Safety Assessment Report for Conformance Monitoring for Controllers

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Abstract

This document contains the Specimen Safety Assessment for the Conformance Monitoring System-supported controllers' operations on the aerodrome movement area. 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 relevant SPR. The requirements in this document were determined through the success and the failure approach.

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Executive summary

This document contains the Specimen Safety Assessment for the Conformance Monitoring System-supported operations on the aerodrome movement area. 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 relevant SPR. The requirements in this document were determined through the success and the failure approach described in [3], reviewed according to the latest available OSED [2] and scoped for the controller's service only.

1 Introduction

1.1 Background

Runway incursions are one of the most serious safety issues for ATM. In 2005 there were more than 600 runway incursions reported, this means that there are two incursions every day in the ECAC region.

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.

ICAO SMGCS Manual (Doc 9476) describes how traffic should be controlled on the surface of an airport, based on the principle of "see and be seen".

ICAO (Doc. 9830), EUROCAE (Doc ED.87A) and EUROCONTROL A-SMGCS Project have established the A-SMGCS Levels 1 (Surveillance function) and 2 (Control function including Safety Nets).

The European Commission (DG TREN) has also initiated major R&D projects (NUP-2, BETA, EMMA, EMMA2) dedicated to the future evolutions of A-SMGCS.

The current A-SMGCS Level 2 systems, which provide an alerting service for runway conflicts, have a limited scope: warnings are given to ATC only with a short time-ahead before a potential collision on active runway(s).

Further improvements are therefore needed

- to broaden the scope of applicability to the whole airport movement area;
- to permit an earlier detection of hazardous situations;
- to eventually enhance the performance of the existing safety nets.

The introduction of Electronic Flight Strips (EFS) means that the instructions given by the ATCO are now available electronically and can be integrated with other data such as flight plan, surveillance, routing, published rules and procedures.

The integration of this data allows the system to monitor the information and when inconsistencies are detected, the ATCO can be alerted via the HMI and audibly with a buzzer. The main benefit of this is the early detection of flight crew / vehicle driver errors that, if not detected and resolved, might result in a hazardous situation.

The current A-SMGCS Level 2 will still exist as the last minute warning system based on the position of the mobiles.

The Conformance Monitoring System therefore intends to ensure that aircraft and vehicles conform to their instructions on the movement area by detecting and providing notifications (information or alerts) for deviations from an assigned trajectory (for example by aircraft which has used an incorrect taxiway) as well as for intended operations not in line with airport operational limitations.

The conflict is notified to the Aerodrome Control Tower so that new instructions or corrections can be sent to the aircraft or vehicle by the appropriate means such as tactical instructions to give way to another movement, or revised surface trajectory.

1.2 General Approach to Safety Assessment

The safety assessment described in this document is a reviewed version of the similar reported in [1], aligned according to the latest available OSED [2] and re-scoped for the controller's service only.

It is conducted in accordance with the SESAR Safety Reference Material [3] and associated Guidance [4]. It is based on a twofold approach:

- a new success approach which is concerned with the safety of Conformance Monitoring-supported operations in the absence of failure within the end-to-end Conformance Monitoring System; and

- a conventional failure approach which is concerned with the safety of Conformance Monitoring - supported operations in the event of failure within the end-to-end Conformance Monitoring System

The two approaches are applied for the derivation of safety properties (Objectives and Requirements) at each of two successive stages of the Conformance Monitoring System development, as follows:

Safety specifications at the OSED Level.

These are defined as what the Conformance Monitoring System has to achieve at the ATM operational level in order that the requirements of the airspace users are satisfied.

The Conformance Monitoring System is taken as a "black-box" view and specifications include what is "shared" between the users (aircraft and ground vehicles) and the ATS Provider.

From a safety perspective, the users' requirements are expressed in the form of Safety Criteria and the specification is expressed in the form of Safety Objectives (functionality, performance and integrity/reliability properties), which are derived during the V1 and V2 phases of the Conformance Monitoring System lifecycle. The purpose here is to check the completeness of the Conformance Monitoring OSED [2] and, if relevant, inform the OSED with additional safety objectives that will be revealed by the safety analysis.

Safe Design at the SPR Level.

This describes what the Conformance Monitoring System itself is actually like internally and includes all those system properties that are not directly required by the users but are implicitly necessary in order for the Conformance Monitoring System to fulfil its specification and thereby satisfy the requirements.

Design is essentially an internal or "white-box" view of the Conformance Monitoring System. Herein, it takes the form of a SPR-level Model of the Conformance Monitoring System which describes the System in terms of the human and machine "actors" that deliver the functionality.

From a safety perspective, the Design is expressed in the form of Safety Requirements (sub-divided into functionality, performance and integrity/reliability properties), which are derived during the V2 phase of the Conformance Monitoring System lifecycle. The purpose here is to check the completeness of the Conformance Monitoring OSED [2] and SPR [5] and, if relevant, inform the OSED and SPR with additional safety requirements that will be revealed by the safety analysis.

