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SAFE

TRAFFIC ALERTS FOR PILOTS FOR AIRPORT OPERATIONS

This report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 734139 under European Union's Horizon 2020 research and innovation programme.



Abstract

This document contains the Safety Assessment Report for the Traffic Alerts for pilots in airport operations. This report intends to define the Safety Requirements in consistency with SESAR SRM. These requirements are then provided to PJ.03b-05 "Final SPR for Traffic Alerts for Pilots" (D4.1.030 part I [9]).

This document is a Final Report that reflects the status issued from

- V2 validation of Traffic Alerts on Runway performed in SESAR 1,
- Validation exercises performed for OI AUO-605 (Traffic Alerts on runways) and AUO-615 (traffic Alerts on Taxiways)

This document is updated and completed to support the Final Data Package.

SPR/OSED/INTEROP Part I is currently in-line with this Part II.

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1 Executive Summary

This document contains the Specimen Safety Assessment for a typical application of the PJ.03b-05 Solution in airport operations. The report 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.03b-05 Solution OSED/SPR/INTEROP.

This document contains the Safety Assessment Report for the Traffic Alerts for Pilots application in airport operations.

This report intends to define the Safety Requirements in consistency with SESAR SRM. These requirements are then provided to PJ.03b-05 “Final SPR for Traffic Alerts for Pilots” (D4.1.030 part I [9]).

It is the result of:

- Traffic Alerts for Pilots on runway and taxiway study in SESAR
 - Refinements of the safety methodology especially dealing with not quantifying the Human Performance in fault trees as agreed between 16.6.1 and 16.6.5 projects,
 - Results from validation exercises

This document has been completed for the Final Data Package including:

- V3 validation of Traffic Alerts on Runway esp. Safety Objectives and Safety Requirements sections,
- V3 validation of Traffic Alerts on Taxiway.

SPR/OSED/INTEROP Part I is currently in-line with this Part II.

It is noted that, as 2 implementations for runways are envisaged. SURF-A is a basic one including only warning level alerts on ground with optional Caution/Advisory in air and SURF-ITA is a more complete one with a CDTI and several levels of indications and alerts. They are both considered throughout this document.

The document has been updated for taxiway part including Traffic Alert for pilots on taxiways with TWY-ITA function.

- A new concept of alerts on taxiways
 - The functional study had been conducted in SESAR 1 and 2020 and added also to PJ.03b-05 “Final SPR/OSED/INTEROP for Traffic Alerts for Pilots” (D4.1.030 part I).

2 Introduction

2.1 Background

Runway incursions are one of the most serious safety issues for ATM.

Safety has been improved thanks to airport surface management systems: A-SMGCS is available on many major airports and ground safety nets (e.g. RWSL) start to be deployed. However, these systems are not expected to fully resolve the runway incursion risk and are not envisaged to be deployed at smaller airports. Incursion rate remains steady (~3/100.000 operations – IATA STEADES database) and events continue to occur (28 near collisions last 5 years – EASA European Plan for Aviation Safety 2018).

In addition to runway incursions a significant number of incidents / accidents occur on taxiways and apron areas. International organisations such as ICAO, EUROCONTROL and European Commission (DG TREN) have run dedicated programmes for the prevention of ground accidents. SURF-A/ITA/TWY-ITA aim to avoid these runways incursions and runway / taxiway collisions with other traffic.

2.2 General Approach to Safety Assessment

The safety assessment has been conducted in accordance with the SESAR Safety Reference Material developed by SESAR 2020 PJ19 [1] which itself is based on a twofold approach:

- A new success approach which is concerned with the safety performance of the Traffic Alerts for Pilots System supported operations in the absence of failures, ensuring that the positive contribution of the new concept to SESAR Safety Target for STEP 1 is reached, and
- A conventional failure approach which is concerned with the safety of the Traffic Alerts for Pilots System supported operations in the event of failure within the system, ensuring that the system-generated risk remains tolerable

The two approaches lead to Safety Objectives and Safety Requirements which set the minimum positive and maximum negative safety contributions of the Traffic Alerts for Pilots System.

2.3 Scope of the Safety Assessment

Scoping and Change assessment is the process, recommended by SESAR 1 SWP16.6 and SESAR 2020, to identify the main safety issues associated with PJ.03b-05 as soon as possible after an SPR/OSED/INTEROP has been updated. This SAR update is in line with the Safety Plan and Safety Assessment (as per the SRM [1]). The process identifies specified operational environment, the pre-existing hazards that are inherent in the operational environment and those hazards that are associated with potential failure modes occurring during the operation.

The report presents the assurance that the Safety Requirements defined herein are complete, correct and (from an implementation standpoint) realistic. Since the properties of the Operational Environment (OE) are crucial to the safety assessment, this assessment cannot be generic.

The SAR document covers the scope of all phases of development from V1 to V3 and provides main safety criteria, objectives and requirements. The main outcome was refinement of the V3 safety design requirements and their validation to prove the system performance.

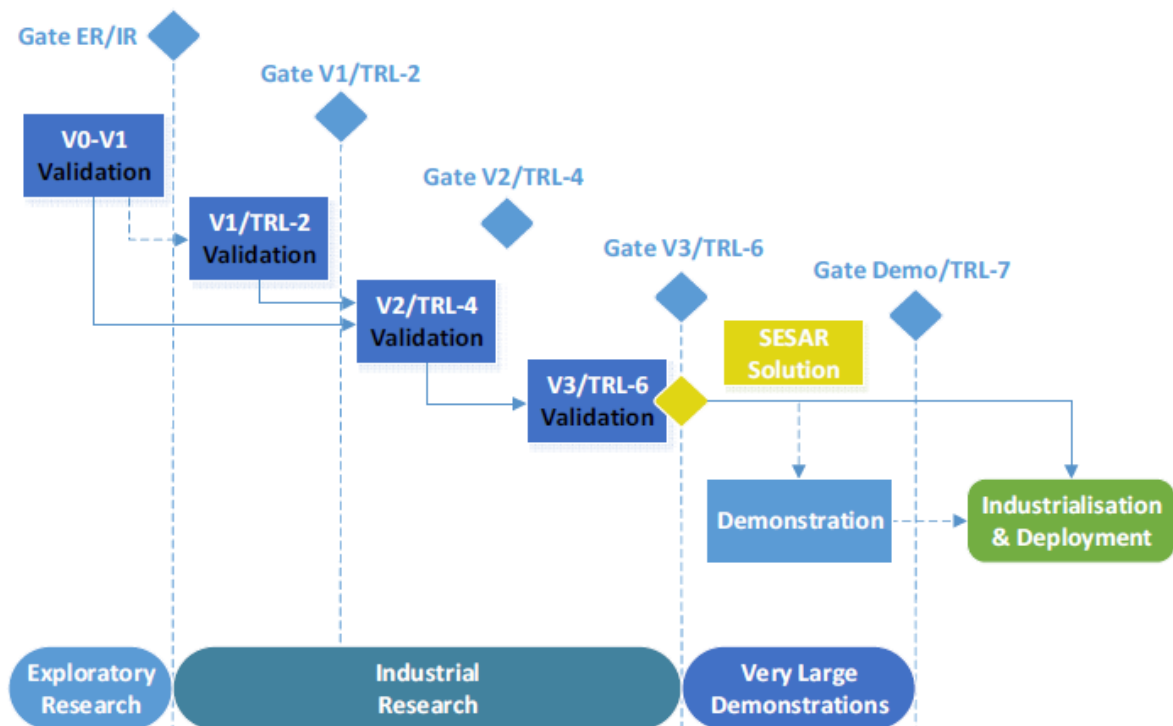


Figure 1 - Gates and phases of SESAR Solution development life cycle

2.4 Layout of the Document

The structure of this Safety Assessment Report follows the SESAR Safety Assessment Report template.

- **Chapter 1 contains a brief Executive Summary, by providing the main context and content of the solution document**
- Chapter 2 (the present section) provides general information about the SAR document
- Chapter 3 refers to the safety specifications at the OSD level
- Chapter 4 contains assurance for a safe design at SPR level
- Chapter 5 will detail activities assuring safe design at physical level.
- Chapter 6 provides with the main sources used to build up the document

Additionally, the following Appendices are provided:

Appendix A contains Accident incident model for runway and taxiway collision barrier model

Appendix A contains the OHA Table

Appendix C contains a list of consolidated requirements and assumptions.

3 Safety Specifications at the OSED Level

3.1 Scope

The SURF-ITA (Surface Indications and Traffic Alerts) is an on-board support which provides flight crew with two-stages of alerts (advisory/caution and warning level) when a condition of potential or imminent collision between ownship and a mobile is detected during runway and taxiway operations¹ (additional safety net, closer loop with direct alert to the pilots).

This section addresses the following activities:

A description of the key properties of the Operational Environment that are relevant to the safety assessment will be done in **chapter 3.2**.

Chapter 3.4 is an identification of the pre-existing hazards that affect traffic in the relevant operational environment (airport airspace and vicinity). Further in this section is an identification of the risks of which operational services may reasonably be expected to mitigate to some degree and extent.

In **chapter 3.5** the setting of the SAFETY Criteria (SAC) had been fulfilled from the PJ.03b SAFE following SESAR 1 OFA Safety Plan and SESAR P16.06.01, Task T16.06.01-006, Guidance to Apply the SESAR Safety Reference Material [1]. It has been updated during SESAR 2020 Wave 1.

Chapter 3.6 is a comprehensive determination of the operational services that are provided to address the relevant pre-existing hazards and derivation of Safety Objectives (success approach) in order to mitigate the pre-existing risks under normal operational conditions.

Chapter 3.7 identifies additional Safety Objectives in order to mitigate the pre-existing risks under abnormal operational conditions

In **chapter 3.8** an assessment of the adequacy of the operational services provided in the case of internal failures and mitigation of the system-generated hazards (derivation of Safety Objectives (failure approach) is done.

Chapter 3.9 describes impact of the SURF-A/ITA system to the ATM environment.

Chapter 3.10 shortly describes achievability of the Safety Criteria.

Chapter 3.11 provides reference to V&V activities of the SESAR 2020.

Description of implementations

This document covers 2 possible runway implementations of “Traffic Alerts for Pilots” SURF-A and SURF-ITA, and one taxiway implementation of TWY-ITA.

Runway Implementation

¹ Runway operations are assumed to start soon after an aircraft is stabilised on final approach up to enter the runway engagement zone on ground. Taxiway operations are assumed on ground and out of the runway engagement zone up to gate area.

A basic implementation SURF-A considers aircraft that have no CDTI for ground traffic. This implementation produces mainly “Warning” alerts (one advisory message can be presented to the crew during approach before triggering the warning).

A full implementation is related to aircraft equipped with display (CDTI). On top of traffic display, RTCA DO-323 [6] (SURF IA) envisages:

- Indications (RSI for Runway Status Indications, TI for Traffic indications)
- Alerts Caution and Warning

In this document, both implementations are considered with the following assumptions:

- Indications are not treated because of their lower criticality compared with alerts,
- In an alternative implementation, an advisory (no voice alert associated with visual cues) can be preferred to a real caution with voice alert but for simplicity they are considered in the same way as “advisory/caution”

So:

- A warning is the highest level of alert when an action is needed immediately,
- A caution (or advisory) is an alert to inform of a potential collision with a few seconds of anticipation.

Taxiway Implementation

An implementation of TWY-ITA, that is extending runway alerts function, considers aircraft that have display capability for ground traffic as the SURF-ITA. This taxiway implementation produces only “Advisory/Caution” alerts with display indication.

The Runway Engagement Zone (REZ) is defining border between TWY-ITA and SURF-ITA/SURF-A application needed for safety assessment. The TWY-ITA application for the safety assessment is intended outside the REZ only on the taxiway system.

The TWY-A implementation of taxiway alerts without indication is not a part of this study and document.

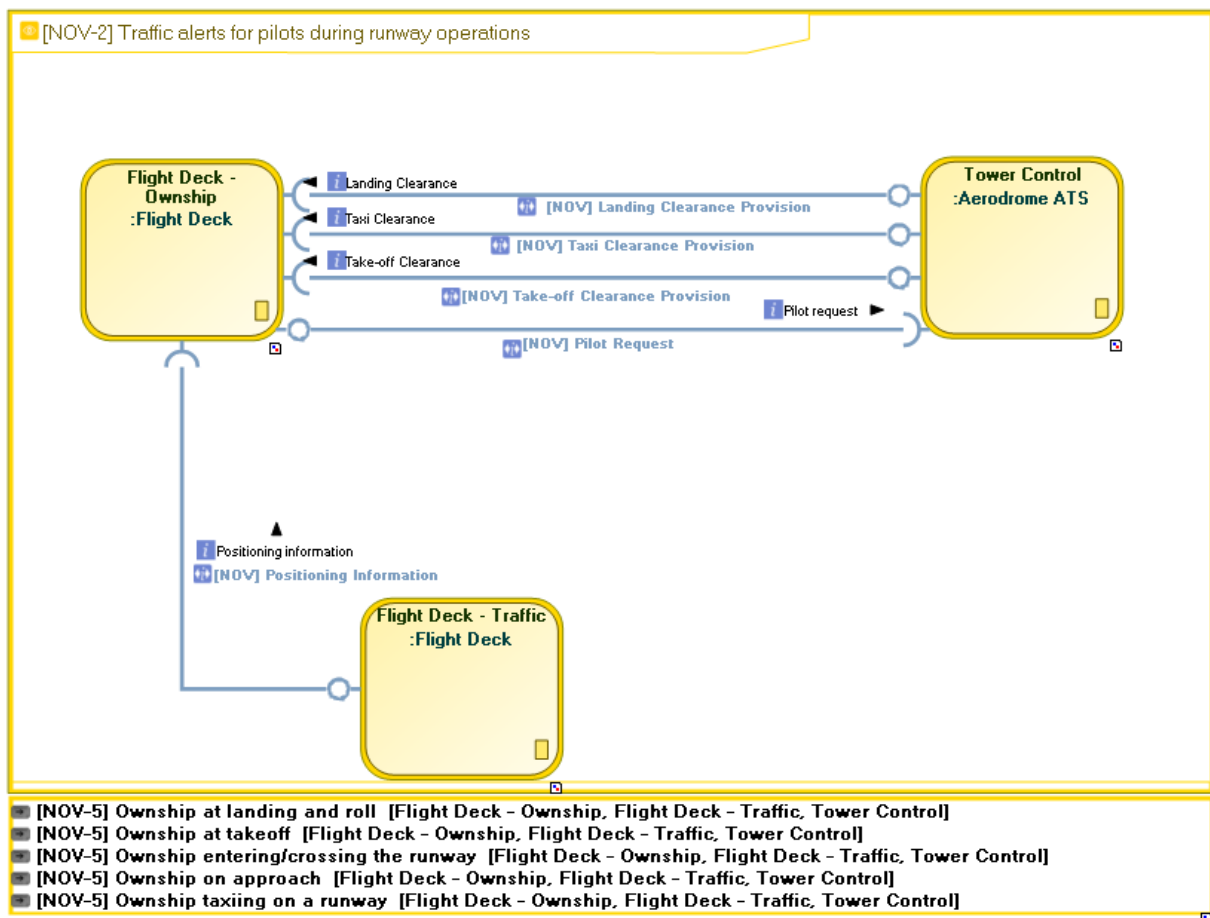


Figure 2: [NOV-2] Traffic alerts for pilots during runway operations – Operational View (MEGA Tool)

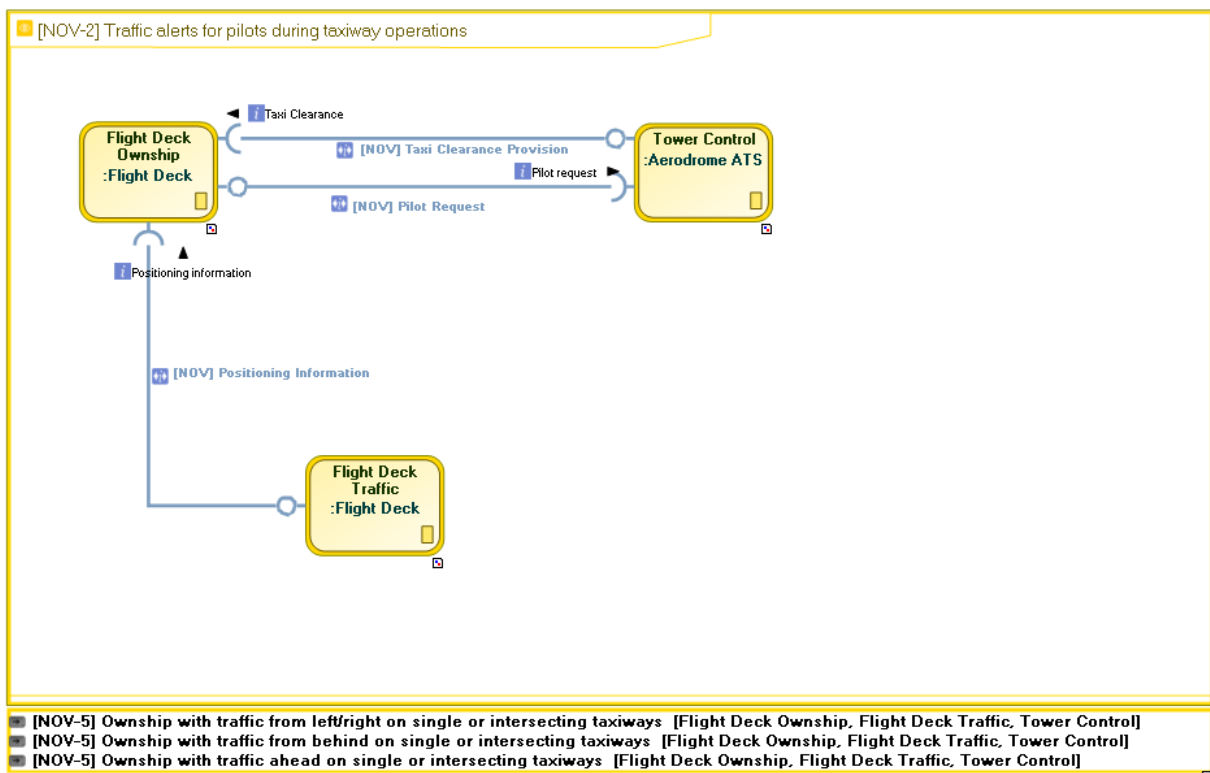


Figure 3: [NOV-2] Traffic alerts for pilots during taxiway operations – Operational View (MEGA Tool)

3.2 Traffic Alerts for Pilots Operational Environment and Key Properties

The Operational Environment defines the characteristics and properties of the environment in which “Traffic Alerts for Pilots” tool is expected to be used. It includes the type of airspace, traffic density, visibility conditions, airport layout characteristics and all of the conditions in general that can have an impact on the performance and safety benefit of the SURF-A/ITA/TWY-ITA applications.

3.2.1 Airport manoeuvring area

PJ.03b-05 “Traffic Alerts for Pilots” are focused on runway and taxiway operations. Taxiway operations solution AUO-615 has been updated to the scope of the runway solution AUO-605 in this document. SURF-ITA shall also work for airborne traffic or ownship on approach.

The application coverage volume identified for SURF-ITA should be a subset of the one defined in DO-323 [6](Area for ownship on the ground within 1500 feet of runway centerline and in the air within 3NM of the runway and below 1000ft above field elevation).

Regarding taxiway operational volume of TWY-ITA and maneuvering area it follows from DO-322 [8] definition. In general it is defined by the area out of the Runway Engagement Zone (REZ). Gate area is not assumed to be the target area for TWY-ITA application at this phase.

3.2.2 Traffic characteristics

For the scope of PJ.03b SAFE, ownship is considered as a mainline, regional aircraft or business aircraft equipped with SURF-A/ITA/TWY-ITA system, with ADS-B IN capability which can operate at controlled and uncontrolled airports. SURF-A/ITA/TWY-ITA is not intended for use on military aircraft, general aviation aircraft and helicopters. However, every ADS-B OUT equipped mobile may act as a target and trigger SURF-A/ITA/TWY-ITA alerts towards the ownship as soon as performance requirements (about integrity and reliability) are achieved.

3.2.3 On-board equipage and ground infrastructures

In order to get maximum safety benefits from SURF-A/ITA/TWY-ITA implementation, ownship should be aware of all of the nearby traffic. Aircraft are expected to be ADS-B OUT equipped (in European Airspace the mandate dates to be compliant with ADS-B OUT are June 2016 for forward fit and June 2020 for retrofit), some ground surveillance infrastructures should compensate this temporary shortage of air-to-air data exchange.

At this scope, TIS-B ground station transmits to ownship position information from mobiles not ADS-B OUT equipped, while ADS-R ground station re-broadcasts position information from aircraft which are transmitting ADS-B data on the other links (*i.e.* UAT datalink for U.S. aircraft).

Moreover, in conjunction with on-board alerting system, a ground ATC systems as Runway Incursion and Monitoring System (RIMS) or new applications as Runway Monitoring and Conflict system (RMCA), Conformance Monitoring Alerts (CMAC), Detection of Conflicting ATC Clearance (CTAC) and Runway Status Lights (RWSL) could be available on ground to detect actual or potential runway incursions and provide controllers with alerts in case of risk of potential or imminent runway collision.

A continuous cost-benefit analysis needs to be undertaken at major airports to determine whether the implementations of these ground services are cost-effective.

On the aircraft side, ownship shall be able to receive both ADS-B data from mobiles and ground surveillance services (TIS-B, ADS-R messages, when provided) to get a complete representation of all the nearby traffic. Finally, it is assumed that ATSA-SURF application and associated CDTI are available if the full SURF-ITA application is implemented

3.2.4 Traffic Density

SURF-A/ITA/TWY-ITA system can be used in every condition of airport traffic density (low, medium, high).

3.2.5 Layout characteristics

The classes identified in the European ATM Master Plan are reported in the following table

Layout Characteristics	LUSL: Low Utilisation (<90% utilisation during 1 or 2 peak periods a day) Simple Layout. • LUCL: Low Utilisation (<90% utilisation during 1 or 2 peak periods a day) Complex Layout
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	• HUSL: High Utilisation airports (>90% utilisation during 3 or more peak periods a day) Simple Layout • HUCL: High Utilisation airports (>90% utilisation during 3 or more peak periods a day) Complex Layout
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SURF-A/ITA/TWY-ITA system can be used in each of these airport layouts but the system is expected to bring maximum benefits in major airports with complex surface layout which are more demanding to be monitored by ATCo.

3.2.6 Visibility conditions

SURF-A/ITA/TWY-ITA system can be used in every visibility conditions classified as follows according to ICAO classification:

Visibility condition 1: Visibility sufficient for the pilot to taxi/to land and to avoid collision with other traffic on taxiways or runway(s) and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance.

Visibility condition 2: Visibility sufficient for the pilot to taxi//to land and to avoid collision with other traffic on taxiways or runway(s) and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance

Visibility condition 3: Visibility sufficient for the pilot to taxi/to land but insufficient for the pilot to avoid collision with other traffic on taxiways or runway(s) and at intersections by visual reference with other traffic, and insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance.

Visibility condition 4: Visibility insufficient for the pilot to taxi by visual guidance only and insufficient for personnel of control units.

The traffic density and the visibility conditions lead to twelve combinations but some are not realistically encountered and some are not very stringent for surveillance applications. Table1 depicts all possible combination with most relevant scenarios with a **dark grey** background; less realistic scenarios with a **light grey** background and non-realistic scenarios with a white background

	Vis Con 1	Vis Con 2	Vis Con 3	Vis Con 4
Low Traffic				
Medium Traffic				
High Traffic				

Table 1: Paired Visibility and Traffic Conditions

3.2.7 Normal Conditions of the Operational Environment

The first step to perform a safety assessment for “Traffic alerts for Pilots” operational concept is to define the normal operational environment, *i.e.* the baseline scenarios in which the SURF-A/ITA/TWY-ITA application is expected to perform in day-to-day operations.

For the purpose of this safety assessment, normal operational environment has been defined as follows:

Traffic Characteristics mainline, regional and business aircraft

On-board equipage and ground infrastructures: In order to maximise the safety benefits brought by the SURF-A/ITA/TWY-ITA application, we assume that in normal operational environment a significant part of traffic is visible to the ownship to reach the objective of safety improvement described in §3.5. This is linked with the following assumptions:

If TIS-B ground surveillance service is available it could help identifying mobiles not qualified by itself for SURF-A/ITA/TWY-ITA application (*e.g.* mobiles not ADS-B OUT equipped or traffic ADS-B OUT equipped without reaching the minimum performance requirements requested by the application)
ADS-R ground surveillance is considered not essential for SURF-A/ITA/TWY-ITA application
RIMS or other ground ATC systems are considered not essential for SURF-A/ITA/TWY-ITA application that is supposed to work at any airport. When fitted, it is an additional alerting system against risk of runway collisions, but the high-level safety performance target quantified is expected to be reached by the only on-board SURF-A/ITA/TWY-ITA alerting system

Traffic density: from low to high

Visibility conditions: Normal visibility conditions encompass VC1 and VC2, *i.e.* those conditions in which external visibility is still sufficient for the flight crew to acquire visually nearby traffic in order to avoid runway collisions.

Layout Characteristics: Baseline airport configurations take into account to perform this safety assessment including LUSL, LUCL, HUSL and HUCL airport surface layouts.

It is worth highlighting that the outcomes of this safety assessment are valid specifically for the normal OE defined above.

3.2.8 Abnormal conditions of the Operational Environment

See paragraph 3.7.

3.3 Airspace Users Requirements

The SURF-A/ITA/TWY-ITA application generates on-board alerts when appropriate during runway and taxiway operations.

This improvement is not to replace the existing A-SMGCS Level 2 RIMS (on ATC side) but rather to complement and provide an extra layer of safety to prevent incidents from occurring. In addition, the on-board application is intended to work at any airport not depending on ground equipment.

Two different types of runway alert are identified and shall be implemented:

Warning alerts shall be triggered when the SURF-A/ITA system detect a situation which can lead to an imminent runway collision between ownship and a mobile within a Runway Engagement Zone (REZ). In this case the alert requires an immediate pilot action.

Optional: Advisory/caution alerts shall be triggered when the SURF-ITA application detects a situation which can lead potentially to a runway collision between ownship and a mobile within a Runway Engagement Zone (REZ). In this case the purpose of the alert is to draw crew's attention to timely evaluate the situation before performing any action.

There is one type of taxiway alert identified:

Advisory/Caution alerts shall be triggered when the TWY-ITA application detects a situation which can lead potentially to a taxiway collision between ownship and a mobile on ground out of the Runway Engagement Zone (REZ). In this case the purpose of the alert is to draw crew's attention to timely evaluate the situation before performing any action.

Warning and Caution alerts consist of an auditory signal produced inside the cockpit and a visual representation of the threat highlighted on display whereas advisory consists only on visual alert on display.

3.4 Relevant Pre-existing Hazards

The pre-existing hazards that the ATM has to mitigate when considering airport operation and the conflicting ATC clearance System are as follows:

Hp#1 : Situation in which the trajectories of two a/c are in conflict on the Runway Engagement Zone (REZ).

Hp#2 : Situation in which the trajectories of two a/c are in conflict on the taxiway system.

By definition, these hazards exist in the Operational Environment before any form of de-confliction has taken place. It is, therefore, the primary purpose of the Traffic Alerts for Pilots to mitigate those hazards such that the SAFETY Criteria is satisfied.

Pre-existing hazards relative to collision with vehicles are not in scope of this SAR/SPR version. Due to missing legislative and integrity requirements, it is recommended to be addressed/reviewed in further steps of industrialization/implementation from legislative, operational and algorithm design aspects.

3.5 Safety Criteria

The SES High-Level goal vs. 2005 is to enable 3-fold increase in ATM capacity. The table below puts in comparison the number of fatal accidents per year for an hypothetical "do nothing case" in which no change are made in ATM with respect to 2012.

N° of accidents / year	RWY-Col	TWY-Col	TOTAL SESAR scope
AIM-2017 (Baseline)	0.21	0.00	0.72
Do Nothing case (2035)	0.27	0.01	1.47
SESAR Changes (with traffic) – after SESAR1	0.23	0.00	1.08

Table 2: Estimations of N° of accidents per year for each scenario and per type of accident (extract)

According to Validation Target Allocation for SESAR2020 ref. D4.8 developed by PJ19, it was estimated that SESAR 2020 solution PJ.03b-05 “Airport Safety Net - Traffic alerts for pilots for airport operations” is mainly safety-driven. The objectives for safety are the following:

	% contribution to SESAR 2020	Solution Validation Target (PJ.03b-05)	SAFETY Validation Targets per Influence Factor	
			RWY-Col	TWY-Col
Objective	4,84 %	- 1,46 %	- 1,40 %	- 0,06 %

This global positive safety contribution (4,84%) in reducing the number of fatal accidents (of all types) per year in the ECAC area identified by PJ19 has been apportioned in each function of the project PJ.03b-05 (RWY-Col and TWY-Col) as Safety Validation Targets. These percentages represent the reduction in the “total number of fatal accidents per year” per influence factor due to SESAR 2020 improvements with respect to an hypothetical “do nothing” case, in which no changes are made to ATM safety of the Baseline (2005) while traffic is allowed to increase until it reaches the capacity level targeted for SESAR in 2035.

No credit is taken from the SESAR 1 phase for this solution as there were no technical implementation of the solution on flying aircraft in this first phase.

Note: for SESAR2020, the validation target for Safety is set to be consistent with a potential increase of very large, large and medium airport capacity of 25,6% in 2035 with respect to baseline (2012). According to the European ATM Master Plan from 2015 a traffic growth of about 50 % is expected between 2012 and 2035 (from 9.5 million flights in 2012 to 14.4 million flights in 2035).

