to the operational hazards (caused by internal failures of the Solution functional system) following Guidance G of Safety Reference Material and additional related SAF-GUI in STELLAR. This section concerns the airport operations supported by the Full Guidance function in the case of internal failures. Before any conclusion can be reached about the adequacy of the safety specification of these operations, at the OSED level, it is necessary to assess the possible adverse effects that failures internal to the end-to-end System might have upon the provision of the relevant operational services described in section 4.2.1 and to derive SRSs (failure approach) to mitigate against these effects

4.4.1 Operational Hazards Identification and Analysis

Present in this section the consolidated results from the hazard identification, analysis and HAZID workshop (detailed working tables, results and HAZID workshop participation are to be included in Appendix D).

- the assessed operational effect,
- the mitigations taken into account for assessing the operational effect (protecting against effect propagation) with a reference to existing safety barriers (as per the relevant AIM model), to existing SRS (functionality and performance) or, if applicable, to new derived SRS (functionality and performance) to be consolidated in Table 8 next sub-section.
- the assessed severity of the most probable effect from hazard occurrence as per the relevant AIM-based Severity Classification Scheme(s) (SCS) from Guidance G.3 of Safety Reference Material.

Note that the Severity Classification Schemes (SCS), as per the safety assessment practices in the ATM community are still in use for Wave 2 although their use is no more aligned with the new regulation 2017/373 and will be changed in the next version of the Safety Reference Material to be developed for use in SESAR 3.

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ID	Operational Hazard Description	Operational Effects	Mitigation of effects propagation	Severity *(most probable effect)*
OH 1	The solution fails to guide AC and vehicle movements (through visual aids on the airport surface) -on taxiways where taxi clearance is needed -during runway entry -during runway crossing -during runway exit	Back to conventional operation.	B3 - Runway Conflict Prevention B3 - Taxiway Conflict Management	No immediate safety effects.
OH 2	The solution fails to enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions.	Mobile is guided to enter runway without valid ATCO clearance.	B3 - Runway Conflict Prevention In LVP: B2 - ATC Runway Collision Avoidance	Severity: RWY-SC4 in LVP: RWY-SC3
OH 3	The solution fails to enable the provision of guidance (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed	Mobile is guided to an imminent taxiway infringement (where an encounter occurs between a taxiing aircraft and another a/c, a vehicle on the taxiway so the safe distance is lost between them).	B3 - Taxiway Conflict Management In LVP: B2 ATC Taxiway Collision Avoidance	Severity: TWY-SC5 in LVP: TWY-SC4

Table 7: Operational Hazards and Analysis

4.4.2 Safety Requirements at ATS Service level (SRS) associated to failure conditions

Table 8 provides the SRS addressing integrity/reliability in order to limit the frequency with which the operational hazards (listed in section 4.4.1) could be allowed to occur.

SRS ID	Safety Requirements at ATS Service level *(integrity/reliability)*	Related Operational Hazard	Severity & IM

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SRS 014	The likelihood that the solution fails to enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions shall be no more than 5E-08 per flight hour.	OH 002	RWY-SC3 IM=10
SRS 015	The likelihood that the solution fails to enable the provision of guidance (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed shall be no more than 3.33E-04 per flight hour.	OH 003	TWY-SC4 IM=10

Table 8: Safety Requirements at Service level - integrity/reliability

Table 9 provides the consolidated list of additional SRS (functionality and performance) associated to failure conditions and therefore mitigating against operational hazard effects (protective mitigation), derived during the operational hazard assessment addressed in previous section and referenced in Table 7 above.

SRS ID	Additional Safety Requirements at ATS Service level *(functionality & performance)*	Mitigated Operational Hazard
SRS 011	Contingency procedures shall be in place in case the solution fails to guide AC and vehicle movements (through visual aids on the airport surface).	OH 1 OH 2 OH 3
SRS 012	Contingency procedures shall be in place in case the solution fails to enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions and potential collisions on taxiways where taxi clearance is needed.	
SRS 013	Training shall include operating method for runway entry and crossing.	

Table 9: Additional SRS (functionality and performance) to mitigate operational hazards

4.5 Process assurance of the Safety Specification at ATS Service level

All SAC and SRS were defined in accordance with the relevant parts of the SRM, the list was reviewed and agreed by all partners within the solution. A Safety and HP workshop was held (for details and results, see 4.4.1 and Appendix D). Detailed results of the validation exercises are available in SESAR Solution PJ02.21.4 VALR, while the relevant results from safety point of view are available in Appendix H.

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5 Safe Design of the Solution functional system

The purpose of this section is to document the Safety Requirements at Design level (SRD) for the corresponding ATS operational Solution.

The Safety Requirements at Design level (SRD) are design characteristics/items of the Solution functional system to ensure that the system operates as specified and is able to achieve the SAC (because based on the verification/demonstration of these characteristics/items, it could be concluded that the SAC are met).

The set of Safety Requirements at Service level (SRS) enables the derivation of a correct and complete set of Safety Requirements at Design level (SRD) for ensuring the achievability of the Safety Criteria.

Any Assumption, Safety Issue or Operational Limitation identified during the design process is to be recorded in Appendix I.

5.1 Overview of activities performed

This section addresses the following activities:

- introduction of the design model (initial or refined) of the Solution functional system – section 5.2
- derivation of Safety Requirements (functionality & performance) at Design level (SRD) in normal conditions of operation from the SRS (functionality & performance) of section 4.2 and supported by the analysis of the initial or refined design model above - section 5.3
- derivation of Safety Requirements (functionality & performance) at Design level (SRD) in abnormal conditions of operation from the SRS (functionality and performance) of section 4.3 and supported by the analysis of the operation of the initial or refined design under abnormal conditions of operation - section 5.4
- assessment of the adequacy of the design (initial or refined) in the case of internal failures and mitigation of the Solution operational hazards (identified at section 4.4) through derivation from SRS (integrity/ reliability) of Safety Requirements (functionality & performance) and Safety Requirements (integrity & reliability) at Design level (SRD)- section 5.5
- realism of the refined safe design (i.e. achievability and “testability” of the SRD) - section 5.6
- safety process assurance at the initial or refined design level - section5.7.

5.2 Design model of the Solution functional system

The design model represents the architecture combining the elements composing the Solution functional system in terms of procedures, human resources and equipment. Safety requirements at design level (SRD) are to be placed on those elements afterwards. EATMA diagrams developed by the Solution, and a model for the purpose of the safety assessment were used.

5.2.1 Description of the Design Model

A logical model of the solution, and respective model elements can be found in Appendix E.1.

5.2.2 Task Analysis

No Task Analysis was performed during the Human Performance Assessment of this Solution.

5.3 Deriving Safety Requirements at Design level for Normal conditions of operation

The purpose of this section is to present the Safety Requirements at Design level (SRD) derived for Normal conditions of operation following related SAF-GUI in STELLAR.

The derivation of the SRD for Normal conditions of operation is mainly driven by the SRS (functionality and performance) for Normal conditions of operation from section 4.2.

Any assumption, safety issue or operational limitation stated during the derivation of the SRDs for Normal conditions of operation are captured in Appendix I.

5.3.1 Safety Requirements at Design level (SRD) – Normal conditions of operation

Table 10 provides the consolidated list of Safety Requirements at Design level (functionality and performance) for Normal conditions of operations derived by mapping the SRS for Normal conditions of operations (documented in section 4.2) onto the related elements of the Design Model. For each SRD the associated SRS is indicated.

The detail of the derivation process is to be included in Appendix E.

Safety Requirement ID [Design Model Element]	Safety Requirement (functionality & performance)	Derived from SRS (ID)
REQ-02.W2.21.4-SPRINTEROP-AL01.0220 [Guidance – Light commands –Stop bars]	The runway stop bar in front of an aircraft shall switch off following the input of a Take Off Clearance by a Tower Runway Controller via the Electronic Clearance Input, when no previous line-up Clearance has been input.	SRS-001
REQ-02.W2.21.4-SPRINTEROP-AL01.0230 [Guidance – Light commands –Stop bars]	The runway stop bar in front of an aircraft shall switch off following the input by a Tower Controller of a Line Up, Cross or Enter Clearance via the Electronic Clearance Input.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0010 [Guidance – Light commands – AGL system]	The Taxiway Centreline Lights shall be switched on in front of a mobile to configurable distances, after an electronic taxi, Line Up, Cross, Enter, Tow or Proceed Clearance input have been performed	
REQ-02.W2.21.4-SPRINTEROP-AL01.0240 [Guidance – Light commands –Stop bars]	A stop bar shall automatically switch on when one or more mobile(s) have passed over it by D metres or T seconds.	

REQ-02.W2.21.4-SPRINTEROP-AL01.0250 [Guidance – Light commands –Stop bars]	When a Stop Bar is active, any TCL installed beyond the stop bar shall be extinguished for a distance of at least 90 m.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0260 [Guidance – Light commands –Stop bars]	A stop bar shall not be switched off if there is another uncleared mobile is between the cleared mobile and the runway stop bar	
REQ-02.W2.21.4-SPRINTEROP-AL01.0270 [Guidance – Light commands –Stop bars]	The runway stop bar in front of an aircraft should switch off following the input of a Conditional Line Up Clearance via the ECI when the condition associated to the Clearance is satisfied.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0030 [Guidance – Light commands –AGL system]	The Taxiway Centreline Lights should be switched on for all the available runway exits (uni-directional from the runway towards the taxiway) up to a point what is defined as the clearance limit of a landing clearance, when an arriving aircraft is T seconds or D nautical miles from the runway threshold.	SRS 002
REQ-02.W2.21.4-SPRINTEROP-AL01.0180 [Guidance – Light commands –AGL system]	The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.	SRS 003
REQ-02.W2.21.4-SPRINTEROP-AL01.0230 [Guidance – Light commands –Stop bars]	The runway stop bar in front of an aircraft shall switch off following the input by a Tower Controller of a Line Up, Cross or Enter Clearance via the Electronic Clearance Input.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0240 [Guidance – Light commands –Stop bars]	A stop bar shall automatically switch on when one or more mobile(s) have passed over it by D metres or T seconds.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0250 [Guidance – Light commands –Stop bars]	When a Stop Bar is active, any TCL installed beyond the stop bar shall be extinguished for a distance of at least 90 m.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0260 [Guidance – Light commands –Stop bars]	A stop bar shall not be switched off if there is another uncleared mobile is between the cleared mobile and the runway stop bar	
REQ-02.W2.21.4-SPRINTEROP-AL01.0040 [Controller HMI]	The Controller shall be provided with the information on lit Taxiway Centreline Lights on the solution HMI.	SRS 004
REQ-02.W2.21.4-TS-INTEROP.0080 [Controller HMI]	The AGL system shall send the TCL status (on/off/other) to the Controller HMI.	

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REQ-02.W2.21.4-TS-PERF.0002 Guidance – Light commands – AGL system	The Controller HMI shall indicate that TCL are switched on/off with a latency that is within acceptable limits from a Safety perspective.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0310 [Controller HMI]	The Stop bar status (on/off) shall be provided to the Tower Controller on the A-SMGCS HMI.	
REQ-02.W2.21.4-TS-INTEROP.0090 [Controller HMI]	The AGL system shall send the stop bar light status (on/off/failure/maintenance) to the Controller HMI.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0050 [Controller HMI]	The Tower Controller shall be able to switch on/off any stop bar individually.	SRS 005
REQ-02.W2.21.4-TS-PERF.0001 [Guidance – Light commands – AGL system]	The Surface Guidance Management shall switch on the TCL with a latency that is within acceptable limits from a Safety perspective.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0180 [Guidance – Light commands – AGL system]	The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0181 [Guidance – Light commands – AGL system]	The Taxiway Centreline Light shall be switched off behind the mobile as it progresses along its route.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0210 [Guidance – Light commands – Stop bars]	Taxiway and apron stop bars shall be switched on or off to control the movement of a mobile along its cleared route.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0250 [Guidance – Light commands – Stop bars]	When a Stop Bar is active, any TCL installed beyond the stop bar shall be extinguished for a distance of at least 90 m.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0280 [Guidance – Light commands – AGL system]	If the solution detects a route deviation, the TCL shall be switched off.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0340 [Controller HMI]	The solution shall receive information whether LVPs are in force.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0010 [Guidance – Light commands – AGL system]	The Taxiway Centreline Lights shall be switched on in front of a mobile to configurable distances, after an electronic taxi, Line Up, Cross, Enter, Tow or Proceed Clearance input have been performed.	