The subsequent step of building and provision the physical Conformance Monitoring System in accordance with the SPR-level Design is not provided in this document being beyond the scope of SESAR.

1.3 Scope of the Safety Assessment

This report covers the V1, V2 and V3 stages of the Conformance Monitoring lifecycle. It also presents the assurance that the Safety Requirements are complete, correct and (from a potential implementation viewpoint) realistic.

The Conformance Monitoring function, which is the subject of this safety assessment, applies to:

- Arriving aircraft
    - from transfer of responsibility from the Approach Control function at the start of final approach to the cessation of ATC responsibility (aircraft On-Blocks state)
    - through transfer of responsibility from the Runway Control function upon completion of the landing run and vacation of the Runway Protected Area to Apron/Ground control function
- Departing aircraft
    - from initial contact with the Apron/ Ground Control function at the gate or stand to transfer of responsibility to the first airborne control function (TMA) or departure from the airport CTZ
    - through transfer of responsibility to the Runway Control function at or close to the runway holding point

- Vehicles and aircraft which are not landing or departing, on the Apron and Taxiway areas (airport movement surface, outside the Runway Protected Area) or requiring access to these areas;

Helicopter taxiing operations, both for wheeled helicopter or vertical take-off and landing (VTOL) aircraft and helicopter proceeding at a slow speed above the surface, are out of scope of this safety assessment.

As per [2] and [6], the list of all the SESAR OI Steps that fall within the scope of this safety assessment is:

- AO-0104-A Airport Safety Nets including Taxiway and Apron: The System detects conflicting ATC clearances during runway operations, and non-conformance to procedures or clearances for traffic on runways, taxiways and in the apron/stand/gate area. Appropriate alerts are provided to controllers.
- AO-0102 Automated Alerting of Controller in Case of Runway Incursion or Intrusion into Restricted Areas: The system detects conflicts and infringements of some ATC rules involving aircraft or vehicles on runways, and provides the controller with appropriate alerts. Whereas the detection of conflicts identifies a possibility of a collision between aircraft and/or vehicles, the detection of infringements focuses on dangerous situations because one or more mobiles infringed ATC rules. This improvement addresses also incursions by an aircraft into an area where the presence of an aircraft (or vehicle) is temporarily restricted or forbidden (e.g. closed taxiway, ILS or MLS critical area).[1]

1.4 Layout of the Document

- Section 2 derives a specification for the Conformance Monitoring System, in the form of Safety Objectives, such that the Safety Criteria specified therein are achievable.
- Section 3 describes an SPR-level Design of the Conformance Monitoring System and derives Safety Requirements such that the specification is satisfied by the Safety Requirements.
- Appendix A presents a consolidated list of all the Safety Objectives
- Appendix B presents a consolidated list of all the Safety Requirements
- Appendix C lists all the Assumptions, Safety Issues & Limitations that arose during safety assessment documented herein.
- Appendix D reports the Accident Incident Model used for the Runway Collision
- Appendix E reports the Accident Incident Model used for the Taxiway Collision

1.5 Acronyms and Terminology

Term	Definition
A/C	Aircraft
A/F	Airframe
ADS – B	Automatic Depend Surveillance – Broadcast
ADS-C	Automatic Depend Surveillance – Contract
AIM	Accident Incident Model

[1] OI step AO-102 is a part of the deployment baseline and therefore it is be mentioned just as background information.

Term	Definition
A-SMGCS	Advanced – Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATC System	In the context of this document the term ATC system refers to a combination of the A-SMGCS (Surveillance and Control) and the Electronic Flight Strips
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Service
BETA	Operational Benefit Evaluation by Testing an A-SMGCS
BC	Basic Cause
CATC	Conflicting ATC Clearances
DG Tren	Directorate-General for Transport and Energy
DOD	Detailed Operational Description
EFS	Electronic Flight Strips
EMMA	European Airport Movement Management by A-SMGCS
EUROCAE	European Organisation for Civil Aviation Equipment
EUROCONTROL	European Organisation for the Safety of Air Navigation
FDP	Flight Data Processing
FHA	Functional Hazard Assessment
HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
OFA	Operational Focus Areas
OHA	Operational Hazard Assessment
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PR	Performance Requirement
PSR	Primary Radar Surveillance
PSSA	Preliminary System Safety Assessment
R&D	Research and Development

Term	Definition
RIMS	Runway Incursion Monitoring System
SDP	Surveillance Data Processing
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
SR	Safety Requirement
SSR	Secondary Surveillance Radar
SWP	Sub Work Package
VALP	Validation Plan
VALR	Validation Report

1.6 References

[1]. SESAR OFA 01.02.01 (Airport Safety Nets) Safety Assessment Report (SAR) for Conformance Monitoring, Edition 00.00.03, 24th April 2013

[2]. SESAR 06.07.01 OSED for "Conflicting ATC Clearances" and "Conformance Monitoring for Controllers", Edition 00.01.00, 4th November 2013.