The collision risk AIM models within ATM definition have been added together with on-board definition assessment for both PJ.03b-05 Runway and Taxiway parts. The SACs below are thus derived from the global SESAR 2020 objectives.

3.5.1 SAC#01 Runway Safety Criterion

SURF-ITA application impacts only the Pilot Runway Collision Avoidance barrier (B1) of the Accident Incident model (AIM) for the Runway Collision (see Appendix E)

1) SAC#01

SAC definition for ATM contribution within ECAC region for runway Barrier B1 (RP1 imminent runway collision) is using SESAR 2020 validation targets based on PJ19.4 assumption due to limited SVT project inputs.

There shall be an improvement 7,5 % of barrier B1 (Pilot Runway Collision Avoidance) to reduce runway collisions per year due to the introduction of the PJ03B-05 runway solution, despite of the traffic increase till 2035.

This value has been derived from multiplication of the baseline P(B1 to fail) with 92.5%.

2) On-board SAC definition and assumption:

According to IATA Safety Report 2016 runway collisions represent around 5% from total accidents. They did not cause a fatal accident in the period 2012-2016 but that value will be further used as it has been judged realistic. Despite the technical solution does not rely on ATM intervention, it has been assumed that a reduction of the total number of fatal accidents will proportionally reduce the number of fatal accidents with ATM contribution.

Based on AIM model it is 29% of RWY collision accidents out of all ATM contribution accidents in ECAC region.

The RWY-Collision solution is to reduce the total number of fatal accidents per year by 1,40 %. Given the proportion of runway collisions in the total number of accidents, this Pilot Runway Collision Avoidance barrier (B1) must be improved by x in the corresponding timeframe (2005-2035), with x evaluated at:

$$\left\{ \begin{array}{l} N_{RC} = 5\% \times N_{TOT} \text{ and } N'_{RC} = 5\% \times N'_{TOT} \\ N'_{TOT} = (1 - 1,4\%) \times N_{TOT} \\ x = \frac{N'_{RC}/N'_{TOT}}{N_{RC}/N_{TOT}} \\ x = \frac{N_{TOT} - N'_{TOT}}{N_{RC}} = \frac{1,4\% \times N_{TOT}}{N_{RC}} = 1,4\% \times \frac{1}{5\%} \approx 28\% \end{array} \right.$$

where:

NTOT = no. of fatal accident p.a. (in 2035, do nothing case)

N'TOT = no. of fatal accident p.a. (in 2035, after SESAR solution implementation)

NRC = no. of fatal runway collisions before PJ.03b-05 implementation

N'RC = no. of fatal runway collisions p.a. after PJ.03b-05 implementation (considered fully deployed in 2035)

x = reduction of number of fatal runway collisions following to PJ.03b-05 implementation

The SESAR 2020 developed technical solution has been developed to cover all the situations considered in the B1 Pilot Collision Avoidance Barrier Model of the AIM. This means that when the system fulfils its function, the crew is warned enough in advance of a threat and this warning does not rely on any visual (out the window) detection by the crew. The only use cases where the solution may be of no help is when the avoidance is impracticable or the crew fails to avoid the other aircraft (17,2 % of the situations). Thus the need to improve the Barrier by 28% means a $28\% / 82,8\% = 34\%$ improvement in the risk of collision at the technical solution level.

So we finally can state, in a conservative manner, the implementation of the Traffic Alerts for Pilots tool shall bring, by itself, 60% of the overall 28% PJ.03b reduction of the number of runway collisions that is:

$60 \times 34/100 \approx 20\%$ decrease of the number of Runway Collisions due to Traffic Alert for Pilot tool

In determining the above Safety Criterion, the success approach has been applied in accordance with the new SESAR methodology, aiming to quantify the positive safety contribution brought by SURF-ITA application.

However, due to the complexity and the novelty of the new operational concept, it is important to highlight that the quantitative measure calculated above (20%) is just a theoretical value based on a number of assumptions and statistic data but currently not supported by any experimental data.

The exercises performed:

- In SESAR 1 (D11 Validation Report for Traffic Alerts for Pilots – [10]SESAR PJ03B-05 V3 SPR-INTEROP/OSED - Part II - Safety Assessment Report)
- Current SESAR 2020 wave 1 (D4.1.180 Validation Report for Traffic Alerts for pilots [11]),
 - Fast Time Simulation,
 - Real Time Simulation in realistic simulators with Pilot-In-the-Loop experiments,
 - Flight Test trial
 - Real RWY cases analysis

They have confirmed the potential efficiency of Traffic alerts to avoid a collision in scenarios typical of events that occurred. So, the objective of a 1,40% (ATM)/ 20% (A/C) reduction seems achievable. As it is a target allocated to the aircraft system, and it is assumed to be able to detect more conflicts, the overall objective could be better than the one presented above.

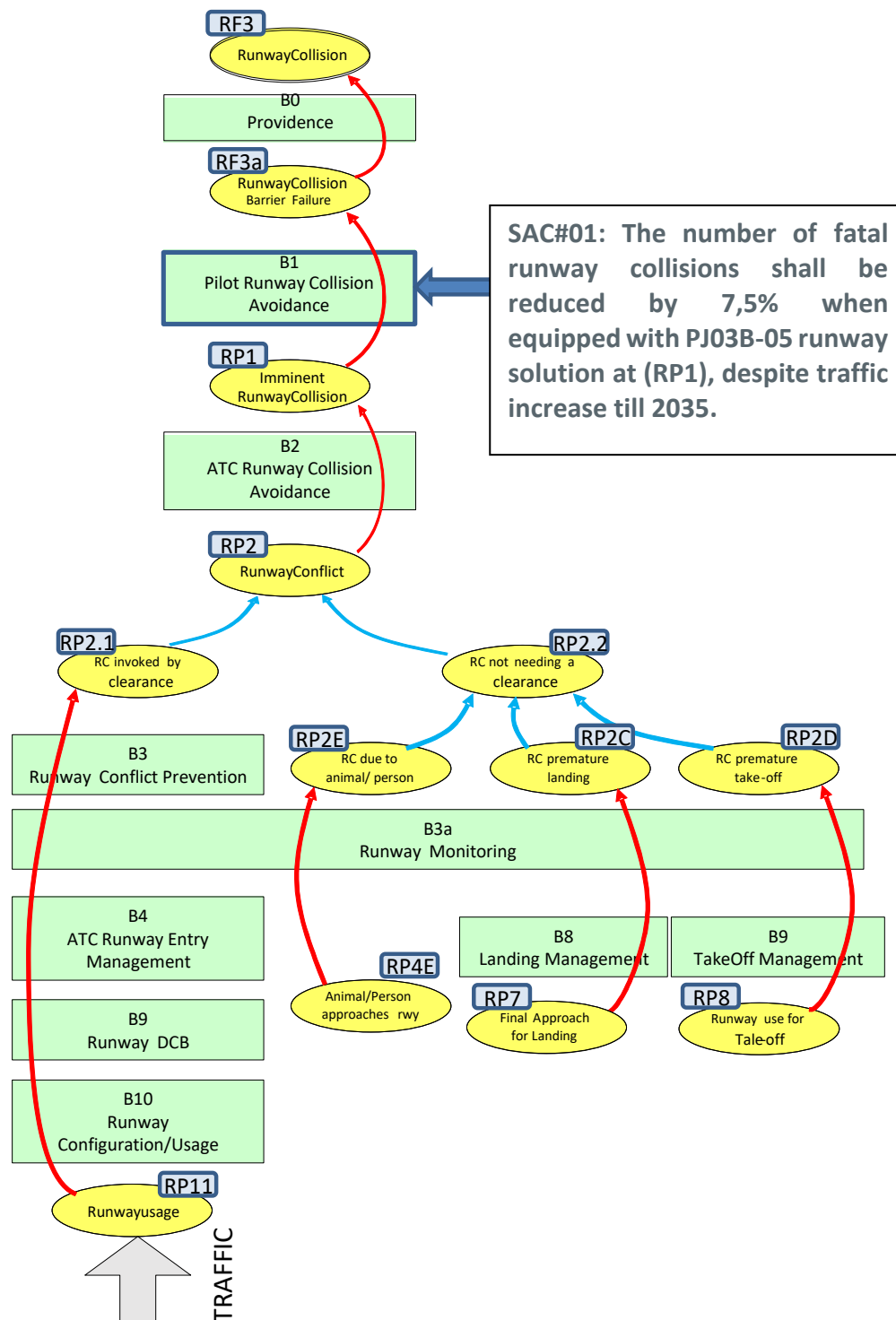


Figure 4: AIM Runway Collision Barrier Model (simplified)

3.5.2 SAC#02 Taxiway Safety Criteria

As per the allocation done within the SESAR Performance Framework, PJ.03b SAFE following from the PJ.03b “Airport Safety Nets” is expected to provide an overall safety improvement of 4.84% (safety improvement meaning, as explained above, reduction of potential number of fatal accidents per year with respect to a hypothetical “do nothing case”).

These values have been determined taking into account the traffic increase foreseen as described in section 3.5.1. Within the SESAR 2020 programme, this has been taken to mean 80-100% increase in IFR movements for Airspace environments and 5-10% runway throughput increase for Airport environments – in consistency with the respective Airspace and Airport capacity targets for 2035 (SRM). That impacts also traffic environment on airport taxiway system and its throughput.

In order to obtain these safety benefits defined above, the following improvements are needed in the performance of the barriers of AIM listed here after:

TWY-ITA application impacts only the Pilot Taxiway Collision Avoidance barrier (B1) of the Accident Incident model (AIM) for the Taxiway Collision (see Figure 5).

1) SAC#02

SAC definition for ATM contribution within ECAC region for taxiway Barrier B1 (Pilot Taxiway Collision Avoidance) is using SESAR 2020 validation targets based on PJ19.4 assumption due to limited SVT project inputs.

There shall be an improvement 5 % of barrier B1 (Pilot Taxiway Collision Avoidance) to reduce taxiway collisions per year due to the introduction of the PJ03B-05 taxiway solution, despite of the traffic increase till 2035.

2) On-board SAC definition and assumption:

The safety on airports’ taxiways is enhanced by means of safety nets tools as they provide better traffic situational and alerting awareness. Traffic alerts for pilots solution brings complementary safety barrier to other Airport Safety Nets solutions.

Taxiway accidents have some impact to aircraft damages, injuries, costs and air traffic flow management and would be required to be reduced with Airport Safety Net, but the definition of fatal accidents is not fulfilled.

Using similar SESAR methodology as runway part for on-board solution, the taxiway fatal accidents and collision improvements would target **0.72%** expected value of reduction for fatal accidents on taxiways.

The statistics show minimum fatal accidents due to low speed operation and approximately 50% of reported accidents between two aircraft, where the Traffic Alerts For Pilots tool could help pilot to avoid taxiway collision.

Based on the statistics of all taxiway collision cases where the TWY-ITA would be applicable, it is be appropriate to propose definition from overall taxiway incidents/accidents where we can calculate x % (*percentage of reduction of Taxiway Collisions following PJ.03b-05 implementation*) :

$$\begin{cases} Ntc = 0,50Ntot \\ 0,95Ntot = N'tc + 0,50Ntot \end{cases}$$

where:

Ntot = no. of taxiway accidents p.a.

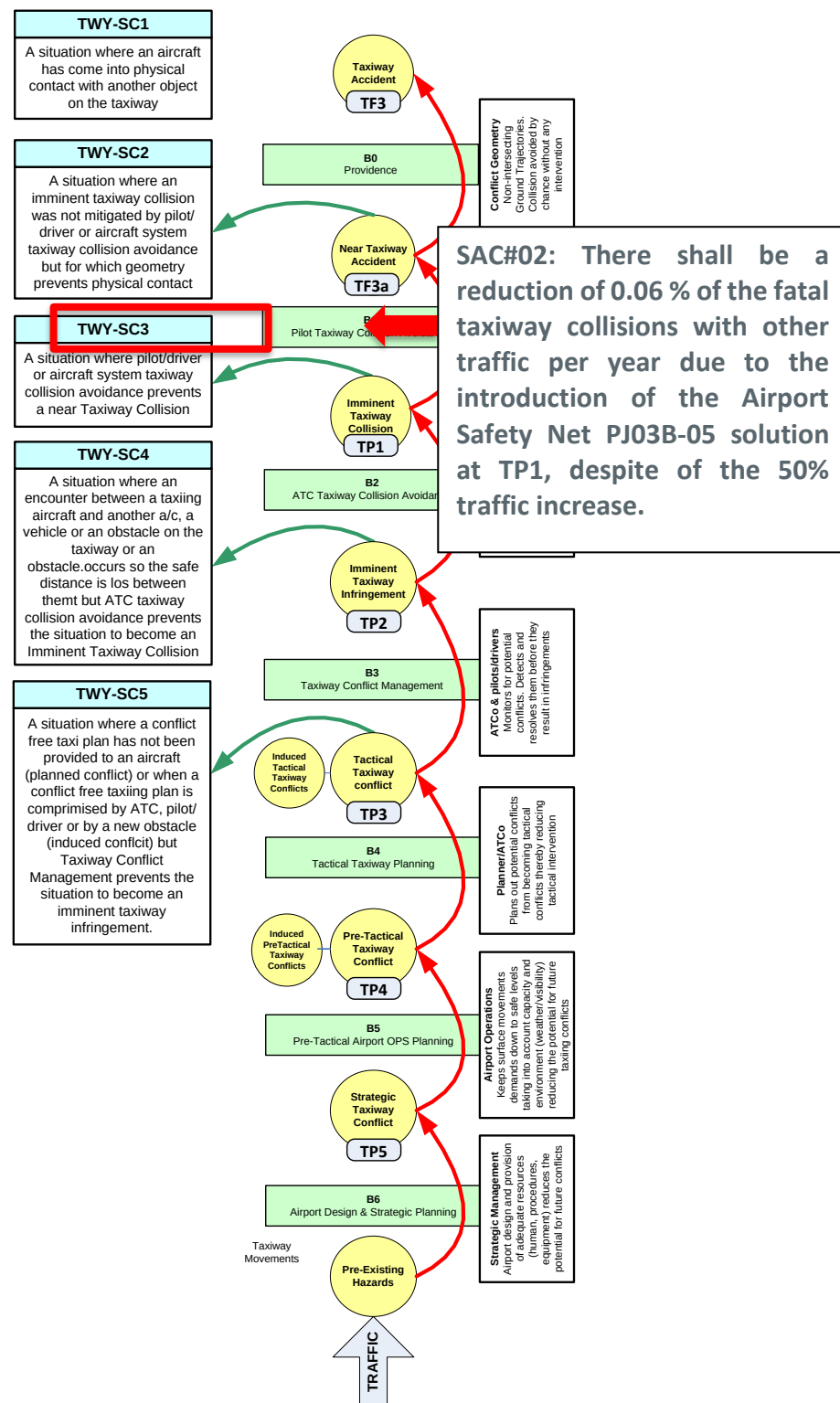
N'tc = no. of taxiway collisions p.a. after PJ.03b-05 implementation

x = reduction of no. of taxiway collisions following to PJ.03b-05 implementation

$$X\% = \frac{Ntc - N'tc}{Ntc} \times 100 = \frac{0,5 - 0,45}{0,5} \times 100 \approx \mathbf{10\%}$$

Note: The statistical data and analysis includes already the factor of pilots contribution, therefore there is no further impact on final result.

It is important to highlight that the quantitative measure calculated above is just a theoretical value based on a number of simplistic assumptions and statistical data.



Severity Class Scheme for Taxiway Collision
AIM TWYCoI BARRIER MODEL v0.2a

Figure 5: Taxiway Collision Barrier Model

3.5.3 Summary of Safety Criteria

The Accident Incident Model (AIM) for the Runway and Taxiway Collision (see Guidance D in [2]) has been used to derive the following Safety Criteria (SAC):

SAC#1 : There shall be an improvement 7,5 % of barrier B1 (Pilot Runway Collision Avoidance) to reduce runway collisions per year due to the introduction of the PJ.03b-05 runway solution, despite of the traffic increase till 2035.

In this safety criterion, both implementations SURF-A/ITA are considered.

SAC#2 : There shall be an improvement 5 % of barrier B1 (Pilot Taxiway Collision Avoidance) to reduce taxiway collisions per year due to the introduction of the PJ.03b-05 taxiway solution, despite of the traffic increase till 2035.

In this safety criterion, TWY-ITA implementation is considered.

3.6 Mitigation of the Pre-existing Risks – Normal Operations (Success approach)

The purpose of this section is to determine what operational services are provided to prevent runway and taxiway conflict, and to derive Safety Objectives (success approach) in order to mitigate the pre-existing risks under normal operational conditions - i.e. those conditions that are expected to occur on a day-to-day basis.

3.6.1 Operational Services to Address the Pre-existing Hazards

The following Operational Services are provided when considering the Traffic Alerts for Pilots System, in order to address the above pre-existing hazards sufficiently to satisfy the Safety Criteria (SAC#01 and SAC#02).

ID	Service Objective	Pre-existing Hazards [Hp xx]
PCRwy1	Prevent collision between aircraft within the Runway Engagement Zone (REZ).	Hp#1 Situation in which the trajectories of two a/c are in conflict on the Runway Engagement Zone (REZ).
PCTwy1	Prevent collision between aircraft on the TWY, out of the REZ	Hp#2 Situation in which the trajectories of two a/c are in conflict out of the Runway Engagement Zone (REZ).

Table 3: ATM and Pre-existing Hazards

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

As mentioned in 3.5 the only safety barrier impacted by the Traffic Alerts for Pilots system is the Pilot Runway Conflict Avoidance (B1) and Taxiway Conflict Avoidance (B1). The success-case Safety Objectives are derived to improve this safety barrier in order to meet the SAFETY Criteria (SAC#01 and SAC#02).

3.6.2.1 Runway Safety Objectives

The runway Safety Objectives are derived using the description of a typical Runway Engagement Zone (REZ), where different mobiles (aircraft and vehicles) want to access. The taxiway safety objectives are derived for taxiway system out of the REZ where other mobiles want to access or operate based on the airport surface management. The Traffic Alerts for Pilots System provides alerts to the pilots during runway and taxiway operations. A consolidated list of the Safety Objectives is available in Appendix A of this document.

In the success approach, safety objectives in normal operations for SURF-ITA are:

SO#101 Provide an alert in case of risk of collision

SURF-ITA shall detect the risk of collision with a probability of 70%

This value is derived from SAC and is in line with the overall target.

No apportionment is done among the different situations and use cases described in the OSED.

SO#102 Improve pilots' awareness (Optional) for SURF-ITA indications, caution.

Another overall Safety Objective is added to refine the scope of the function:

SO#103 SURF-ITA shall work as a supplemental means of safety to current operations.

This is to remind that any additional function, especially safety net, must not bring any reduction of safety as a counter part of its improvement e.g. leading to increase the risk of collision by an inappropriate human reaction following an alert.

The following table gathers the safety objectives derived from the use cases covered by SURF-ITA.

Ref	Phase of Flight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
	PCRwy1	Pilot Runway Collision Avoidance (B1)	Overall objectives: SO#101 Provide an alert in case of risk of collision SURF-ITA shall detect the risk of collision with a probability above 70%* SO#102 Improve pilots' awareness on runways SO#103 SURF-ITA shall work as a supplemental means of safety to current operations.

1	PCRwy1	Pilot Runway Collision Avoidance (B1)	When the ownship is on final approach, SURF-ITA system shall timely detect the risk of runway collision caused by an aircraft lined up on the runway threshold and ready for take-off (SO#001) When ownship is entering/crossing the runway, SURF-ITA system shall timely detect the risk of runway collision with an aircraft landing, taking off or that is going to take off from the same runway (SO#003) When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if another a/c is holding on the runway ready for take-off (SO#006) When the ownship is entering/crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same ownship's runway (SO#009) When the ownship is entering/crossing the runway, SURF-ITA shall trigger an advisory/caution alert if another a/c is holding on the runway ready for take-off (SO#012) When the ownship is entering/crossing the runway and a warning alert is triggered by SURF-ITA system, the pilot shall immediately either stop the ownship or expedite vacation (SO#016) When the ownship is entering/crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat and perform appropriate action (SO#019)
2	PCRwy1	Pilot Runway Collision Avoidance (B1)	When the ownship is landing, SURF-ITA system shall timely detect the risk of runway collision caused by a mobile entering the runway ahead of the ownship (SO#002) When the ownship is lined up awaiting a take-off clearance, SURF-ITA system shall timely detect the risk of runway collision with a mobile that is entering/crossing the same runway (SO#004) When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall timely detect the risk of runway collision if a mobile is entering/crossing the runway ahead the ownship (SO#005)

			When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the same runway (SO#007) When the ownship is landing, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the runway ahead of ownship (SO#008) When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead the ownship (SO#010) When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory/caution alert if a mobile is entering/crossing the runway ahead the ownship (SO#013) When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, a go-around should be initiated under pilot's decision (SO#014) When the ownship is landing and a warning alert is triggered by SURF-ITA system, the pilot shall perform the appropriate action based on the specific situation (SO#015) When the ownship is in the low-speed regime during the take-off roll and a warning alert is triggered by SURF-ITA, pilot shall initiate a rejected take-off (SO#017) When the ownship is on final approach and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat (SO#018) When ownship is lined up awaiting a take-off clearance and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat (SO#020) SURF-ITA alerts shall be inhibited at high-speed regime during take-off roll (SO#022)
3	PCTwy1	Pilot Taxiway Collision Avoidance (B1)	SO#050 to SO#054 (for list see Appendix A)

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

(*) Probability of missed detection is the metric to measure the safety benefits of the SURF-ITA application. It has been preliminarily estimated on the basis of the assumptions adopted when setting SAC#01 (see §2.6.2.1). Missed alerts represent a reduction in SURF-ITA benefits and high rate of missed detection leads to a situation similar to today where on board alerts are not provided. This value is derived from the 60% safety improvement due to detection of Pilot Deviations and takes into account

the SURF-ITA system failures. It is based on assumptions from chapter 2.4 (no degradation at air traffic controller level or other stakeholders and 60% of runway incursions are caused by pilots deviations)

For the TWY-ITA analysis we have concluded in very similar human factors results of Pilot Deviation and Operational Errors, therefore it is proposed to re-use the above analysis focused on runway cases and final detection probabilities.

The false alert rate of SURF-A/ITA/TWY-ITA system shall not be greater than 5×10^{-4} per operation (**PO#01**)**.

*(**) This Objective is actually a Performance Objective in order to limit the increase of flight crew workload induced by nuisance/false alerts (see §2.6.2.1). Such spurious or unnecessary alerts may reduce confidence in the system and affect the operational effectiveness of the system.*

The analysis for TWY-ITA system is following from the assumption the taxiway part is an extended function of runway SURF-ITA and therefore would be required to keep the same false alert definition following from OHA severity class and requirements for overall system.

The following table shows how Safety Objectives are identified through a list of Use Cases reflecting situations where a risk of collision might happen. The SOs are presented in a matrix which links each “ownership state” being encountered by the ownship during runway operations (within the normal OE defined in paragraph 0) with the “traffic states” representing a threat for the ownship. The situations considered hereafter refer to the Use Cases defined in the Final OSED [4].

To facilitate the readability of the table the following coloured labels has been used to easily identify the typologies of the SOs:

- **Detect**: this colour indicates a situation where SURF-ITA application shall timely inform the crew about a potential or imminent risk of runway collision
- **Advisory/caution**: this colour indicates a situation where a SURF-ITA advisory/caution alert shall be triggered (if aircraft equipped)
- **Warning**: this colour indicates a situation where a SURF-ITA warning alert shall be triggered
- **Flight crew / Pilot**: this colour indicates that an action is required by the flight crew following to a SURF-ITA detection

Ownership State Mobile State	Final approach (USE CASE 1)		Landing (Flare + roll- out on Runway) (USE CASE 2)	Entering/Crossing the runway (USE CASE 3 + USE CASE 5)	Lined up awaiting a taking off clearance (USE CASE 4)	Take-off roll in low- speed regime (derived from USE CASE 4)
	Initial part of the FAS	Final part of the FAS				
a/c landing at the same runway	N/A	N/A	N/A	When ownship is entering/ crossing the runway, SURF- ITA system shall timely detect the risk of runway collision with an aircraft landing, taking off or that is going to take off from the same runway (SO#003) When the ownship is entering/ crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same ownship's runway (SO#009) When the ownship is entering/ crossing the runway and a warning alert is triggered by SURF-ITA system, the pilot shall immediately either stop the ownship or expedite vacation (SO#016)	N/A	N/A
a/c taking off from the same runway	N/A	N/A	N/A	When ownship is entering/ crossing the runway, SURF- ITA system shall timely detect the risk of runway	N/A	N/A

Ownship State Mobile State	Final approach (USE CASE 1)		Landing (Flare + roll- out on Runway) (USE CASE 2)	Entering/Crossing the runway (USE CASE 3 + USE CASE 5)	Lined up awaiting a taking off clearance (USE CASE 4)	Take-off roll in low- speed regime (derived from USE CASE 4)
	Initial part of the FAS	Final part of the FAS				
				collision with an aircraft landing, taking off or that is going to take off from the same runway (SO#003) When the ownship is entering/ crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same ownship's runway (SO#009) When the ownship is entering/ crossing the runway and a warning alert is triggered by SURF-ITA system, the pilot shall immediately either stop the ownship or expedite vacation (SO#016)		
Mobile entering/crossing the runway	When the ownship is on final approach and an advisory/caution	When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a	When the ownship is landing, SURF-ITA system shall timely detect the risk of	N/A	When the ownship is lined up awaiting a take-off clearance, SURF-ITA	When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall timely

Ownship State Mobile State	Final approach (USE CASE 1)		Landing (Flare + roll- out on Runway) (USE CASE 2)	Entering/Crossing the runway (USE CASE 3 + USE CASE 5)	Lined up awaiting a taking off clearance (USE CASE 4)	Take-off roll in low- speed regime (derived from USE CASE 4)
	Initial part of the FAS	Final part of the FAS				
ahead of the ownship	alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat (SO#018)	warning alert if a mobile is entering/crossing the same runway (SO#007) When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, a go-around should be initiated under pilot's decision (SO#014)	runway collision caused by a mobile entering/crossing the runway ahead of the ownship (SO#002) When the ownship is landing, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the runway ahead of ownship (SO#008) When the ownship is landing and a warning alert is triggered by SURF-ITA system, the pilot shall immediately perform the appropriate action based on the specific situation (SO#015)		system shall timely detect the risk of runway collision with a mobile that is entering/crossing the runway (SO#004) When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory/caution alert if a mobile is entering/crossing the runway ahead the ownship (SO#013) When ownship is lined up awaiting a take-off clearance and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the	detect the risk of runway collision if a mobile is entering/crossing the runway ahead the ownship (SO#005) When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead the ownship (SO#010) When the ownship is in the low-speed regime during the take-off roll and a warning alert is triggered by SURF-ITA, pilot shall initiate a rejected take-off (SO#017)

Ownship State Mobile State	Final approach (USE CASE 1)		Landing (Flare + roll- out on Runway) (USE CASE 2)	Entering/Crossing the runway (USE CASE 3 + USE CASE 5)	Lined up awaiting a taking off clearance (USE CASE 4)	Take-off roll in low- speed regime (derived from USE CASE 4)
	Initial part of the FAS	Final part of the FAS				
					potential threat (SO#020)	
a/c lined up and ready for take-off	When the ownship is on final approach, SURF-ITA system shall timely detect the risk of runway collision caused by an aircraft lined up on the runway threshold and ready for take-off (SO#001) When the ownship is on final approach and an advisory/caution alert is triggered by SURF-ITA system, flight crew should use OTW scan (if permitted by visibility conditions) and communication with ATCo (if permitted by current crew workload) to	When the ownship is on final approach, SURF-ITA system shall timely detect the risk of runway collision caused by an aircraft lined up on the runway threshold and ready for take-off (SO#001) When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if another a/c is holding on the runway ready for take-off (SO#006) When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, a go-	N/A	When ownship is entering/ crossing the runway, SURF-ITA system shall timely detect the risk of runway collision with an aircraft landing, taking off or that is going to take off from the same runway (SO#003) When the ownship is entering/ crossing the runway, SURF-ITA shall trigger an advisory/caution alert if another a/c is holding on the runway ready for take-off (SO#012) When the ownship is entering/ crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat and	N/A	N/A

Ownship State Mobile State	Final approach (USE CASE 1)		Landing (Flare + roll- out on Runway) (USE CASE 2)	Entering/Crossing the runway (USE CASE 3 + USE CASE 5)	Lined up awaiting a taking off clearance (USE CASE 4)	Take-off roll in low- speed regime (derived from USE CASE 4)
	Initial part of the FAS	Final part of the FAS				
	acquire situational awareness of the threat (SO#018)	around should be initiated under pilot 's decision (SO#014)		perform appropriate action (SO#019)		

Table 5 Runway Safety Objectives with ownship/mobile states

3.6.2.2 Taxiway Safety Objectives

In the success approach, safety objectives in normal operations for TWY-ITA are:

SO#111 Provide an alert/indication in case of risk of collision - TWY-ITA system shall detect the risk of collision with a probability of 70%.

SO#112 Improve pilots' awareness on taxiways

Based on DO-322 [8] Taxiway states there have been recognized all states from ownship on taxiway with all possible states on airport surface including runways. As we are focused on TWY-ITA function only the Safety Objectives for taxiways have been used only.