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REQ-02.W2.21.4-SPRINTEROP-AL01.0380 [Guidance – Light commands – Stop bars]	The taxiway or apron stop bar in front of an aircraft shall switch off following the input of a Taxi clearance by the Tower Controller via the Electronic Clearance Input.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0400 [Controller HMI]	When the solution detects a conflicting situation, the Controller shall be provided with information that a conflict is detected, who has priority, and where the predicted conflict is, preferably without having to make input to the system.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0140 [Controller HMI]	When a mobile's TCLs are being restricted in order to prioritise converging mobiles at intersections or to avoid a deadlock situation, the Controller shall be provided with information indicating the last lit TCL.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0290 [Controller HMI]	The Tower Controller shall receive an Alert when an aircraft is moving on a taxiway without having received a TAXI instruction. This includes when it is being guided by a means such as activated TCL (Follow the Greens) and it overruns the activated TCL.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0040 [Controller HMI]	The Controller shall be provided with the information on lit Taxiway Centreline Lights on the solution HMI.	
REQ-02.W2.21.4-TS-INTEROP.0080 [Controller HMI]	The AGL system shall send the TCL status (on/off/other) to the Controller HMI.	
REQ-02.W2.21.4-TS-PERF.0002 [Guidance – Light commands – AGL system]	The Controller HMI shall indicate that TCL are switched on/off with a latency that is within acceptable limits from a Safety perspective.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0310 [Controller HMI]	The Stop bar status (on/off) shall be provided to the Tower Controller on the A-SMGCS HMI.	
REQ-02.W2.21.4-TS-INTEROP.0090 [Controller HMI]	The AGL system shall send the stop bar light status (on/off/failure/maintenance) to the Controller HMI.	
A001	Routing function is implemented in the ATCO HMI in order for ATCOs to safely monitor the routes and manage conflicts while using full guidance follow the greens function.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0090 [Guidance – Light commands – AGL system]	Priority of mobiles in conflict situations shall be based on rules, and use data such as distance from intersection, departure/arrival, TTOT, or order of electronic flight strips.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0110 [Guidance – Light commands – AGL system]	The Taxiway Centreline Lights shall discontinue to be switched on in front of the appropriate mobile(s) on the taxiway when a conflicting converging situations have been	

	detected, and give the priority to the other mobile to achieve adequate spacing between the mobiles.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0150 [Controller HMI]	The Tower controller shall be allowed to swap the priority between converging mobiles or mobiles in a predicted deadlock situation.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0180 [Guidance – Light commands – AGL system]	The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0190 [Guidance – Light commands – AGL system]	Spacing rules shall take into account if routes are merging or in-line, the types of aircraft the weather conditions, and other conditions requiring different spacing.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0050 [Controller HMI]	The Tower Controller shall be able to switch on/off any stop bar individually.	

Table 10. Safety Requirements at design level (functionality and performance) satisfying SRS for Normal conditions of operation

5.3.2 Static analysis of the functional system behaviour – Normal conditions of operation

No new SRS or SRD was identified from a static analysis of the functional system behaviour.

5.3.3 Dynamic Analysis of the functional system behaviour – Normal conditions of operation

No new SRS or SRD was identified from Real Time Simulations. For more information see Validation Report [4].

5.3.4 Effects on Safety Nets – Normal conditions of operation

No new SRS or SRD were identified impacting Safety Nets. For more information see Validation Report [4].

5.4 Deriving Safety Requirements at Design level for Abnormal conditions of operation

The purpose of this section is to present the Safety Requirements at Design level (SRD) for Abnormal conditions of operation following related SAF-GUI in STELLAR.

The Safety requirements at design level - SRD (functionality and performance) are derived from the SRS (functionality and performance) which have been identified when mitigating risks inherent to aviation in abnormal conditions of operations (section 4.3).

Contingency procedures associated to the degraded modes of operation in which the functional system might enter as a result of certain abnormal conditions of operation need to be captured as SRD.

Any additional SRD identified from the analysis of the system behaviour in abnormal operational conditions conducted to show completeness/correctness of the Safety Requirements (Functionality and Performance) are also to be documented here.

Remind if necessary that any assumption, safety issue or limitation stated during the derivation of the SRDs for Abnormal conditions of operation are captured in Appendix I.

5.4.1 Safety Requirements at Design level (SRD) for Abnormal conditions of operation

Table 11 provides the consolidated list of Safety Requirements at Design level (functionality and performance) for Abnormal conditions of operations derived from the Service Requirements at Service level (SRS) documented in section 4.3. For each SRD indicate the element of the design model on which the SRD is placed, as well as the associated SRS.

The details of the derivation process are included in Appendix F.

Safety Requirement ID [Design Model Element]	Safety Requirement (functionality & performance) for abnormal operation	Derived from SRS (ID)
REQ-02.W2.21.4-SPRINTEROP-AL01.0060 [Guidance – Light commands – AGL system]	The Tower Controller shall be able to activate and deactivate the Full Guidance Assistance to mobiles solution.	SRS 009
SREC 001 [Controller HMI]	ATCOs should be able to manually prioritise aircraft in emergency situations in all conflicts.	
SREC 002 [Controller HMI]	ATCOs should be able to stop via guidance all other aircrafts to give way for aircraft in emergency.	
REQ-02.W2.21.4-SPRINTEROP-AL01.0290 [Controller HMI]	The Tower Controller shall receive an Alert when an aircraft is moving on a taxiway without having received a TAXI instruction. This includes when it is being guided by a means such as activated TCL (Follow the Greens) and it overruns the activated TCL.	SRS 010
REQ-02.W2.21.4-SPRINTEROP-AL01.0420 [Guidance – Light commands – AGL system]	Operating method shall be defined in case of pilots are not able to see TCL.	
REQ-02.W2.21.4-TS-SAFE.0070 [Guidance – Light commands – AGL system]	The TCL and stop bars shall have high brightness so that they can be used in daytime and sunny conditions.	

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REQ-02.W2.21.4-TS-SAFE.0080 [Guidance – Light commands – AGL system]	The TCL and stop bars brightness shall be adjustable based on the conditions.	

Table 11. Safety Requirements at design level (functionality and performance) satisfying SRS for Abnormal conditions

5.4.2 Analysis of the functional system behaviour – Abnormal conditions of operation

No new SRS or SRD was identified from Real Time Simulations. For more information see Validation Report [4].

5.5 Safety Requirements at Design level addressing Internal Functional System Failures

The purpose of this section is to present the Safety Requirements at Design level (SRD) associated to internal failures of the Solution functional system.

Safety requirements at design level - SRD are derived from the SRS (functionality and performance) and SRS (integrity and reliability) which have been identified when mitigating system generated risks (section 4.4).

The following Safety requirements at design level (SRD) are to be included (derived from a top down causal analysis of the operational hazards identified at §4.4.1, from a bottom up failure modes and effects analysis encompassing the analysis of common causes and, if applicable, from the SRS (functionality & performance) derived during the operational hazard assessment at §4.4.1):

- SRD (functionality and performance) derived to provide adequate mitigations to reduce the likelihood that specific failures would propagate up to the operational hazard
- SRD (integrity/ reliability) to limit the frequency with which failure of modified/new equipment elements in the Solution Functional system could be allowed to occur
- SRD (functionality and performance) derived to provide mitigation against operational hazard effects (protective mitigation, from the SRS (functionality & performance) derived during the operational hazard assessment at §4.4.1).

5.5.1 Design analysis addressing internal functional system failures

Casual analyses of SRS 014 and SRS 015 are available in Appendix G.1.

5.5.2 Safety Requirements at Design level associated to internal functional system failures

Table 12 provides the consolidated list of Safety Requirements at Design level (integrity/reliability) associated to internal system failures derived from the Service Requirements at Service level (integrity/reliability) documented in section 4.4.2, with due consideration of any potential common cause failure. For each SRD (integrity/reliability) indicate the element of the design model on which the SRD is placed, as well as the originating SRS.

The detail of the derivation process is to be included in Appendix G.

Safety Requirement ID	Safety Requirement at Design level (SRD) (integrity /reliability)	Derived from SRS integrity & reliability (ID)
REQ-02.W2.21.4-TS-PERF.0005	The likelihood of Solution technical malfunction shall be operationally acceptable as per regulation applicable to local implementation.	SRS 014 SRS 015
REQ-02.W2.21.4-TS-PERF.0006	The likelihood of total/partial loss of information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation.	SRS 014 SRS 015
REQ-02.W2.21.4-TS-PERF.0007	The likelihood of delay of information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation.	SRS 014 SRS 015
REQ-02.W2.21.4-TS-PERF.0008	The likelihood of inadequate information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation.	SRS 014 SRS 015
REQ-02.W2.21.4-TS-PERF.0009	The likelihood that the solution fails to provide guidance conformance monitoring on manoeuvring area (involving aircraft, vehicles) shall be operationally acceptable as per regulation applicable to local implementation.	SRS 014 SRS 015

Table 12. SRD (integrity/reliability) to mitigate the operational hazards

Table 13 provides the consolidated list of Safety Requirements at Design level (functionality and performance) associated to internal system failures. Include the following:

- the SRD (functionality and performance) derived from the SRS (integrity/reliability) from section 4.4.2 to provide adequate mitigations to reduce the likelihood that specific failures would propagate up to the operational hazard, with due consideration for mitigating the common cause failures,
- the SRD (functionality and performance) derived to provide mitigation against operational hazard effects (protective mitigation, from the SRS (functionality & performance) derived during the operational hazard assessment at §4.4.1), with due consideration for mitigating the common cause failures.

The details of the derivation process are included in Appendix G.

Safety Requirement ID	Safety Requirement at Design level (SRD) (functionality & performance)	Derived from SRS (ID) or Common cause failure
REQ-02.W2.21.4-SPRINTEROP-AL01.0330	The Tower Controller shall be informed about the status of the solution and be alerted in case of a failure.	SRS 011

REQ-02.W2.21.4-SPRINTEROP-AL01.0330	The Tower Controller shall be informed about the status of the solution and be alerted in case of a failure.	
REQ-02.W2.21.4-SPRINTEROP-SAFE.0001	Contingency procedures shall be in place in case the solution fails to guide AC and vehicle movements (through visual aids on the airport surface).	
REQ-02.W2.21.4-SPRINTEROP-SAFE.0002	ATCO training shall include contingency procedures in case of FtG failure.	
REQ-02.W2.21.4-SPRINTEROP-SAFE.0006	ATCO shall be able to prevent overload and manage workload by reducing capacity.	SRS 011 SRS 012
REQ-02.W2.21.4-SPRINTEROP-AL01.0060	The Tower Controller shall be able to activate and deactivate the Full Guidance Assistance to mobiles solution	SRS 011 SRS 012
REQ-02.W2.21.4-SPRINTEROP-SAFE.0003	ATCO training shall include contingency procedures in case of FtG malfunction.	
REQ-02.W2.21.4-SPRINTEROP-SAFE.0004	ATCO training shall include operating method for runway entry and crossing.	SRS 013
REQ-02.W2.21.4-SPRINTEROP-SAFE.0005	Vehicle driver and pilot training shall include operating method for runway entry and crossing.	
SREC 003	Runway stop bars should be switched on by default during the operation.	SRS 012
SREC 004	RIMCAS alert should be implemented on A-SMGCS system.	SRS012

Table 13. SRD (functionality & performance) to mitigate the operational hazards

5.6 Realism of the safe design

To prove that the Safety Requirements in Solution PJ02.21.4 are achievable and implementable, a complete table of all Safety Requirements is included in Appendix H. This table contains the evidence that they are achievable – that is, the trial, workshop discussion or expert judgement that validate the concept.