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

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

[5]. SESAR P06.07.01, Preliminary SPR for Conformance Monitoring, D22, Edition 00.01.00, 3rd February 2012

[6]. SESAR Airport DOD Step 1, Edition 01.00.01, 20th February 2012

[7]. ICAO, Annex 14, Aerodromes, Volume 1, 5th edition, July 2009

[8]. SESAR, PB4.1, Validation Target Allocation for Step 1, Edition 00.02.00, 25th November 2011

[9]. ICAO DOC 9830, Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual, 1st edition, 2004

[10]. SESAR P06.07.01 D25 V2 Validation Report for Conformance Monitoring for controllers, Edition 00.00.02, 10th January 2013

2 Safety specifications at the OSED Level

2.1 Scope

This section addresses the following activities:

- Description of the key properties of the Operational Environment that are relevant to the safety assessment – section 2.2
- Setting of the Safety Acceptance Criteria – sections 2.3 and 2.4.
- Identification of the pre-existing hazards that affect traffic in the Conformance Monitoring System relevant operational environment (airspace) and the risks of which operational services provided by Conformance Monitoring-supported ATS System may reasonably be expected to mitigate to some degree and extent – section 2.5.
- Comprehensive determination of the operational services that are provided by Conformance Monitoring-supported ATS System to address the relevant pre-existing hazards and derivation of Safety Objectives (success approach) in order to mitigate the pre-existing risks under normal operational conditions – section 2.6.
- Assessment of the adequacy of the operational services provided by the Conformance Monitoring-supported ATS System under abnormal conditions of the Operational Environment – section 2.7.
- Assessment of the adequacy of the operational services provided by the Conformance Monitoring-supported ATS System in the case of internal failures and mitigation of the system-generated hazards (derivation of Safety Objectives (failure approach)) – section 2.8.
- Impacts of Conformance Monitoring-supported operations upon adjacent airspace – section 2.9.
- Achievability of the Safety Acceptance Criteria – section 2.10.
- Validation & verification of the safety specification – section 2.11.

2.2 Operational Environment and Key Properties

The key properties of the Airport Operational Environment, which are crucial to the safety argument that Conformance Monitoring System Specification satisfies the Safety Criteria, are reported in the following sections.

2.2.1 Types of Airports

The Detection of non-conformance to ATC instructions and/or procedures shall be applied to:

- all traffic that is moving on the manoeuvring area (runways, taxiways)
- all traffic under, or foreseen to be under, Air Traffic Control on the apron.

The Conformance Monitoring application is designed to account for operations carried out by larger aircraft with higher take-off and/or final approach speeds. For this reason, used runways have distances valid for ICAO code 3 and 4 aerodromes according to [7].

2.2.2 Types of Airspace

The Airspace around the airport is classified as “Managed” including the airspace between the airport CTA and Terminal Airspace.

2.2.3 Users

The aircraft fleet using the airport will be commercial air traffic (scheduled, charter, cargo and executive aviation). Users include ground vehicles (e.g. vehicle that is towing the aircraft).

2.2.4 Traffic Levels and complexity

Aerodrome complexity includes the full range of aerodrome types from relatively simple aerodrome layouts and low-density operations, to highly complex runway and taxiway layouts with:

- multiple dependent or independent parallel runways
- intersection runways
- traffic with 26 or more hourly movements per runway or more than 35 for total aerodrome

2.2.5 ATM capabilities

The Conformance Monitoring application for checking non-conformance to ATC instructions is using in all cases A-SMGCS Surveillance data.

The following ATM capabilities are required to support the operation of the Conformance Monitoring System:

- A-SMGCS should be capable of supporting the following primary functions as defined in [9]
  - surveillance;
  - safety nets (Level 2)
  - routing.
- The carriage of SSR transponders and/or ADS-B transmitters is mandatory for all mobiles which receive instructions from controllers.
- Flight Data Processing system supported by e.g. Electronic Flight Strips (EFS) is required to enable integration of ATC instructions with A-SMGCS surveillance data

2.2.6 Visibility conditions

Conformance Monitoring is intended to be an aid to situational awareness in all visibility conditions. Visibility conditions as defined in [9] from 1 (sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance) to 4 (Visibility insufficient for the pilot to taxi by visual guidance only at an RVR of 75 m or less).

2.3 Airspace Users Requirements

The key requirements for this safety assessment are:

- a substantial reduction in the number of potential conflicts/incursions involving mobiles (and stationary traffic) on runways per annum; and
- no increase in the number of taxiways accidents per annum;

Both requirements despite the targeted increase 14% in runway throughput per hour as stated in the Intermediate Target for Step 1 for Best In Class (BIC) airports

This is further translated in a set of SAfety Criteria (SAC) below reported.

2.4 SAfety Criteria

SAfety Criteria (SAC) relevant for the Conformance Monitoring System are reported in accordance of Appendix E and Appendix D where the relevant Accident Incident Models (AIM) for Apron and Taxiway accidents and Runway accidents are described jointly with the rationale behind the SAC statements.

Three SACs have been identified.