Ownship State Mobile State	Taxiing on single taxiway, leaving or entering the REZ (USE CASE 1)	Taxiing on single taxiway, leaving or entering the REZ (USE CASE 2)	Taxiing on single taxiway, leaving or entering the REZ (USE CASE 3)	TWY Safety Objectives
Taxiing ahead ownship - single taxiway - crossing taxiway - fast RWY exit	When ownship is taxiing with ahead traffic as a collision threat, TWY-ITA shall detect the risk of taxiway collision. When the ownship detected colliding traffic ahead and Advisory/ Caution alert was triggered by TWY-ITA system, the pilot shall timely acquire the position of the potential threat by OTW scan, on display or stop the aircraft. If necessary contact ATC.	N/A	N/A	123SO#050 SO#051 SO#052 SO#053 SO#054
Taxiing from the left/right of ownship - single taxiway - crossing taxiway - fast RWY exit	N/A	When ownship is taxiing with traffic taxiing from left or right as a collision threat, TWY-ITA shall detect the risk of taxiway collision. When the ownship detected colliding traffic from left or right and Advisory/ Caution alert was triggered by TWY-ITA system, the pilot shall timely acquire the position of the potential threat by OTW scan, on display or stop the aircraft. If necessary contact ATC.	N/A	123SO#050 SO#051 SO#052 SO#053 SO#054
Taxiing behind the ownship	N/A	N/A	When ownship is taxiing with traffic taxiing behind as a collision	123SO#050 SO#052

Ownship State Mobile State	Taxiing on single taxiway, leaving or entering the REZ (USE CASE 1)	Taxiing on single taxiway, leaving or entering the REZ (USE CASE 2)	Taxiing on single taxiway, leaving or entering the REZ (USE CASE 3)	TWY Safety Objectives
			threat, TWY-ITA shall detect the risk of taxiway collision. When the ownship detected colliding traffic from behind sector and Advisory/Caution alert was triggered by TWY-ITA system, the pilot shall timely acquire the position of the potential threat by display if available for better traffic situational awareness, without stopping the aircraft. If necessary contact ATC.	SO#053 SO#054

Table 6 Taxiway Safety Objectives with ownship/mobile states

3.6.2.3 False detection Vs. Missed detection trade-off – Runway SURF-ITA

False/Nuisance detection rate and Missed detection rate represent the metrics to measure respectively the performance and the benefits of the SURF-ITA application. As stated in the DO-323 [6], a complex relationship exists among Nuisance detection, missed detection and system accuracy. At the light of the similarities existing between the U.S. SURF-IA application and the European SURF-ITA application, some OPA/OSA outcomes performed within the DO-323 can be considered realistically applicable to this safety assessment.

According to DO-323, operational experts have determined an operationally acceptable nuisance rate of 10-3 per operation² (relevant to both advisory/caution and warning alerts).

False detection output rate has been set $5 \cdot 10^{-4}$ per operation (both advisories and warnings). Hence, the overall untrue detection rate (i.e. the sum of nuisance detection rate and false detection rate) is roughly $1,5 \cdot 10^{-3}$ per operation. From the above reference the SO has been derived also for SURF-ITA.

Concerning missed detection rate, DO-323 does not impose any requirement for an acceptable missed detection rate, since SURF-IA benefits has not been quantified yet. However, a preliminary benefit analysis indicates a probability of missed detection ranging from 0,01 to 0,1.

By contrast, within this safety assessment we have quantified the SURF-ITA safety benefits under the form of a Safety Criterion, i.e. a theoretical 10% reduction of the number of near runway collisions. This implies that, within this safety assessment, a threshold value of missed detection rate should be specifically defined in order to reach our safety target.

After an internal discussion at level of PJ.03b SAFE project, we agreed that, at this stage, the experience feedback is not sufficient to define the relationship among nuisance detection, missed detection and system accuracy in order to determine an acceptable value of missed detection rate. However, we can follow a more simplistic logic to preliminarily define a rough probability of missed detection.

Based on the assumptions adopted to set SAC#01 (see § 2.4), it is estimated that the SURF-ITA system is able to detect at least the 60% of the real situations (PD) which can lead to a potential/imminent runway collision.

The figure below provides a diagram of the different conditions associated with the SURF-ITA System summarizing the rates measuring the performance and the benefits of the application.

² This value is a cumulative probability which encompasses single probability expressed per ownship states. See § 2.6.2.2

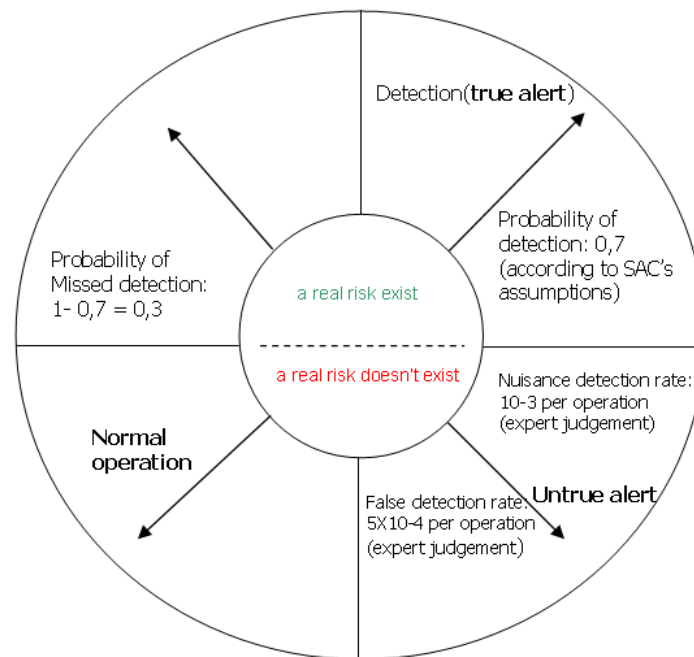


Figure 6: Diagram of the SURF-ITA conditions

3.6.2.4 False detection Vs. Missed detection trade-off – Taxiway TWY-ITA

False/Nuisance detection rate and Missed detection rate represent the metrics to measure respectively the performance and the benefits of the TWY-ITA application. The only reference so far is in the DO-323 [6] for runway traffic alerts and existing OSA definition from ATSA-SURF RTCA DO-322. In most cases as it is defined for runways a complex relationship exists among Nuisance detection, missed detection and system accuracy. At the light of the similarities existing between the U.S. SURF-IA application, the European SURF-ITA application and the taxiway TWY-ITA function, some OPA/OSA outcomes performed within the DO-323 and DO-322 can be considered realistically applicable to this safety assessment.

According to DO-323, operational experts have determined an operationally acceptable nuisance rate of 10^{-3} per operation³ (relevant to both advisory/caution and warning alerts). That assumption defined for runway has been proposed also for Taxiway function as the most stringent requirement. Due to low energy collision, criticality and outcomes from the OSA based on RTCA DO-322 analysis it was supposed lower requirement to be validated. Realistic assumption of nuisance alert rate based on Severity Class for TWY-Collision SC3 and proposal from expert working group based on previous SESAR 1, 2020 PJ28 and PJ.03b-05 exercises and fast time simulations is 10^{-2} per ownship operations.

Acceptable false detection rate has been set 5×10^{-4} per operation on runways derived within DO-323.

³ This value is a cumulative probability which encompasses single probability expressed per ownship states. See § 2.6.2.2

That definition can be used also for TWY-ITA false alerts rate (advisory/caution alerts based on DO-323) per ownship operation as the most stringent requirement validated for extended function of the runway part.

Concerning missed detection rate, RTCA DO-323 and RTCA DO-322 does not impose any requirement for an acceptable missed detection rate. Due to RF impacts and expected detection rate on taxiways, missed alert detection rate would be reasonable with 3×10^{-1} following from acceptable detection rate confirmed by PJ28 ADS-B data analysis.

However, we can follow a more simplistic logic to preliminarily define a rough probability of missed detection. It is recommended also to follow the analysis of a real ADS-B data gaps to interpret the missed benefit from operational aspects.

By contrast, within this safety assessment we have quantified the TWY-ITA safety benefits under the form of a Safety Criterion, i.e. a theoretical 5% reduction of the number of taxiway collisions.

Based on the assumptions adopted to set SAC#02, it is estimated that the TWY-ITA system is able to detect real situations at barrier B1 which can lead to a potential taxiway collision between two ADS-B Out eligible aircraft that is approximately 50% of all taxiway cases and not impacted by environmental issues as some radio frequency issues, which could results approximately in 30% of all aircraft/aircraft cases.

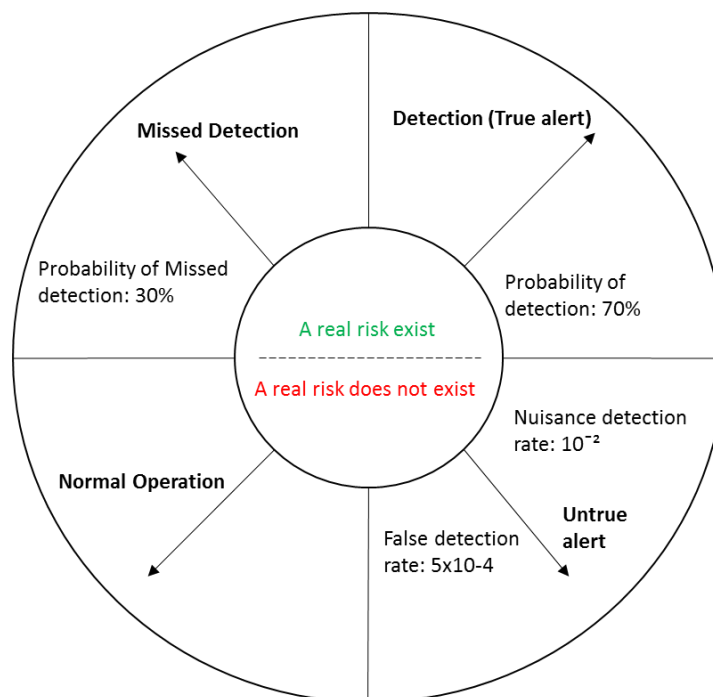


Figure 7: Diagram of the TWY-ITA conditions

3.6.2.5 Ownship State vs. Ownship Operation

The condition to trigger a SURF-A/ITA/TWY-ITA alert is based on the ownship's position (on the airport surface or on approach) in relation with other mobiles position in the vicinity. At this scope a number of use cases have been defined in the OSED, resulting from the possible combination of ownship states in conjunction with the potential threat position.

The ownship states here considered are the following:

Taxi on taxiway
Hold short of runway
Enter/Exit/Crossing of runway
Line-up and Hold
Take-off Roll at low-speed regime
Landing on runway
Initial part of the Approach
Final part of the Approach

The following table summarizes the typical exposure time for each state⁴:

Ownship state	Exposure time [sec]
Taxi	1000
Holding short of runway	60
Enter/Exit/Crossing of runway	20
Line-up and Hold	60
Take-off Roll at low-speed regime	25
Take-off Roll at low-speed regime	15
Landing on runway	60
Initial part of the Approach	75
Final part of the Approach	15

Table 7: Durations for phases of Operations

In this safety assessment, "*an operation*" is defined as all of the ownship states that make up a take-off operation plus a landing operation. This assumes taxiing once for the take-off procedure and once

⁴ Exposure times for aircraft in specific states was developed during SC-186 work group with the help of experienced pilots, air traffic controllers and FAA personnel. This table represents the basis for the conversion from unit of *per operational hour* into unit of *per operation*.

for the landing procedure. The table below indicates how many times each state is included in an operation and the average duration of an operation.

Ownship state	States per operation	Total exposure time [sec]
Taxi	2	2000
Holding short of runway	1	60
Enter/Exit/Crossing of runway	1	20
Line-up and Hold	1	60
Take-off Roll at low-speed regime	1	25
Take-off Roll at low-speed regime	1	15
Landing on runway	1	60
Initial part of the Approach	1	75
Final part of the Approach	1	15
Total operation duration		2330 sec (0,64 hr)

Table 8: Ownship states in one Operation

Operational Safety Assessment (OSA) has been performed on a *per operation* basis rather than *per ownship state*. As a consequence, false alert rate, nuisance alert rate, missed detection rate and any other SOs and SRs derived in this SAR generally has been expressed in unit *per operation* and they represent average values applicable across all the ownship states.

State-specific OSAs could be developed in the next SAR version by addressing each single ownship state in order to distinguish the different performance and benefit that the SURF-A/ITA/TWY-ITA application is expected to meet.

3.6.3 Analysis of the Concept for a Typical Flight

The analysis is reflected in the Safety Objectives presented in 3.6.2 where objectives are issued from typical use cases.

3.7 Solution Operations under Abnormal Conditions

The purpose of this section is to assess the ability of runway operations supported by SURF-ITA system to work through (robustness), or at least recover easily from (resilience), any abnormal conditions, external to the SURF-ITA system, that might be encountered relatively infrequently.

Abnormal conditions are those under which the system has to operate in a reversionary mode due to, for example:

Conditions of the operation environment that the system may exceptionally encounter,
equipment failures external to the ATM system concerned (here: SURF-A/ITA/TWY-ITA system),
Maintenance interventions – out of scope

Regarding “Traffic Alerts”, the application is not supposed to be depending on external environment (weather conditions and visibility, traffic conditions).

So, the abnormal conditions that are retained are mostly conditions that may prevent the function from providing a full service to the crew in its role of collision avoidance on the runway and taxiway. The identified conditions are mainly linked with conditions that bring limit in the avoidance manoeuvre.

So, Hz#4 is the main Hazard impacted.

3.7.1 Identification of Abnormal Conditions

Abnormal condition ID	Abnormal condition title	Description	Associated pre-existing hazards
1	Aircraft braking system failure	The aircraft has not enough efficiency to brake in the expected time/distance. This failure cannot be covered by any MEL items (in case of departure).	Hz#3
2	Aircraft has to land in any case (short of fuel at landing, severe failure)	The aircraft has to land because it is short of fuel and a go-around may not be an option.	Hz#4

Table 9: Identification of Abnormal Conditions

3.7.2 Potential Mitigations of Abnormal Conditions

Ref	Abnormal Conditions	Operational Effect	Mitigation of Effects / [SO xx]
1	Aircraft braking system failure	It may happen in Use Cases when ownship is on-ground. If the capability to stop is reduced, the aircraft may not stop when needed. The alert system has already informed the crew who has to bring	(Operational objective) In flight, the crew shall inform ATCo about aircraft braking limitations involving runway availability. (SO#055)

		the aircraft back to the gate for maintenance.	
2	Aircraft has to land in any case (short of fuel at landing, severe failure)	In case of alert in final approach, the expected avoidance is a go-around but may not be possible. The crew informs ATC that will be all the more aware of the increased criticality and take special care of the full runway availability. So, the risk of collision will be reduced	(Operational objective) The crew shall inform ATC of failures involving landing with a limited capability of go-around (e.g. short of fuel, severe failure) in order to take special care of the full runway availability. (SO#056)

Table 10: Additional Safety Objectives (success approach) for Abnormal Conditions

The consequence of the analysis is that no specific SO is implied by abnormal operations regarding the “Traffic Alerts for Pilots” function.

3.8 Mitigation of System-generated Risks (failure approach)

This section concerns runway and taxiway operations supported by SURF-A/ITA/TWY-ITA system in the case of internal failures. Before any conclusion can be reached concerning the adequacy of the safety specification of PJ.03b-05 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 3.6.1 and to derive safety objectives (failure approach) to mitigate against these effects.

3.8.1 Identification and Analysis of System-generated Hazards

From the analysis of the above description of the operational services and by considering, for each safety objective (from the success approach in Table 4 and 5 above), what would happen if the objectives were not satisfied (*i.e.* negate the safety objectives derived with the success approach), the system-generated hazards were identified and reported in Table 9 hereafter. For each hazard the following information is provided:

- the immediate operational effect
- the safety barrier which can mitigate the safety consequence of each hazard
- the severity of the most probable effect from hazard occurrence as per the relevant Risk Classification Scheme (RCS) from Guidance E.2 of Reference [2]
- the rationale justifying the Severity Classification

Appendix A (OHA Table Appendix A) provides the details on how the System-generated hazards have been identified and aggregated

ID	Description	Related SO (success approach)	Operational Effects	Mitigations of Effects	Severity (most probable effect)
Hz 001	Imminent runway collision between ownship and a mobile goes undetected by SURF-ITA application.	SO#001; SO#002; SO#003; SO#004; SO#005; SO#006; SO#007; SO#008; SO#009; SO#010; SO#012; SO#013;	Ownship executes a trajectory which can lead to a runway collision with a mobile within the REZ	Pilot Runway Collision Avoidance (B1) In normal conditions being defined in §2.2.7, B1 safety barrier is still partially working. On-board alerting system fails but flight crew can still rely on OTW scan to avoid runway collision.	SC2(b) (See OHA table)
Hz 002	Imminent RWY collision with mobile is detected but flight crew has incomplete information	SO#001; SO#002; SO#003; SO#004; SO#005; SO#006; SO#007; SO#008; SO#009; SO#010; SO#012; SO#013;	SURF-ITA detects the risk of imminent runway collision but one or some information are missing (e.g. warning displayed without threat identification, warning displayed on CDTI without aural) announcement in cockpit,...)	Pilot Runway Collision Avoidance (B1) Crew reacts to the partial alert and monitors the situation. Crew determines the missing information and compensate it by OTW scan and/or by contacting ATC. This hazard leads to slight increase of crew workload	SC2(b)
Hz 003	Imminent RWY collision with mobile is detected	SO#001; SO#002; SO#003; SO#004; SO#005; SO#006; SO#007; SO#008;	SURF-ITA detects the risk of imminent runway collision but one or some	Pilot Runway Collision Avoidance (B1)	SC2(b)

Founding Members

	but flight crew has incorrect information	SO#009; SO#010; SO#012; SO#013;	information are incorrect (e.g. warning displayed with wrong threat identification,...)	Crew reacts to the partial alert and monitors for imminent risk of collision. Crew determines the wrong information and compensate it by OTW scan and/or by contacting ATC. This hazard leads to slight increase of crew workload.	
Hz 004	Unresolved imminent RWY collision with mobile after SURF-ITA system detection	SO#014; SO#015; SO#016; SO#017; SO#018; SO#019; SO#020;	SURF-ITA timely detects the risk of imminent runway collision but crew momentarily ignores the alert and does not timely aware of the situation	Pilot Runway Collision Avoidance (B1) In the worst case (pilot completely disregards the alert), this hazard leads to a situation similar to today's situation (no on-board alert triggered). Pilot can mitigate the hazard when he/she acquires visually the potential threat or when Pilot/Driver of the other mobile	SC2(b)

				acquires the ownship	
HZ 005	Near-accident situation generated by failure to inhibit SURF-ITA alert during take-off roll at high-speed regime	SO#022		In certain critical phase, pilot's decision making process shall be negatively affected by an alert. Pilot can take a safety-related undesired action (e.g. a rejected take-off with a significant risk)	Pilot Runway Collision Avoidance (B1) SC2(b)
HZ 006	Taxiway conflict not prevented by Pilot due to TWY-ITA System credible erroneous traffic indication or alert	SO#050, SO#052, SO#054	SO#051, SO#053,	A perceived threat exists when in reality there is no threat; No threat exists - when one may exist in reality.	Pilot Taxiway Collision Avoidance (B1) - Crew OTW scan and detect - Display info and prediction - Voice comm. TInc-SC3
HZ 007	Taxiway conflict not prevented by Pilot due to TWY-ITA System missing traffic indication or alert	SO#50, SO#52, SO#64	SO#051, SO#54,	The hazard addresses unintentional misuse of the system by the flight crew (e.g., misunderstanding of the mixed equipage environment, misinterpretation of the system, or an over-confidence in the system). Perception bias.	Pilot Taxiway Collision Avoidance (B1) - Crew OTW scan and detect - Display info and prediction - No Perception bias - Voice comm. TInc-SC3
HZ 008	Taxiway conflict not prevented by Pilot due to TWY-ITA System erroneous	SO#50, SO#52, SO#64	SO#51, SO#54,	Erroneous Traffic Identification would result in the TWY-ITA flight crew recognizing an inconsistency	Pilot Taxiway Collision Avoidance (B1) - Display info and verification TInc-SC3

	traffic identification information		between data sources which would require them to take an action to clarify which information is correct. As a result, the worst-case effect due to an erroneous Traffic Identification is a workload increase needed to resolve the discrepancy and eliminate any confusion.	- Crew OTW scan and detect - Voice comm.	
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Table 11: System-Generated Hazards and Analysis

From the above table, additional safety objectives are derived in next section.

3.8.2 Derivation of Safety Objectives (integrity/reliability)

Safety Objectives (addressing integrity/reliability) shall limit the frequency with which the above System-generated hazards could be allowed to occur using the relevant Risk Classification Scheme.

Here, we consider:

- The Risk Classification Scheme (RCS) for the Runway Collision and the formula proposed to derive the safety objectives in SRM [1], the following intrinsic safety objectives have been derived:

$$SO = \frac{\text{Maximum_Tolerable_Freq_of_occurrence}_{\text{relevant_severity_class}}}{N \times IM}$$

With: Max tolerable frequency of occurrence⁵ = 1E-06 *per movement* for SC2(b)

N=10 for SC2(b)

IM=1 (2 mobiles involved)

- SURF-ITA service which is supposed to reduce the frequency of unresolved occurrence. SURF-ITA is not responsible for generating the consequences of pre-existing hazards. This is why the Safety Objectives related to SURF-ITA are apportioned to the Safety Objective SO#101, not to the overall current ATM situation.
 - This SO is derived from ATM Equipment Risk Severity Classifications definitions which corresponds to 10⁻⁷ per movement. Based on definition of the on-board avionics requirements, system baseline coverage by pilot standard operational procedures and current means, the SO will be 10⁻⁵ per operation (movement). This is a current approach for similar systems and has been also taken into account for final definition of the SO.
 - The same it is for TWY-ITA system with minor classification for on-board system definition. The final number based on ATM equipment risk severity classification is 10⁻³ per movement. Due to low criticality of the system with coverage of existing means there is a reasonable assumption with 10⁻², including pilots' acceptability, human performance, validations and fast time simulation results.

ID	Safety Objectives
Hz 001	SO#024 The frequency of occurrence of undetected risk of imminent runway collision with SURF-ITA system, shall be not greater than 10 ⁻⁵ per movement

⁵Current RCS for Runway Collisions reported in [2] Guidance E, erroneously reports *Max tolerable frequency of occurrence expressed per flight hour*. The values indicated are actually expressed *per movement* (*i.e.* per operation)

Hz 002	SO#025 The frequency of occurrence of detected risk of imminent runway collision with incomplete SURF-ITA information shall not be greater than 10^{-5} per movement
Hz 003	SO#026 The frequency of occurrence of detected risk of imminent runway collision with incorrect SURF-ITA information shall not be greater than 10^{-5} per movement
Hz 004	SO#027 The frequency of occurrence of unresolved imminent runway collision after a positive detection of SURF-ITA system shall not be greater than 10^{-5} per movement
Hz 005	SO#028 The frequency of occurrence of a SURF-ITA alert triggered during take-off roll at high-speed regime shall not be greater than 10^{-5} per movement
HZ 006	SO#56 Taxiway conflict not prevented by Pilot due to TWY-ITA System credible erroneous traffic indication or alert shall not be greater than 10^{-2} per movement.
HZ 007	SO#57 Taxiway conflict not prevented by Pilot due to TWY-ITA System missing traffic indication or alert shall not be greater than 10^{-2} per movement.
HZ 008	SO#58 Taxiway conflict not prevented by Pilot due to TWY-ITA System erroneous traffic identification information shall not be greater than 10^{-2} per movement.

Table 12: Safety Objectives (integrity/reliability)

Frequency of occurrence above reported are expressed per movement (per operation). For the purpose of this safety assessment, and in line with RTCA DO-323, a movement (an operation) is defined as all of the ownship states that make up one take-off operation plus one approach and landing operation.

In accordance with DO-323, the average exposure time of an operation is about 0.64 hr.

3.9 Impacts of SURF-ITA/TWY-ITA Solution operations on adjacent airspace or on neighbouring ATM Systems

Identify the changes in the Operational Environment to host the Solution operations and derive any required additional safety objectives (functionality and performance) for compatibility.

The Operational Environment is not changed by the introduction of SURF-A/ITA and TWY-ITA. Adjacent airspace are not impacted because of the aircraft movement.

3.10 Achievability of the Safety Criteria

From safety criteria, safety objectives are derived.

At the functional level, SESAR 2020 RTS validation exercises reported in VALR have validated the success approach by covering the different use cases.

FTS and Data collection analyses provide evidence of credibility of safety criteria (reference VAL EXE table 4.3.3).

3.11 Validation & Verification of the Safety Specification

Regarding the success approach, the specification is reported in the TS document since SURF-ITA and TWY-ITA are “safety” functions.

The failure approach is reflected by the Safety Objectives.

Safety workshops have been done in DSNA and Airbus premises in 2018 and 2019 with pilots and controllers, and PJ.03b members.

4 Safe Design at SPR Level

4.1 Scope

This section addresses the following main activities:

description of the SPR-level model of the Traffic Alerts for Pilots System – section 4.2.1
derivation from the Safety Objectives (Functionality and Performance) of Safety Requirements for the SPR-level design – section 4.2.2,
analysis of the operation of the SPR-level design under normal operational conditions by means of a Thread analysis – section 4.3.2.

4.2 The SURF-A/ITA/TWY-ITA system Solution SPR-level Model

The SPR-level Model is a high-level architectural representation of the Traffic Alerts for Pilots System design that is entirely independent of the eventual physical implementation of the design. The SPR-level Model is a logical model thus the human-machine interfaces are not shown explicitly on the model, they are implicit between human actors and machine-based functions.

4.2.1 Description of SPR-level Model

The SPR-level Model associated to the Traffic Alerts for Pilots System is shown in the figure below. It describes the main functionalities, human tasks, machine functions (on ground and on-board) and explains what each actors shall perform in term of functionality and performance. This model doesn't show physical element such as hardware, software, procedures, etc... The SPR-level design is the level at which Safety Requirements (success case) for Traffic Alerts for Pilots System are specified. Success-Case SRs are derived from the proper allocation of each Success-Case Safety Objective on the functional blocks of the SPR-level model.

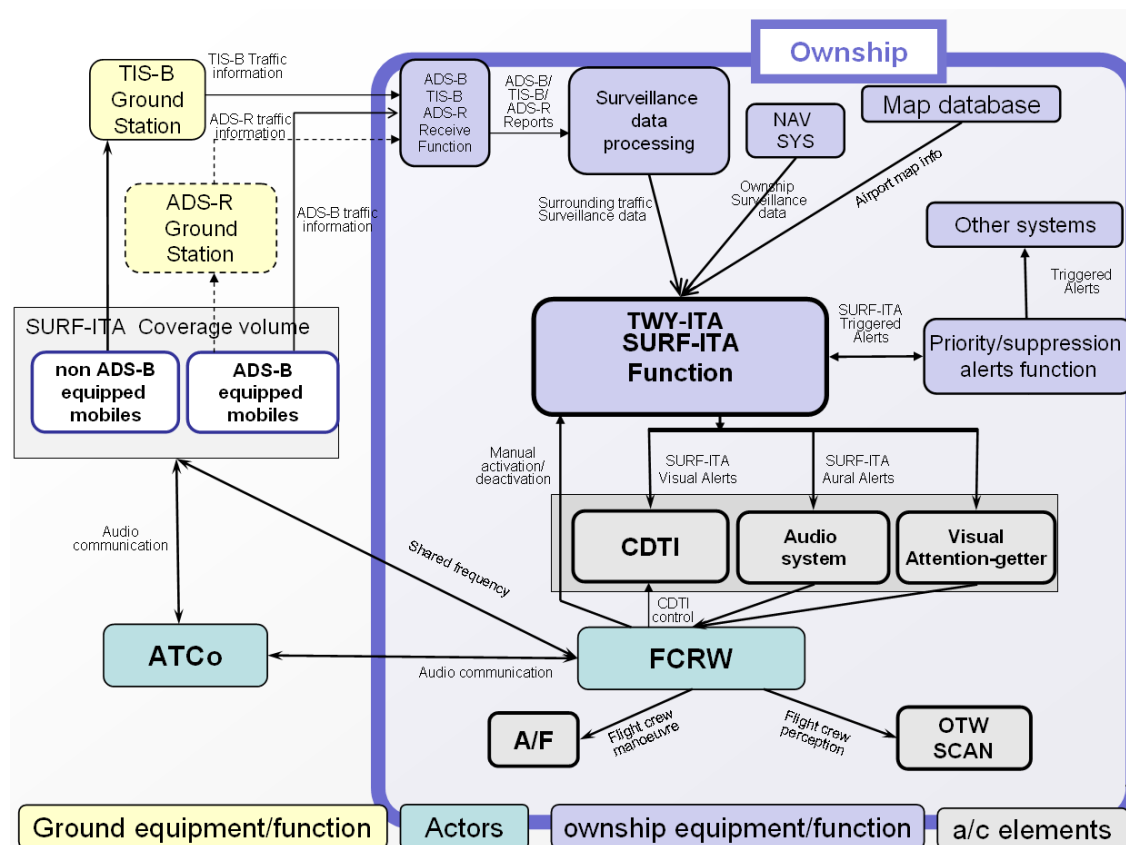


Figure 8: SURF-ITA/TWY-ITA system Solution SPR-level Model

The SURF-A version has the same model without CDTI linkage from the function and crew.