5.7 Process assurance for a Safe Design

All SRDs were defined in accordance with the relevant parts of the SRM, the list was reviewed and agreed by all partners within the solution. A Safety and HP workshop was held (for details and results,

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see 4.4.1 and Appendix D). Detailed results of the validation exercises are available in SESAR Solution PJ02-21-4 VALR, while the relevant results from safety point of view are available in Appendix H.

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6 Safety Criteria achievability

No quantitative evidence on the achievability of the Safety Criteria through the specification of the SRSs has been collected.

From the Safety Criteria listed in section 3.4, and following the SRM process, the SRS and Operational Hazards have been developed and identified. Therefore the Safety Criteria are implicitly achieved through the demonstration of the aforementioned.

The Validation Report [4] captured the Safety Validation Objectives, among others. These Safety Validation Objectives were covered by the Validation exercises and/or the HP and Safety workshop (see Appendix H of this document, and chapters 4. and 5. of the Validation Report [4]).

Appendix H also presents the traceability table that links the SRS covering all Safety Validation Objectives for ATCOs and pilots/vehicle drivers as well.

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

The Safety Validation Objectives for **abnormal conditions** were validated in some cases during Validation Exercises. Discussions show that the Solution would not impede ATCOs to deal with abnormal situations, although further assessment needs to be conducted locally for implementation, including the mitigations (i.e. correct brightness of TCLs in low visibility conditions).

Some of the Safety Validation Objectives related to **degraded modes** of operations have been also covered during the validations, and those have been further discussed during the HP and Safety workshop.

Evidences collected for abnormal and failure conditions are partially subjective feedback from operational people involved in the project and in the validation exercises, together with some scenarios that were simulated but that do not cover all cases. This feedback has been collected by questionnaires and group discussions in a Safety and Human Performance workshop with pilots, vehicle drivers and ATCOs in Budapest, 2022.06.13. and 2022.06.18.

The working table(s) for the demonstration of the Safety Criteria achievability is provided in Appendix H.

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7 Acronyms and Terminology

Acronym	Definition
AART	Airport Airside and Runway Throughput
ACARS	Aircraft Communication Addressing and Reporting System
A-CDM	Advanced Collaborative Decision Making
ACK	Acknowledgement message
AGL	Airfield Ground Lighting
AMAN	Arrival Manager
AMM	Airport Moving Map
ANSP	Air Navigation Service Provider
AOC	Airport Operation Centre
AoR	Area of Responsibility
APTR	Alternative Parallel Taxiway Routing
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATIS	Automatic terminal information service
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
BIM	Benefit Impact Mechanism
CBA	Cost Benefit Analysis
CMAC	Conformance Monitoring Alerts for Controllers
CNS	Communication Navigation and Surveillance
CONOPS	Concept of Operations
CPDLC	Controller Pilot Data Link Communication
CTA	Controlled Time of Arrival
CWP	Controller Working Position
DM	Downlink Message
DMAN	Departure Manager
EATMA	European ATM Architecture
EBS	Enhanced Braking Systems
EIBT	Estimated In-Block Time

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EFB	Electronic Flight Bag
ECI	Electronic Clearance Input
ENVIAR	Environmental Impact Assessment Report
EOBT	Estimated Off Block Time
FDPS	Flight Data Processing System
FtG	Follow the Greens
GNSS	Global Navigation Satellite System
GTD	Ground Traffic Display
HLOR	High Level Operational Requirement
HMI	Human Machine Interface
HP	Human Performance
HPAR	Human Performance Assessment Report
ICAO	International Civil Aviation Organization
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specifications
KPA	Key Performance Area
LVP	Low Visibility Procedures
MLAT	Multi-lateration
NOTAM	Notice To Airmen
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PCIL	Project Content Integration Leader
PCIT	Project Content Integration Team
PRAI	Planned Route and Airport Information
R&D	Research & Development
R/T	Radio Telephony
RWY	Runway
SE-DMF	System Engineering Data Management Framework)
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking
SPR	Safety and Performance Requirements
TCL	Taxiway Centreline Lights
TLDT	Target Landing Time
TS	Technical Specification

TSAT	Target Start Up Approval Time
TTOT	Target Take-Off Time
TWY	Taxiway
UC	Use Case
UM	Uplink Message
VALP	Validation Plan
VALR	Validation Report
VBC	Virtual Block Control
VDS	Vehicle Display System
VHF	Very High Frequency

[…]

Table 14: Acronyms

Term	Definition	Source of the definition
Advanced Routing	In addition to the "basic routing" investigated during SESAR 1, the advanced routing function of SESAR 2020 is expected to suggest alternative routes to the cleared routes of one or more of the mobiles, to remove the potential deadlock / conflicting situations or to dynamically adapt routing to known operational constraints or traffic behaviour situation.	SESAR 2020 PJ03a-01 and PJ.02-W2-21.6
Advanced Surface Movement Guidance and Control System (A-SMGCS)	A system providing as a minimum Surveillance and can include Airport Safety Support, Routing and Guidance to aircraft and vehicles in order to maintain the airport throughput under all local weather conditions whilst maintaining the required level of safety.	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
Alternative route-choice function	Means for the controller to choose a route from a provided list of alternative routes, e.g. via a menu	PJ03a-01 definition
A-SMGCS Guidance service	The Guidance Service provides individual guidance information using visual aids to any mobile which has a cleared taxi route. It comprises the following three functions: Automated switching of Taxiway Centreline Lights (TCL). Automated switching of stop bars. Automated activation of Advanced-Visual Guidance Docking Systems (A-VDGS).	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
A-SMGCS Routing service	The Routing Service generates individual routes for mobiles based on known aerodrome parameters and constraints or following an interaction by the Controller and is a key enabler for the Guidance Service	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020

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	and some elements of the Airport Safety Support Service.	
Electronic Clearance Input (ECI)	A generic term used to describe the means for a Controller to input Clearances or instructions.	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
Intermediate Holding Position	A designated position intended for traffic control at which taxiing aircraft and vehicles shall stop and hold until further cleared to proceed, when so instructed by the aerodrome control tower	ICAO Annex 14
Routing	The planning and assignment of a route to individual aircraft and vehicles to provide safe, expeditious and efficient movement from its current position to its intended position.	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
Visibility Condition 3 (VIS 3)	Visibility enough for the pilot to taxi but insufficient for the pilot to avoid collision with other traffic on taxiways and at intersections by visual reference, and insufficient for personnel of control units to exercise control over all traffic based on visual surveillance. For taxiing, this is normally taken as visibilities equivalent to an RVR of less than 400 m but more than 75.	ICAO Doc 9830 (Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual).

Table 15: Glossary of terms

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8 References

Safety

[1] (EU) No 2017/373 laying down common requirements for service providers and the oversight in air traffic management/air navigation services and other air traffic management network functions, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011 and (EU) No 1035/2011 and amending Regulation (EU) No 677/2011 (and associated AMC and GM)

[2] SAM EUROCONTROL Safety Assessment Methodology, Edition 2.0

[3] SESAR Solution PJ.02-W2-21.4 SPR-INTEROP/OSED for V3

[4] SESAR Solution PJ.02-W2-21.4 VALR

Appendix A Preliminary safety impact assessment

This appendix presents the outcomes of the preliminary safety impact assessment and Safety Criteria determination, conducted within the "SAF&HP Scoping and Change Assessment" and documented in Section 4.2 of the Safety Plan, performed in accordance with the relevant SAF-GUI in STELLAR.

A.1 Relevant Hazards Inherent to Aviation

Hazards inherent to aviation	ATM-related accident type & AIM model
Ha 01: A situation leading to collision with another aircraft, ground vehicle or other object on RWY	Runway collision – RWY Collision AIM model
Ha 02 A situation leading to collision with an obstacle, ground vehicle, another aircraft on apron or TWY ground or close to ground on landing / take-off	Taxiway collision – TWY Collision AIM model

Table 16. Hazards inherent to aviation relevant for the Solution

A.2 Functional system-generated hazards (preliminary)

Functional system-generated hazards (preliminary)	Impacted (new/modified) & justification
Hs 01 Erroneous TCL Segment	TCL segment(s) mislead(s) pilot/driver which results in deviation from ATC clearance. At intersections it can lead to deadlock or conflicting situations due to uncleared turns. R/T communication is increased between ATCO and pilot/driver which effects ATCO workload.
Hs 02 Total loss of TCL (loss of all AGL segments)	Pilot/driver gets back to conventional operation. R/T communication has to be recovered between ATCO and pilot/driver.
Hs 03 Partial loss of TCL (loss of one or more AGL segments)	At specific segments of airport pilot/driver gets back to conventional operation. R/T communication has to be recovered between ATCO and pilot/driver.
Hs 04 TCL Segment not visible	Pilot/driver is not able to see TCL which effects their situational awareness. R/T communication is increased between ATCO and pilot/driver which effects ATCO workload.
Hs 05 TCL segment misinterpreted by pilot	Misinterpretation results in deviation from ATC clearance. In VFR it can lead to deadlock or conflicting situations at intersections due to uncleared turns. R/T communication is increased between ATCO and pilot/driver which effects ATCO workload.
Hs 06 Erroneous stopbar control	Stop bar misleads pilot/driver which results in deviation from ATC clearance and runway incursion.
Hs 07 Total loss of stopbars	Without functioning stop bars R/T communication is increased between ATCO and pilot/driver. In case of any confusion it can lead to runway incursion.

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Hs 08 Partial loss of stopbar	Without functioning stop bars R/T communication is increased between ATCO and pilot/driver. In case of any confusion it can lead to runway incursion.
Hs 09 Total loss of conflict detection and resolution function	In a reduced situational awareness ATCO is not completely aware of conflicts. ATCO has to take over conflict detection and resolution and R/T communication has to be recovered.
Hs 10 Partial loss of conflict detection and resolution function	In a reduced situational awareness ATCO is not completely aware of conflicts. ATCO has to take over conflict detection and resolution and R/T communication has to be recovered.
Hs 11 Undetected corruption of conflict detection and resolution function	ATCO is not aware of conflicts. Conflict detection relies on pilot side. In VFR it can lead to deadlock or conflicting situations at intersections due to uncleared turns.
Hs 12 Detected corruption of conflict detection and resolution function	ATCO takes over conflict detection and resolution which leads to increased R/T communication.

Table 17. Functional system-generated hazards applicable to the Solution (preliminary list)

Appendix B Derivation of SRS (Functionality & Performance) for Normal conditions of operation

B.1 Derivation of SRS for Normal Operations

B.1.1 Derivation of SRS for Use Case 1, 2, 3

For deriving SRS the following EATMA models [Figure 1 to 3] and the detailed description of Use Cases were used from OSED Part I Section 3.3.2.5.