SAC#1: The number of Runway Incursions[2] arising from inefficient entry/exit management, take-off management or landing management shall be reduced when ATM is supported by the conformance monitoring tool.

In addition Conformance Monitoring will allow an early detection of some runway incursions, therefore reducing the number of runway conflicts and the severity of the runway incidents. Therefore the following additional SAC has been identified:

SAC#1a: The number of Runway Conflicts shall be reduced when ATM is supported by the conformance monitoring tool due to the early detection of runway incursions.

SAC#2: The number of Taxiway infringement arising from induced taxiway conflict and from induced pre-tactical taxiway conflict shall be reduced by 15% when ATM is supported by the conformance monitoring tool.

There is no AIM model for runway excursion (veer off or overrun off the runway surface). However the conformance monitoring elements relative to the "Runway type" and the "Attempt to Take-Off from taxiway" could participate to the reduction of the overrun off the runway surface occurrence.

Indeed by indicating to the controller that the assigned runway is unsuitable for the aircraft due to its characteristics (e.g. length, width, weight) or that the pilot is taking off from a taxiway, it could limit the occurrence of runway excursion (taking-off from a too short runway/taxiway).

Therefore the following additional Safety Criteria has been derived:

SAC#3: Risk of runway overrun during take-off or landing shall be decreased when ATM is supported by the conformance monitoring tool.

2.5 Relevant Pre-existing Hazards

A number of pre-existing hazards associated with airport operations have been identified as reported in [4]. The pre-existing hazards include both traffic-related hazards (hazards associated with aircraft and vehicle movements) and environmental hazards (due for example to weather phenomena).

These pre-existing hazards are associated with a pre-existing risk, which is the risk that would be associated with them in the absence of any ATM service. The reason for identifying these hazards is that the Runway, Apron and Taxiway control services are designed to control or mitigate at least some such hazards and it is important to demonstrate that all relevant hazards are indeed controlled and mitigated by those services.

The pre-existing hazards that the ATM Services / Systems associated to WA4 have to mitigate are as follows:

- **Hp#1:** a situation in which the intended 3-D route of a taxiing aircraft could lead to collision with an obstacle, a ground vehicle or another aircraft on ground or close to ground on landing / take-off
- **Hp#2:** all preceding departing or landing aircraft are not clear of the runway-in-use
- **Hp#3:** another aircraft or vehicle inside landing-aid protection area during instrument approach or inside RPA
- **Hp#4:** another aircraft or vehicle inside OFZ during a Cat II / III instrument approach
- **Hp#5:** aircraft uses closed or not suitable (e.g. too short) runway / taxiway
- **Hp#6:** aircraft inadvertently taking off from a taxiway
- **Hp#7:** aircraft taking off from or landing on the wrong runway

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 relevant Conformance Monitoring service to mitigate those hazards such that the Safety Criteria are satisfied.

[2] Any occurrence at an aerodrome involving the incorrect presence of an aircraft or vehicle on the protected area of a surface designated for the landing and take-off of aircraft

2.6 Mitigation of the Pre-existing Risks – Normal Operations

The purpose of this section is to determine what operational services are provided to prevent runway and taxiway conflicts, 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.

2.6.1 Operational Services to address the pre-existing hazards

The following ATM Services are provided by the Aerodrome Control Tower to departing, arriving and taxiing traffic on the manoeuvring area, in order to address the above pre-existing hazards sufficiently to satisfy the Safety Criteria:

- Ensure separation of departing aircraft
- Ensure separation of landing aircraft and preceding landing and departing aircraft using the same runway
- Ensure that aircraft and vehicles operations on the taxiway do not create a collision hazard
- Monitor aircraft and vehicles on the manoeuvring area for compliance with clearances and instructions
- Ensure separation of an arriving and a departing aircraft to ensure protection of the sensitive and critical areas when category II/III approaches are in use in conditions of low visibility

Table 1 reports the correspondence between ATM provided services and pre-existing hazards.

ID	Service Objective	Pre-existing Hazards [Hp xx]
SP_D	Determine that a runway is clear of traffic prior to a take-off	Hp#2
SP_A	Determine that a runway is clear of traffic prior to a landing	Hp#3
SP_T	Prevent collision hazards created by aircraft and vehicles operation on the taxiway.	Hp#1
MON_TWY	Monitor aircraft and vehicles on the part of the aerodrome used for the taxiing of aircraft and the apron(s) for compliance with Air Traffic Control clearances, instructions (Aerodrome Control Tower) and airport operational limitations	Hp#1, Hp#5, Hp#6
MON_RWY	Monitor aircraft and vehicles on the part of the aerodrome used for the landing and take-off of aircraft for compliance with Air Traffic Control clearances, instructions (Aerodrome Control Tower) and airport operational limitations. This includes the prevention of unauthorized entry into ILS/MLS critical / sensitive area.	Hp#2 to Hp#5 , Hp#7

Table 1: ATM services and Pre-existing Hazards

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

This section identifies the safety objectives in term of functionality and performance that are needed in order to mitigate the pre-existing hazards described in 2.5 and linked with the service objectives in previous Table 1.