The diagram has been used to depict the MEGA model. Here-below the actors related to the alert generation are described:

- ADS-B In
- Flight crew
- Ownship alert
- ATC

MEGA model example (refer to TS/IRS D4.1.181 for all diagrams) for ownship on approach is provided below:

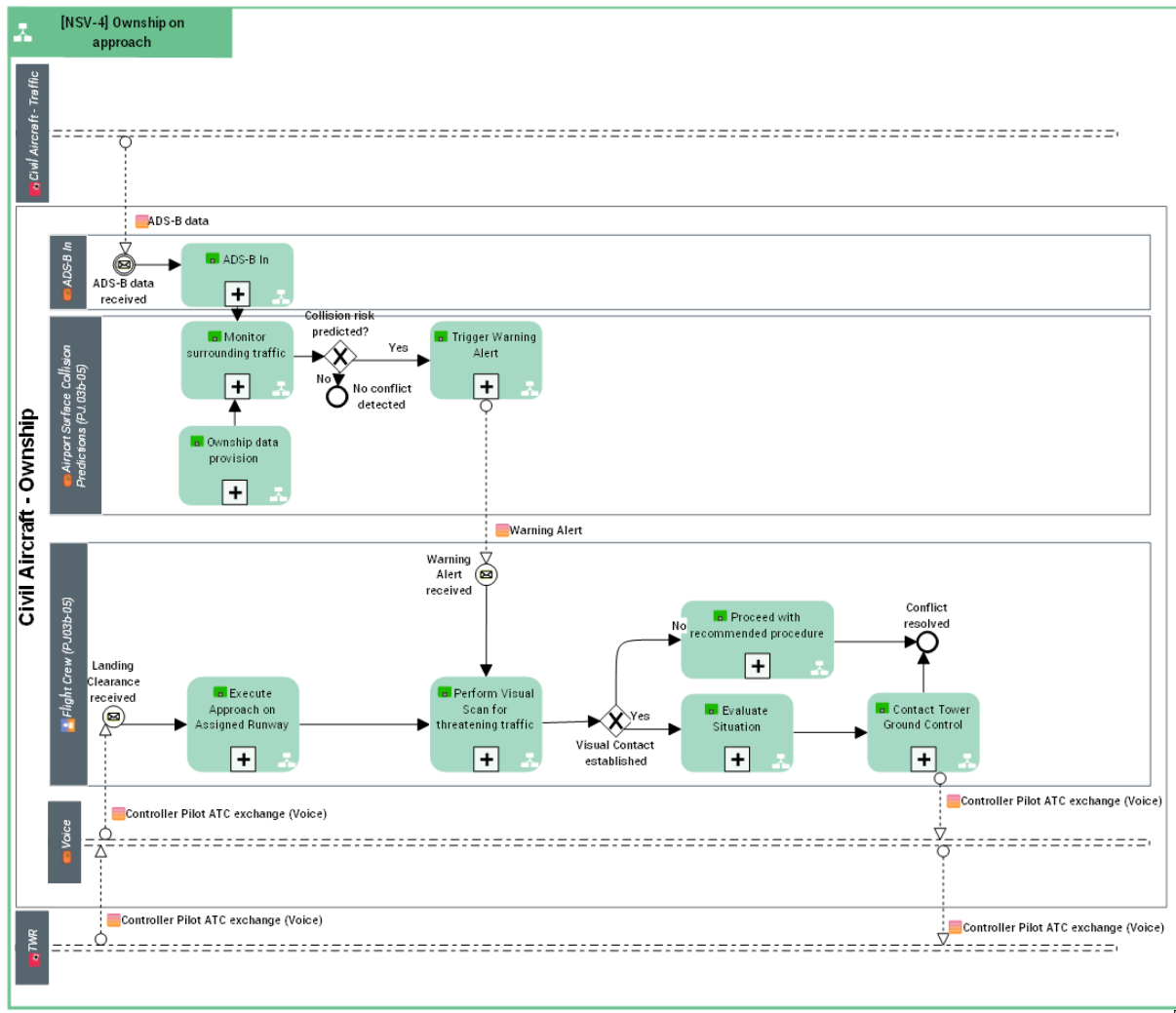


Figure 9: [NSV-4] Ownship on approach SPR-level model (MEGA Tool)

4.2.1.1 Flight Crew (ownship)

FCRW

Flight Crew. One of crew tasks is to communicate with ATC and ensure aircraft safety in accordance with ATC clearances and instruction and to monitor airport traffic primarily by means of OTW scan and then by means of on-board equipment.

4.2.1.2 Ownship alerting system

SURF-ITA function	<i>It is the core of the runway SURF-ITA application. It processes ownship and other traffic surveillance data, and provides output to the traffic display function (e.g. advisory/caution and warning alert) and to the audio system</i>
TWY-ITA function	<i>It is the core of the taxiway TWY-ITA application. It processes ownship and other traffic surveillance data, and provides output to the traffic display function (e.g. advisory/caution alert) and to the audio system</i>

The alerting functions are connected with the following aircraft elements as part of the basic pre-existing configuration:

Surveillance Data Processing	<i>On- board function capable to process ADS-B/TIS-B/ADS-R traffic information. It provides the traffic surveillance data as input to SURF-A/ITA/TWY-ITA function.</i>
Rx Surv Data	<i>On- board system capable to receive ADS-B/TIS-B/ADS-R traffic information. It provides ADS-B/TIS-B/ADS-R reports to Surveillance Data Processing.</i>
NAV SYS	<i>Navigation System: On board system (including sensors) which provides to SURF-A/ITA/TWY-ITA system with ownship's navigation data (position, speed, altitude, etc.)</i>
Map database	<i>An on-board database which provides to SURF-A/ITA/TWY-ITA with electronic airport maps and runway data.</i>
Other systems	<i>Other ownship's systems capable to generate on-board alerts</i>
Priority/suppression alerts function	<i>On- board function capable to manage all the alerts according to a predefined priority logic and to inhibit certain alerts which can generate undesired safety-related pilot's actions</i>
CDTI	<i>Cockpit Display of Traffic Information. On board display capable to show airport traffic information on the electronic airport map. In conjunction with SURF-ITA application, it allows for the visual depiction of traffic related to REZ and SURF-ITA alerts (advisory/caution and warning) triggered by the surrounding traffic.</i>
Audio System	<i>On board system capable to produce all the system-generated aural alerts (including SURF-ITA auditory alerts).</i>
Visual Attention-getter	<i>A visual element located in the primary field of view used to catch the crew's attention, when active</i>

4.2.1.3 Surrounding traffic

ADS-B equipped mobiles		Mobiles within the SURF-ITA/TWY-ITA volume coverage with ADS-B OUT capability
No ADS-B equipment mobiles		Mobiles within the SURF- ITA/TWY-ITA volume coverage without ADS-B OUT capability

Traffic information can also be broadcasted by:

TIS-B station	ground	On-ground system capable to provide the ownship with traffic data about non ADS-B equipped mobile moving on the ground or in proximity of the airport surface.
ADS-R station	ground	On-ground system capable to re-transmit ADS-B information by using dual links for Universal Access Transceivers (UAT) and Mode S Extender Squitter (1090 ES)

4.2.1.4 External Entities

ATCo		<i>Air Traffic Controller:</i> Principal tasks are to provide information and clearances to mobiles in particular for the prevention of collisions between mobiles
For airports	controlled	ATC communicates with ownship flight crew and other mobiles giving the pertinent clearances to manage the traffic.
For airports	uncontrolled	Ownship flight crew communicates with other mobiles via a shared frequency informing about the actions they do.

4.2.2 Task Analysis

The task analysis is reflected in the model developed for Part I SPR/OSED.

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

The table below shows how the Safety Objectives (Functionality and Performance) derived in section 3 map on to the related elements of the SPR-level Model. Requirements and assumptions are derived based on the analysis of the SPR-level Model and this mapping exercise.

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#001 : When the ownship is on final approach, SURF-ITA system shall timely detect the risk of runway collision caused by an aircraft lined up on the runway threshold and ready for take-off	A#001	FCRW monitors visually the runway during runway operations	FCRW → OTW SCAN	
	A#002	TIS-B ground surveillance system provides ownship with traffic information about mobiles not ADS-B equipped	TIS-B	It was assumed that TIS-B ground domain is always available in order to provide ownship with a more complete traffic picture in situation where not all nearby mobiles are ADS-B equipped.
	A#003	Ownship is equipped to receive ADS-B/TIS-B/ADS-R surveillance data	Rx Surv Data	
	SR#001	When SURF-ITA is enabled, the traffic on CDTI shall be depicted by using a symbology able to clearly distinguish among: ●ownship ●other a/c moving within the REZ ●ground vehicles moving within the REZ	SURF- ITA→CDTI	Shapes and other graphical features of the symbols used to depict the traffic will be defined in the next version of SPR

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#002	When SURF-ITA is enabled, ownship shall be displayed on CDTI as a symbol with a label containing the following information: ● identity (24-bit address) ● horizontal position ● vertical position (when airborne) or on ground indication ● horizontal velocity ● vertical rate (when airborne) ● heading (when on ground) ● aircraft size ● distance or time between ownship and traffic triggering an alert (for off-scale traffic)	SURF-ITA → CDTI	Some of these information are expected to be mandatory to qualify ownship for SURF-ITA application, others can be optional. They distinction should be done after validation exercises
	SR#003	When SURF-ITA is enabled, each a/c shall be displayed on CDTI as a symbol with a label containing, as a minimum, the following information: ● identity (24-bit address) ● horizontal position ● vertical position (when airborne) or on ground indication	SURF-ITA → CDTI	Shape and other graphical features of the symbols used to depict the traffic will be defined in the next version of SPR

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#004	Ownship shall be able to process : • ADS-B surveillance data transmitted by ADS-B equipped mobiles, • TIS-B and ADS-R surveillance data transmitted by ground stations	Surveillance Data Processing	
	SR#005	ADS-B/TIS-B/ADS-R data shall meet certain data quality requirements to be qualified for SURF-ITA application	SURF-ITA	These data quality requirements refer to surveillance quality indicators identified in DO-323 paragraph 4.3.7 for SURF-IA application. They should be the same for SURF-ITA application To date, TIS-B doesn't broadcast integrity parameters. In order to qualify TIS-B traffic for SURF-ITA application, integrity information must be provided <i>(FAA is working on a solution about this issue, so we can assume that, in the frame of SESAR, a similar work will be faced in Europe)</i>

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#006	SURF-ITA system shall trigger: both aural and visual alerts when a warning level is requested only visual alert when an advisory/caution level is requested	SURF-ITA → CDTI SURF-ITA → AUDIO SYS SURF-ITA → Visual attention-getter	
	SR#007	SURF ITA equipment shall provide the flight crew with capability status	SURF-ITA function	
	SR#008	Ownship shall have a priority alert function capable to manage and prioritise all the ownship's alerts being generated, including SURF- ITA alerts.	Priority/suppression alert function	
	SR#010	With a full implementation with traffic display, CDTI shall display the airport map at different scale selectable by the flight crew and the relevant traffic (airborne and on ground)	CDTI	

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#015	When the ownship is on final approach, SURF-ITA system shall trigger a warning alert if there is an immediate risk of collision with another a/c on the runway ready for take-off.	SURF-ITA → CDTI SURF-ITA → Audio Sys SURF-ITA → visual attention-getter	Such a value avoids spurious alerts and is also to be associated with a risk of collision.
SO#002: When the ownship is landing, SURF-ITA system shall timely detect the risk of runway collision caused by a mobile entering the runway ahead of the ownship	Satisfied by : A#001; A#002; A#003; SR#001; SR#002; SR#003; SR#004; SR#005; SR#006; SR#007; SR#008; SR#009; SR#010; SR#011; SR#012; SR#013; Plus the following SR:			
	SR#016	When the ownship is landing, SURF-ITA system shall trigger a warning alert if a mobile is entering the runway ahead of the ownship	SURF-ITA → CDTI SURF-ITA → Audio Sys SURF-ITA → Visual attention-getter	According to ICAO definition, landing phase starts from the beginning of the landing flare until aircraft exits the landing runway, or comes to a stop on the runway

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#003: When ownship is entering/crossing the runway, SURF-ITA system shall timely detect the risk of runway collision with an aircraft landing, taking off or that is going to take off from the same runway	Satisfied by : A#001; A#002; A#003; SR#001; SR#002; SR#003; SR#004; SR#005; SR#006; SR#007; SR#008; SR#009; SR#010; SR#011; SR#012; SR#013; Plus the following SRs:			
	SR#017	Full implementation: When the ownship is entering/crossing the runway, SURF-ITA shall trigger an advisory/caution alert if another a/c is moving on the runway with a possible risk of collision	SURF-ITA → CDTI	
	SR#018	When the ownship is entering/crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same runway with a risk of collision.	SURF-ITA → CDTI SURF-ITA → AUDIO SYS SURF-ITA → Visual attention-getter	
SO#004: When the ownship is lined up awaiting a take off clearance, SURF-ITA system shall timely detect the risk of runway collision with a mobile that is	Satisfied by : A#001; A#002; A#003; SR#001; SR#002; SR#003; SR#004; SR#005; SR#006; SR#007; SR#008; SR#009; SR#010; SR#011; SR#012; SR#013; Plus the following SR:			

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
entering/crossing the same runway	SR#019	When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory/caution alert if a mobile is entering/crossing the runway ahead the ownship.	SURF-ITA → CDTI	
SO#005: When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall timely detect the risk of runway collision if a mobile is entering/crossing the runway ahead the ownship	Satisfied by : A#001; A#002; A#003; SR#001; SR#002; SR#003; SR#004; SR#005; SR#006; SR#007; SR#008; SR#009; SR#010; SR#011; SR#012; SR#013; plus the following SR:			
	SR#020	When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead.	SURF-ITA → CDTI SURF-ITA → AUDIO SYS SURF-ITA → Visual attention-getter	

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#006: When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if another a/c is holding on the runway ready for take-off	Satisfied by : A#001; A#002; A#003; SR#001; SR#002; SR#003; SR#004; SR#005; SR#006; SR#007; SR#008; SR#009; SR#010; SR#011; SR#012; SR#013:SR#015			
SO#007: When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the same runway	Satisfied by : A#001; A#002; A#003; SR#001; SR#002; SR#003; SR#004; SR#005; SR#006; SR#007; SR#008; SR#009; SR#010; SR#011; SR#012; SR#013; plus the following SR:			
	SR#021	When the ownship is on final approach, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the same runway and there is a risk of collision.	SURF-ITA → CDTI SURF-ITA → AUDIO SYS SURF-ITA → Visual attention-getter	

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#008: When the ownship is landing, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the runway ahead of ownship		see SO#002		
SO#009: When the ownship is entering/crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same ownship's runway		see SO#003		
SO#010: When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead the ownship		see SO#005		

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#012: When the ownship is entering/crossing the runway, SURF-ITA shall trigger an advisory/caution alert if another a/c is holding on the runway ready for take-off	See SO#003			
SO#013: When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory/caution alert if a mobile is entering/crossing the runway ahead the ownship	See SO#004			
SO#014: When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, a go-around should be initiated under pilot's decision	See SO#007 plus the following SR:			
	SR#022	When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, pilot shall decide under his/her own decision if initiate a go-around	FCRW → OTW FCRW → A/F	SCAN

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#015: When the ownship is landing and a warning alert is triggered by SURF-ITA system, the pilot shall perform the appropriate action based on the specific situation	See SO#008 plus the following SR:			
	SR#023	When the ownship is landing and a warning alert is triggered by SURF-ITA system due to a mobile entering/crossing the runway ahead of the ownship, the pilot shall promptly be aware of the threat's position and decide the appropriate action: maximise the braking action to stop the ownship as early as possible or retard the braking action to overtake the threat as early as possible or exit the runway through a high-speed taxiway (if possible)	FCRW → OTW SCAN FCRW → A/F	This scenario is one of the most demanding for the pilot's decision making process.
SO#016: When the ownship is entering/crossing the runway and a warning alert is triggered by SURF-ITA system, pilot shall	See SO#009 plus the following SR:			

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
immediately either stop the ownship or expedite vacation	SR#024	When the ownship is entering/crossing the runway and a warning alert is triggered by SURF-ITA system, pilot shall immediately either stop the ownship or expedite vacation .	FCRW → OTW SCAN FCRW → A/F	
SO#017: When the ownship is in the low-speed regime during the take-off roll and a warning alert is triggered by SURF-ITA, pilot shall initiate a rejected take-off	See SO#010 plus the following SR:			
	SR#025	When a warning alert is triggered by SURF-ITA during take-off roll at low-speed regime, pilot shall perform a rejected take-off	FCRW → OTW SCAN FCRW → A/F	
SO#018: When the ownship is on final approach and an advisory/caution alert is triggered by SURF-ITA system, flight crew	See the following SR:			

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
shall timely acquire the position of the potential threat	SR#026	Full implementation with CDTI: When an advisory/caution alert is triggered by SURF-ITA system on final approach, pilot shall timely acquire the position of the threat by: • looking at the CDTI, or • by communicating with ATCo, or • by performing OTW scan before performing the appropriate action	FCRW → OTW SCAN FCRW → A/F	
SO#019: When the ownship is entering/crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential	See SO#012 plus the following SR:			

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
threat and perform appropriate action	SR#027	When the ownship is entering/crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, pilot shall timely acquire the position of the potential threat by: • looking at the CDTI, or • by communicating with ATCo, or • by performing OTW scan before performing the appropriate action	FCRW → OTW SCAN FCRW → A/F	
SO#020: When ownship is lined up awaiting a take off clearance and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat	See SO#013 plus the following SR:			
	SR#028	Full implementation: When the ownship is lined-up on the runway and an advisory/caution alert is triggered by SURF-ITA system pilot shall timely acquire the position of the potential threat by: looking at the CDTI, or by communicating with ATCo, or	FCRW → OTW SCAN FCRW → A/F	

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
		by performing OTW scan before performing the appropriate action		
SO#022: SURF-ITA alerts shall be inhibited at high-speed regime during take-off roll	SR#009	Ownship shall be equipped with an alert suppression system which disables SURF-ITA alerts during take-off roll at high-speed regime	Priority/Suppression alert function	
SO#023: SURF-ITA application shall detect real A and B runway incursions with a probability of 70%	This value shall be confirmed at SPR system level (see Hz#001 fault tree)			

Table 13: Mapping of Safety Objectives to SPR-level Model Elements for SURF-ITA

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#050 : When the ownship is taxiing on taxiway, TWY-ITA system	A#101	FCRW monitors visually the OTW during taxiway operations	FCRW → OTW SCAN	

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
shall timely detect the risk of taxiway collision caused by Traffic Taxiing on Taxiway and trigger advisory/caution alert. SO#051 : When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Stopped Behind hold line and trigger advisory/caution alert. (Within RWY Engagement Zone)	A#002	TIS-B ground surveillance system provides ownship with traffic information about mobiles not ADS-B equipped	TIS-B	It was assumed that TIS-B ground domain is always available in order to provide ownship with a more complete traffic picture in situation where not all nearby mobiles are ADS-B equipped.
	A#003	Ownship is equipped to receive ADS-B/TIS-B/ADS-R surveillance data	Rx Surv Data	
	SR#101	When TWY-ITA is enabled, the traffic on CDTI shall be depicted by using a symbology able to clearly distinguish among: ●ownship ●other a/c moving within the Taxiway Relevant Zone (TRZ) ●ground vehicles moving within the TRZ	TWY-ITA→CDTI	Shapes and other graphical features of the symbols used to depict the traffic will be defined in the next version of SPR

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
SO#052 : When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Entering Runway at Taxiway Speeds and trigger warning/advisory/caution alert. (Within Runway Engagement Zone) SO#053 : When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Exiting Runway at Taxiway Speeds and trigger warning/advisory/caution alert. (Within Runway Engagement Zone)	SR#002	When SURF-ITA is enabled, ownship shall be displayed on CDTI as a symbol with a label containing the following information: ● identity (24-bit address) ● horizontal position ● vertical position (when airborne) or on ground indication ● horizontal velocity ● vertical rate (when airborne) ● heading (when on ground) ● aircraft size ● distance or time between ownship and traffic triggering an alert (for off-scale traffic)	SURF-ITA → CDTI	Some of these information are expected to be mandatory to qualify ownship for SURF-ITA application, others can be optional. They distinction should be done after validation exercises
	SR#003	When SURF-ITA is enabled, each a/c shall be displayed on CDTI as a symbol with a label containing, as a minimum, the following information: ● identity (24-bit address) ● horizontal position ● vertical position (when airborne) or on ground indication	SURF-ITA → CDTI	Shape and other graphical features of the symbols used to depict the traffic will be defined in the next version of SPR

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#004	Ownship shall be able to process : • ADS-B surveillance data transmitted by ADS-B equipped mobiles, and rebroadcasted messages with ADS-SLR • TIS-B and ADS-R surveillance data transmitted by ground stations	Surveillance Data Processing	
	SR#005	ADS-B/TIS-B/ADS-R data shall meet certain data quality requirements to be qualified for SURF-ITA/TWY-ITA application	SURF- ITA/TWY-ITA	These data quality requirements refer to surveillance quality indicators identified in DO-323 paragraph 4.3.7 for SURF IA application. They should be the same for SURF-ITA/TWY-ITA application To date, TIS-B doesn't broadcast integrity parameters. In order to qualify TIS-B traffic for SURF- ITA/TWY-ITA application, integrity information must be provided <i>(FAA is working on a solution about this issue, so we can assume that, in the frame of SESAR, a similar work will be faced in Europe)</i>

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#106	TWY-ITA system shall trigger: both aural and visual alerts when a caution level is requested	TWY-ITA → CDTI TWY -ITA → AUDIO SYS TWY -ITA → Visual attention- getter	
	SR#007	SURF- ITA/TWY-ITA equipment shall provide the flight crew with capability status	SURF- ITA/TWY-ITA function	
	SR#008	Ownship shall have a priority alert function capable to manage and prioritise all the ownship's alerts being generated, including SURF- ITA/TWY-ITA alerts.	Priority/suppression alert function	
	SR#010	With a full implementation of traffic display, CDTI shall display the airport map at different scale selectable by the flight crew and the relevant traffic (airborne and on ground)	CDTI	

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
	SR#115	When the ownship is taxiing on taxiway airport surface, TWY-ITA system shall trigger a caution alert if there is an immediate risk of collision with another a/c on the taxiway or stopped/leaving/exiting the Runway Engagement Zone (REZ).	TWY-ITA → CDTI TWY-ITA → Audio Sys TWY-ITA → visual attention-getter	Such a value avoids spurious alerts and is also to be associated with a risk of collision.
SO#054: When the ownship is taxiing on taxiway and an advisory/caution alert is triggered by TWY-ITA system, flight crew shall	Satisfied by : A#101; A#002; A#003; SR#101; SR#002; SR#003; SR#004; SR#005; SR#106; SR#007; SR#008; SR#009; SR#010; SR#115;			

Safety Objectives (from success approach)	ID	Safety Requirements (SR#0xx) and/or Assumption(A0xx)	Maps on to/interface flow	Note
timely acquire the position of the potential threat.	SR#150	When the ownship is taxiing on taxiway and an advisory/caution alert is triggered by the TWY-ITA system, before flight crew takes any decision, pilot shall timely acquire the position of the potential threat by, - OTW scan - looking at the CDTI, or - by voice communicating with ATCo, or ACFT	FCRW → OTW SCAN Optional FCRW → DISPLAY Optional FCRW → VOICE COMM FCRW → A/F	

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

Appendix B provides the formalisation of the Safety Requirements (functionality and performance) which have been identified in **Table 32** and 35:

- B1 Functional and performance safety requirements
- B2 Integrity safety requirements

4.2.4 Traceability

Traceability is done in via modelling and SE-DMF.

Traceability between OI steps and SPR-level Model Elements

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

4.3.1 Scenarios for Normal Operations

The Normal Operational Runway Scenarios are extracted from the OSED and captured in the Table 15 below

ID	Scenario	Rationale for the Choice
Use Case 1	Ownship on approach	Use Case as identified in the OSED
Use Case 2	Ownship at landing and roll	Use Case as identified in the OSED
Use Case 3	Ownship entering or crossing the runway	Use Case as identified in the OSED
Use Case 4	Ownship at take-off	Use Case as identified in the OSED
Use Case 5	Ownship taxiing on the runway	Use Case as identified in the OSED

Table 15: Operational Scenarios – Normal Conditions – Runway

The Normal Operational Taxiway Scenarios are extracted from the OSED and captured in the Table 16 below.

ID	Scenario	Rationale for the Choice
Use Case 1	Ownship taxiing with ahead traffic	Use Case as identified in the OSED
Use Case 2	Ownship taxiing with side traffic	Use Case as identified in the OSED

Founding Members

Use Case 3	Ownship taxiing with behind traffic	Use Case as identified in the OSD
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Table 16: Operational Scenarios – Normal Conditions - Taxiway

4.3.2 Thread Analysis of the SPR-level Model – Normal Operations

Thread Analysis is similar to Use Case analysis except that it uses a particular graphical presentation in which the actions of the individual elements of the SPR-level Model, and the interactions between those elements, are represented as a continuous ‘thread’, from initiation to completion.

Thread Analysis for the different scenario identified in Table 15 and Table 16 is carried out in order to identify potential additional safety requirements (functionality and performance).

The thread analysis in

Figure 10: Thread analysis for Traffic alerts for Pilots is generic and applicable to all use cases.

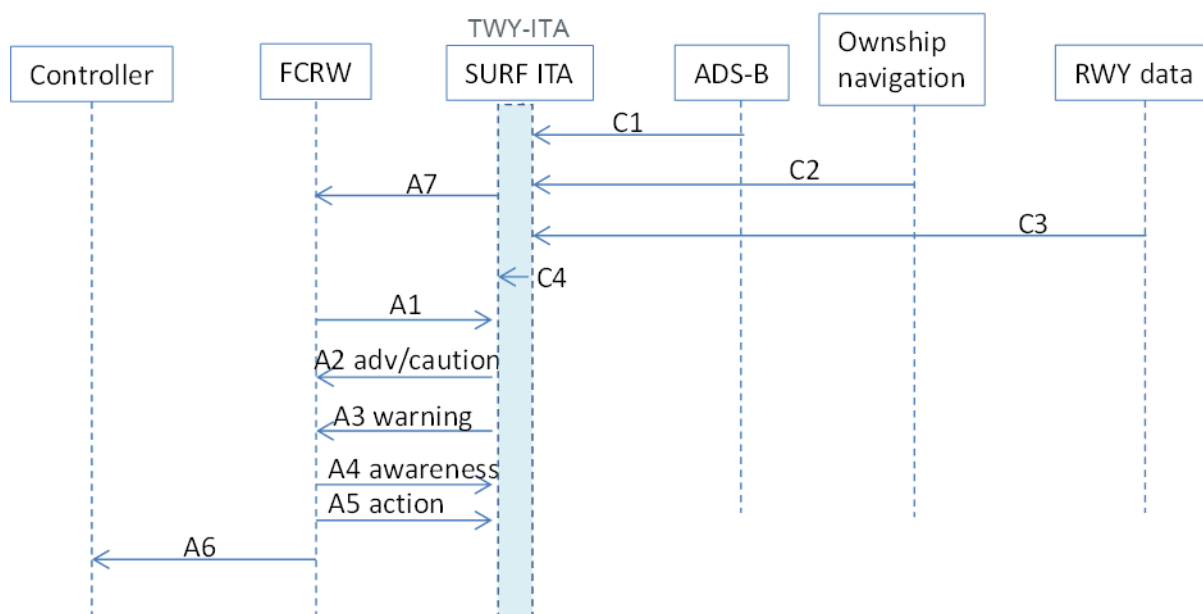


Figure 10: Thread analysis for Traffic alerts for Pilots

Continuous Flow – SURF-ITA and TWY-ITA	
C1	ADS-B provides continuously other aircraft data to SURF-ITA/TWY-ITA. (SR#001, SR#101) (A#002, A#003)
C2	Ownship navigation provides continuously aircraft data. (SR#030)
C3	Runway data are available. SR#031
C4	SURF ITA/TWY-ITA filters data SR#004, SR#005, manage priority (SR#008)

Actions SURF-ITA	
1	Ownship is on approach Or enters or is within the runway zone and an aircraft approaches with less than 25 seconds from threshold or aircraft is taking off or is taking off or just landed or taxiing on the runway And is getting close to another aircraft on or close to the runway. (A#001)
2	SURFITA function detects the conflict between ownship and aircraft and raise a advisory/caution or warning alert. (SR#007)
3	SURFITA function detects a possible conflict between ownship and aircraft and raise a warning alert. (SR#018, SR#020 and SR#021)
4	The Flight Crew reacts to the advisory/caution by looking outside and on traffic display. (SR#010, SR#011, SR#014, SR#017, SR#019)
5	The Flight Crew reacts to the warning alert with an avoidance according to the context action until the alert conditions disappear SR#012, SR#015 & SR#021, SR#022 (final approach), SR#016 & SR#023 (landing & roll), SR#018 (enter/cross the runway), SR#020 (take-off),
6	The Flight Crew contacts the Controller for further instructions. (SR#032)
7	SURF ITA informs the crew about the system state. (SR#007)

Some SR like SR#013 (manual enabling/disabling) is distinct and does not need to appear in the thread as its use fall back to the current situation without SURF-A/ITA.