Use Case 1	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)
Use case 2	[NOV-5] [GUID-02] Guidance of Vehicles – AGL environment
Use case 3	[NOV-5] [CMAC-03] No Taxi Alert / No FtG Alert

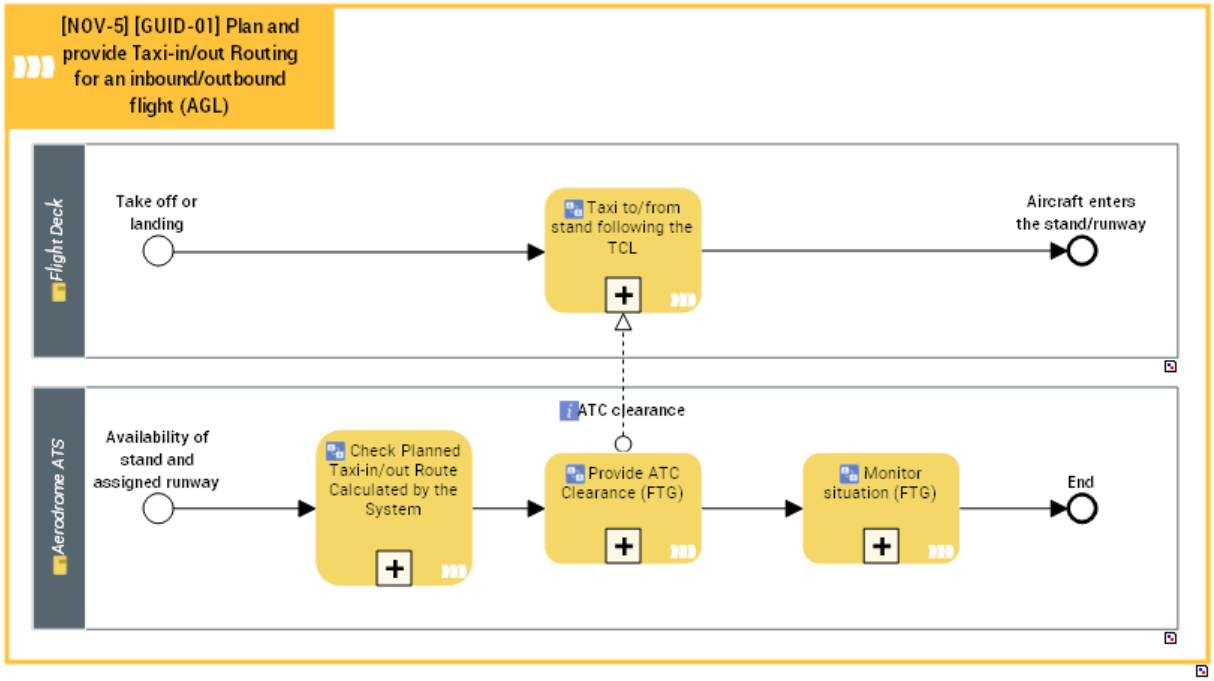

Figure 1 [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

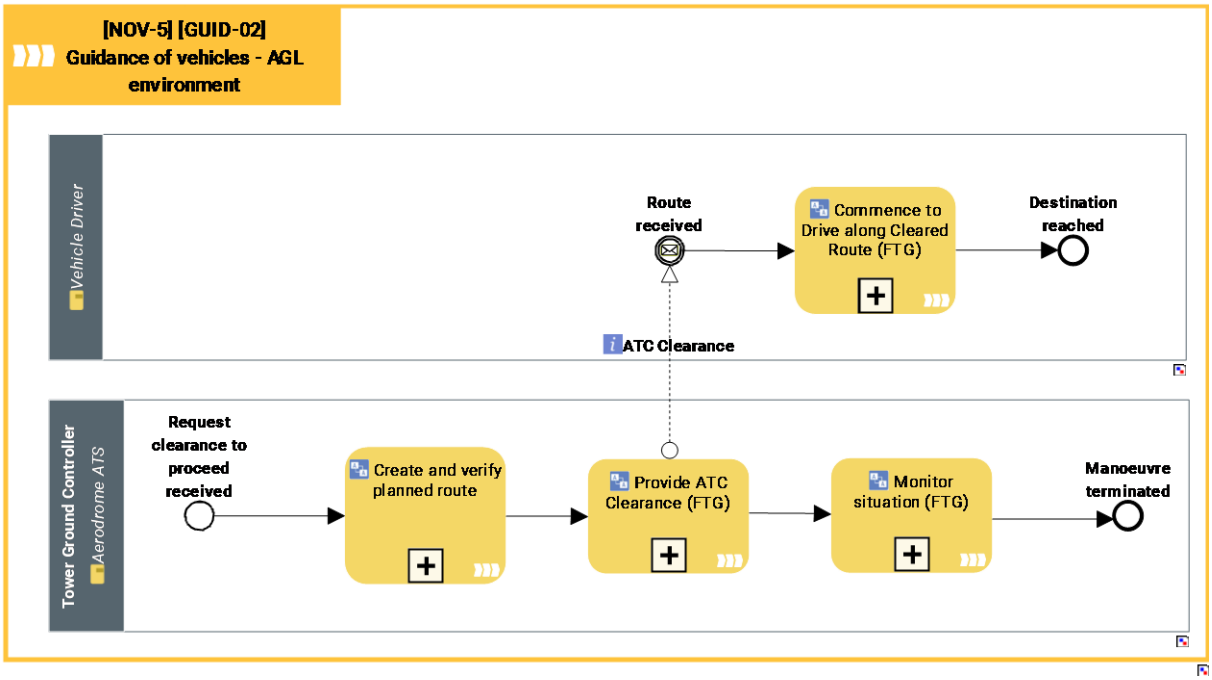

Figure 2 [NOV-5] [GUID-02] Plan and provide routing for an airport vehicle

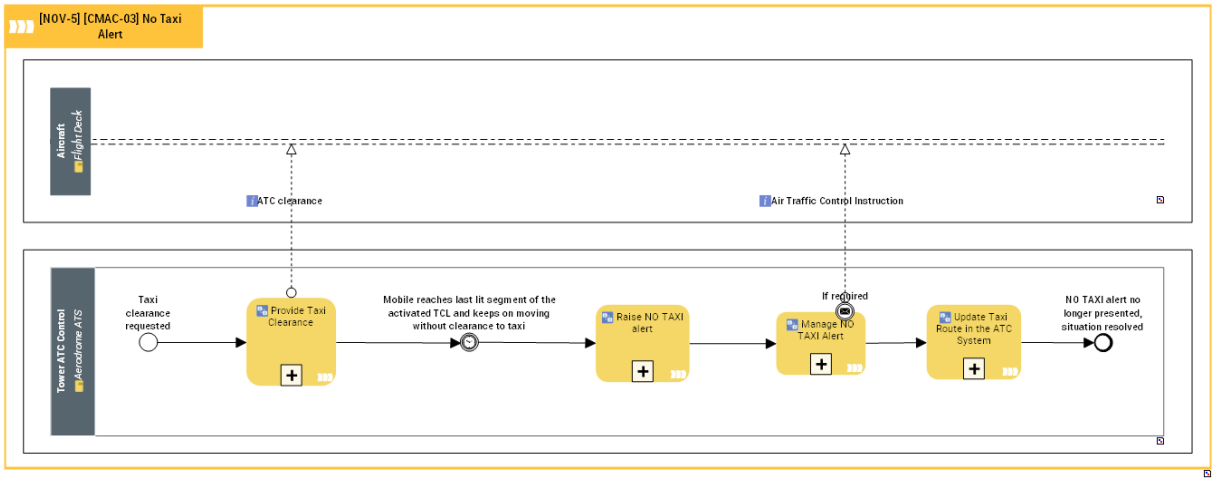

Figure 3 [NOV-5] [CMAC-03] No Taxi Alert / No FtG Alert

ATS Operational Service	EATMA Use Case- Activity or Flow	Derived SRS	Related SAC# (AIM Barrier or Precursor)
[GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)			

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ATS Operational Service	EATMA Use Case- Activity or Flow	Derived SRS	Related SAC# (AIM Barrier or Precursor)
[GUID-02] Guidance of Vehicles – AGL environment			
[CMAC-03] No Taxi Alert / No FtG Alert			
ATS-01 Traffic Monitoring on the RWY and RWY Conflict prevention	**UC1** "Provide ATC Clearance" "Taxi to/from stand following TCL" "Monitoring situation" **UC2** "Provide ATC Clearance" "Commence to drive along cleared route" "Monitoring situation"	**SRS 001** The solution shall guide AC and vehicle movements during runway entry (through visual aids on the airport surface). **SRS 002** The solution shall guide AC movements during runway exit (through visual aids on the airport surface). **SRS 003** The solution shall guide aircraft and vehicle movements during runway crossing (through visual aids on the airport surface). **SRS 004** The solution shall enable ATC detection of imminent runway incursions (AC, vehicle). **SRS 005** The solution shall enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions.	**SAC#1** (Induced Incursion (RWY Col RP3))
ATS-02 Traffic Monitoring on taxiways where taxi clearance is needed and TWY Conflict resolution	**UC1** "Provide ATC Clearance" "Taxi to/from stand following TCL" "Monitoring situation" **UC2** "Provide ATC Clearance" "Commence to drive along cleared route" "Monitoring situation" **UC3** "Raise No Taxi alert"	**SRS 006** The solution shall enable to guide AC and vehicle movements on taxiways where taxi clearance is needed (through visual aids on the airport surface). **SRS 007** The solution shall enable ATC detection of conflicting situations on taxiways where taxi clearance is needed (involving aircraft, vehicles, and obstacles). **SRS 008** The solution shall enable the provision of guidance (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed	**SAC#2** (Imminent Taxiway Infringements (TWY Col TP2))

Table 18 Derived SRS for normal conditions

Appendix C Risk analysis of Abnormal conditions and derivation of SRS (functionality & performance)

Ref	Abnormal Conditions	Operational Effect	Mitigation of Effects / [SRS xxx]
ABN 1	Aircraft with emergency (gear problem, brakes overheating - fire on the tires, tail strike, bird strike, etc.).	All these emergencies may induce landing or take-off accidents.	**SRS 009** ATCOs shall be able to provide appropriate support for managing aircrafts in abnormal conditions.
ABN 2	Unplanned closure of an airport, closing ATC service	Operations on the aerodrome shall be stopped as conditions are not safe for aircraft, passengers and airport personnel.	
ABN 3	Fire at airport	Operations on the aerodrome/s may need to be stopped as conditions may not be safe for aircraft, passengers and airport personnel.	
ABN 4	Unplanned runway closure	Runway cannot be used for operation.	
ABN 5	Unplanned taxiway closure	Taxiway cannot be used for operation.	
ABN 6	(Unplanned) ATCO overload	Increased ATCO workload	Full Guidance via FtG system aims to reduce ATCO workload. All SRSs are relevant.
ABN 7	Extreme sun glare or heavy snow	Pilots/vehicle drivers are not able to see TCL not visible (covered in snow or pilots/drivers are blinded by sun).	**SRS 010:** The solution shall be able to provide guidance for aircrafts in abnormal conditions.

Table 19: Risk analysis for Abnormal conditions of operation

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Appendix D Risk analysis addressing internal functional system failures and derivation of SRS

This appendix presents the risk analysis done at the level of the ATS service specification, including operational hazards identification and analysis in view of deriving additional SRS.

D.1 HAZID workshop

The outcomes from the preliminary safety impact assessment included in Appendix A were used as input for the HAZID workshop. The HAZID workshop was prepared and hazards were identified and analysed as per Guidance G of the Safety Reference Material and the relevant SAF-GUI available in STELLAR.

The hazards were identified during two separated workshops (one with pilots and vehicle drivers, and one with air traffic controllers).

The first workshop took place at HungaroControl premises on June 13 and it was a mix of online and personal meeting which two pilots and two drivers attended from HungaroControl.

The second workshop took place on June 28 and was organised online with two ATCOs from HungaroControl.