Table 3 reports the list of these Safety Objectives (SO) while Table 2 shows the link of the SOs with operational services and the AIMs points where these have to be applied.

Ref	Phase of Fight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
1	Push-back / MON_TWY	**Apron and Taxiway Barrier Model:** •Taxiway conflict Management barrier (B3)	**[SO 001], [SO 002], [SO 009], [SO 020]**
2	Taxi-out / MON_TWY, SP_T	**Apron and Taxiway Barrier Model:** •Taxiway conflict Management barrier (B3) **Runway Barrier Model:** •Runway monitoring barrier (B3A)	**[SO 001], [SO 003], [SO 004], [SO 006], [SO 009], [SO 010], [SO 011], [SO 012], [SO 013], [SO 014], [SO 015], [SO 020], [SO 030], [SO 035],**
3	Line-up / MON_RWY	**Runway Barrier Model:** •Runway monitoring barrier (B3A)	**[SO 001], [SO 008], [SO 017], [SO 018], [SO 019], [SO 020], [SO 030]**
4	Take-off / MON_RWY, SP_D	**Runway Barrier Model:** •Runway monitoring barrier (B3A)	**[SO 001], [SO 008], [SO 016], [SO 017], [SO 020], [SO 021], [SO 022], [SO 028], [SO 030],**
5	Runway alignment / MON_RWY	**Runway Barrier Model:** •Runway monitoring barrier (B3A)	**[SO 001], [SO 026]**
6	Landing / MON_RWY, SP_A	**Runway Barrier Model:** •Runway monitoring barrier(B3A)	**[SO 001], [SO 023], [SO 025], [SO 027], [SO 028], [SO 030], [SO 034],**
7	Taxi-in / MON_TWY, SP_T	**Runway Barrier Model:** •Runway monitoring barrier(B3A) **Apron and Taxiway Barrier Model:** • Taxiway conflict Management barrier (B3)	**[SO 001], [SO 004], [SO 006], [SO 009], [SO 010], [SO 011], [SO 012], [SO 013], [SO 014], [SO 015], [SO 020], [SO 024], [SO 030],**

Table 2: Operational Services & Safety Objectives (success approach)

ID	Description	SAC
SO 001	All air traffic control clearances related to aircraft and vehicles operations on the movement area shall be timely entered in the Conformance Monitoring System. Timely means that the detection of the non-conformance to ATC clearances/instructions is not impaired (miss-detection, late detection) by any delay to enter clearances in the Conformance Monitoring System. This also implies an adaptation of the controllers' working method in order to ensure that the clearances are input into the system when they are given by voice.	SAC#1, SAC#1a, SAC#2, SAC#3
SO 002	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft is being pushed back or is under tow without a pushback clearance (only applicable if engine start is accomplished at the gate and a push is required to taxi-out).	SAC#2
SO 003	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to taxi-out without a taxi clearance	SAC#2
SO 004	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft or vehicles do not conform to their taxiing instructions and surface trajectory	SAC#2
SO 005	The On-board Conformance Monitoring System shall detect and notify the flight crew if the aircraft does not conform to its taxiing instructions and surface trajectory.	SAC#2
SO 006	The Conformance Monitoring System shall detect and notify the aerodrome control tower when the taxi (in or out) clearances includes designator(s) of taxiway(s) that are actually closed	SAC#2
SO 007	The On-board Conformance Monitoring System shall detect and notify the flight crew when the taxi (in or out) clearances includes designator(s) of taxiway(s) that are actually closed	SAC#2
SO 008	The Conformance Monitoring System shall detect and notify the aerodrome control tower when a movement is likely to enter an active runway (runway strip), or any designated protected area as required by airport authorities, without a clearance	SAC#1, SAC#1a
SO 009	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to move without a clearance irrespective of whether the movement is executed under the aircraft's own power or by means of a tug	SAC#1, SAC#1a, SAC#2
SO 010	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the aircraft crosses a holding position marking without a clearance	SAC#1, SAC#1a, SAC#2
SO 011	The Conformance Monitoring System shall detect and notify the aerodrome control tower if an instructed aircraft to take immediate action to stop at any intermediate positions on the taxiway that may be required does not stop.	SAC#2
SO 012	The Conformance Monitoring System shall detect and notify the aerodrome control tower in the following hazardous situations: • an aircraft attempting to use a closed taxiway or other closed surface area	SAC#1, SAC#1a, SAC#2, SAC#3