Actions TWY-ITA	
1	Ownship is taxiing on taxiway Or Entering the Runway Engagement Zone or

	Leaving the Runway Engagement Zone or Stopped at the Runway Engagement Zone (SO#50/51/52/54)
2	TWY-ITA function detects the conflict between ownship and aircraft and raise an advisory/caution alert. (SR#115)
3	The Flight Crew reacts to the advisory/caution by looking outside, on traffic display, and voice communication. (SR#115)
4	The Flight Crew contacts the Controller for further instructions. (SR#032)
5	TWY-ITA informs the crew about the system state (SR#007)

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

Validation exercises have been conducted ref. VALR [10]:

- Exercise for Mainline aircraft with Warning alerts during runway operations
- Business aircraft with:
 - Indications and Alerts on runway configurations
 - Alerts on taxiway configuration.
- Common Flight Test exercises with mainline and business aircraft on runway

The results per objectives are presented in the table below:

Validation Objective ID	Validation Objective Title	Exercise Results
OBJ-03b.05-V3-VALP-0010	[SURF-A] Assess usability of traffic alerts information for pilots' situation understanding and task performance.	Validated
OBJ-03b.05-V3-VALP-0020	[SURF-A] Assess timeliness of alerts to support pilots' decision making and recovery action performance.	Validated
OBJ-03b.05-V3-VALP-0030	[SURF-A] Assess the intelligibility of traffic alerts information.	Validated

OBJ-03b.05-V3-VALP-0040	[SURF-A] Assess clarity of responsibility and authority between air and ground for conflict resolution when alerts trigger on both sides and impact on task performance.	Validated
OBJ-03b.05-V3-VALP-0050	[SURF-A] Assess efficiency to cooperate with ATC in case of potential threat detected by on-board systems.	Validated
OBJ-03b.05-V3-VALP-0060	[SURF-A] Impact of the alerts understanding on cockpit crew workload	Validated
Business aircraft results (SURF-ITA)		
OBJ-03b.05-V3-VALP-0070	[SURF-ITA] Assess usability of traffic alerts information for pilots' situation understanding and task performance.	Validated
OBJ-03b.05-V3-VALP-0080	[SURF-ITA] Assess timeliness of alerts to support pilots' decision making and recovery action performance.	Validated
OBJ-03b.05-V3-VALP-0090	[SURF-ITA] Assess the intelligibility of traffic alerts information.	Validated
OBJ-03b.05-V3-VALP-0100	[SURF-ITA] Assess the relevance of the CDTI information to successfully perform the task	Validated
OBJ-03b.05-V3-VALP-0110	[SURF-ITA] Assess clarity of responsibility and authority between air and ground for conflict resolution when alerts trigger on both sides and impact on task performance.	Validated
OBJ-03b.05-V3-VALP-0120	[SURF-ITA] Assess efficiency to cooperate with ATC in case of potential threat detected by on-board systems.	Validated
OBJ-03b.05-V3-VALP-0130	[SURF-ITA] Assess impact of the alerts and indications understanding on workload	Validated

Business aircraft results (TWY-ITA)		
OBJ-03b.05-V3-VALP-0140	[TWY-ITA] Usability	Validated
OBJ-03b.05-V3-VALP-0150	[TWY-ITA] Timeliness of alerts	Validated
OBJ-03b.05-V3-VALP-0160	[TWY-ITA] Intelligibility	Validated
OBJ-03b.05-V3-VALP-0170	[TWY-ITA] Conflict resolution	Validated
OBJ-03b.05-V3-VALP-0180	[TWY-ITA] Assess efficiency to cooperate with ATC in case of potential threat detected by on-board systems.	Validated
OBJ-03b.05-V3-VALP-0190	[TWY-ITA] Assess impact of the alerts and indications understanding on workload.	Validated
OBJ-03b.05-V3-VALP-0191	[TWY-ITA] Assess the relevance of the CDTI information to successfully perform the task	Validated
FTS		
OBJ-03b.05-V3-VALP-0200	[SURF-A] [SURF-ITA] [TWY-ITA] Verify that the spurious alerts rate is lower than the limits defined in the TS/IRS (DO-323)	Validated
OBJ-03b.05-V3-VALP-0210	[SURF-A] [SURF-ITA] [TWY-ITA] Gaps analysis from real ADS-B data and missed alerts fast time simulation.	Validated

Table 17: Validation results

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

Additional safety requirements are derived below.

ID [SPR-level Model element]	Description	Thread [Scenario # xx]	Action	Number
SR#030	Ownship navigation shall provide continuously aircraft data.	C2	All scenarios	
SR#031	Runway data shall be available.	C3		

		All scenarios
SR#032	After the avoidance maneuver is ended, the Flight Crew shall contact the Controller for further instructions.	Action 6 All scenarios

Table 18: Additional SR from Thread Analysis – Normal Operational Conditions

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

4.4.1 Scenarios for Abnormal Conditions

Possible scenarios are:

ID	Scenario	Rationale for the Choice
AC1 Use Case 1	Braking system failure & Ownship on ground (entering or crossing the runway, taxiing on the runway)	Absence or very limited efficiency of braking can be a strong limitation in case of traffic alert. The mitigation means is that the aircraft needs to stop taxiing or does not initiate take-off in these conditions. At landing, ATCo will be aware of such situation and will enhance awareness and e.g. increase separation at landing, focus monitoring on aircraft on ground.
AC2 Use Case 2	Ownship on approach and cannot perform a go-around in safe conditions	In case of an aircraft presence on the runway, the aircraft cannot perform a go-around. As said in section 2.7, this is mitigated by an early communication with ATCo to enhance awareness and e.g. increase separation at landing, focus monitoring on aircraft on ground.

Table 19: Operational Scenarios – Abnormal Conditions

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

As said in section 2.7, no safety requirement appears as existing procedures will mitigate the failures effect.

The new system cannot cover external systems failures.

4.4.3 Thread Analysis of the SPR-level Model – Abnormal Conditions

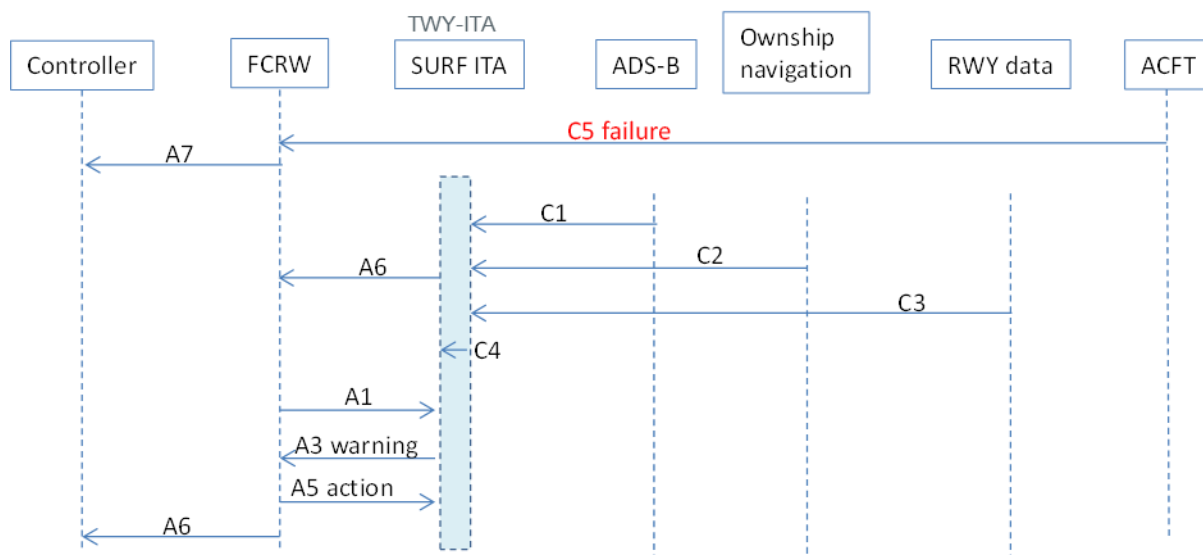


Figure 11: Thread analysis in case of abnormal conditions

The event is here:

- C5: external system failure
- A7: the crew informs ATCo

Compared with the thread analysis in normal conditions, the event occurs before or in parallel with the steady process.

4.4.4 Effects on Safety Nets – Abnormal Operational Conditions

The thread analysis leads to show that abnormal conditions do not lead to add new Safety Requirements.

It can just be said that Traffic Alerts efficiency is limited by these remote cases.

4.5 Design Analysis – Case of Internal System Failures

The objective of this analysis consists in determining how the system architecture (encompassing people, procedures, equipment) designed for Traffic alerts for Pilots tool can be made safe. For that purpose, the method consists in apportioning the Failure Case-Safety Objectives of each hazard into Safety Requirements to elements of the system.

Fault tree analysis is used to identify the causes of hazards and combinations thereof, accounting for safeguards already specified in the current standards and for any indication on their effectiveness. Quantitative Safety Requirements are the means to express Safety Requirements for elements/parts of the system that will be subject to more in-depth safety assessment in further lifecycle steps. The validity of the quantitative Safety Requirements is conditioned upon the validity of the Safety Objectives and on the accuracy of probabilistic data input to the fault trees.

4.5.1 Causal Analysis

For each system-generated hazard, a top-down identification of internal system failures that could cause the hazard was conducted. The hazards identified are:

SURF-ITA

- Hz#001: Imminent runway collision between ownship and a mobile goes undetected by SURF-ITA application.
- Hz#002: Imminent RWY collision with mobile is detected but flight crew has incomplete information.
- Hz#003: Imminent RWY collision with mobile is detected but flight crew has incorrect information.
- Hz#004: Unresolved imminent RWY collision with mobile after SURF-ITA system detection.
- Hz#005: Near-accident situation generated by failure to inhibit SURF-ITA alert during take-off roll at high-speed regime.

A fault tree has been produced for each above runway hazard providing an overview of all the contributions for a given hazard. Fault trees are elaborated by decomposing the hazard in a combination of failures (i.e. Basic Causes) linked by different gates: “AND” gates and “OR” gates. Once the qualitative fault tree is defined, the safety objective assigned to each hazard should be apportioned among the basic causes and safety requirements should be allocated.

Two types of SRs may be derived depending on the nature of the basic cause being considered:

- Technical-system related basic causes: quantitative safety requirements may be derived indicating, for example, the maximum allowable probability or frequency of occurrence for a specific failure. Some other qualitative SRs may be also identified concerning for example the system Design Assurance Levels (DAL) or establishing specific procedures related to the use of some functions. Some of the base event figures can be taken from already existing safety assessments (*e.g.* DO-323, DO-322, etc.)
- Human-procedures related basic causes: No quantitative SRs are derived from these kinds of causes.

TWY-ITA

- Hz#006: Taxiway conflict not prevented by Pilot due to TWY-ITA System credible erroneous traffic indication or alert.
- Hz#007: Taxiway conflict not prevented by Pilot due to TWY-ITA System missing traffic indication or alert.
- Hz#008: Taxiway conflict not prevented by Pilot due to TWY-ITA System erroneous traffic identification information.

Founding Members

A fault tree has been produced for hazard Hz#007 only due to safety criteria significance providing an overview of contributions for a given taxiway hazard.

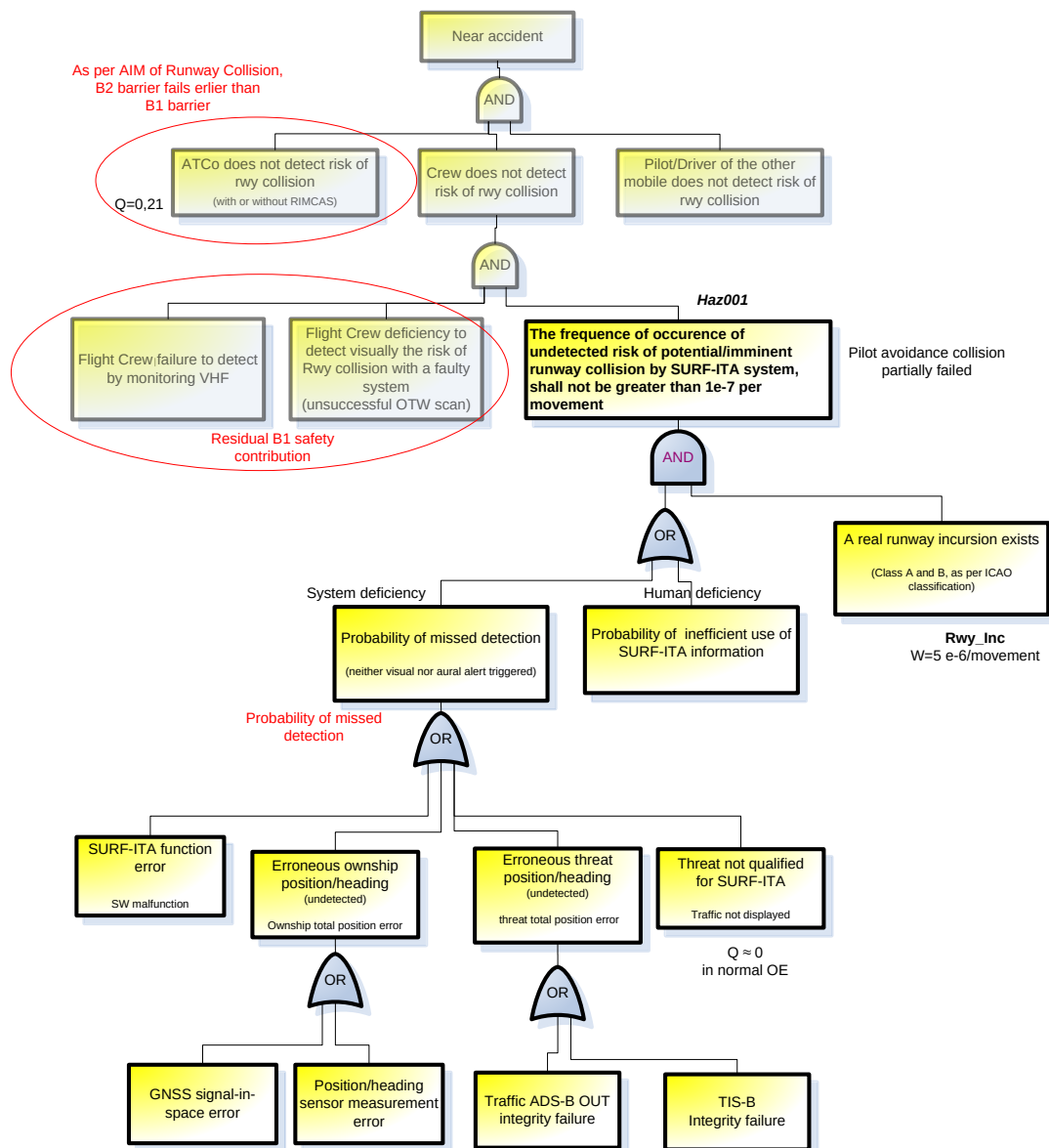
4.5.1.1 Hz#001: Imminent runway collision between ownship and a mobile goes undetected by SURF-ITA application

- The SURF-ITA does not detect a real risk of potential/imminent runway collision
- The SURF-ITA detects a risk of potential/imminent runway collision but the crew disregards the SURF-ITA information

Summary: Hazard Hz #001 is covered with :

- System detection that fulfil the objectives,
- Software level chosen as per conventional systems,
- Reduced human error thanks to training and appropriate function design.

For major completeness, this fault-tree reports (shaded boxes) also the events at a higher level than Hz#001 which contribute to the Runway Collision Barriers failure (near accident).



The following table reports some basic causes identified for Hz#001, including quantitative allocation aspect, where possible.

Hz001 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
ATCo_fail [ATCo]	Controller deficiency in detecting potential/imminent risk of runway collisions	0,21	This probability has been defined by operational expert and reported in the AIM of the Runway Collision as failure rate of “ATC Runway Collision Avoidance” Barrier
Probability of ineffective use of SURF-ITA information [FLCW]	SURF-ITA works correctly but crew is not able to interpret/use effectively the information. Possible causes: - in case of alerts pilot does not select the appropriate range on CDTI to display the actual threat’s position, or - in case of alert, pilot is reluctant to be head-down and remains unaware of the threat’s position - Pilot misinterprets CDTI information - Crew disregards SURF-ITA alert due to an high workload	HP not quantified	In setting SAC (see § 2.4) we have assumed that pilot is sufficiently trained to interpret all the SURF-ITA information. It is considered that no probability can be established to determine when SURF-ITA alerts is ineffectively used by the crew because: - Warning situation: the cases where the crew completely disregard SURF-ITA alert (e.g. crew voluntarily ignores SURF-ITA alerts due to a higher priority task. In this critical situation the risk of RWY collision could remain undetected until crew visually acquire the threat. Validation has shown that during this phase, monitoring the situation is part of the priority tasks (no-information) – - the case where crew becomes partially aware of a potential/imminent risk of RWY collision but not perform appropriate actions to

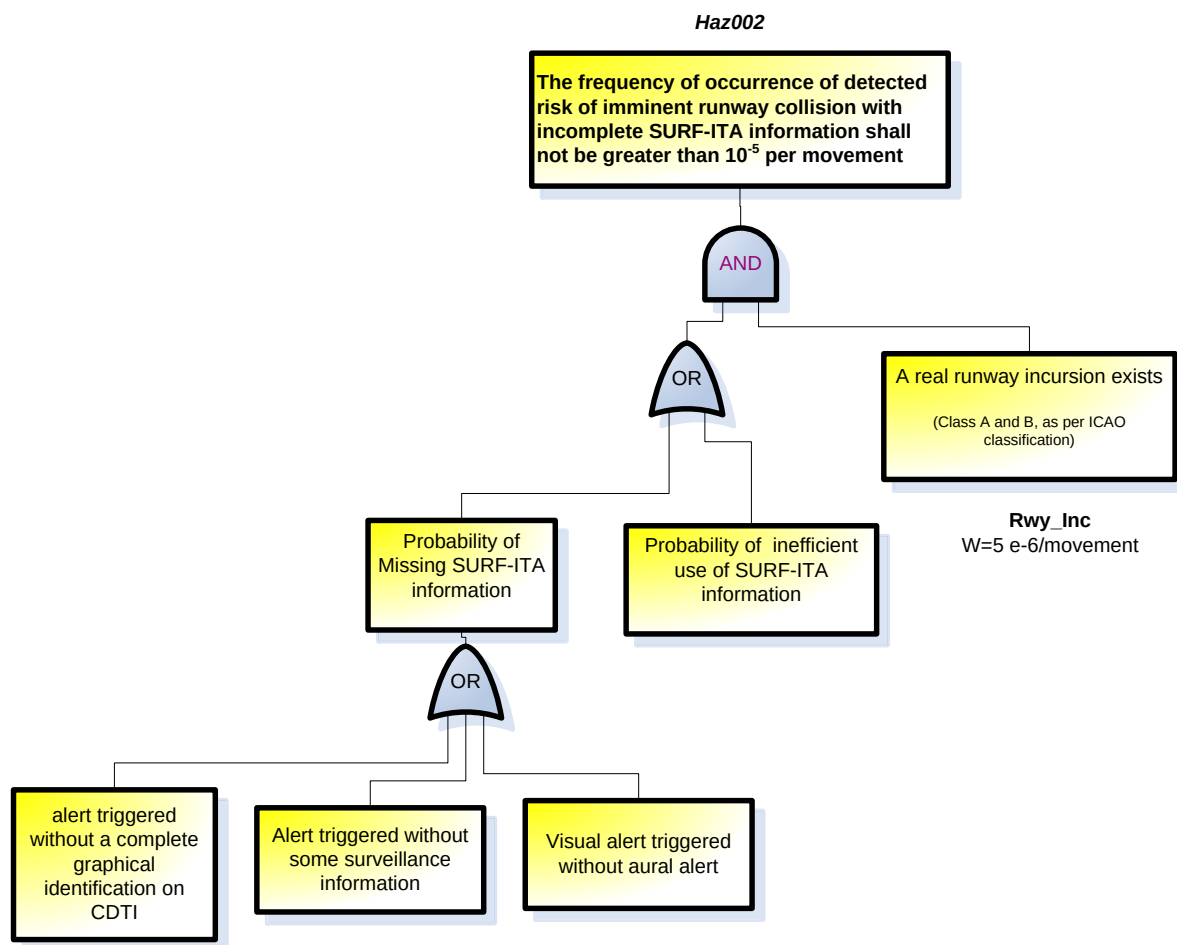
Hz001 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
			get a complete situation awareness (e.g. crew does not select the correct range to see the threat's position) but it is not expected in case of warning to look at CDTI (incomplete information) the case where crew becomes partially aware of a potential/imminent risk of RWY collision but mishandle/misinterpret SURF-ITA information on CDTI. It can only happen with a 1st level of alert (caution/advisory) (incorrect information) It is reasonable to think that the above types of “ineffective use of SURF-ITA alerts” occur with different frequencies of occurrence.
A real runway incursion exists	Class A and B runway incursion are the type of RWY incursions that SURF-ITA system should mitigate	$5 \cdot 10^{-6}$ per movement	It is a statistic data reported in the. EASA annual Safety Review 2011. Class A and B (according to ICAO classification) runway incursions registered in Eurocontrol Member States was around five per million aircraft movements
SURF-ITA function error	It encompasses avionics software or complex electronic hardware errors	Not available	Probability associated with the appropriate system Design Assurance Level(DAL)

Hz001 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
	that occur in ownship's avionics that remain undetected		
GNSS signal-in-space error	It affects a wide number of mobiles and it is most likely be manifested through a bias error with all targets shifted accordingly (including ownship)	10^{-4} per FH	This failure rate value has been assumed into DO-322/ED-165 "SPR for ATSA-SURF application" This is an assumption because it falls outside the boundary of the SURF-ITA system
Position Sensor measurement error	It encompasses possible errors in ownship's position measurement (e.g. GNSS position sensor error) or in ownship's heading measurement (e.g. INS, AHRS error)	Not available	
Traffic ADS-B OUT integrity failure	For ADS-B equipped mobiles, this failure refers to all integrity failures in transmitting the ADS-B data. (GNSS sensor integrity errors, integrity failure of the Transmit Processing Function and heading sensor integrity errors) This failure includes errors arising from equipment malfunction, "bit-flips" or other non-nominal causes	$3 \cdot 10^{-5}$ per FH	This value has been assumed into DO-322/ED-165 "SPR for ATSA-SURF.

Table 20: HZ#001 causal analysis

4.5.1.2 Hz#002: Imminent RWY collision with mobile is detected but flight crew has incomplete information

- The SURF-ITA detects the risk of potential/imminent runway collision but does not provide all the information to the crew (e.g. threat symbol not highlighted, threat identification missing, etc.) or,
- The SURF-ITA detects the risk of potential/imminent runway collision but the crew does not use properly the SURF-ITA information (e.g. crew does not select the correct range on CDTI to be aware of the real threat's position)



Summary: Hazard Hz #002 is covered with:

- System detection that fulfil the objectives,
- Software level chosen as per conventional systems,
- Reduced human error thanks to training and appropriate function design.

It is noted that a part of errors occurs in situations of low level alert because there is still time to react.

The following table describes the basic causes identified for Hz#002.

Haz002 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
Probability of ineffective use of SURF-ITA information	SURF-ITA works correctly but crew is not able to interpret/ use effectively the SURF-ITA information. Possible causes are:	HP not quantified	In setting SAC (see § 2.4) we have assumed that pilot is sufficiently trained to interpret all the SURF-ITA information

Hz002 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
	For a caution/advisory (optional implementation): in case of alerts pilot does not select the appropriate range on CDTI to display the actual threat's position, or in case of alert, pilot is reluctant to be head-down and remains unaware of the threat's position or Pilot misinterprets CDTI information Crew disregards SURF-ITA alert due to an high workload		It is considered that no probability can be established to determine when SURF-ITA alerts is ineffectively used by the crew because: - Warning situation: the cases where the crew completely disregard SURF-ITA alert (e.g. crew voluntarily ignores SURF-ITA alerts due to a higher priority task. In this critical situation the risk of RWY collision could remain undetected until crew visually acquire the threat. Validation has shown that during this phase, monitoring the situation is part of the priority tasks (no-information) – - the case where crew becomes partially aware of a potential/imminent risk of RWY collision but not perform appropriate actions to get a complete situation awareness (e.g. crew does not select the correct range to see the threat's position) but it is not expected in case of warning to look at CDTI (incomplete information) - the case where crew becomes partially aware of a potential/imminent risk of RWY collision but mishandle/misinterpret SURF-ITA information on CDTI. It can only happen

Hz002 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
			with a 1st level of alert (caution/advisory) (incorrect information) It is reasonable to think that the above types of “ineffective use of SURF-ITA alerts” occur with different frequencies of occurrence.
A real runway incursion exists	Class A and B runway incursion are the type of rwy incursions that SURF-ITA system should mitigate	$5 \cdot 10^{-6}$ per movement	It is a statistic data reported in the EASA annual Safety Review 2011. Class A and B (according to ICAO classification) runway incursions registered in Eurocontrol Member States was around five per million aircraft movements
alert triggered without a complete graphical identification on CDTI	SURF-ITA function triggers aural alert but visual information are incomplete: Threat symbol is not properly highlighted Runway status indication not displayed Label is not displayed	Not available	Software causes which will be DAL C (see SR#034)
Alert triggered without some surveillance information	SURF-ITA function triggers both aural and visual alert but one or more threat's surveillance information is/are missing (e.g. identity, a/c size, vertical position, etc.)	Not available	Software causes which will be DAL C (see SR#034)
Visual alert triggered without aural alert	SURF-ITA aural alert is not triggered. Crew can be aware of the potential/imminent risk of RWY collision only head-down	Not available	Software causes which will be DAL C (see SR#034)

Table 21: HZ#002 causal analysis

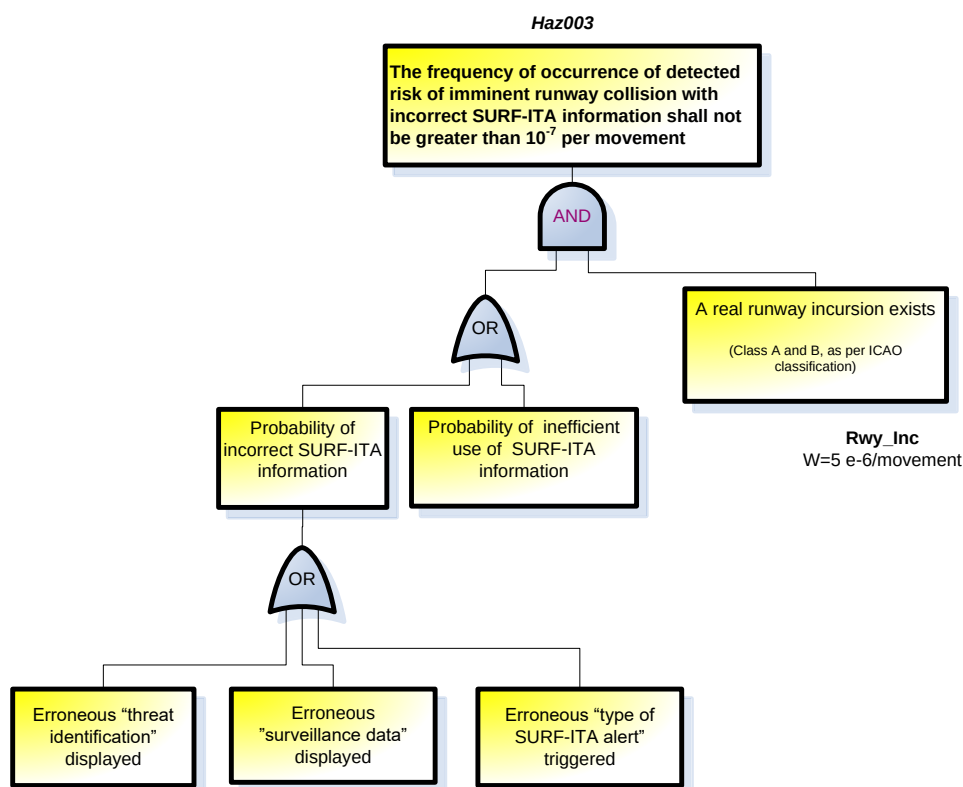
4.5.1.3 Hz#003: Imminent RWY collision with mobile is detected but flight crew has incorrect information

- The SURF-ITA detects the risk of potential/imminent runway collision but provide incorrect information to the crew (e.g. an advisory/caution alert is triggered instead of a warning alert, the threat has a wrong identification, the position of the threat is incorrect, etc.) or,
- The SURF-ITA detects the risk of potential/imminent runway collision but the crew misinterprets the SURF-ITA information (e.g. after an alert, pilot identifies as threat the wrong mobile and perform inappropriate actions)

Summary:

Hazard Hz #003 is covered with:

- System detection that fulfils the objectives,
- Software level chosen as per conventional systems is sufficient to ensure the expected service,
- Even though it happens, the crew is aware of a conflict being developing and increases one's awareness and manoeuvres or informs ATC.



The following table describes the basic causes identified for Hz#003.