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Use Case / Operational failure mode	Example of causes& preventive mitigations	Operational effect	Mitigations protecting against propagation of effects	Operational hazard & Severity
Total/partial loss of Full Guidance via FtG function	TCL segment failure	Back to conventional operation.	B3 - Runway Conflict Prevention B3 - Taxiway Conflict Management **Assumption:** Entering or crossing the runway is only allowed by explicit clearance of the ATCO on R/T. **SRD candidate:** ATCO training shall include operating method for runway entry and cross. **SRD candidate:** Vehicle driver and pilot training shall include operating method for runway entry and cross. **SRD candidate:** Stop bars shall be switched on by default during the operation. **SRD candidate:** The A-SMGCS HMI shall display illuminated individual TCLs or segments based on information received from the AGL system. **SRD candidate:** The A-SMGCS HMI shall display illuminated stop bars based on information received from the AGL system. **SRD candidate:** In case of detected malfunction ATCOs shall be able to switch off FtG and conventional operation shall be returned.	**OH 1:** The solution fails to guide AC and vehicle movements (through visual aids on the airport surface) - on taxiways where taxi clearance is needed -during runway entry -during runway crossing -during runway exit **No immediate safety effects.**

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Corruption of Full Guidance Follow the Greens function during runway entry or cross	TCL segment malfunction - The solution incorrectly switches on TCL at runway entry or cross (while stop bars are off). The solution fails to enable ATC detection of imminent runway incursions (AC, vehicle). Human error – the ATCO click a clearance button (line-up, take-off, cross.) unintentionally.	Mobile is guided to enter runway without valid ATCO clearance.	B3 - Runway Conflict Prevention In LVP: B2 - ATC Runway Collision Avoidance **Assumption:** Crossing the runway is only allowed by explicit clearance of the ATCO on R/T. **Assumption:** Entering the runway is only allowed by explicit clearance of the ATCO on R/T. **SRD candidate:** The A-SMGCS HMI shall display illuminated individual TCLs or segments based on information received from the AGL system. **SRD candidate:** The A-SMGCS HMI shall display illuminated stop bars based on information received from the AGL system. **SRD candidate:** ATCO training shall include operating method for runway entry and crossing. **SRD candidate:** Vehicle driver and pilot training shall include operating method for runway entry and crossing. **SRD candidate:** CATC warning shall be displayed on HMI in case of conflicting line up/entry ATC clearance. **SRD candidate:** Runway stop bars shall be switched on by default during the operation. **SRD candidate:** RIMCAS alert should be in use on A-SMGCS system. **SRD candidate:** In case of detected malfunction ATCOs shall be able to switch off FtG and conventional operation shall be returned.	**OH 2:** The solution fails to enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions. **Severity: RWY-SC4** **in LVP: RWY-SC3**

Corruption of Full Guidance Follow the Greens function during taxiing on taxiways where taxi clearance is needed.	TCL segment malfunction - The solution incorrectly switches on TCL in a taxiway intersection. The solution fails to enable ATC detection of conflicting situations on taxiways where taxi clearance is needed (involving aircraft, vehicles, and obstacles). The solution fails to enable ATC detection of guidance conformance monitoring CMAC no taxi (no FtG) and route deviation on taxiways where taxi clearance is needed (involving aircraft, vehicles). The solution fails to provide in-line spacing in LVP.	Mobile is guided to an imminent taxiway infringement (where an encounter occurs between a taxiing aircraft and another a/c, a vehicle on the taxiway so the safe distance is lost between them).	B3 - Taxiway Conflict Management In LVP: B2 ATC Taxiway Collision Avoidance **SRD candidate:** The A-SMGCS HMI shall display illuminated individual TCLs or segments based on information received from the AGL system. **SRD candidate:** The A-SMGCS HMI shall display illuminated stop bars based on information received from the AGL system. **SRD candidate:** In case of detected malfunction ATCOs shall be able to switch off FtG and conventional operation shall be returned.	**OH 3:** The solution fails to enable the provision of guidance (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed **Severity: TWY-SC5** **in LVP: TWY-SC4**

Table 20. Full HAZID working table

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D.2 HAZID participation list

HungaroControl
Magyar Légiforgalmi Szolgálat Zrt.

JELENLÉTI ÍV

Projekt neve:	**SESAR2020 Wave 2 – PJ02 AART**			Kód:	SESAR PJ02 W2
Időpont	**2022.06.13.**		Hely	**Budapest**	
Kezdete	9:00	Vége 11:00	Összehívta	Csekő Tamás	
Témák:	PJ02 W2 Pilot/Driver workshop				

	Név	Szervezeti egység	Aláírás
1.	Wilson-Szűcs László	LMKO	
2.	Zsóka János	RRCS	
3.	Horváh Attila	EITM	
4.	Vranesics Csaba	BTWR	
5.	Tófalvi Nándor	RRCS	

Figure 4 Pilot/driver HAZID workshop participants attended in person

Role	Company
Product Advisor Tower System	INDRA
Human Factor Expert	Deep Blue
Product Advisor	INDRA
Project manager	HungaroControl
Safety Expert	HungaroControl

Table 21 Online participants of pilot/driver workshop

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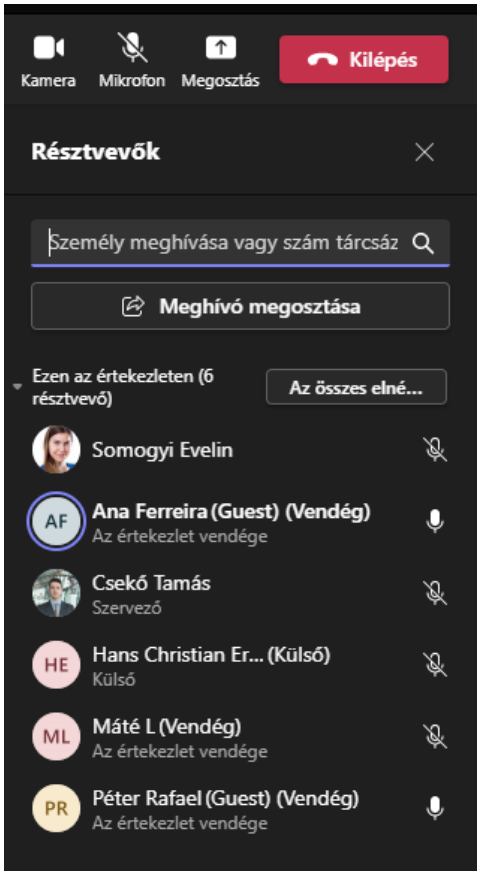

Figure 5 ATCO HAZID workshop participants

Appendix E Designing the Solution functional system for normal conditions

E.1 Deriving SRD from the SRS

This section contains a global functional model built on the basis of the information found in the PJ02-W2-21.4 SPR-INTEROP/OSED.

A functional model is a structured flow-representation of the main functions of a system (application) with the aim to define the relationships between the related inputs and outputs. The functions broadly translate into processes that transform input to output. Therefore, the functional model is sometimes referred to as a process model.

It provides an efficient baseline for functional assessment (safety and performance assessment) because it decomposes the system (application) into structured subsystems and processes and hereby visualises the critical transactions. Therefore, the functional model will be used as a baseline for a systematic assessment of a system (application).

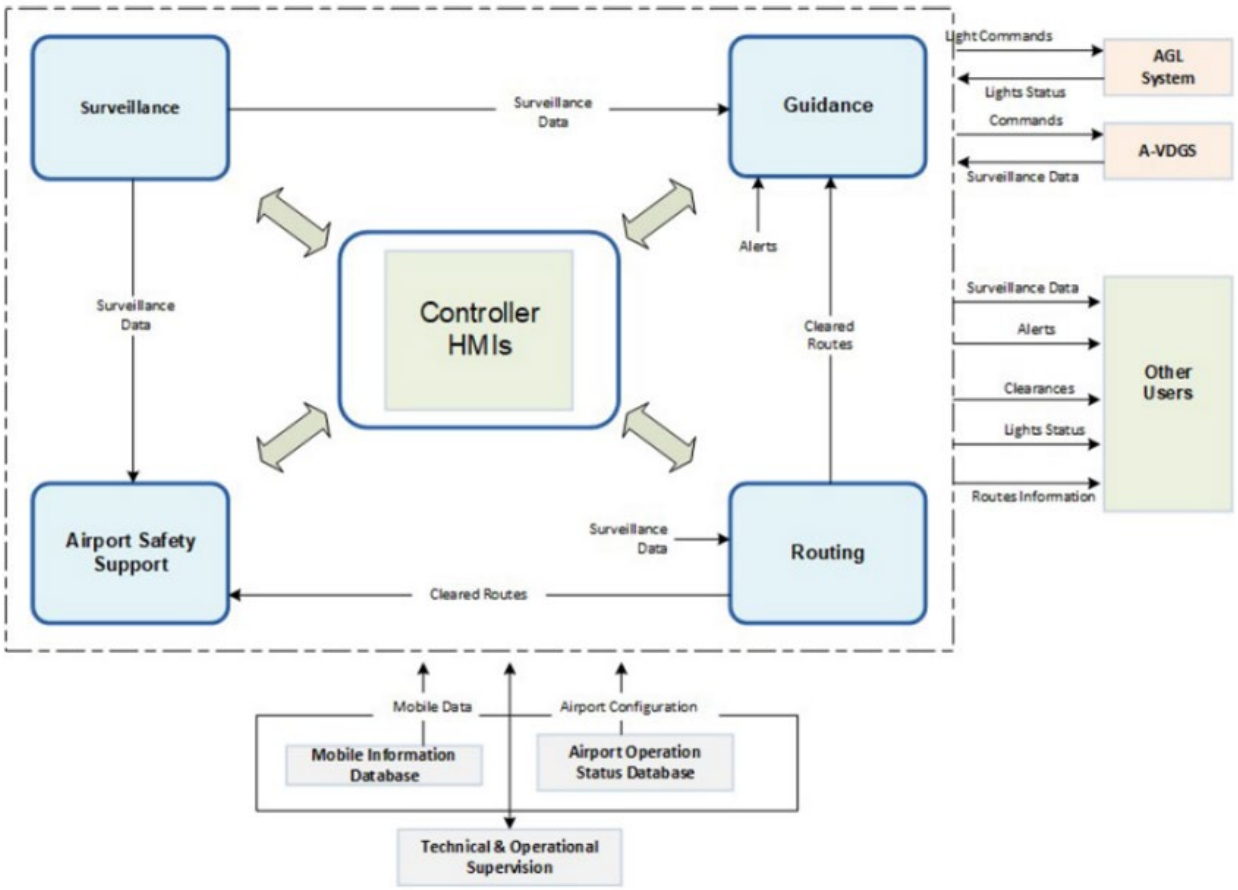

Figure 6 Surface Guidance and Routing Management context diagram

Table 22 shows how the Safety Requirements at ATS Service level (SRS) for normal conditions of operation derived in section 4.3 map onto the related elements of the Design Model (functional system components or interactions/data flows) and derive Safety Requirements at Design level (SRD) (functionality and performance) for normal conditions of operation.