ID	Description	SAC
SO 013	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft or vehicle infringes the holding position limit defined by a stop bar or stop markings without a clearance	SAC#1, SAC#1a, SAC#2
SO 014	The Conformance Monitoring System shall detect and notify the aerodrome control tower when, depending on visibility conditions (VIS-1- VIS-4), the longitudinal separation on taxiways if any and as specified for each particular aerodrome by the appropriate ATS authority is infringed	SAC#2
SO 015	The Conformance Monitoring System shall detect and notify the aerodrome control tower when the aircraft passes the runway-holding position without a clearance	SAC#1, SAC#1a
SO 016	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft attempt to take-off from a wrong runway	SAC#1, SAC#1a, SAC#3
SO 017	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the control of the flight has not been transferred from/to Apron/Ground Control, from Approach to Runway and from Runway to Departure controls, when the aircraft proceeds past a point for which further authority is required	SAC#1, SAC#1a, SAC#2
SO 018	The Conformance Monitoring System shall detect and notify the aerodrome control tower if an aircraft enters the runway to line up without instructions	SAC#1, SAC#1a,
SO 019	The Conformance Monitoring System shall detect and notify the aerodrome control tower if an aircraft lines up for a runway for which the designator differs from the designator of the intended departure runway.	SAC#1, SAC#1a, SAC#3
SO 020	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft for which a clearance has been issued remains stationary for a period of time exceeding a predetermined value. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc..) and the local operational procedures.	SAC#1, SAC#1a, SAC#2
SO 021	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft for which a line-up clearance has been issued does not receive a take-off clearance within a period of time exceeding a predetermined value even though appropriate separation exists. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc.) and the local operational procedures.	SAC#1, SAC#1a,
SO 022	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the aircraft starts the take-off roll without a clearance	SAC#1, SAC#1a,
SO 023	The Conformance Monitoring System shall detect and notify the aerodrome control tower if a clearance to land or any alternative clearance has not been entered in the Conformance Monitoring System before the aircraft reaches a certain distance from touchdown.	SAC#1, SAC#1a,
SO 024	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to taxi-in from the runway exit point without a taxi clearance	SAC#2

ID	Description	SAC
SO 025	When category II/III approaches are in use, the Conformance Monitoring System shall detect and notify the aerodrome control tower when sensitive and/or critical areas are infringed.	SAC#2
SO 026	The Conformance Monitoring System shall detect and notify the aerodrome control tower when the runway alignment of an approaching aircraft differs from the designator of the landing runway the landing clearance includes	SAC#1, SAC#1a, SAC#3
SO 027	The Conformance Monitoring System shall detect and notify the aerodrome control tower if a landed aircraft becomes stationary for a period of time exceeding a predetermined value in the critical portion of the runway strip including the runway in use, the area surrounding it within the distance outlined by taxi-holding positions, the take-off/approach surfaces in addition to any areas established for the protection of navigation and landing aids. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc.) and the local operational procedures.	SAC#1, SAC#1a,
SO 028	The Conformance Monitoring System shall detect and notify the aerodrome control tower when a take-off or landing-clearance indicates the runway designator of a closed runway.	SAC#1, SAC#1a, SAC#3
SO 029	The On-board Conformance Monitoring System shall detect and notify the flight crew when a take-off or landing-clearance indicates the runway designator of a closed runway.	SAC#1, SAC#3
SO 030	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the type of aircraft for which a clearance to operate on the manoeuvring area has been issued exceeds the limitations of this area (e.g. aircraft all-up mass exceeding pavement resistance).	SAC#1, SAC#1a, SAC#2, SAC#3
SO 031	The On-board Conformance Monitoring System shall detect and notify the flight crew if the aircraft type exceeds the limitations of the runway or taxiway (e.g. aircraft all-up mass exceeding pavement resistance, runway length, aircraft size versus taxiway width, etc.) for which a taxiing, landing or take-off clearance has been issued.	SAC#1, SAC#2, SAC#3
SO 032	The Conformance Monitoring System shall detect and notify the aerodrome control tower if a vehicle enters a Runway Protected Area without having received a clearance	SAC#1, SAC#1a,
SO 033	The On-board Conformance Monitoring System shall detect and notify the flight crew when the aircraft initiates a take-off from a wrong runway	SAC#1, SAC#3
SO 034	The On-board Conformance Monitoring System shall detect and notify the flight crew when the aircraft deviates from the localizer axis indicating an attempt to land on a wrong runway or on a taxiway	SAC#1, SAC#2 SAC#3

Table 3: List of Safety Objectives (success approach) for Normal Operations

Note: In

Table 3, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.

In addition of the previous Safety Objectives, the following Performance Objectives have been derived to address the Conformance Monitoring System

Non-conformances true alerts need to be detected with a defined detection probability.

Non-conformances alerts that prove not to involve true potential conflicts will lower controller trust in the System and will increase controller workload explaining why such objective is necessary for an appropriate design of the System.