Hz003 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
Probability of ineffective use of SURF-ITA information	SURF-ITA works correctly but crew misinterprets SURF-ITA information. This risky condition could occur when a SURF-ITA alert is triggered in high-workload scenario in conjunction with a crew not properly trained to manage the SURF-ITA in critical situation.	HP not quantified	In setting SAC (see § 2.4) we have assumed that pilot is sufficiently trained to interpret all the SURF-ITA information. However SURF-ITA alerts is ineffectively used by the crew: - the cases where the crew completely disregard SURF-ITA alert (<i>e.g.</i> crew voluntarily ignores SURF-ITA alerts due to an higher priority task. In this critical situation the risk of RWY collision could remain undetected until crew visually acquire the threat. (no-information)) - the case where crew becomes partially aware of a potential/imminent risk of RWY collision but not perform appropriate actions to get a complete situation awareness (<i>e.g.</i> crew does not select the correct range to see the threat's position) (incomplete information) - the case where crew becomes partially aware of a potential/imminent risk of RWY collision but mishandle/misinterpret SURF-ITA information on CDTI (incorrect information) It is reasonable to think that the above types of “ineffective use of SURF-ITA alerts” occur with different frequencies of

Hz003 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
			occurrence. To date, a realistic quantification of such events is not available
A real runway incursion exists	Class A and B runway incursion are the type of rwy incursions that SURF-ITA system should mitigate	$5 \cdot 10^{-6}$ per movement	It is a statistic data reported in the EASA annual Safety Review 2011. Class A and B (according to ICAO classification) runway incursions registered in Eurocontrol Member States was around five per million aircraft movements
Erroneous “threat identification” displayed	SURF-ITA function triggers alert but the threat is erroneously identified (e.g. the threat is depicted as an aircraft instead of a vehicle)	not available	Software causes which will be DAL C (see SR#034)
Erroneous “surveillance data” displayed	SURF-ITA function triggers aural alert but one or more threat’s surveillance information is/are incorrect (e.g. identity, a/c size, vertical position, etc.)	Not available	Software causes which will be DAL C (see SR#034)
Erroneous “type of SURF-ITA alert” triggered	- Incorrect type of SURF-ITA aural alert is triggered - incorrect type of visual alert is triggered (e.g. threat symbol is amber-highlighted instead of red-highlighted)	Not available	Software causes which will be DAL C (see SR#034)

Table 22: HZ#003 causal analysis

4.5.1.4 Hz#004: Unresolved imminent RWY collision with mobile after SURF-ITA system detection

SURF-ITA detects a potential/imminent risk of runway collision but pilot fails to perform an appropriate response to the alert. The base events leading to an inappropriate response can be the following:

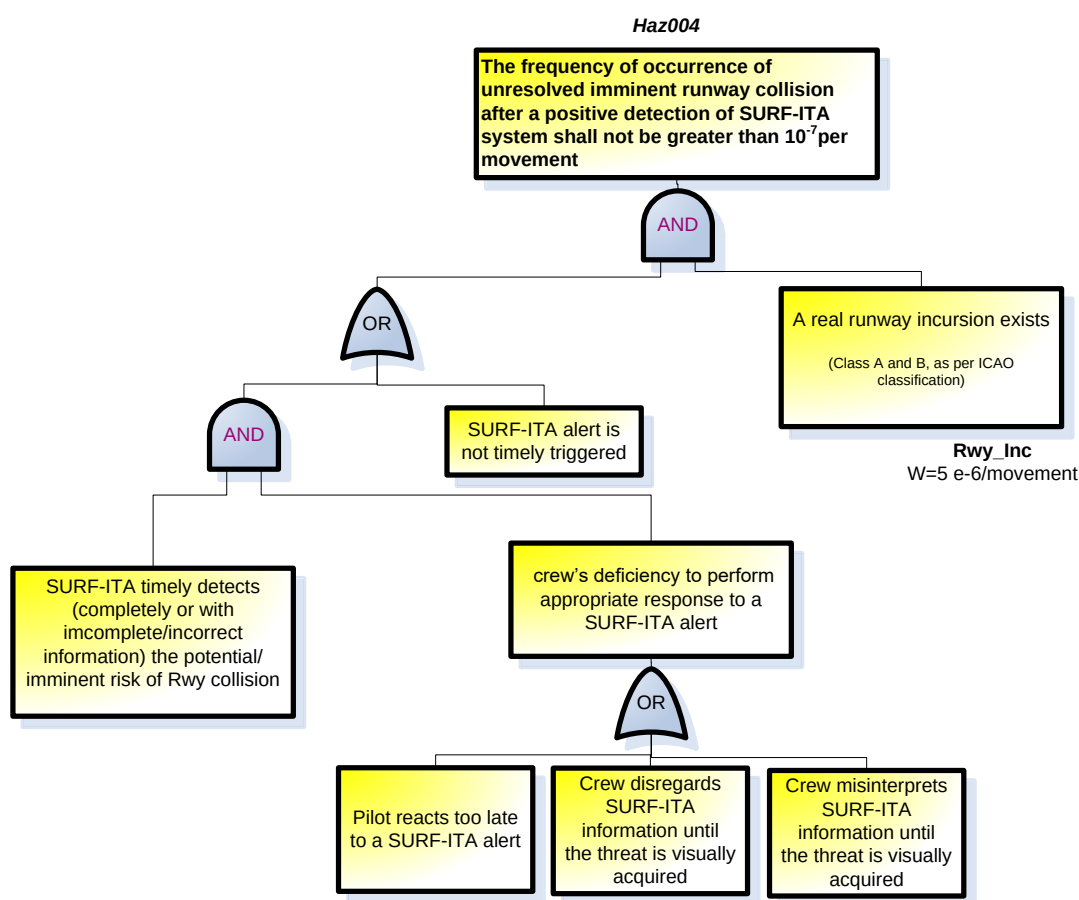
- Pilot is aware of the SURF-ITA alert but reacts too late
- Crew ignores SURF-ITA alert

- Crew misinterprets the SURF-ITA alert

Common causes for all the above human-dependent base events could be a condition of high crew's workload when the SURF-ITA alert occurs in conjunction with a lack of expertise in facing this critical situation with the SURF-ITA system being implemented. An adequate crew's training can significantly reduce the frequency of occurrence of this root causes.

- SURF-ITA alert is not timely triggered (this is considered as a non-detection similar to Hz#001)

This system-dependent base event is strictly linked to the system design (horizontal position accuracy, probability of false detection, probability of nuisance detection, etc.).



The following table describes the basic causes identified for Hz#004.

Hz004 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
Cumulative probability of SURF-ITA detection	This value refers to the overall probability for the system to detect a real risk of potential/imminent runway collision. The detection can be:	Proposed 0,7	This value is proposed as being the contribution of SURF-ITA to the overall reduction of near-collisions on runway.

Hz004 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
	- a complete and correct detection of the threat (the application works as intended) - a detection with missing information - a detection with incorrect information However, in all the above cases, the primary SURF-ITA's objective to gather crew's attention on a critical situation is achieved.		This value looks realistic and it is expected to reach a much better detection rate regarding the low false alert rate.
A real runway incursion exists	Class A and B runway incursion are the type of RWY incursions that SURF-ITA system should mitigate	$5 \cdot 10^{-6}$ per movement	It is a statistic data reported in the EASA annual Safety Review 2011. Class A and B (according to ICAO classification) runway incursions registered in Eurocontrol Member States was around five per million aircraft movements
Pilot reacts too late to a SURF-ITA alert	High pilot's workload + lack of expertise in handling SURF-ITA alert in critical situation	HP not quantified	
Crew disregards SURF-ITA information	High pilot's workload + lack of expertise in handling SURF-ITA alert in critical situation	HP not quantified	
Crew misinterprets SURF-ITA information	High pilot's workload + lack of expertise in handling SURF-ITA alert in critical situation	HP not quantified	

HZ004 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
SURF-ITA alert is not timely triggered	ADS-B data or Position sensor	6.10^{-5}	Assumption for this kind of airborne function: here the logic is working but input data are erroneous ADS-B data or Position sensors are assumed to have similar values.

Table 23: HZ#004 causal analysis

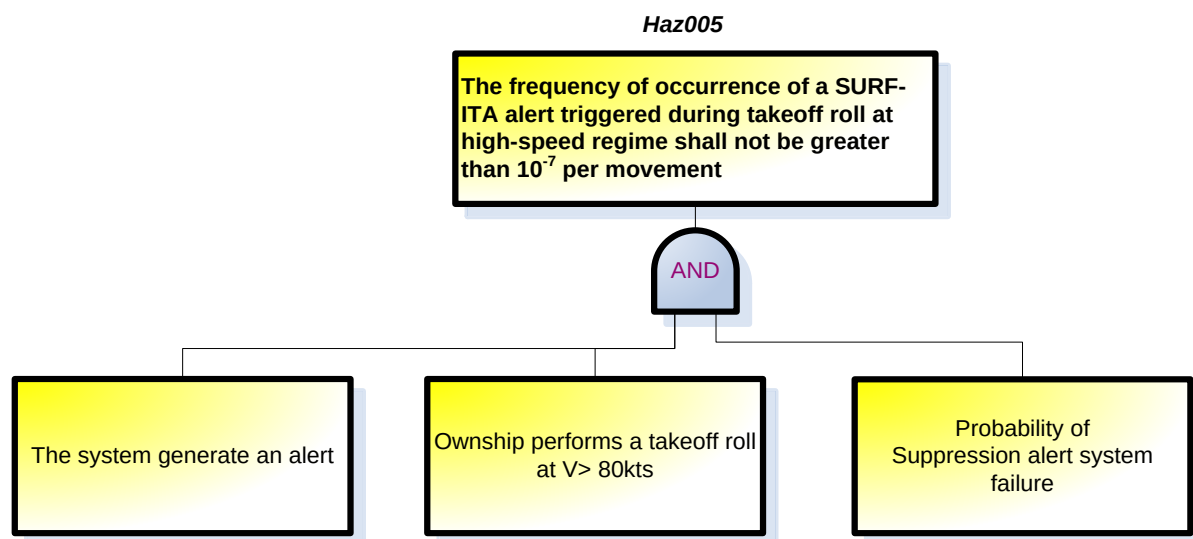
4.5.1.5 HZ#005: Near-accident situation generated by failure to inhibit SURF-ITA alert during take-off roll at high-speed regime

SURF-ITA alerts should be inhibited in this critical phase (take-off roll with a speed of 100 kt to avoid potential unsafe pilot's reaction but it is not. The root cause is the failure of the suppression alert system.

Summary:

Hazard HZ #005 is covered with :

- Low probability of occurrence of respective events,
- Software level chosen as per conventional systems,
- Non directive alert messages that yield the possibility of deciding to complete take-off.



The following table describes the basic causes identified for HZ#005.

Hz005 Basic Causes [SPR-level Model Element]	Failure –cause description	Quantification/ assumption	justification
A real risk of runway incursion ahead the ownship exist	It represents a subpart of the total amount of class A and B runway incursion. It refers to the cases in which a mobile is entering or crossing the runway in front of the ownship that is going to take-off	10^{-6} per movement or less	We assume that this type of event occurs with a frequency of 1 out of one million of movement or less
Ownship is performing a take-off roll and is at V>80 kts		$6.4 \cdot 10^{-3}$	Based on the data reported in table 5, the ownship is exposes to this specific state the 0.64% of the time during a movement. Meaning that the probability that the ownship in rolling at V>80 kts is $6.4 \cdot 10^{-3}$
Probability of Suppression alert system failure	It encompasses avionics software or complex electronic hardware errors that occur in ownship's avionics that remain undetected	not available	Probability associated with the appropriate system Design Assurance Level(DAL) which is DAL C (see SR#034)

Table 24: Hz#005 causal analysis

4.5.1.6 Hz#006: Taxiway conflict not prevented by Pilot due to TWY-ITA System credible erroneous traffic indication or alert

This hazard addresses the TWY-ITA provision of erroneous information to the flight crew that results in the flight crew being persuaded that:

- A perceived threat exists when in reality there is no threat;
- No threat exists - when one may exist in reality.

Hazard Hz #006 is covered with:

- System detection that fulfil the objectives,
- Software level chosen as per conventional systems,
- Reduced human error thanks to training and appropriate function design.

The information presented to the flight crew could be construed as a threat through a combination of erroneous state parameter. To analyses the hazard, an assessment of the effects (event trees) and causes (fault tree) was carried out. The fault tree analysis is used to determine the probability that the flight crew are presented with erroneous information through a combination of systematic failures and a representation of the position and direction of other traffic. The event tree analysis is used to

examine the mitigation means that limit the severity of operational effects stemming from the flight crew reacting to the system erroneous information.

During taxi operations, the flight crew will be completing flight checks and routing the aircraft to the runway or the gate. The underlying assumption in determining the hazard effect and the severity is that the flight crew will resolve any hazard before proceeding with the flight.

Under these circumstances, operational experts stated that the hazard would result in a negligible increase in workload. If a perceived threat was noticed on the display, the flight crew would taxi the aircraft slower and maintain a visual scan out-the-window. It was not thought possible for the perceived threat to lead to a safety-related effect. Therefore, for each of the cases identified in the perceived threat case, an SC5 (no safety impact) severity was assigned.

For the real threat case (erroneous information), the severity SC1 case could result if the flight crew do not detect and resolve out the window and near runway operation within the REZ applicable to SURF-ITA is taken into account. Even in this case, the system is only penalized if the flight crew follow the system instead of current procedures. Outside the REZ where TWY-ITA is applicable, only the SC5 has been assigned.

4.5.1.7 Hz#007: Taxiway conflict not prevented by Pilot due to TWY-ITA System missing traffic indication or alert

The Operational Hazard addresses missing information that should be provided by the TWY-ITA, but is not. The hazard addresses unintentional misuse of the system by the flight crew (e.g., misunderstanding of the mixed equipage environment, misinterpretation of the system, or an over-confidence in the system), the effect that the TWY-ITA may have influencing a pilot's decision making based solely on the information presented (or not presented) by the system as opposed to out the window checks and standard operating procedures (this effect is sometimes referred to as "perception bias").

Missing information may be due to partial equipage or mixed equipage (i.e., where no ADS-B messages for certain elements of traffic are sent on the applicable data link for the Ownship); however, this is not seen as an SPR issue, as it is a procedural or policy issue. The fault tree includes a basic cause (of partial or mixed equipage), but does not apply any safety requirement, instead placing all the allocation on the system failures.

The strategy used in developing the event tree:

1. When is missing information critical and for which targets?
2. Would any difference be apparent, if a complete target was missing from the display or a subset of displayed information?
3. What would influence the flight crew from being prevented from identifying the threat out the window?
4. How would the lack of information being displayed contribute to the flight crew's perception and situational awareness?
5. What would be the operational consequence of lack of missing information being displayed on the TWY-ITA Traffic Display?

Missing information only becomes an issue for the flight crew when the information that is missing is that of a real threat. If the missing information is not a threat, it will not impact upon the flight crew (in a safety manner). Only the real threat case exists for OH2 (as the missing information is only hazardous if a real threat is present).

The fault tree is constructed by assessing the systematic way in which information may not be provided. The lack of information provided is down a number of elements.

- The dominant mitigation is whether or not a real threat exists
- The TWY-ITA system has to be operational
- The subsystem elements calculating position and heading have to fail

On this basis the following fault tree is constructed and proposed for Hz#007.

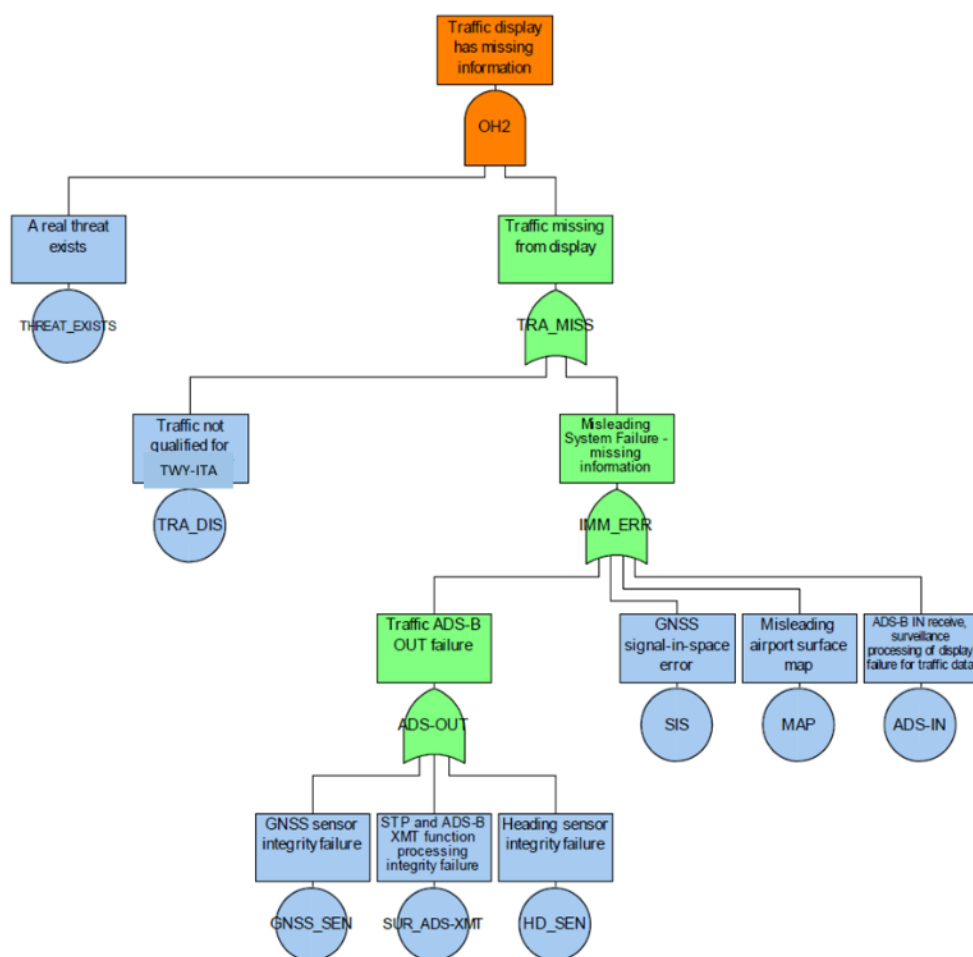


Figure 12 - Hz#007 Fault tree

For the real threat case, the key effects occur when the flight crew suffers from perception bias; i.e., they are misled by the system, rather than using information OTW or via party-line ATC or CTAF.

In this case, if a real threat is present, a severity SC1 effect will conservatively result with low probability and only near runway operations within the REZ are taken into account. Therefore TWY-ITA application outside the REZ has been assigned with SC5. As the Hz#006, the system is only penalized if the flight crew follow the system instead of current procedures and therefore have perception bias.

4.5.1.8 Hz#008: Taxiway conflict not prevented by Pilot due to TWY-ITA System erroneous traffic identification information

The hazard associated with TWY-ITA Traffic Display has erroneous Traffic Identification; Hz#008 is independent of whether there is an actual or perceived threat. Therefore, it is not related to Hz#006 or Hz#007, and has a separate event tree strategy.

Traffic Identification refers to both aircraft that may be displayed on the TWY-ITA aircraft's traffic display.

Erroneous Traffic Identification would result in the TWY-ITA flight crew recognizing an inconsistency between data sources which would require them to take an action to clarify which information is correct. As a result, the worst-case effect due to an erroneous Traffic Identification is a workload increase needed to resolve the discrepancy and eliminate any confusion.

Since this hazard is associated with an erroneous AC Identification, it is assumed that the position of the target is correct. Therefore, there is a significant likelihood that the TWY-ITA aircraft flight crew will observe the other traffic out the window, detect the inconsistency and recognize there is confusing situation that needs to be rectified.

The Safety Objectives are determined from comparing the probability with the safety targets derived for the different safety target categories.

The Safety Objectives can be determined by considering the accumulation of all probabilities for each safety category and using this to drive the Safety Objectives. For TWY-ITA it derives SC3 with assigned taxiway safety objectives.

4.5.2 Common Cause Analysis

No detailed common cause analysis has been done at this stage as many parameters are not defined yet and the on board architecture or the ground equipment are not specified for instance. However, the common causes leading to the causes and hazards as listed in the table below shall be minimised and assessed acceptable. The common cause analysis shall pay particular attention to the human operational performance.

SURF-ITA

Cause ID	Cause description	H-FTA SSC	Related Hazard (Hz)
SURF-A/SURF-ITA-01	Fail to detect the risk of runway collision between ownship in final approach and another a/c lined up on the runway threshold	SC2(b)	Hz#001

SURF-A/SURF-ITA-02	Partially fail to detect the risk of runway collision between ownship in final approach and another a/c lined up on the runway threshold	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-03	Fail to detect the risk of runway collision between ownship that is landing and a mobile that is entering the same runway ahead the ownship	SC2(b)	Hz#001
SURF-A/SURF-ITA-04	Partially fail to detect the risk of runway collision between ownship that is landing and a mobile that is entering the same runway ahead the ownship	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-05	Fail to detect the risk of runway collision between ownship and an aircraft that is using the same runway to land or take-off	SC2(b)	Hz#001
SURF-A/SURF-ITA-06	Partially fail to detect the risk of runway collision between ownship and an aircraft that is using the same runway to land or take-off	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-07	Fail to detect the risk of runway collision between ownship and a mobile that is entering the same runway	SC2(b)	Hz#001
SURF-A/SURF-ITA-08	Partially fail to detect the risk of runway collision between ownship and a mobile that is entering the same runway	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-09	Fail to detect the risk of runway collision between ownship that is taking off and a mobile that is entering the same runway	SC2(b)	Hz#001
SURF-A/SURF-ITA-10	Partially fail to detect the risk of runway collision between ownship that is taking off and a mobile that is entering the same runway	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-11	Fail to detect the risk of runway collision between ownship performing the final part of the approach and an a/c lined-up on the same runway ready to take-off	SC2(b)	Hz#001
SURF-A/SURF-ITA-12	Partially fail to detect the risk of runway collision between ownship performing the final part of the approach and an a/c lined-up on the same runway ready to take-off	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-13	Fail to detect the risk of runway collision between ownship performing the final part of the approach and a mobile that is entering the same runway	SC2(b)	Hz#001
SURF-A/SURF-ITA-14	Partially fail to detect the risk of runway collision between ownship performing the final part of the approach and a mobile that is entering the same runway	SC2(b)	Hz#002 Hz#003
SURF-A/SURF-ITA-15	Fail to timely perform the appropriate action after a SURF-ITA	SC2(b)	Hz#004
SURF-A/SURF-ITA-16	Fail to inhibit the SURF-ITA alert during high-speed regime	SC2(b)	Hz#005
SURF-A/SURF-ITA-17	Triggers an alert when no real conflict exists	SC2(b)	None

Table 25: Causes table for alerts on runway

TWY-ITA

Founding Members



Cause ID	Cause description	SC	Related Hazard (Hz)
TWY-ITA-01	Fail to detect the risk of taxiway collision between ownship taxiing and another a/c on taxiway.	SC3	Hz#007
TWY-ITA-02	Partially fail to detect the risk of taxiway collision between ownship taxiing and another a/c on taxiway.	SC3	Hz#006
TWY-ITA-03	Partially fail to detect the risk of taxiway collision between ownship taxiing and another a/c on taxiway.	SC3	Hz#008
TWY-ITA-04	Fail to timely perform the appropriate action after a TWY-ITA alert is triggered.	SC3	All

Table 26: Cause table for alerts on taxiways

4.5.3 Formalization of Mitigations

Mitigations are issued from OHA described in Appendix A OHA Table 36.

MM-ID	MM Definition	Related A-xxx/ Cause ID	Related HZ	Related SR (forward ref)
MM-01	In normal OE flight crew can still relies on OTW scan to avoid runway collision. Pilot detects a risk of runway collision and performs appropriate action. ATCo is also monitoring the situation as usual.	A#001 A#002 A#003 SURF-A/SURF-ITA-01 SURF-A/SURF-ITA-03 SURF-A/SURF-ITA-05 SURF-A/SURF-ITA-07 SURF-A/SURF-ITA-09 SURF-A/SURF-ITA-11 SURF-A/SURF-ITA-13	Hz#001	SR#001 SR#002 SR#003 SR#004 SR#005 SR#006 SR#007 SR#008 SR#010 SR#011 SR#012 SR#013 SR#015 SR#016
MM-02	Crew reacts to the alert and monitors the situation. Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo.	A#001 A#002 A#003 SURF-A/SURF-ITA-02 SURF-A/SURF-ITA-04 SURF-A/SURF-ITA-06	Hz#002 Hz#003	SR#001 SR#002 SR#003 SR#004 SR#005 SR#006 SR#007 SR#008 SR#010

		SURF-A/SURF-ITA-08 SURF-A/SURF-ITA-10 SURF-A/SURF-ITA-14		SR#011 SR#012 SR#013 SR#015 SR#016
MM-03	In the most critical situations, erroneous data could remain hidden before being discovered by crew. Pilot could perform inappropriate actions before identifying the incorrect information. In any case, in normal OE, crew can compensate with the OTW scan and ATC communication the incorrect information.	A#001 A#002 A#003 SURF-A/SURF-ITA-02 SURF-A/SURF-ITA-08	Hz#003	SR#001 SR#002 SR#003 SR#004 SR#005 SR#006 SR#007 SR#008 SR#010 SR#011 SR#012 SR#013 SR#015 SR#016
MM-04	Crew reacts to the partial alert and monitors the situation. Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo (if possible). The crew acquires the threat before MAP and pilot performs a go-around.	A#001 A#002 A#003 SURF-A/SURF-ITA-12	Hz#002	SR#001 SR#002 SR#003 SR#004 SR#005 SR#006 SR#007 SR#008 SR#010 SR#011 SR#012 SR#013 SR#015
MM-05	In normal OE, crew acquires visually the threat (e.g. an a/c on runway threshold or a mobile crossing the runway)	A#001 A#002 A#003	Hz#004	SR#001 SR#002 SR#003
MM-06	It appeared during validation tests that pilots reacted as expected with increased braking which also increases the time to collision	SURF-A/SURF-ITA-15 SURF-A/SURF-ITA-15		SR#004 SR#005 SR#006
MM-07	In normal OE, crew performs OTW scan and acquires visually the potential threat.			SR#007 SR#008

	Based on the ownship position and threat position, pilot can decide under his/her own decision: to stop the a/c to expedite a runway taxiing to expedite a runway crossing	SURF-A/SURF-ITA-15 SURF-A/SURF-ITA-15		SR#010 SR#011 SR#012 SR#013 SR#016 SR#023
MM-08	In normal OE, crew can visually acquire the potential threat in front of the ownship. He/she performs the RTO under his/her own decision.			
MM-09	Pilot shall be adequately trained to perform appropriate actions and procedures in any possible situation. The inhibition speed is close to V1 and the crew can decide that the intruder is far enough to take-off before a possible collision.	SURF-A/SURF-ITA-16	HZ#005	SR#009
N/A	Crew reacts as if it was a real alert. When on ground at low speed the crew can report to ATC.	SURF-A/SURF-ITA-17	None	SR#037

Table 27: Mitigation table SURF-ITA

TWY-ITA

MM-ID	MM Definition	Related A-xxx/ Cause ID	Related HZ	Related SR (forward ref)
MM-102	Conservatively, it is determined that 99% of perceived threats will be able to be identified out the window. Pilot detects a risk of taxiway collision and performs appropriate action.	A#101 A#002 TWY-ITA-01 TWY-ITA-02	HZ#006 HZ#007	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-103	Conservative estimates are made per phase for the probability that the missing real threats can be resolved OTW (i.e., the flight crew sees the threat). For the TWY-ITA application, no penalty should be taken as the system is not changing the safety effect,	A#101 A#002 TWY-ITA-01 TWY-ITA-02	HZ#006 HZ#007	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007

				SR#008 SR#010 SR#115
MM-104	For the perceived threat case, this barrier has been set as 99% (i.e., the flight crew operational experts stated that they would contact ATC or use CTAF once in a 100 times). For the taxi phase, this communication would be with the Ground frequency; it was assumed that this small additional communication would not lead to safety impacts. Although both branches therefore lead to SC3 from this mitigation. For the real threat case, if there is no means of visually acquiring the real threat out-the-window (and the Traffic Display is not displaying the real threat), and if the flight crew suffer perception bias (using the Traffic Display to believe that no threat exists), This is used to capture the probability that, for 50% of the time, they may still stop before an accident due to communications procedures.	A#101 A#002 TWY-ITA-02	Hz#006	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-106	It is estimated that for the real threat case, the flight crew will perform a visual check out the window 99% of the time (such that they are then able to detect and resolve OTW).	A#101 A#002 TWY-ITA-02	Hz#006	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-107	The flight crew should follow current procedures (and therefore not suffer from perception bias) 99% of the time; this is equivalent to a 1E-02 human error rate. This perception bias may mean the target is missed and action that could have been taken is not.	A#101 A#002 TWY-ITA-01 TWY-ITA-02	Hz#006 Hz#007	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007

				SR#008 SR#010 SR#115
MM-108	The probability that the aircraft is not moving when an erroneous traffic ID is displayed.	A#101 A#002 TWY-ITA-03	Hz#008	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-109	The probability that the flight crew observes the erroneous traffic ID on the Traffic Display, thus leading to potential operational effects.	A#101 A#002 TWY-ITA-03	Hz#008	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-110	Flight crew contacts ATC or traffic through voice communications, and resolves confusion.	A#101 A#002 TWY-ITA-03	Hz#008	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-111	Probability of traffic with two similar Traffic Identifiers being in the vicinity of the aircraft. There is less likelihood of any operational effect due to confusion over Traffic ID, if there is no	A#101 A#002 TWY-ITA-03	Hz#008	SR#101 SR#002 SR#003 SR#004

	similar ID with which the erroneous ID could be confused			SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-113	The flight crew observability of the Traffic Display in taxi operations was assumed to be 50%. Expert input stated that most crews will be visually scanning out-the-window (and single pilots will certainly be heads-up), meaning that a certain proportion of potential hazards are not seen on the display. For the alert case, it is assumed that the flight crew will receive traffic information every time an alert is triggered on.	A#101 A#002 TWY-ITA-01	HZ#006	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-114	This barrier shows the total amount of time during the taxi phase that the Ownship may be at risk, this being 50%. It arises as operational expertise stated that an aircraft in taxi would usually be stationary for a certain period of the time of exposure.	A#101 A#002 TWY-ITA-01	HZ#006	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115
MM-115	Only the taxi phase of flight is analysed so the proportion to the total operation is assumed to be 100%.	A#101 A#002 TWY-ITA-01	HZ#006	SR#101 SR#002 SR#003 SR#004 SR#005 SR#106 SR#007 SR#008 SR#010 SR#115

Table 28: Mitigation table TWY-ITA

4.5.4 Safety Requirements (integrity/reliability)

The table below present the list of new requirements from Common Cause Analysis (Table 25).