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SRS for Normal Operation (ID & content)	Safety Requirement at Design level[1] (SRD) or Assumption	Maps onto
SRS 001 The solution shall guide AC and vehicle movements during runway entry (through visual aids on the airport surface).	**REQ-02.W2.21.4-SPRINTEROP-AL01.0220** The runway stop bar in front of an aircraft shall switch off following the input of a Take Off Clearance by a Tower Runway Controller via the Electronic Clearance Input, when no previous line-up Clearance has been input.	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0230 The runway stop bar in front of an aircraft shall switch off following the input by a Tower Controller of a Line Up, Cross or Enter Clearance via the Electronic Clearance Input.	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0010 The Taxiway Centreline Lights shall be switched on in front of a mobile to configurable distances, after an electronic taxi, Line Up, Cross, Enter, Tow or Proceed Clearance input have been performed	[Guidance – Light commands – AGL system]
	REQ-02.W2.21.4-SPRINTEROP-AL01.0240 A stop bar shall automatically switch on when one or more mobile(s) have passed over it by D metres or T seconds.	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0250 When a Stop Bar is active, any TCL installed beyond the stop bar shall	Guidance – Light commands – Stop bars

[1] iSRD for the initial design or rSRD for the refined design

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	be extinguished for a distance of at least 90 m.	
	REQ-02.W2.21.4-SPRINTEROP-AL01.0260 A stop bar shall not be switched off if there is another uncleared mobile is between the cleared mobile and the runway stop bar	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0270 The runway stop bar in front of an aircraft should switch off following the input of a Conditional Line Up Clearance via the ECI when the condition associated to the Clearance is satisfied.	Guidance – Light commands – Stop bars
SRS 002 The solution shall guide AC movements during runway exit (through visual aids on the airport surface).	**REQ-02.W2.21.4-SPRINTEROP-AL01.0030** The Taxiway Centreline Lights should be switched on for all the available runway exits (uni-directional from the runway towards the taxiway) up to a point what is defined as the clearance limit of a landing clearance, when an arriving aircraft is T seconds or D nautical miles from the runway threshold.	Guidance – Light commands – AGL System
SRS 003 The solution shall guide aircraft and vehicle movements during runway crossing (through visual aids on the airport surface).	**REQ-02.W2.21.4-SPRINTEROP-AL01.0180** The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.	Guidance – Light commands – AGL System
	REQ-02.W2.21.4-SPRINTEROP-AL01.0230 The runway stop bar in front of an aircraft shall switch off following	Guidance – Light commands – Stop bars

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	the input by a Tower Controller of a Line Up, Cross or Enter Clearance via the Electronic Clearance Input.	
	REQ-02.W2.21.4-SPRINTEROP-AL01.0240 A stop bar shall automatically switch on when one or more mobile(s) have passed over it by D metres or T seconds.	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0250 When a Stop Bar is active, any TCL installed beyond the stop bar shall be extinguished for a distance of at least 90 m.	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0260 A stop bar shall not be switched off if there is another uncleared mobile is between the cleared mobile and the runway stop bar	Guidance – Light commands – Stop bars
	REQ-02.W2.21.4-SPRINTEROP-AL01.0040 The Controller shall be provided with the information on lit Taxiway Centreline Lights on the solution HMI.	[Controller HMI]
	REQ-02.W2.21.4-TS-INTEROP.0080 The AGL system shall send the TCL status (on/off/other) to the Controller HMI.	[Controller HMI]
	REQ-02.W2.21.4-TS-PERF.0002 The Controller HMI shall indicate that TCL are switched on/off with a latency that is within acceptable limits from a Safety perspective.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0310	[Controller HMI]

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	The Stop bar status (on/off) shall be provided to the Tower Controller on the A-SMGCS HMI.	
	REQ-02.W2.21.4-TS-INTEROP.0090 The HMI shall receive information of the illuminated stop bars from the AGL system.	[Controller HMI]
SRS 005 The solution shall enable the provision of guidance (to aircraft and vehicles) to avoid runway incursions.	**REQ-02.W2.21.4-SPRINTEROP-AL01.0050** The Tower Controller shall be able to switch on/off any stop bar individually.	Controller HMI
	REQ-02.W2.21.4-TS-PERF.0001 The Surface Guidance Management shall switch on the TCL with a latency that is within acceptable limits from a Safety perspective.	Guidance – Light commands – AGL system
SRS 006 The solution shall enable to guide AC and vehicle movements on taxiways where taxi clearance is needed (through visual aids on the airport surface).	**REQ-02.W2.21.4-SPRINTEROP-AL01.0180** The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0181 The Taxiway Centreline Light shall be switched off behind the mobile as it progresses along its route.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0210 Taxiway and apron stop bars shall be switched on or off to control the movement of a mobile along its cleared route.	Guidance – Light commands – Stop bars

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	REQ-02.W2.21.4-SPRINTEROP-AL01.0250 When a Stop Bar is active, any TCL installed beyond the stop bar shall be extinguished for a distance of at least 90 m.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0280 If the solution detects a route deviation, the TCL shall be switched off.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0340 The solution shall receive information whether LVPs are in force.	Controller HMI
	REQ-02.W2.21.4-SPRINTEROP-AL01.0010 The Taxiway Centreline Lights shall be switched on in front of a mobile to configurable distances, after an electronic taxi, Line Up, Cross, Enter, Tow or Proceed Clearance input have been performed	[Guidance – Light commands – AGL system]
	REQ-02.W2.21.4-SPRINTEROP-AL01.0380 The taxiway or apron stop bar in front of an aircraft shall switch off following the input of a Taxi clearance by the Tower Controller via the Electronic Clearance Input.	[Guidance – Light commands – Stop bars]
SRS 007 The solution shall enable ATC detection of conflicting situations on taxiways where taxi clearance is needed (involving aircraft, vehicles, and obstacles).	**REQ-02.W2.21.4-SPRINTEROP-SDU1.0001** When the solution detects a conflicting situation, the Controller shall be provided with information that a conflict is detected, who has priority, and where the predicted conflict is, preferably without having to make input to the system	Controller HMI

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	REQ-02.W2.21.4-SPRINTEROP-AL01.0140 When a mobile's TCLs are being restricted in order to prioritise converging mobiles at intersections or to avoid a deadlock situation, the Controller shall be provided with information indicating the last lit TCL.	Controller HMI
	REQ-02.W2.21.4-SPRINTEROP-AL01.0290 The Tower Controller shall receive an Alert when an aircraft is moving on a taxiway without having received a TAXI instruction. This includes when it is being guided by a means such as activated TCL (Follow the Greens) and it overruns the activated TCL.	[Controller HMI]
	REQ-02.W2.21.4-SPRINTEROP-AL01.0040 The Controller shall be provided with the information on lit Taxiway Centreline Lights on the solution HMI.	Controller HMI
	REQ-02.W2.21.4-TS-INTEROP.0080 The AGL system shall send the TCL status (on/off/other) to the Controller HMI.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-TS-PERF.0002 The Controller HMI shall indicate that TCL are switched on/off with a latency that is within acceptable limits from a Safety perspective.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0310 The Stop bar status (on/off) shall be provided to the Tower Controller on the A-SMGCS HMI.	[Controller HMI]
	REQ-02.W2.21.4-TS-INTEROP.0090 The AGL system shall send the stop bar light status (on/off/failure/maintenance) to the Controller HMI.	[Controller HMI]

	A001 Routing function is implemented in the ATCO HMI in order for ATCOs to safely monitor the routes and manage conflicts while using full guidance follow the greens function.	[Controller HMI]
SRS 008 The solution shall enable the provision of taxi instructions (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed	**REQ-02.W2.21.4-SPRINTEROP-AL01.0090** Priority of mobiles in conflict situations shall be based on rules, and use data such as distance from intersection, departure/arrival, TTOT, or order of electronic flight strips.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0110 The Taxiway Centreline Lights shall discontinue to be switched on in front of the appropriate mobile(s) on the taxiway when a conflicting converging situations have been detected, and give the priority to the other mobile to achieve adequate spacing between the mobiles.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0150 The Tower controller shall be allowed to swap the priority between converging mobiles or mobiles in a predicted deadlock situation.	Controller HMI
	REQ-02.W2.21.4-SPRINTEROP-AL01.0180 The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.	Guidance – Light commands – AGL system

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	REQ-02.W2.21.4-SPRINTEROP-AL01.0190 Spacing rules shall take into account if routes are merging or in-line, the types of aircraft the weather conditions, and other conditions requiring different spacing.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0050 The Tower Controller shall be able to switch on/off any stop bar individually.	[Controller HMI]

Table 22: SRD derived by mapping SRS for normal conditions of operation to Design Model Elements

Appendix F Designing the Solution Functional system for Abnormal conditions of operation

F.1 Deriving SRD from SRS

Table 23 shows how the Safety Requirements at ATS Service level (SRS) for abnormal conditions of operation derived in section 4.3 map onto the related elements of the Design Model (functional system components or interactions/data flows) and derive Safety Requirements at Design level (SRD) (functionality and performance) for abnormal conditions of operation.

SRS for Abnormal Operation	Derived SR 0xx and/or A 0xx	Map on to
SRS 009 ATCOs shall be able to provide appropriate support for managing aircrafts in abnormal conditions.	**REQ-02.W2.21.4-SPRINTEROP-AL01.0060** The Tower Controller shall be able to activate and deactivate the Full Guidance Assistance to mobiles solution	Guidance – Light commands – AGL system
	SREC 001 ATCOs should be able to manually prioritise aircrafts in emergency situations in all conflicts.	Controller HMI
	SREC 002 ATCOs should be able to stop via guidance all other aircrafts to give way for aircraft in emergency.	Controller HMI
SRS 010: The solution shall be able to provide guidance for aircrafts in abnormal conditions.	**REQ-02.W2.21.4-SPRINTEROP-AL01.0290** The Tower Controller shall receive an Alert when an aircraft is moving on a taxiway without having received a TAXI instruction. This includes when it is being guided by a means such as activated TCL (Follow the Greens) and it overruns the activated TCL.	Controller HMI
	REQ-02.W2.21.4-SPRINTEROP-AL01.0420 Operating method shall be defined in case of pilots are not able to see TCL.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-TS-SAFE.0070	Guidance – Light commands – AGL system

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	The TCL and stop bars shall have high brightness so that they can be used in daytime and sunny conditions.	
	REQ-02.W2.21.4-TS-SAFE.0080 The TCL and stop bars brightness shall be adjustable based on the conditions.	Guidance – Light commands – AGL system

Table 23: SRD derived by mapping SRS for Abnormal conditions of operation onto Design Model element

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Appendix G Designing the Solution functional system addressing internal functional system failures

This appendix presents the detailed risk evaluation and mitigation of the operational hazards identified at 4.4, performed at the level of the design of the Solution functional system.

G.1 Deriving SRD from the SRS (integrity/reliability)

For two operational hazard, top-down identification was performed. The following Fault Trees for each operational hazard show its causes and the associated mitigations should be used. It represents preventive mitigations for the operational hazard, but they might either prevent a basic cause to occur or they protect against the propagation of the basic cause effect up to the operational hazard occurrence.

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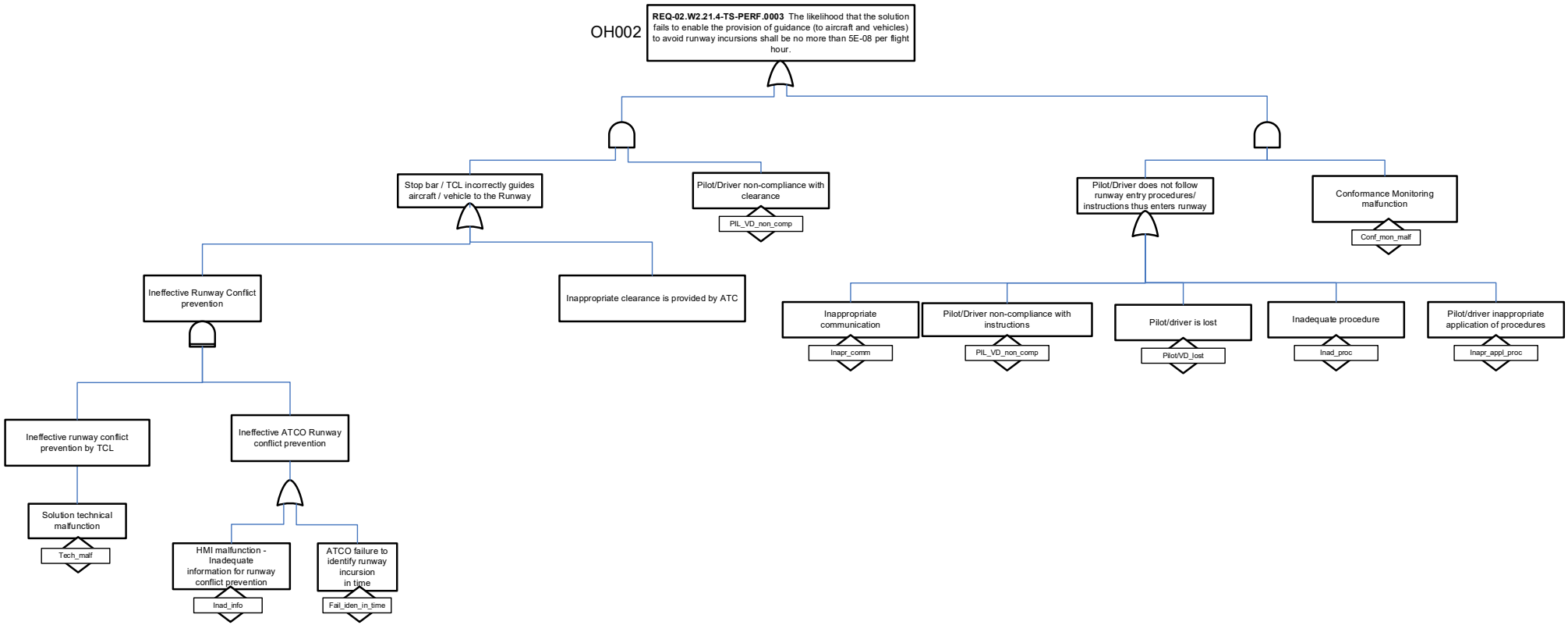