ID	Description
PO 01	During Runway operations, the false alert rate of the Conformance Monitoring System shall not be greater than 10^{-4} per movement
PO 02	During Taxiway operations, the false alert rate of the Conformance Monitoring System shall not be greater than 10^{-4} per movement

Table 4: List of Performances Objectives

2.6.3 Analysis of the Concept for a Typical Airport Operations

The OSED section 3.2.2 of [2] describes the different operational situations where Non-Conformance to ATC instructions can occur. These operational situations are:

- Route deviation: a mobile is detected deviating from the cleared taxi route on the taxiway or crossing a runway.
- No Push Back approval: an aircraft is detected moving from its stand without approval
- No Taxi approval: an aircraft not been cleared to taxi is detected starting to taxi after its push-back or directly from a stand position where taxi is possible without push back or a mobile been given instructions to stop at an intermediate point on the taxi route (e.g. hold short of taxiway bravo) fails to adhere to the instruction.
- Stationary: The A-SMGCS detects if a mobile is given an instruction on the EFS (e.g. push back, taxi, cross, enter, Line Up, take off) but doesn't move within a certain time frame. A mobile that has vacated a runway but has stopped within the runway protection area and is a potential hazard to arriving or departing aircraft. An aircraft is lined up on the runway and doesn't receive a take-off clearance within X seconds
- No Contact: the system detects when a flight is transferred and the aircraft fails to contact the tower within a certain distance from the runway
- No Transfer Take-off: the system detects when ATC control has not been transferred after aircraft take-off from a certain distance from runway or after a certain time.
- No Line Up or Crossing Clearance: An aircraft (or vehicle in the case of a crossing) is supposed to be at a holding point but is detected by surveillance to be moving past the holding point (and across stop bars if they are lit).
- No Take Off Clearance: Aircraft is supposed to line up and wait but is detected moving outside of a specified area on the runway.
- No Landing Clearance: Aircraft is detected at a certain distance from the runway without having received a landing clearance
- Landing on wrong runway: An arriving aircraft is detected to be aligned to a runway that differs to the assigned runway.
- Red Stop Bar Crossed: A mobile is detected crossing a red stop bar, which can be positioned at an intermediate holding point or at the limit between control positions areas of responsibility.
- Lining Up on the wrong runway: A departing aircraft is detected lining up on a runway that differs to assigned runway.

- Runway Incursion: Mobile detected within the RPA without clearance (e.g. Line Up, Take off, Cross, Enter).

- Runway or Taxi Type: the system detects that the runway or taxi route is suitable for the aircraft type and the response is negative.
- Runway Closed: the system detects when a selected runway is declared as closed within the system and a mobile is assigned to use that runway or is on that runway.

- Taxiway Closed: the system detects when a selected taxiway, or segment of the taxiway, is declared as closed within the system and a mobile's taxi route includes the closed area or the mobile is already on that area.

- High Speed: the system detects when, for a mobile, a high speed on a taxiway is detected and where it could endanger itself and/or other mobiles.

The OSED section 6 reports the requirements for the Conformance Monitoring service.

Table 5 gives the traceability between identified safety objectives and OSED requirements.

SO (success approach)	OSED requirements [2]
SO 001	Requirements for the need to input clearances into the systems are covered in section 6.5 of [2] under the title of "Non Conformance to ATC instructions and/or procedures". However the content of SO 001 is not fully covered within OSED on the working methods aspects As the similar requirements are needed also for the Conflicting ATC Clearances service, it is suggested to introduce these requirements and to allocate them into a common section of the two services.
SO 002	REQ-06.07.01-OSED-CMAC-0002
SO 003	REQ-06.07.01-OSED-CMAC-0003
SO 004	REQ-06.07.01-OSED-CMAC-0001
SO 005	Not Applicable
SO 006	REQ-06.07.01-OSED-CMAC-0015
SO 007	Not Applicable
SO 008	REQ-06.07.01-OSED-CMAC-0006, REQ-06.07.01-OSED-CMAC-0007, REQ-06.07.01-OSED-CMAC-0008
SO 009	REQ-06.07.01-OSED-CMAC-0002, REQ-06.07.01-OSED-CMAC-0003, REQ-06.07.01-OSED-CMAC-0009,
SO 010	REQ-06.07.01-OSED-CMAC-0006, REQ-06.07.01-OSED-CMAC-0007, REQ-06.07.01-OSED-CMAC-0008, REQ-06.07.01-OSED-CMAC-0009, REQ-06.07.01-OSED-CMAC-0025
SO 011	REQ-06.07.01-OSED-CMAC-0025. Note: this requirement is too generic.

SO (success approach)	OSED requirements [2]
SO 012	REQ-06.07.01-OSED-CMAC-0015, REQ-06.07.01-OSED-CMAC-0017
SO 013	REQ-06.07.01-OSED-CMAC-0012. Note the taxiways intersection marking not covered
SO 014	Requirement non covered in OSED
SO 015	REQ-06.07.01-OSED-CMAC-0006, REQ-06.07.01-OSED-CMAC-0007, REQ-06.07.01-OSED-CMAC-0008
SO 016	REQ-06.07.01-OSED-CMAC-0011
SO 017	Requirement non covered in OSED
SO 018	REQ-06.07.01-OSED-CMAC-0006
SO 019	REQ-06.07.01-OSED-CMAC-0011
SO 020	REQ-06.07.01-OSED-CMAC-0004
SO 021	REQ-06.07.01-OSED-CMAC-0030
SO 022	REQ-06.07.01-OSED-CMAC-0009
SO 023	REQ-06.07.01-OSED-CMAC-0010
SO 024	REQ-06.07.01-OSED-CMAC-0003
SO 025	Requirement non covered in OSED
SO 026	REQ-06.07.01-OSED-CMAC-0024
SO 027	REQ-06.07.01-OSED-CMAC-0004
SO 028	REQ-06.07.01-OSED-CMAC-0016
SO 029	Not Applicable
SO 030	REQ-06.07.01-OSED-CMAC-0013
SO 031	Not Applicable
SO 032	REQ-06.07.01-OSED-CMAC-0008
SO 033	Not Applicable
SO 034	Not Applicable