These requirements are compatible to achieve hazard target.

Reference	Safety requirements (integrity/reliability)	Hz ref
Airborne system		
SR#033	Requirement from DO-323 (SPR.64):“The probability that the horizontal position for traffic is erroneous shall be equal to or less than 1×10^{-5} per hour”.	HZ#001, HZ#003, HZ#004, HZ#005 HZ#006 HZ#007 HZ#008
SR#034	Software used in SURF-ITA System shall be compliant with a Software Assurance Level: level C.	HZ#002, HZ#001, HZ#003, HZ#004, HZ#005 HZ#006 HZ#007 HZ#008
ADS-B Out		
SR#035	For ADS-B equipped mobiles, this failure refers to all integrity failures in transmitting the ADS-B data. (GNSS sensor integrity errors, integrity failure of the Transmit Processing Function and heading sensor integrity errors). This failure includes errors arising from equipment malfunction, “bit-flips” or other non-nominal causes. The probability of error shall be equal to or less than 3×10^{-5} per hour.	HZ#002, HZ#001, HZ#003, HZ#004, HZ#005 HZ#006 HZ#007 HZ#008
Flight Crew		
SR#036	Flight Crew shall be trained to use SURF-A/ITA/TWY-ITA function.	HZ#004 HZ#006 HZ#007 HZ#008

Table 29: New integrity/reliability requirements

4.6 Achievability of the Safety Criteria

Achievability of safety criteria is assessed through expert judgment.

Safety Criterion	Description	Achieved through	Validation Technique
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Founding Members

SAC#1	There shall be an improvement 7,5 % of barrier B1 (Pilot Runway Collision Avoidance) to reduce runway collisions per year due to the introduction of the PJ.03b-05 runway solution, despite of the traffic increase till 2035.	Realism of the proposed figure relies on both: identification of Imminent Runway Collision events to be covered reflecting real events, real time simulation performed with pilots with representative systems. Real time simulation has demonstrated that in presence of realistic scenarios, pilots have had the correct reaction and avoided the collision. Fast Time Simulation was performed: - to prove a compliance with real collected data sample from airport environment, - go through a large number of scenarios and check the function coverage as well as limits. Real cases assessment has been analysed during RTS.	Fast Time Simulations (FTS) Real Time Simulations EXE-03b.05-V3-VALP-01, 02 and 03
SAC#2	There shall be an improvement 5 % of barrier B1 (Pilot Taxiway Collision Avoidance) to reduce taxiway collisions per year due to the introduction of the PJ.03b-05 taxiway solution, despite of the traffic increase till 2035.	Realism of the proposed figure relies on both: identification of imminent Taxiway Collision events to be covered reflecting real events, real time simulation performed with pilots with representative systems. Real time simulation has demonstrated that in presence of realistic scenarios, pilots have had the correct reaction and avoided the collision. Fast Time Simulation is required to prove a compliance with real collected data sample from airport environment. Real cases assessment has been analysed during RTS.	Real Time Simulation and Fast Time Simulations EXE-03b.05-V3-VALP-01, 02 and 03

Table 30: Safety criteria achievability

Safety Criteria are considered achievable if the mechanisms described therein can be demonstrated on the SPR level model underlying the Safety Requirements. The SPR level model was developed and validated iteratively in close cooperation with operational, safety and quality experts, as were all Safety Objectives and Operational Hazards and the derived Safety Requirements. This continuity is considered a sufficient guarantee that the Safety criteria will be achieved.

4.7 Realism of the SPR-level Design

4.7.1 Achievability of Safety Requirements / Assumptions

Safety requirements derived in this assessment target mainly two domains: equipment and human factor.

Equipment related Safety Requirements including functionality and system performance are explicit (success approach) or quantified (failure approach). The lowest quantified failure rate corresponds to the order of $1e-4$, therefore well within the range of typical reliability requirement imposed on equipment in civil aviation.

Human factor related Safety Requirements are explicit and qualitative in either approach, therefore considered fully achievable.

Therefore, all requirements defined in this SAR are considered achievable.

4.7.2 “Testability” of Safety Requirements

Referring to the list of safety requirements in appendix B.1, regarding testability, we can sort Safety Requirements in 3 categories:

- SR#001, 101 CDTI depending on the option of aircraft implementation
- SR#002 to 5: data communication between aircraft
 - ADS-B implementation is on-going
 - When equipped, it will be tested in a real environment to check the actual performance when using ADS-B on ground or close to the ground
- SR#006 to SR#032, 106 and SR#036 are operational requirements that can be tested in real time simulation first, then exposed in real flight.

All requirements are verifiable.

4.8 Validation & Verification of the Safe Design at SPR Level

Safety objectives were obtained through analysis with concerned PJ.03b project partners.

- DSN workshop in 2018
- Airbus workshop in 2019 in Toulouse

Safety requirements are gathered in Appendix B.

Validation exercises were performed within the scope of project SESAR 2020 Wave 1 PJ.03b-05 for both Mainline aircraft and Business Aircraft.

Real-time simulation exercises have permitted to validate the use of the functions with real equipment by pilots and consolidated the definition of the SPR/OSED. Fast Time Simulation testing has been analysed with high number of iterations and error distributions.

In addition, real aircraft data and exposure in real situations will complete the validation.

5 Detailed Safe Design at Physical Level

This section is considered out of scope of this document because it addresses a physical architecture which is mostly airborne using inputs from other aircraft. So, details of this architecture will be studied and checked against SPR requirements outside this scope.

6 Acronyms and Terminology

Term	Definition
A/C	Aircraft
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-R	Automatic Dependent Surveillance – Rebroadcast
AHRS	Attitude and Heading Reference System
A-SMGCS	Advanced – Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATCo	Air Traffic Control Officer
ATS	Air Traffic Service
ATSA-SURF	Enhanced Traffic Situational Awareness on the Airport Surface
AU	Airspace User
CDTI	Cockpit Display Traffic Information
DOD	Detailed Operational Description
ECAC	European Civil Aviation Conference
HMI	Human Machine Interface
HP	Holding PointHuman Performance
ICAO	International Civil Aviation Organization
IRS	Inertial Reference System
FAS	Final Approach Segment
FH	Flight Hour
MAP	Missed Approach Point
NO.	Number
OFA	Operational Focus Areas
OE	Operational Environment
OI	Operational Improvement

OHA	Operational Hazard Analysis
OPA	Operability Performance Assessment
OSA	Operability Safety Assessment
OSED	Operational Service and Environment Definition
OTW	Out-The-Windows (scan)
PD	Pilot Deviation
RIMS	Runway Incursion Monitoring System
REZ	Runway Engagement Zone
RSI	Runway Status Indication
SJU	SESAR Joint Undertaking
SAC	Safety Criteria
SO	Safety Objective
SPR	Safety and Performance Requirements
SW	Software
SWP	Safety Work Package
SR	Safety Requirements
SURF IA <i>(RTCA-definition)</i>	Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts
SURF-ITA <i>(SESAR- definition)</i>	Surface Indications and Traffic Alerts
TIS-B	Traffic Information Services – Broadcast
TWY-ITA	Surface Traffic Indication & Alerts on taxiways for pilots (Caution alerts only)
WA	Working Area

Table 31: Acronyms and terminology

Term	Definition
Advisory Alert	An alert that requires flight crew awareness and may require subsequent flight crew response
A-SMGCS (Advanced – Surface Movement Guidance and Control System)	A system providing routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety.
Caution Alert	Alert level that requires crew awareness and potential subsequent crew action with two senses of attention getter.
Conflict	A condition which can lead to a collision if no avoidance action is taken
Coverage volume	It is the amount of airspace where SURF-ITA alerts can be triggered
High-speed regime	For the purpose of this safety assessment, aircraft are referred to as moving at the high-speed regime if they move at or above 80 Knots
Entering/crossing the runway	For the purpose of this safety assessment, mobiles are referred to as entering or crossing the runway when they have already passed the stop bar but have not yet crossed the runway shoulder edge. (The minimum distance between the stop bar and the shoulder edge for a 30m wide runway is assumed to be 45m)
False alert	Incorrect or spurious alert that does not reflect a real critical situation. It is triggered due to avionics integrity failure
Final Approach	In the frame of this Safety Assessment, it is equivalent to Final Approach Segment.[see Final Approach Segment]
Final Approach Segment	The Final Approach Segment is defined as beginning at the Final Approach Fix (FAF) and ending at the touchdown For the purpose of this safety assessment , FAS can be divided into two sub-parts: initial part of the FAS (from FAF to a specific waypoint along the glide path) final part of the FAS (from a specific waypoint along the glide path to touchdown) This specific waypoint can be defined in terms of “time remaining to touchdown”
Flight crew response	The activity accomplished due to the presentation of an alert such as an action, decision, prioritisation, or search for additional information
Integrity (System)	System integrity is the probability per operating hour of an undetected failure of a functional element that results in erroneous information
Landing	According to ICAO definition, landing phase starts from the beginning of the landing flare until aircraft exits the landing runway, or comes to a stop on the runway
Low-speed regime	For the purpose of this safety assessment, aircraft are referred to as moving at the low-speed regime if they move below 80 Knots
Missed alert	It occurs in situations where an alert should be triggered, but is not presented. This includes traffic not qualified for SURF-ITA application

Probability of Missed alert	It is an objective reflecting the expected benefits of SURF-ITA application. It evaluates the reduction on safety benefits and an high rate/probability of missed alert leads to a situation similar to today where on board alerts are not provided
Missed Approach Point	It is a published point along the FAS at which a missed approach procedure shall be executed if the required visual reference does not exist. A pilot must execute a missed approach (go-around) if a required visual reference (normally the runway or its environment) is not in sight upon reaching the MAP or if the pilot decides it is unsafe to continue with the approach and landing to the runway.
Mobile	For the purpose of this safety assessment, mobile is referred to as any aircraft or vehicle
Movement	For the purpose of this safety assessment, “a movement” is equivalent to an “operation” [see Operation]
Nuisance Alert	Inappropriate and unnecessary alert generated by the system that is functioning as designed
Nuisance alert rate/ Probability of nuisance alert	It is the metric to measure the performance of the SURF-ITA application. Nuisance alerts can distract crew and potentially deteriorate his performance. A high rate/probability of nuisance alert can reduce the confidence of the pilot in the system and negatively affect the safety and operational effectiveness.
Operation	For the purpose of this safety assessment and in line with RTCA DO-323, “an operation” is defined as all of the ownship states that make up one take-off operation plus one approach and landing operation.
Operational Error	Action of an ATCo than results in less than required minimum separation between two or more mobiles or between an aircraft and obstacles (equipment, personnel on runways) or clearing an aircraft to take off or land on a closed runway
OTW (Out The Window) scan	Used by flight crew to establish the current position of the ownship and other traffic in the vicinity of ownship.
Pilot Deviation	Any pilot action which violates an ATCo instruction (e.g. a pilot crosses a runway without an ATC clearance)
Relevant traffic	Traffic is “relevant” for ownship if that traffic position, orientation and movement leads to or could potentially lead to a runway collision
Runway Incursion	Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the runway protected area (REZ) of a surface designated for the landing and take-off of aircraft. The ICAO identifies four types of runway incursions on the basis of their severity, as follows Category A: A serious incident in which a collision was narrowly avoided. Category B: An incident in which separation decreases and a significant potential for collision exists, which may result in a time-critical corrective/evasive response to avoid a collision. Category C: An incident characterized by ample time and/or distance to avoid a collision. Category D: An incident that meets the definition of runway incursion such as incorrect presence of a single vehicle/person/aircraft on the protected

	area of a surface designated for the landing and take-off of aircraft but with no immediate safety consequences. A and B runway incursions are considered to be serious incursions that the SURF-ITA application is expected to mitigate.
State	A phase of operation (e.g. “landing on runway”) is referred to as an ownship “state”. When using the SURF-ITA application, it is possible for ownship to be in a number of different states [see DO-323 for more details]
Vehicle/Pedestrian Deviation	Pedestrian or vehicle entering any portion of the airport movement area (runway/taxiway) without authorization from ATCo
Untrue detection probability	It represents the cumulative probability of inappropriate alerts being triggered by the system, due to avionics malfunctions (false alerts) or being generated when the alerting is working as designed (nuisance alert)
Warning Alert	An alert that requires immediate flight crew awareness and immediate flight crew response

7 References

Safety

- [1] SESAR P16.06.01, Task T16.06.01-006, SESAR 2020 Safety Reference Material, SRM (Ed. 00.04.01)
- [2] SESAR P16.06.01, Task T16.06.01-006, Guidance to Apply the SESAR 2020 Safety Reference Material, SRM (Ed. 00.03.01)
- [3] FAA Annual Runway Safety Report 2010
- [4] Runway Safety U.S. Department of Transportation, Volpe Center, Cambridge, MA (February 12, 2010)
- [5] 2019 CONOPS available in PJ19.2 deliverables on STELLAR
- [6] RTCA DO-323 Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF-IA), 8th December 2010
- [7] EASA Annual Safety Review 2011
- [8] RTCA DO-322 Safety, Performance and Interoperability Requirements Document for ATSA-SURF Application
- [9] D4.1.190 SESAR 2020 PJ.03b-05 V3 OSED-SPR-INTEROP final
- [10] SESAR1 D11 Validation Report for Traffic Alerts for Pilots
- [11] D4.1.180 SESAR 2020 Validation Report V3 for Traffic Alerts for pilots

Appendix A Safety Objectives

Safety objectives are gathered here-below.

Then, safety requirements derived from these objectives are presented in the next appendices.

Id	Description
SO#001	When the ownship is on final approach, SURF-ITA system shall timely detect the risk of runway collision caused by an aircraft lined up on the runway threshold and ready for take-off
SO#002	When the ownship is landing, SURF-ITA system shall timely detect the risk of runway collision caused by a mobile entering the runway ahead of the ownship
SO#003	When ownship is entering/crossing the runway, SURF-ITA system shall timely detect the risk of runway collision with an aircraft landing, taking off or that is going to take off from the same runway
SO#004	When the ownship is lined up awaiting a take-off clearance, SURF-ITA system shall timely detect the risk of runway collision with a mobile that is entering/crossing the same runway
SO#005	When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall timely detect the risk of runway collision if a mobile is entering/crossing the runway ahead the ownship
SO#006	When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if another a/c is holding on the runway ready for take-off
SO#007	When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the same runway
SO#008	When the ownship is landing, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the runway ahead of ownship
SO#009	When the ownship is entering/crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same ownship's runway
SO#010	When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead the ownship
SO#012	When the ownship is entering/crossing the runway, SURF-ITA shall trigger an advisory/caution alert if another a/c is holding on the runway ready for take-off
SO#013	When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory/caution alert if a mobile is entering/crossing the runway ahead the ownship
SO#014	When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, a go-around should be initiated under pilot's decision
SO#015	When the ownship is landing and a warning alert is triggered by SURF-ITA system, the pilot shall perform the appropriate action based on the specific situation

SO#016	When the ownship is entering/crossing the runway and a warning alert is triggered by SURF-ITA system, the pilot shall immediately either stop the ownship or expedite vacation
SO#017	When the ownship is in the low-speed regime during the take-off roll and a warning alert is triggered by SURF-ITA, pilot shall initiate a rejected take-off
SO#018	When the ownship is on final approach and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat
SO#019	When the ownship is entering/crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat and perform appropriate action
SO#020	When ownship is lined up awaiting a take-off clearance and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat
SO#022	SURF-ITA alerts shall be inhibited at high-speed regime during take-off roll
SO#050	When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Taxiing on Taxiway and trigger advisory/caution alert.
SO#051	When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Stopped Behind Holdline and trigger advisory/caution alert. (Within RWY Engagement Zone)
SO#052	When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Entering Runway at Taxiway Speeds and trigger advisory/caution alert. (Within Runway Engagement Zone)
SO#053	When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Exiting Runway at Taxiway Speeds and trigger advisory/caution alert. (Within Runway Engagement Zone)
SO#054	When the ownship is taxiing on taxiway and an advisory/caution alert is triggered by TWY-ITA system, flight crew shall timely acquire the position of the potential threat.
SO#055	(Operational objective) In flight, the crew shall inform ATCo about aircraft braking limitations involving runway availability. (SO#055)
SO#056	(Operational objective) The crew shall inform ATC of failures involving landing with a limited capability of go-around (e.g. short of fuel, severe failure) in order to take special care of the full runway availability. (SO#056)

SO#101	Provide an alert in case of risk of collision - SURF-ITA shall detect the risk of collision with a probability of 70%
SO#102	Improve pilots' awareness on runways
SO#103	SURF-ITA shall work as a supplemental means of safety to current operations.

SO#111	Provide an alert in case of risk of collision - TWY-ITA system shall detect the risk of collision with a probability of 70%
SO#112	Improve pilots' awareness on taxiways

Appendix B Consolidated List of Safety Requirements

B.1 Safety Requirements (Functionality and Performance)

Note: some requirements are optional due to the different possibility of implementation (like describe in OSED, ref [11]). These requirements are tagged with an “(Optional)” at the start of the requirement.

As reminder, the two validated implementation are:

- A concept based on a full SURF IA implementation
- A concept based on a partial SURF IA implementation and consisting on a “warning only” implementation without assuming ATSA-SURF on board and named “optional” in this document.

ID	Requirements (functionality and performance)	Status
SR#001	(Optional) When SURF-ITA is enabled, the traffic on CDTI shall be depicted by using a symbology able to clearly distinguish among: ● ownship ● other a/c moving within the REZ ● ground vehicles moving within the REZ	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#002	(Optional) When SURF-ITA is enabled, ownship shall be displayed on CDTI as a symbol with a label based on the following information: ● identity (24-bit address) ● horizontal position ● vertical position (when airborne) or on ground indication ● horizontal velocity ● vertical rate (when airborne) ● heading (when on ground) ● aircraft size ● distance or time between ownship and traffic triggering an alert (for off-scale traffic)	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#003	(Optional) When SURF-ITA is enabled, each a/c shall be displayed on CDTI as a symbol with a label using the following information: ● a/c identity (call-sign) ● horizontal position ● vertical position (when airborne) or on ground indication	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#004	Ownship shall be able to process : ● ADS-B surveillance data transmitted by ADS-B equipped mobiles, ● TIS-B and ADS-R surveillance data transmitted by ground stations	Validated partially EXE-03b.05-V3-VALP-03

SR#005	ADS-B/TIS-B/ADS-R data shall meet minimum data quality requirements to be qualified for SURF-ITA application	Validated partially EXE-03b.05-V3-VALP-03
SR#006	SURF-ITA system shall trigger: 1) both aural and visual alerts when a warning level is requested 2) only visual alert when an advisory/caution level is requested	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#007	SURF ITA equipment shall provide the flight crew with a system capability status	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#008	Ownship shall have an alert prioritisation function capable of managing and prioritising all the ownship's alerts being generated, including SURF-ITA alerts.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#009	Ownship shall have an automatic alert suppression function capable of inhibiting SURF-ITA alerts during take-off roll at high-speed regime.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#010	(Optional) With a full implementation with traffic display, CDTI shall display the airport map at different scale selectable by the flight crew and the relevant traffic (airborne and on ground)	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#011	<i>Deleted</i>	
SR#012	<i>Deleted</i>	
SR#013	<i>Deleted</i>	
SR#014	<i>Deleted</i>	
SR#015	When the ownship is on final approach, SURF-ITA system shall trigger a warning alert if there is a risk of collision with another a/c on the runway.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#016	When the ownship is landing, SURF-ITA system shall trigger a warning alert if a mobile is entering the runway ahead the ownship	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#017	(Optional) Full implementation: When the ownship is entering/crossing the runway, SURF-ITA shall trigger an	Validated

	advisory/caution alert if another a/c is moving on the runway with a possible risk of collision	EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#018	When the ownship is entering/crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same runway with a risk of collision.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#019	(Optional) When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory alert if a mobile is entering/crossing the runway ahead the ownship.	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#020	When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#021	When the ownship is on final approach, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the same runway and there is a risk of collision.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#022	When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, the crew shall initiate a go-around under his/her own decision.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#023	When the ownship is landing and a warning alert is triggered by SURF-ITA system due to a mobile entering/crossing the runway ahead of the ownship, the pilot shall promptly be aware of the threat position and decide the appropriate action: to maximise the braking action to stop the ownship as early as possible or to retard the braking action to overtake the threat as early as possible or to exit the runway through an high-speed taxiway (if possible) or to perform a touch and go (if possible)	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#024	When the ownship is entering/crossing the runway and a warning alert is triggered by SURF-ITA system, pilot shall immediately either stop the ownship or expedite vacation.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04

SR#025	When a warning alert is triggered by SURF-ITA during take-off roll at low-speed regime, pilot shall perform a rejected take-off	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#026	Deleted (Optional) When an advisory/caution alert is triggered by SURF-ITA system on final approach, pilot shall timely acquire the position of the threat by: by performing OTW scan looking at the CDTI, or by communicating with ATCo, or before performing the appropriate action	
SR#027	(Optional) When the ownship is entering/crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, pilot shall timely acquire the position of the potential threat by: by performing OTW scan looking at the CDTI, or by communicating with ATCo, or before performing the appropriate action	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#028	(Optional) When the ownship is lined-up on the runway and an advisory alert is triggered by SURF-ITA system pilot shall timely acquire the position of the potential threat by: by performing OTW scan looking at the CDTI, or by communicating with ATCo, or before performing the appropriate action	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#029	<i>Deleted</i>	
SR#030	Ownship navigation shall provide continuously aircraft data.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#031	Runway data shall be available.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#032	After the avoidance manoeuvre is ended, the Flight Crew shall contact the Controller for further instructions.	Validated partially EXE-03b.05-V3-VALP-02

		EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#036	Flight Crew shall be trained to use SURF-A/ITA/TWY-ITA function.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#037	The false alert rate shall be better than 5×10^{-4} per operation.(REQ-03B.05-V3-TS-031-01)	Validated EXE-03b.05-V3-VALP-01
SR#052	SURF-ITA shall display aircraft at risk on AMM.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#053	SURF-ITA function shall issue a warning level alert requiring an immediate and appropriate crew action only when, with given available parameters, a risk of collision can be identified.	Validated EXE-03b.05-V3-VALP-02 EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#101	When TWY-ITA is enabled, the traffic on CDTI shall be depicted by using a symbology able to clearly distinguish among: ●ownship ●other a/c moving within the Taxiway Relevant Zone (TRZ) ●ground vehicles moving within the TRZ	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#106	TWY-ITA system shall trigger: both aural and visual alerts when a caution level is requested.	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#115	When the ownship is taxiing on taxiway airport surface, TWY-ITA system shall trigger a caution alert if there is an immediate risk of collision with another a/c on the taxiway or stopped/leaving/exiting the Runway Engagement Zone (REZ).	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04
SR#150	When the ownship is taxiing on taxiway and an advisory/caution alert is triggered by the TWY-ITA system, before flight crew takes any decision, pilot shall timely acquire the position of the potential threat.	Validated EXE-03b.05-V3-VALP-03 EXE-03b.05-V3-VALP-04

Table 32: Safety Requirements (functionality and performance)

B.2 Safety Requirements (Integrity)

ID	Requirements (integrity)	Status
SR#033	Requirement from DO-323 (SPR.64): "The probability that the horizontal position for traffic is erroneous shall be equal to or less than 1×10^{-5} per hour".	Validated EXE-03b.05-V3- VALP-01
SR#034	Software used in SURF- ITA/TWY-ITA System shall be compliant with a Software Assurance Level : level C (RTCA DO 178 C)	Validated EXE-03b.05-V3- VALP-01
SR#035	For ADS-B equipped mobiles, probability to fail to transmit the ADS-B data (GNSS sensor integrity errors, integrity failure of the Transmit Processing Function and heading sensor integrity errors), including errors arising from equipment malfunction, "bit-flips" or other non-nominal causes shall be equal to or less than 3×10^{-5} per hour.	Validated EXE-03b.05-V3- VALP-01 EXE-03b.05-V3- VALP-04

Table 33: Safety Requirements (integrity)

Appendix C Assumptions, Safety Issues & Limitations

C.1 Assumptions log

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

Ref	Assumption	Validation
A#001	FCRW monitors visually the runway during runway operations	Validated during RTS exercises (see VALR)
A#002	TIS-B ground surveillance system may provide ownship with traffic information about mobiles not ADS-B equipped	Technical assumption used for architecture design
A#003	Ownship is equipped to receive ADS-B/TIS-B/ADS-R surveillance data	Technical assumption used for architecture design
A#101	FCRW monitors visually the OTW during taxiway operations.	Validated during RTS exercises (see VALR)

Table 34: Assumptions log

C.2 Safety Issues log

The following Safety Issues were raised at the level of Human Performance. They are reminded here after. They are further discussed in Part IV HP Report.

HP argument	HP Issue
Arg. 1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).	[SURF A] [TWY-ITA] Depending on the use case and on the operational context (traffic density, low visibility conditions, equipment failure, etc.), traffic conflict situations understanding and subsequent decision making may be complex to do upon alert triggering. It is expected that the alerting function support pilots' assessment of the situation and facilitate decision making in all situations and all contexts while enhancing safety.
Arg. 2.3: The design of the human-machine interface supports the human in carrying out their tasks.	[SURF-A][TWY-ITA] If alert information are not well understood by the crew, it can confuse pilots on the situation and lead to time-critical issues concerning expected actions to answer to the alert. Audio and textual messages have to be unambiguous and perceived by pilots in all operational contexts.
Arg. 1.1: Roles and responsibilities of human actors are clear and exhaustive.	[SURF-A][TWY-ITA] With or without alerts provided to ATCO through ATC tools, potential issues of contradictory resolution instructions may occur and may impact pilots understanding of the situation and their reaction to the alerts that may at the end impact safety of operations.

	Consistency between the two alerts (air and ground) as well as authority sharing should be further investigated. ATC keeps usual authority for traffic de-confliction and pilots are able to decide if an avoidance maneuver is needed due to an issue on-board not perceptible by ATC (e.g. windshear, failure) but it has to be confirmed if onboard maneuvers in response to SURF-A alerts are in line with ATC expectations and/or instructions, to avoid contradictory maneuvers and potential impact on safety.
Arg. 1.3.3: The level of workload (induced by cognitive and/or physical task demands) is acceptable.	[SURF-A] [TWY-ITA] Depending on the use case and on the operational context (traffic density, low visibility conditions, equipment failure, etc.), traffic conflict situations understanding and subsequent decision making may be complex to do upon alert triggering. It has to be ensured that workload induced by the alerts is acceptable to make a decision and perform the action in time.

Table 35: Safety Issues log

C.3 Operational Limitations log

No Operational Limitation was raised during the safety assessment.