Figure 7 Causal analysis of OH 002

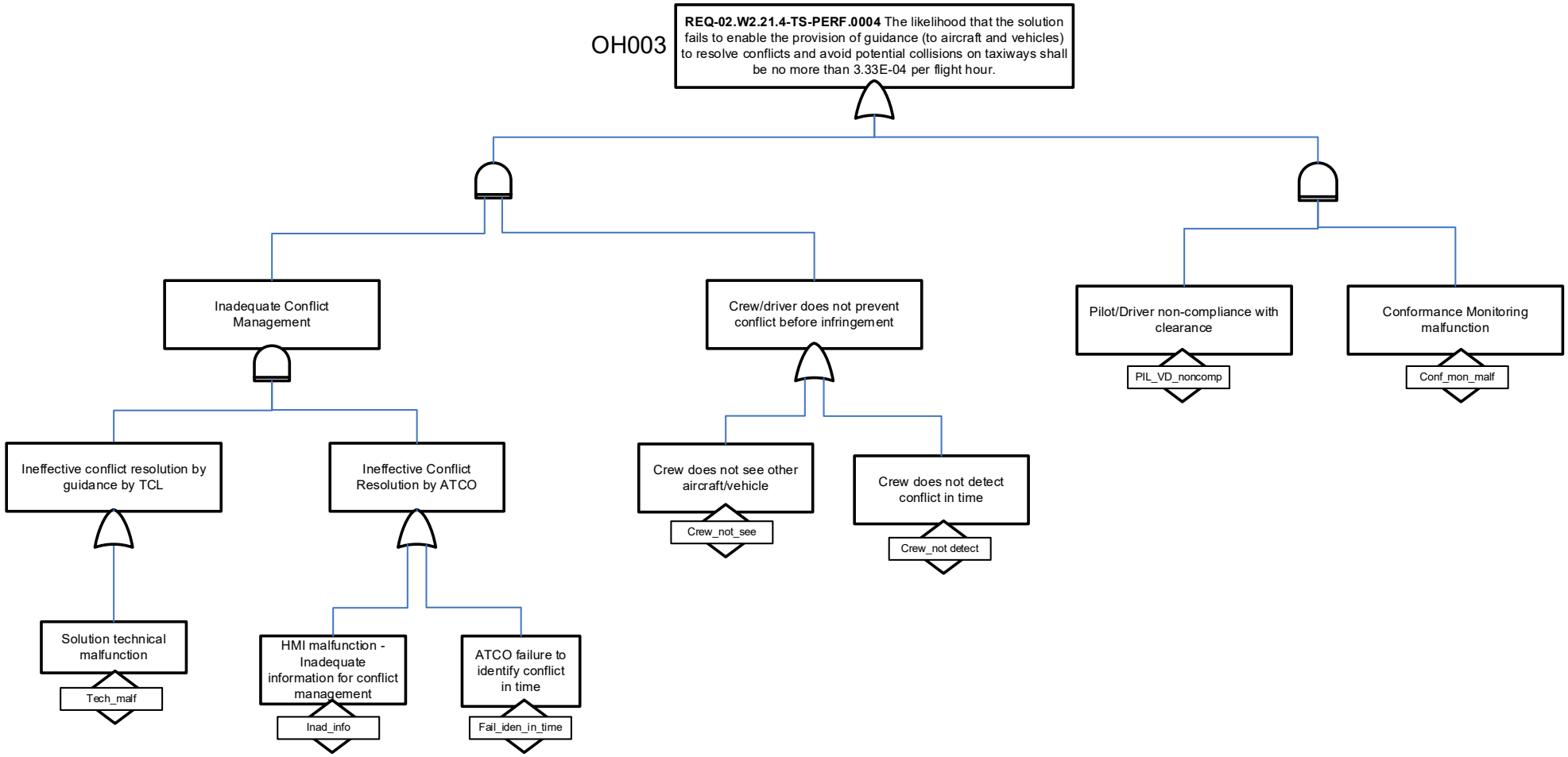

Figure 8 Causal analysis of OH 003

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Derivation of SRDs is available in Table 24. Exact likelihoods are defined only on SRS-level, and not on SRD level, these should be derived from local assessments.

SRS	Cause & description	Mitigation/Safety Requirement
SRS 014 The likelihood that the solution fails to enable the provision of guidance to aircraft and vehicles) to avoid runway incursions shall be no more than 5E-08 per flight hour.	See Figure 7	**REQ-02.W2.21.4-TS-PERF.0005** The likelihood of Solution technical malfunction shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0006** The likelihood of total/partial loss of information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0007** The likelihood of delay of information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0008** The likelihood of inadequate information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0009** The likelihood that the solution fails to provide guidance conformance monitoring on manoeuvring area (involving aircraft, vehicles). shall be operationally acceptable as per regulation applicable to local implementation.
SRS 015 The likelihood that the solution fails to enable the provision of guidance (to aircraft and vehicles) to resolve conflicts and avoid potential collisions on taxiways where taxi clearance is needed shall be no more than 3.33E-04 per flight hour.	See Figure 8	**REQ-02.W2.21.4-TS-PERF.0005** The likelihood of Solution technical malfunction shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0006** The likelihood of total/partial loss of information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0007** The likelihood of delay of information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0008** The likelihood of inadequate information for conflict management on controller HMI shall be operationally acceptable as per regulation applicable to local implementation. **REQ-02.W2.21.4-TS-PERF.0009** The likelihood that the solution fails to provide guidance conformance monitoring on manoeuvring area (involving aircraft, vehicles). shall be operationally acceptable as per regulation applicable to local implementation.

Table 24. Table detailing the fault tree causes and associated mitigations (SRD, preventing operational hazard occurrence)

G.2 Deriving SRD from the SRS (functionality & performance) for protective mitigation

The purpose is to derive SRD (functionality & performance) from the SRS (functionality & performance) that have been derived in §4.4.2 to provide mitigation against operational hazard effects (protective mitigation), with due consideration of the potential common cause failures that might affect the operational hazard causes and its protective mitigation.

Table 25 shows how the Safety Requirements at ATS Service level (SRS) functionality & performance derived in section 4.4.2 for protective mitigation map onto the related elements of the Design Model (functional system components or interactions/data flows) and derive additional Safety Requirements at Design level (SRD) (functionality and performance) for internal failure conditions of operation.

SRS (functionality & performance) for protective mitigation (ID & content)	Safety Requirement at Design level[2] (SRD) or Assumption	Maps onto
SRS 011 Controllers shall be able to handle system failures in a safe and timely manner.	**REQ-02.W2.21.4-SPRINTEROP-AL01.0330** The Tower Controller shall be informed about the status of the solution and be alerted in case of a failure.	Controller HMI
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0001Contingency procedures shall be in place in case the solution fails to guide AC and vehicle movements (through visual aids on the airport surface).	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0002ATCO training shall include contingency procedures in case of FtG failure.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0006ATCO shall be able to prevent overload and manage workload by reducing capacity in case of FtG failure.	Guidance – Light commands – AGL system
SRS 012 Controllers shall be able to handle system malfunction in a safe and timely manner.	**REQ-02.W2.21.4-SPRINTEROP-AL01.0060** The Tower Controller shall be able to activate and deactivate the Full	Controller HMI

[2] iSRD for the initial design or rSRD for the refined design

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	Guidance Assistance to mobiles solution	
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0006ATCO shall be able to prevent overload and manage workload by reducing capacity.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0001 Contingency procedures shall be in place in case the solution fails to guide AC and vehicle movements (through visual aids on the airport surface).	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0003ATCO training shall include contingency procedures in case of FtG malfunction.	Guidance – Light commands – AGL system
	REQ-02.W2.21.4-SPRINTEROP-AL01.0390 The ATCO shall be able to see the clearances / instructions on the HMI inputted into the system.	Controller HMI
	SREC 003 Runway stop bars should be switched on by default during the operation.	Guidance – Light commands – Stop bars
	SREC 004 RIMCAS alert should be implemented on A-SMGCS system.	Controller HMI
SRS 013 Training shall include operating method for runway entry and crossing.	REQ-02.W2.21.4-SPRINTEROP-SAFE.0004ATCO training shall include operating method for runway entry and crossing.	Guidance – Light commands – AGL system/Stop bars
	REQ-02.W2.21.4-SPRINTEROP-SAFE.0005Vehicle driver and pilot training shall include operating method for runway entry and crossing.	Guidance – Light commands – AGL system/Stop bars

Table 25: SRD derived by mapping SRS (functionality & performance) for protective mitigation on to Design Model Elements

Appendix H Demonstration of Safety Criteria achievability

The achievability of the Safety Criteria has been demonstrated through the satisfaction of the success criteria of the safety validation objectives defined in relation to the Solution planned validation exercises and other specific validation means (Safety and HP workshop).

The safety-related outcomes of the validation exercises (traced back to the safety validation objectives) bring an essential contribution to the demonstration of the Safety Criteria achievability by the Solution design. Decision for deriving (or not) additional Safety Requirements might be taken from these results (SRD to be included at §5.3.3 or §5.4.2). Indeed, an SRS functionality & performance addressing human factors or procedures might be covered by a validation exercise but the validation outcome might be that it can be satisfied only partially or even not satisfied, in which case the design should ensure adequate risk mitigation.

The safety-relevant results of the validation exercises and of any other specific validation means (Safety and HP workshop) are summarized in Table 26, whilst indicating for each safety validation objective / success criteria the extent to which the relevant SRS have been covered.

Exercise ID, Name, Goals	Exercise Safety Validation Objective & related SAC(s)	Success criterion	Coverage (SRS and/or SRD)	Validation results
OBJ-02.21.4-V3-VALP-001	To assess if the automated switching of Taxiway Centreline Lights (TCL) provides guidance to an individual mobile. SAC#1 SAC#2	CRT-02.21.4-V3-VALP-001-001 According to the ATCOs the TCL operates correctly in conjunction with the electronic clearance –TAXI, LINE UP, CROSS.	SRS 001-003, SRS 006	**OK -** All ATCOs agree that the TCL operated correctly for a single mobile at crossings, line up and with clearances.
		CRT-02.21.4-V3-VALP-001-002 According to the ATCOs the TCL on runway exits are correctly activated for an aircraft on approach		**OK –** Only one of the ATCOs somewhat disagreed that the Taxiway Centreline Lights on runway exits were correctly activated for an aircraft on approach but this opinion could have been related to simulation platform issues or to the fact that pseudo pilots were not always following the greens correctly due to

				issues in their platform and were managing too many flights.
		CRT-02.21.4-V3-VALP-001-003 Based on the ATCO feedback, following a route deviation the TCL turns on correctly when a new route and clearance are input.		**OK -** Overall, all ATCOs agreed that the mobile guidance function was correctly guiding the mobile after a route modification.
OBJ-02.21.4-V3-VALP-002	To assess if the automated switching of Taxiway Centreline Lights (TCL) controls the spacing of mobiles correctly in converging situations where the required separation between them would not be achieved. SAC#2	CRT-02.21.4-V3-VALP-002-001 According to ATCOs the TCL applied the correct spacing between mobiles converging at a junction.	SRS 005, SRS008	**P-OK –** According to ATCOs sometimes the sequencing between two conflicting aircraft were in the wrong order compared to the "logical" solution, but only rarely.
		CRT-02.21.4-V3-VALP-002-002 ATCOs confirm the adequacy of the sequencing logic (i.e. priority rules).		**OK –** According to ATCOs sometimes the sequencing between two conflicting aircraft were in the wrong order compared to the "logical" solution, but only rarely. There was at least one occasion when a vehicle was prioritized over an a/c taxiing in the solution scenario.
		CRT-02.21.4-V3-VALP-002-003 The ATCOs can swap priorities efficiently and effectively.		**P-OK –** The majority of ATCOs were in general able to swap priorities however they mentioned that the functionality was far from optimal.

OBJ-02.21.4-V3-VALP-003	To assess if the automated switching of Taxiway Centreline Lights (TCL) control the flow of mobiles taxiing in sequence or queuing at a holding point correctly in all normal visibility and LVP conditions. SAC#1 SAC#2	CRT-02.21.4-V3-VALP-003-001 According to ATCOs the TCL triggers correct spacing between mobiles taxiing/queuing in sequence on a taxiway in normal visibility conditions.	SRS 005, SRS 008	**OK**- Only one ATCO mentioned he was not so pleased that sometimes the second a/c was let too close to the one in front. In normal VMC condition scenario they went too close to each other. In similar situations, sometimes the system kept the same distance and the ATCO felt that the spacing was not a consistent.
		CRT-02.21.4-V3-VALP-003-002 According to ATCOs the TCL triggers correct spacing between mobiles taxiing/queuing in sequence on a taxiway in low visibility conditions.		**POK** – Some ATCOs mentioned that the spacing applied in LVP between mobiles taxiing/queuing in sequence on a taxiway was not acceptable. Some of them mentioned based on spacing it felt like it was a normal VMC operation. Also ATCOs felt that the spacing application was not a consistent all the time.
		CRT-02.21.4-V3-VALP-003-003 According to ATCOs the TCL applied correct spacing between mobiles queuing in sequence at a holding point.		**OK** – Only some ATCOs mentioned that the spacing applied in LVP between mobiles queuing in sequence at a holding point. was not acceptable. Some of them mentioned based on spacing it felt like it was a normal VMC operation. Also ATCOs felt that the spacing application was not a consistent all the time.
OBJ-02.21.4-V3-VALP-004	To assess if the automated switching of Taxiway Centreline	CRT-02.21.4-V3-VALP-004-001	SRS 005, SRS 008	**OK** - All ATCOS agreed that the guidance function correctly switched the TCL to

	Lights (TCL) correctly controls the flow of mobiles approaching a bi-directional taxiway where a deadlock situation was predicted. SAC#2	The Controllers feedback indicated that the function correctly switched the TCL to avoid a deadlock situation on a bi-directional taxiway.		avoid a deadlock situation on a bi-directional taxiway. Although based on observation in some cases incorrectly working TCL would have guided mobiles into a deadlock situation during the simulation ATCOs were able to detect and prevent a taxiway conflict in time.
OBJ-02.21.4-V3-VALP-005	To assess if the automated switching of stop bars operates correctly when linked to the input of electronic clearances. SAC#1 SAC#2	CRT-02.21.4-V3-VALP-005-001 According to the ATCOs the Stop Bars positioned on Taxiways and Aprons operate correctly in conjunction with electronic clearance -TAXI.	SRS 001-003, SRS 006	The validation platform was set up with only stop bars at runway entries, so criterion CRT-02.21.4-V3-VALP-005-001 could not be validated
		CRT-02.21.4-V3-VALP-005-002 According to the ATCOs the Stop Bars positioned at Runway holding Positions operate correctly in conjunction with Electronic Clearances –LINE UP, CROSS, ENTER, TAKE OFF.		**OK** -All ATCOs agreed that the Stop Bars positioned at Runway holding Positions operate correctly in conjunction with Electronic Clearances.
		CRT-02.21.4-V3-VALP-005-003 According to the ATCOs the Stop Bars positioned at Runway holding Positions operates correctly in conjunction with the electronic clearance -CONDITIONAL LINE UP.		Conditional clearances like cleared to line up behind landing aircraft was not implemented in the validation platform, so CRT-02.21.4-V3-VALP-005-003 could not be validated

		CRT-02.21.4-V3-VALP-005-004 According to the ATCOs turning stop bars off and TCL on is sufficiently quick.		**OK** – The criterium was positively validated however AGL and stop bars were stimulated.
		CRT-02.21.4-V3-VALP-005-005 When the Automated Switching of Stop Bars function is illuminating a stop bar, any TCL installed beyond the stop bar is extinguished for an adequate distance.		**OK** – The criterium was positively validated however only limited to runway entry stop bars.
OBJ-02.21.4-V3-VALP-007	Assess the adequacy of the phraseology SAC#1 SAC#2	CRT-02.21.4-V3-VALP-007-001 Phraseology is judged as being appropriate for all encountered operating conditions	N/A	**OK** - The FtG full guidance phraseology was considered appropriate but for the degraded scenarios some further wording might need to be implemented and simplified in order to manage workload related to communication and avoid miscommunication. According to pilots it would be helpful if the ATCO phraseology can integrate some other important operational aspects (i.e. priority information in certain crossings).
OBJ-02.21.4-V3-VALP-010	Assess the efficiency and effectiveness of the manual route modification.	CRT-02.21.4-V3-VALP-010-001 The ATCO can select between route proposals when editing a route.	N/A	N/A

	SAC#2	CRT-02.21.4-V3-VALP-010-002 The ATCO has quick access to route proposals on the HMI.		N/A
		CRT-02.21.4-V3-VALP-010-003 The ATCO can quickly modify a route by selecting a different route element in other parts of the HMI than the radar view (a flight strip or a radar label).		N/A
		CRT-02.21.4-V3-VALP-010-004 The ATCO can edit the aircraft's route graphically (radar view) in an effective and efficient manner.		N/A
		CRT-02.21.4-V3-VALP-010-005 The guidance service is correctly guiding the mobile after a route modification.		**OK** -When a route was modified beyond the lit guiding TCL (the flight crew was not aware of it as the crew does not really know the full planned route), the situations were fine. However, when a route was modified such that already lit TCL switched off, and TCL indicating a different route suddenly disappeared the situation could be very confusing for the flight crew.

OBJ-02.21.4-V3-VALP-011	Assess Controllers acceptance of route generation when providing ATS with the automated switching of AGL and A-SMGCS Routing Service.	CRT-02.21.4-V3-VALP-011-001 According to the ATCOs the route generation is appropriate in normal visibility conditions.	N/A	N/A
		CRT-02.21.4-V3-VALP-011-002 According to the ATCOs the route generation is appropriate in low visibility conditions.		N/A
		CRT-02.21.4-V3-VALP-011-003 According to ATCOs the capability of defining the end point of a pushback, pull out, or push-pull procedure manually and independent from any pre-defined destination point provided by the A-SMGCS Routing Service is acceptable.		N/A
OBJ-02.21.4-V3-VALP-012	Assess flight crew acceptance of route generation when providing ATS with the automated switching of AGL and A-SMGCS Routing Service. SAC#1	CRT-02.21.4-V3-VALP-012-001 According to the flight crew the automated switching of AGL concept is acceptable.	SRS 001-003, SRS 005, SRS 006, SRS 008	**OK** - From safety point of view with a well described operating method (including contingency procedures) and an adequate training the automated switching of AGL concept is acceptable by pilots. However, they highlighted that in case of route modifications (changing of lit TCL) R/T communication would be still necessary and in conflicting situations

	SAC#2			extra information would be appreciated (i.e. who has priority at an intersection).
OBJ-02.21.4-V3-VALP-013	Assess airport service vehicles drivers acceptance of route generation when providing ATS with the automated switching of AGL and A-SMGCS Routing Service. SAC#1 SAC#2	CRT-02.21.4-V3-VALP-013-001 According to the airport service vehicles the automated switching of AGL concept is acceptable.	SRS 001-003, SRS 005, SRS 006, SRS 008	**OK** - From safety point of view with a well described operating method (including contingency procedures) and an adequate training the automated switching of AGL concept is acceptable by airport service vehicle drivers In case when vehicle drivers and pilots speak on a separated frequency with ATCOs Full Guidance FtG has a beneficial effect on drivers' situational awareness and safety.
OBJ-02.21.4-V3-VALP-013	Assess the impact of route generation when providing ATS with the automated switching of AGL and A-SMGCS Routing Service on safety. SAC#1 SAC#2	CRT-02.21.4-V3-VALP-014-001 ATCOs perceived level of safety is not negatively impacted by the introduction of automated switching of AGL and A-SMGCS Routing Service	SRS 001-008	**OK** - ATCOs were able to continuously monitor the operation based on the information provided by the HMI (illuminated TCLs; but routing also impacted this) and were informed well about conflicts. ATCOs confirm that the system detected most of the potential taxiway conflicts in a timely manner and if not they were able to intervene (due to route modification function). ATCOs appreciated „No FtG" and „Route deviation" alerts that worked correctly and attracted their attenion. Since the solution is basically an automatisation of ATCO tasks the most important safety aspect is related to the

				reduced situational awareness. During degraded mode (total loss of guidance) all ATCOs were able to realise what happened and take over their tasks immediately. However the traffic was not so demanding in this specific scenario that is why some of them mentioned that before implementation they would test the solution with extremely high traffic with a degraded mode. The solution was tested in LVP as well which has the most effect on safety since under 50m RVR pilots and/or vehicle drivers are not able to see each other while ATCO intervention is based only on the information provided by A-SMGCS. The scenario was handled safely but during the HAZID workshop ATCOs mentioned that a malfuntion of FtG during LVP would be an unacceptable risk. However due to the fact that in LVP ATCOs have to pay extra attention to all mobiles at the airport by regulation and they are able to continuously follow the change of illuminated TCLs on A-SMGCS there is a high chance that they would be able to detect such a malfunction in time and act before mobiles would collide. When incorrectly working TCL would have guided mobiles into a deadlock situation in some case during the simulation ATCOs

				were able to detect and prevent a taxiway conflict in time. However taking into account a key aspect that after implementing Full Guidance FtG ATCOs will be getting used to it and trust in the solution will increase the effects on the controllers in terms of taxiway/runway conflict monitroing shall be assessed carefully. Based on ATCO experience in-line spacing in LVP was not enough for providing safe distance for mobiles following each other.
		CRT-02.21.4-V3-VALP-014-002 The number of Runway Conflicts is not increased by the introduction of automated switching of AGL and A-SMGCS Routing Service		**OK** - During the real-time simulation no runway conflicts happened. However taking into account a key aspect that after implementing Full Guidance FtG ATCOs will be getting used to the solution and trust will increase the effects on the controllers in terms of runway conflict monitroing shall be assessed carefully.
		CRT-02.21.4-V3-VALP-014-003 The number of Taxiway Conflicts is not increased by the introduction of automated switching of AGL and A-SMGCS Routing Service		**OK** - Although in some cases incorrectly working TCL would have guided mobiles into a deadlock situation during the simulation ATCOs were able to detect and prevent a taxiway conflict in time. However taking into account a key aspect that after implementing Full Guidance FtG ATCOs will be getting used to the solution

				and trust will increase in it the effects on the controllers in terms of taxiway conflict monitroing shall be assessed carefully.

Table 26: Solution Safety Validation results

Appendix I Assumptions, Safety Issues & Limitations

I.1 Assumptions log

Table 30 includes all the Assumptions that were necessarily raised in deriving the Safety Requirements.

Ref	Assumption	Validation
A001	Routing function is implemented in the ATCO HMI in order for ATCOs to safely monitor the routes and manage conflicts while using full guidance follow the greens function.	

Table 27: Assumptions log

I.2 Safety Issues log

No specific issue was identified.

I.3 Operational Limitations log

No specific operational limitation was identified.

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