Appendix D OHA TABLE

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SO#001: When the ownship is on final approach, SURF-ITA system shall timely detect the risk of runway collision caused by an aircraft lined up on the runway threshold and ready for take-off					
SURF-A/SURF-ITA-01: Fail to detect the risk of runway collision between ownship in final approach and another a/c lined up on the runway threshold	- Software error of the SURF-ITA function - Erroneous calculated ownship's position - Erroneous calculated threat position - Threat not SURF-ITA qualified - Pilot disregards SURF-ITA alert	No alert is triggered. The ownship continues the approach phase until the crew acquires visually the potential threat. With this failure, the situation is similar to the absence of "Traffic Alerts".	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. Pilot detects a risk of runway collision and performs appropriate action. ATCo is also monitoring the situation as usual.	Hz#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile. (*) (*) This hazard happens when all ATM/CNS systems fail to deliver the ATM operational services. It is important to highlight that pilot "see & avoid" safety barrier does not relies on any ATM/CNS services to prevent runway collision, but only on human capabilities. Hence, Hz#001 shall not encompass also the failure of this ultimate safety layer which is still active in normal visual conditions	SC2(b) Note: Although the AIM for Runway Collision shows that Pilot Avoidance Collision Barrier performs at an higher level than ATC Avoidance Collision Barrier (B1 and B2 are in series), in a real operational scenario B1 and B2 safety barriers can perform simultaneously (B1 and B2 are in parallel) to prevent potential runway collisions (in the reality also the TWR controller, in normal OE, could detect the risk of a runway collision and inform the pilots). In performing this safety analysis, in order to be coherent with AIM model of Runway Collision, we assume that B1 and B2

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
					safety barriers are strictly in series. This assumption leads to a conservative approach in determining the severity of Haz#001 since we are assuming to be in the worst case in which ATCo is not able to detect the risk of runway collision (i.e. B2 totally failed)
SURF-A/SURF-ITA-02: Partially fail to detect the risk of runway collision between ownship in final approach and another a/c lined up on the runway threshold	- Audio system failure - CDTI malfunction - missed surveillance data - pilot's partial use of SURF-ITA information	The crew gets incomplete information by the SURF-ITA system.(e.g. missing element in the alert message)	Pilot runway collision avoidance Crew reacts to the alert and monitors the situation. Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo. This hazard leads to a slight increase of crew workload	Haz#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has <u>incomplete</u> information Haz#003: SURF-ITA detects a risk of runway collision with a mobile but flight crew has <u>incorrect</u> information	SC2(b) SC2(b)
	- Corrupted surveillance data - software error - pilot misinterprets SURF-ITA information	The crew gets incorrect information by the SURF-ITA system (e.g. alert triggered with a wrong message)	Pilot runway collision avoidance In the most critical situations, erroneous data could remain hidden before being discovered by crew. Pilot could perform inappropriate actions before identifying the incorrect information. In any case, in normal OE, crew can compensate with the		

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
			OTW scan and ATC communication the incorrect information. This hazard leads to moderate increase of crew workload		
SO#002: When the ownship is at landing and roll, SURF-ITA system shall timely detect the risk of runway collision caused by a mobile entering/crossing the runway ahead of the ownship					
SO#008: When the ownship is at landing and roll, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the runway ahead of ownship					
SURF-A/SURF-ITA-03: Fail to detect the risk of runway collision between ownship that is landing and a mobile that is entering the same runway ahead the ownship	• Software error of the SURF-ITA function • Erroneous calculated threat position • Threat not SURF-ITA qualified • Pilot disregards SURF-ITA alert	No alert is triggered. The ownship continues the landing roll until pilot acquires visually the potential threat. With this failure, the situation is similar to the absence of "Traffic Alerts".	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. Two pilot's actions are possible on the basis of the threat's position to avoid runway collision: • Pilot can decide to perform maximum braking action to stop the a/c as soon as possible • Pilot can decide to retard the braking action to overtake the threat In both scenario this hazard leads to high increase of crew workload	H#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SURF-A/SURF-ITA-04: Partially fail to detect the risk of runway collision between ownship that is landing and a mobile that is entering the same runway ahead the ownship	- Audio system failure - CDTI malfunction - missed surveillance data - Corrupted surveillance data - software or complex electronics hardware errors - pilot misinterprets SURF-ITA information	- The crew gets incomplete information by the SURF-ITA system (e.g. partial alert messages) - The crew gets incorrect information by the SURF-ITA system(e.g. advisory/caution alert being triggered instead of a warning alert in a full implementation, wrong warning message in the basic implementation)	Pilot runway collision avoidance Crew reacts to the alert and monitors the situation. Crew can acquire the threat by OTW scan and decide the appropriate action to be performed. This hazard leads to high increase of crew workload Pilot runway collision avoidance Crew reacts to the alert and monitors the situation. Crew can compensate the incorrect information by OTW scan and decide the appropriate action to be performed. This hazard leads to high increase of crew workload	Hz#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incomplete information Hz#003: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incorrect information	SC2(b) SC2(b)
SO#003: When ownship is entering/crossing the runway, SURF-ITA system shall timely detect the risk of runway collision with an aircraft landing, taking off or that is going to take off from the same runway SO#009: When the ownship is entering/crossing the runway, SURF-ITA shall trigger a warning alert if another a/c is landing on or taking off from the same ownship's runway					

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SO#012: When the ownship is entering/crossing the runway, SURF-ITA shall trigger an advisory/caution alert if another a/c is holding on the runway ready for take-off					
SURF-A/SURF-ITA-05: Fail to detect the risk of runway collision between ownship and an aircraft that is using the same runway to land or take-off	- Software error of the SURF-ITA function - Erroneous calculated ownship position - Threat not SURF-ITA qualified - Pilot disregards SURF-ITA alert	No alert is triggered. The ownship continues to taxi toward the runway until the crew acquires visually the potential threat. With this failure, the situation is similar to the absence of "Traffic Alerts".	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. Pilot detects a risk of runway collision and performs appropriate action (e.g. to stop the aircraft before crossing the runway shoulder edge)	HZ#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile	SC2(b)
SURF-A/SURF-ITA-06: Partially fail to detect the risk of runway collision between ownship and an aircraft that is using the same runway to land or take-off	- Audio system failure - CDTI malfunction - missed surveillance data - Corrupted surveillance data - software or complex electronics hardware errors - pilot misinterprets SURF-ITA information	- The crew gets incomplete information by the SURF-ITA system.(e.g. missing parts of messages) - The crew gets incorrect information by the SURF-ITA system(e.g. alert	Pilot runway collision avoidance Crew reacts to the alert and monitors the situation and/or perform adequate action (e.g. stop the aircraft). Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo (when possible). This hazard leads to slight increase of crew workload Pilot runway collision avoidance Crew reacts to the alert and monitors the situation and/or perform adequate action (e.g. stop the aircraft), crew can compensate the wrong information with the OTW scan	HZ#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incomplete information HZ#003: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incorrect information	SC2(b) SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
		triggered with a wrong type of alert)	and/or by contacting ATCo (when possible). This hazard leads to moderate increase of crew workload		
SO#004: When the ownship is lined up awaiting a take-off clearance, SURF-ITA system shall timely detect the risk of runway collision with a mobile that is entering/crossing the runway SO#013: When the ownship is lined up awaiting a take-off clearance, SURF-ITA shall trigger an advisory/caution alert if a mobile is entering/crossing the runway ahead the ownship					
SURF-A/SURF-ITA-07: Fail to detect the risk of runway collision between ownship and a mobile that is entering the same runway	- Software error of the SURF-ITA function - Erroneous calculated threat's position or heading - Threat not SURF-ITA qualified - Pilot disregards SURF-ITA alert	No alert is triggered or triggered too late. The pilot is not informed (or informed too late) by the system until the crew acquires visually the potential threat. With this failure, the situation is similar to the absence of "Traffic Alerts".	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. Pilot detects a risk of runway collision and performs appropriate action	Hz#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile	SC2(b)
SURF-A/SURF-ITA-08: Partially fail to detect the risk of runway collision between ownship and a mobile that is entering the same runway	- Audio system failure - CDTI malfunction - missed surveillance data	The crew gets incomplete information by the SURF-ITA system.(e.g. partial alert messages)	Pilot runway collision avoidance Crew reacts to the alert and monitors the situation. Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo. This hazard leads to slight increase of crew workload	Hz#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incomplete information	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
	- Corrupted surveillance data - software or complex electronics hardware errors - pilot misinterprets SURF-ITA information	The crew gets incorrect information by the SURF-ITA system(e.g. alert triggered with a wrong aircraft identification o with a wrong type of incursion)	Pilot runway collision avoidance In the most critical situations, erroneous data could remain hidden before being discovered by crew. Pilot could perform inappropriate actions (e.g. start the take-off roll) before identifying the incorrect information. In any case, in normal OE, crew can compensate with the OTW scan and ATC communication the incorrect information.	Hz#003: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incorrect information	SC2(b)
SO#005: When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall timely detect the risk of runway collision if a mobile is entering/crossing the runway ahead the ownship					
SO#010:When the ownship is in the low-speed regime during the take-off roll, SURF-ITA shall trigger a warning alert if a mobile is entering/crossing the runway ahead the ownship					
SURF-A/SURF-ITA-09: Fail to detect the risk of runway collision between ownship that is taking off and a mobile that is entering the same runway	- Software error of the SURF-ITA function - Erroneous calculated threat's position or heading - Threat not SURF-ITA qualified - Pilot disregards SURF-ITA alert	No alert is triggered or triggered too late. The ownship continues to roll until the crew acquires visually the potential threat. With this failure, the situation is similar	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. Pilot detects a risk of runway collision and performs appropriate action (e.g. rejected take-off or continue the take-off roll based on threat's position)	Hz#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
		to the absence of "Traffic Alerts".			
SURF-A/SURF-ITA-10: Partially fail to detect the risk of runway collision between ownship that is taking off and la mobile that is entering the same runway	- Audio system failure - CDTI malfunction - missed surveillance data	The crew gets incomplete information by the SURF-ITA system (e.g. partial alert messages)	Pilot runway collision avoidance Crew reacts to the alert and monitors the situation. Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo (if possible). This hazard leads to slight increase of crew workload	Hz#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incomplete information	SC2(b)
	- Corrupted surveillance data - software or complex electronics hardware errors - pilot misinterprets SURF-ITA information	The crew gets wrong information by the SURF-ITA system(e.g. alert triggered with a wrong type of incursion)	Pilot runway collision avoidance in normal OE, crew can compensate wrong information with the OTW scan and ATC communication (if possible). This hazard leads to moderate increase of crew workload	Hz#003: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incorrect information	SC2(b)
SO#006: When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if another a/c is holding on the runway ready for take-off					
SURF-A/SURF-ITA-11: Fail to detect the risk of runway collision between ownship performing the final part of the approach and an a/c lined-up on the same runway ready to take-off	- Software error of the SURF-ITA function - Erroneous calculated threat's position - Threat not SURF-ITA qualified - Pilot disregards SURF-ITA alert	No alert is triggered or triggered too late. The ownship continues to descent until pilot acquires visually the potential threat. With this failure, the	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. The crew acquires the threat before MAP and pilot performs a go-around	Hz#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
		situation is similar to the absence of "Traffic Alerts".			
SURF-A/SURF-ITA-12: Partially fail to detect the risk of runway collision between ownship performing the final part of the approach and an a/c lined-up on the same runway ready to take-off	- Audio system failure - CDTI malfunction - missed surveillance data	The crew gets incomplete information by the SURF-ITA system(e.g. alert triggered without the a/c identification o without the type of the mobile)	Pilot runway collision avoidance Crew reacts to the partial alert and monitors the situation. Crew can determine and compensate the missing information by OTW scan and/or by contacting ATCo (if possible). The crew acquires the threat before MAP and pilot performs a go-around.	Hz#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incomplete information	SC2(b)
	- Corrupted surveillance data - software or complex electronics hardware errors	The crew gets wrong information by the SURF-ITA system(e.g. advisory/caution alert being triggered instead of a warning alert)	Pilot runway collision avoidance In normal OE, crew can compensate wrong information with the OTW scan and ATC communication (if possible). The crew acquires the threat before MAP and pilot performs a go-around.	Hz#003: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incorrect information	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SO#007: When the ownship is on the final part of the FAS, SURF-ITA system shall trigger a warning alert if a mobile is entering/crossing the same runway					
SURF-A/SURF-ITA-13: Fail to detect the risk of runway collision between ownship performing the final part of the approach and a mobile that is entering the same runway	- Software error of the SURF-ITA function - Erroneous calculated threat's position - Threat not SURF-ITA qualified	No alert is triggered or triggered too late. The ownship continues to descent until pilot acquires visually the potential threat. With this failure, the situation is similar to the absence of "Traffic Alerts".	Pilot runway collision avoidance In normal OE flight crew can still relies on OTW scan to avoid runway collision. Two scenarios are possible: - If the crew acquires the threat before MAP, pilot should perform a go-around under his/her own decision - If the crew acquires the threat after MAP, pilot should land and perform appropriate manoeuvre after touchdown (e.g. to maximise the braking action or to vacate the runway by an high-speed taxiway).	H#001: Failure to detect, with SURF-ITA application, a risk of runway collision between ownship and a mobile	SC2(b)
SURF-A/SURF-ITA-14: Partially fail to detect the risk of runway collision between ownship performing the final part of the approach and a mobile that is entering the same runway	- Audio system failure - CDTI malfunction - missed surveillance data - Corrupted surveillance data - software or complex electronics hardware errors	- The crew gets incomplete information by the SURF-ITA system (e.g. partial alert messages) - The crew gets wrong information by the SURF-ITA system (e.g.	Pilot runway collision avoidance Crew reacts to the alert and monitors the situation. Crew should acquire the threat by OTW scan before reaching MAP and pilot should perform a go-around. Pilot runway collision avoidance Crew reacts and monitors the situation. Crew should acquire the	H#002: SURF-ITA detects a risk of runway collision with a mobile but flight crew has incomplete information H#003: SURF-ITA detects a risk of runway collision with a mobile but flight	SC2(b) SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
		advisory/caution alert being triggered instead of a warning alert in case of full implementation, wrong warning message)	threat by OTW scan before reaching MAP and pilot should perform a go-around.	crew has incorrect information	
SO#014: When the ownship is on final approach and a warning alert is triggered by SURF-ITA system, a go-around should be initiated under pilot's decision					
SURF-A/SURF-ITA-15: Fail to timely perform the appropriate action after a SURF-ITA alert	- Pilot is focused on other tasks and momentarily ignores the warning alert - Pilot is not appropriately trained to face this situation	Pilot does not react promptly as expected and continues to execute the approach. A go-around remains possible as long as the aircraft is still in an appropriate flight configuration. With this failure, the situation is similar to the absence of "Traffic Alerts".	Pilot runway collision avoidance In normal OE, crew acquires visually the threat (e.g. an a/c on runway threshold or a mobile crossing the runway) at or before reaching MAP. Pilot performs a go-around	Hz#004: Failure to solve an imminent runway collision after SURF-ITA system detection	SC2(b)
SO#015: When the ownship is at landing and roll and a warning alert is triggered by SURF-ITA system, the pilot shall perform the appropriate action based on the specific situation					
SURF-A/SURF-ITA-15: Fail to timely perform	Pilot focused on other tasks	In such a critical scenario, pilots could react promptly but with	Pilot runway collision avoidance	Hz#004: Failure to solve an imminent runway	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
the appropriate action after a SURF-ITA alert	- Pilot is not appropriately trained to face this situation - Crew does not see/hear timely the alert	an inappropriate action or can react with delay. If a mobile is entering/crossing the runway in front the ownship the correct action could be: - to maximise the braking action which is the normal expected action in this situation, or - to retard the braking action to overtake the threat, or - to exit the runway through a high-speed taxiway (if possible) This complex decision making process could lead to inappropriate pilot's action	It appeared during validation tests that pilots reacted as expected with increased braking which also increases the time to collision. This alert is worth	collision after SURF-ITA system detection	
SO#016: When the ownship is entering/crossing the runway and a warning alert is triggered by SURF-ITA system, the pilot shall immediately either stop the ownship or expedite vacation SO#019: When the ownship is entering/crossing the runway and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat and perform appropriate action					

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SURF-A/SURF-ITA-15: Fail to timely perform the appropriate action after a SURF-ITA alert	- Pilot focused on other tasks - Pilot is not appropriately trained to face this situation - Crew does not see/hear timely the alert	- In case of warning alert, pilot does not stop promptly the aircraft and ownship arrives in close proximity to the runway shoulder edge. - In case of advisory/caution alert, crew does not timely acquire (by CDTI information) the potential threat and enter/cross the runway	Pilot runway collision avoidance In normal OE, crew performs OTW scan and acquires visually the potential threat. Based on the ownship position and threat position, pilot can decide under his/her own decision: - to stop the a/c - to expedite a runway taxiing - to expedite a runway crossing	HZ#004: Failure to solve an imminent runway collision after SURF-ITA system detection	SC2(b)
SO#017: When the ownship is in the low-speed regime during the take-off roll and a warning alert is triggered by SURF-ITA, pilot shall initiate a rejected take-off					
SURF-A/SURF-ITA-15: Fail to timely perform the appropriate action after a SURF-ITA alert	- Pilot focused on other tasks - Pilot is not appropriately trained to face this situation - Crew does not see/hear timely the alert	Pilot does not initiate promptly a rejected take-off when the alert is triggered	Pilot runway collision avoidance In normal OE, crew can visually acquire the potential threat in front of the ownship. He/she performs the RTO under his/her own decision. With this failure, the situation is similar to the absence of "Traffic Alerts".	HZ#004: Failure to solve an imminent runway collision after SURF-ITA system detection	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SO#018: When the ownship is on final approach and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat					
SURF-A/SURF-ITA-15: Fail to timely perform the appropriate action after a SURF-ITA alert	- Pilot focused on other tasks - Pilot is not appropriately trained to face this situation - Crew does not see/hear timely the alert	Pilot continues the approach without acquiring the potential threat	Pilot runway collision avoidance If the critical situation continues, crew can rely on a subsequent warning alert triggered by SURF-ITA system. With this failure, the situation is similar to the absence of "Traffic Alerts". In normal OE, crew performs OTW scan to visually acquire the threat	HZ#004: Failure to solve an imminent runway collision after SURF-ITA system detection	SC2(b)
SO#020: When ownship is lined up awaiting a take-off clearance and an advisory/caution alert is triggered by SURF-ITA system, flight crew shall timely acquire the position of the potential threat					
SURF-A/SURF-ITA-15: Fail to timely perform the appropriate action after a SURF-ITA alert	- Pilot focused on other tasks and ignore the alert - Crew does not see the CDTI display to acquire the threat's position	Pilot is not aware of a potential threat ahead and start the take-off roll	Pilot runway collision avoidance Crew can rely on a warning alert triggered by SURF-ITA system when ownship starts to roll In normal OE, crew performs OTW scan of the runway to visually acquire the threat In case of advisory/caution, the risk of collision is not yet immediate and ATCo has still time to react.	HZ#004: Failure to solve an imminent runway collision after SURF-ITA system detection	SC3(b) B3 is still active
SO#022: SURF-ITA alerts shall be inhibited at high-speed regime during take-off roll					
SURF-A/SURF-ITA-16: Fail to inhibit the SURF-ITA alert during high-speed regime	Suppression system malfunction	In this critical phase, pilot's decision making process shall be negatively affected by	Pilot runway collision avoidance Pilot shall be adequately trained to perform appropriate actions and procedures in any possible situation.	HZ#005: SURF-ITA causes safety-related unsafe action	SC2(b)

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
		an alert. Pilot can take a safety-related undesired action (e.g. a rejected take-off with a significant risk)	The inhibition speed is close to V1 and the crew can decide that the intruder is far enough to take-off before a possible collision.		
SO#023: SURF-ITA application shall detect real A and B runway incursions with a probability of 70%					
SURF-A/SURF-ITA-17: Fail to detect the risk of runway collision between the ownship and a mobile within the REZ	See results for SO#001, SO#002, SO#003, SO#004, SO#005, SO#006, SO#007, SO#008, SO#009, SO#010, SO#012, SO#013,				
SO#024: SURF-ITA application shall minimize false alerts					
SURF-A/SURF-ITA-18: Fail to inhibit the SURF-ITA alert during high-speed regime	• Software error of the SURF-ITA function • Erroneous calculated threat's position • Threat not SURF-ITA qualified	Crew reaction disturbing the normal traffic flow. Crew reports then to ATC who confirms there is no problem.	None	No specific hazard	SC4

Table 36: OHA Table SURF-ITA

TWY-ITA OHA table is provided below:

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
SO#050: When the ownship is taxiing on taxiway, TWY-ITA system shall timely detect the risk of taxiway collision caused by Traffic Taxiing on taxiway and trigger advisory/caution alert. SO#051: When the ownship is taxiing on taxiway, SURF-ITA system shall timely detect the risk of taxiway collision caused by Traffic Stopped Behind Holdline and trigger advisory/caution alert. (Within RWY Engagement Zone) SO#052: When the ownship is taxiing on taxiway, SURF-ITA system shall timely detect the risk of taxiway collision caused by Traffic Entering Runway at Taxiway Speeds and trigger advisory/caution alert. (Within Runway Engagement Zone) SO#053: When the ownship is taxiing on taxiway, SURF-ITA system shall timely detect the risk of taxiway collision caused by Traffic Exiting Runway at Taxiway Speeds and trigger advisory/caution alert. (Within Runway Engagement Zone)					
TWY-ITA-01 Fail to detect the risk of taxiway collision between ownship taxiing and another a/c on taxiway.	- Traffic ADS-B data not available - Software error of the TWY-ITA function - Threat not TWY-ITA qualified - Pilot disregards TWY-ITA alert - Audio system failure - CDTI malfunction - missed surveillance data - software or complex electronics hardware errors	No alert/indication is triggered. The ownship continues taxiing phase until the crew acquires visually the potential threat. With this failure, the situation is similar to the absence of "Traffic Alerts". Perception Bias of the crew.	Pilot taxiway collision avoidance (B1) MM-102 MM-103 MM-107	H#007: TWY-ITA System has missing traffic indication or alert.	SC5
TWY-ITA-02 Fail or erroneously detect the risk of taxiway collision between	- Corrupted surveillance data - Software error of the TWY-ITA function	The crew gets incorrect information by the TWY-ITA system. Perception bias of the crew. Provision of	Pilot taxiway collision avoidance (B1) MM-102 MM-103	H#006: TWY-ITA System has credible erroneous traffic indication or alert.	SC5

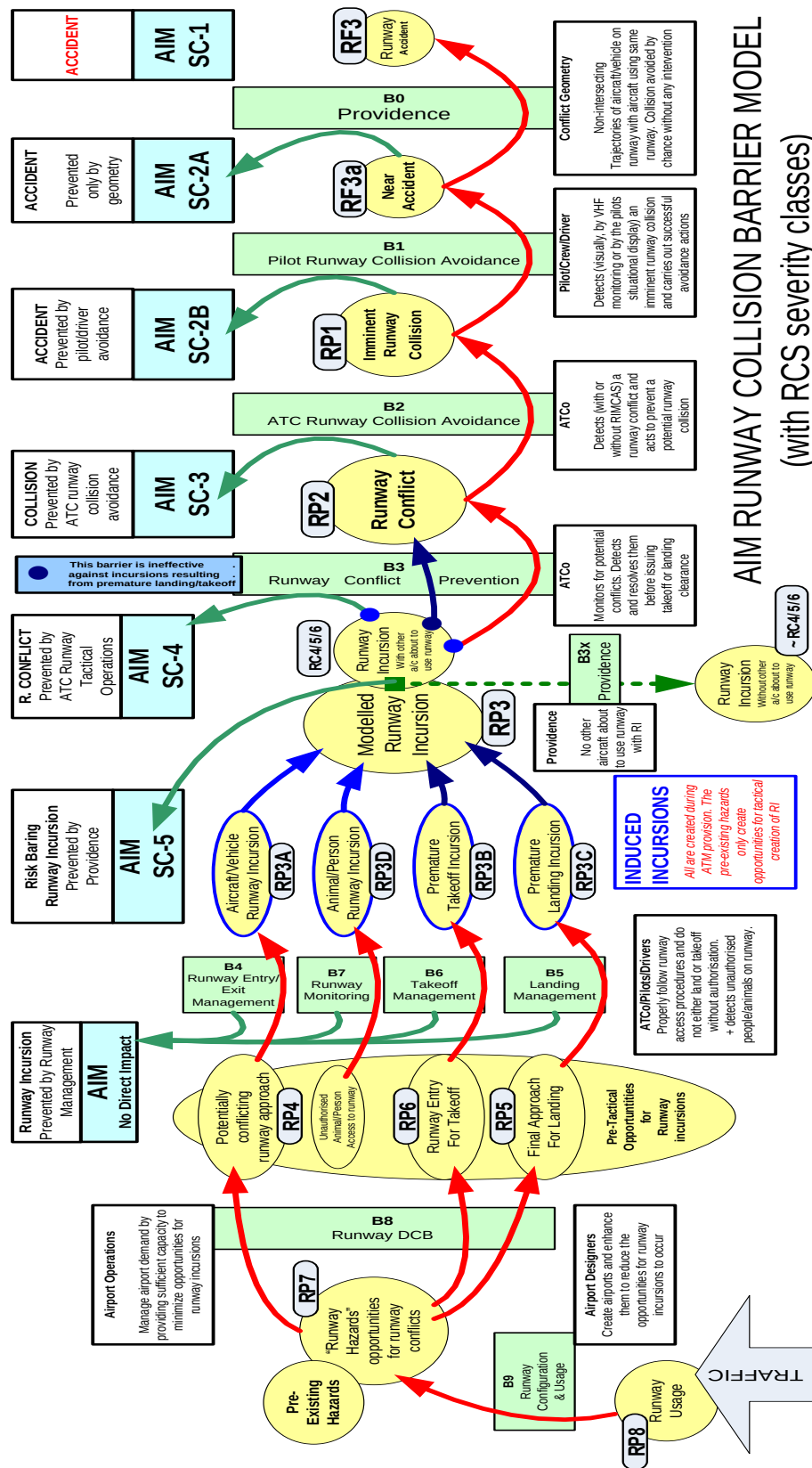
Founding Members

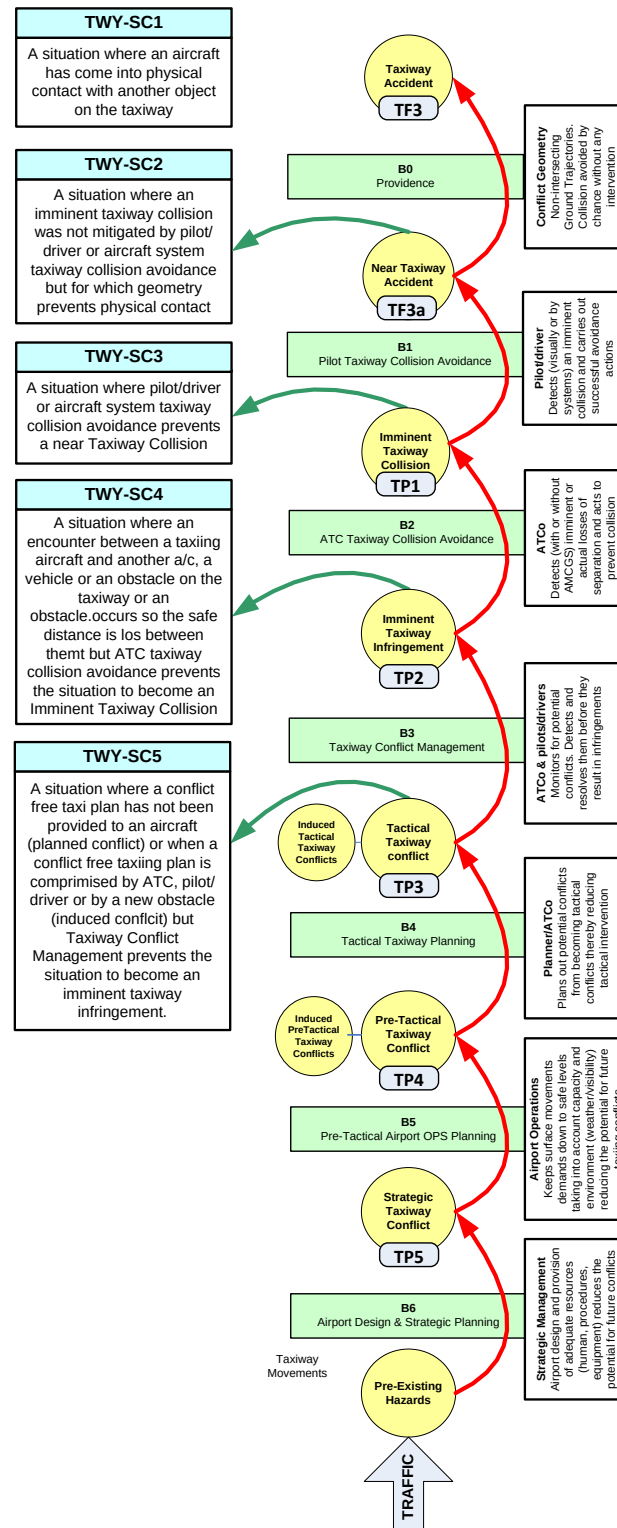
Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
ownship taxiing and another a/c on taxiway.	- Erroneous calculated ownship's position/heading/ground speed - Erroneous calculated threat position/heading/ground speed - Pilot misinterprets TWY-ITA information - Pilot's partial use of TWY-ITA information	erroneous information to the flight crew that results in the flight crew being persuaded that: - a perceived threat exists when in reality there is no threat; - a no threat exists - when one may exist in reality.	MM-104 MM-107 MM-113 MM-114 MM-115		
TWY-ITA-03 Partially fail to detect the risk of taxiway collision between ownship taxiing and another a/c on taxiway.	- Erroneously provided threat's ID - Software error of the TWY-ITA functions - Pilot misinterprets TWY-ITA information	Crew is provided with erroneous Traffic Identification of TWY-ITA Traffic Display.	Pilot taxiway collision avoidance (B1) MM-102 MM-103 MM-110 MM-111	Hz#008: TWY-ITA System has erroneous traffic identification information.	SC5
SO#054: When the ownship is taxiing on taxiway and an advisory/caution alert is triggered by TWY-ITA system, flight crew shall timely acquire the position of the potential threat.					

Failure of services	Example of causes (logical level)	Operational Effects	Possible mitigations of Effects	Hazards generated at service level	Severity
TWY-ITA-04 Fail to timely perform the appropriate action after a TWY-ITA alert is triggered.	- Pilot focused on other tasks - Pilot is not appropriately trained to face this situation - Crew does not see/hear timely the alert	Crew does not timely acquire the potential threat and increase the possibility of taxiway collision.	Pilot taxiway collision avoidance (B1) Pilot shall be adequately trained to perform appropriate actions and procedures in any possible situation. In normal OE, crew performs OTW scan to visually acquire the threat. MM-102 MM-103	H_z#006, H_z#007	SC5

Table 37: OHA Table TWY-ITA

Appendix E AIM Runway and Taxiway collision Barrier Model





Severity Class Scheme for Taxiway Collision
AIM TWYCoI BARRIER MODEL v0.2a

Figure 14: AIM Taxiway Collision Barrier model

Project PJ.03b Members



Project PJ.03b Active Organizations

ADP	ENAV	LPS SR
AIRBUS SAS	EUROCONTROL	MICROSTEP-MIS
AIRBUS OPS	FREQUENTIS	NLR
ANS CR	HONEYWELL SAS	PANSA
BULATSA	HONEYWELL Inc.	TECHNO SKY
DASSAULT	HONEYWELL Sro	THALES LAS
DFS	INDRA	THALES AVIONICS
DLR	INDRA NAVIA	R-SYS
DSNA	INTEGRA	UNIWARSAW
EDISOFT	LEONARDO	UNIZA

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