Table 5: Traceability between Safety Objectives (success approach) and OSED requirements

2.7 Operations under Abnormal Conditions of Conformance Monitoring System

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

Such conditions cover both:

- failures (human or technical) external to the Conformance Monitoring System; and
- other significant, but infrequent events in the operational environment of the Conformance Monitoring System.

2.7.1 Identification of Abnormal Conditions

The following have been identified as abnormal conditions relevant to the operations of the Conformance Monitoring System:

- situation where the speed of an aircraft on the taxiway exceeds the speed limitations in a proportion that indicates that the aircraft may intend to take-off from the taxiway in use
- unplanned closure of section(s) of the movement area

Potential Mitigations of Abnormal Conditions

Table 6 below shows, for each abnormal condition:

- the assessed immediate operational effect, and
- the possible mitigations of the safety consequence of the operational effect with a reference to existing Safety Objectives or to new Safety Objectives [thus] described in
- Table 7 below.

Ref	Abnormal Conditions	Operational Effect	Mitigation of Effects / [SO xx]
1	Speed of an aircraft on the taxiway exceeds the speed limitations in a proportion that indicates that the aircraft may intend to take-off from the taxiway in use	Aircraft mistaking a certain taxiway for a runway (eventually plane rolling off taxiway, plane not clearing the ground before striking an object, etc.)	Pilot is instructed or makes the decision to slow down and/or stop as result of a notification from the Conformance Monitoring System / **[SO 035]**[3] & **[SO 036]**
2	Unplanned closure of section(s) of the movement area	Aircraft intending (following a clearance) to use taxiway(s) or a runway that have been suddenly closed (e.g. due to FOD, runway or equipment damage, etc.); i.e. Conformance Monitoring System not informed by updated NOTAM	ATC to revert back to standard practices for coordination of unplanned runway/taxiway closures. ATC uses surveillance by electronic means (A-SMGCS Level 1) and voice communications to send new instructions to the aircraft / **[SO 037]** If A-SMGCS supports

			the capability to directly input by ATCO aerodrome layout status changes, then ATCO could directly perform such actions.

Table 6: Additional Safety Objectives (success approach) for Abnormal Conditions

ID	Description	Related SAC
SO 035	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the speed of the aircraft on the taxiway exceeds the speed limitations in a proportion that indicates that the aircraft may intend to take-off from the taxiway in use.	SAC#1, SAC#1a, SAC#2 SAC#3
SO 036	The On-board Conformance Monitoring System shall detect and notify the flight crew if the throttle position or speed of the aircraft on the taxiway indicates that the aircraft may intend to take-off from the taxiway in use.	SAC#1, SAC#2 SAC#3
SO 037	In the event of sudden closure of section(s) of the movement area, ATC shall revert back to standard practices for coordination of unplanned runway/taxiway closures and suspend further aircraft operations on the section(s) until the airport advises the runway or taxiway is open	SAC#1, SAC#1a, SAC#2

Table 7: List of Safety Objectives (success approach) for Abnormal Operations

Notes:

- Table 7, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.
- SO35 is covered by REQ-06.07.01-OSED-CMAC-0017

2.8 Mitigation of system-generated risks (failure approach)

This section concerns the airport operations supported by the Conformance Monitoring System in the case of internal failures. Before any conclusion can be reached concerning the adequacy of the safety specification of these operations, at the OSED level, it is necessary to assess the possible adverse effects that failures internal to the end-to-end System might have upon the provision of the relevant operational services described in section 2.6.1 and to derive safety objectives (failure approach) to mitigate against these effects.

2.8.1 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 3 above), what would happen if the objectives were not satisfied (i.e. negate the safety objectives derived both for normal and abnormal conditions), the following system-generated hazards are documented in Table 8 below together with

- the assessed immediate operational effect,

- the possible mitigations of the safety consequence of the operational effect with a reference to existing safety objectives (functionality and performance) and
- the assessed severity of the most probable effect from hazard occurrence as per the relevant Severity Classification Scheme(s) from Guidance E.2 of [4]

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 001	Ground ATC failure to detect the non-conformance to ATC clearances or instructions during taxiway operation	SO 001; SO 002; SO 003; SO 004; SO 006; SO 009; SO 011; SO 012; SO 013; SO 014; SO 017; SO 020;; SO 024; SO 030	An aircraft or a vehicle does not respect the ATC clearance/instruction and the ground ATC conformance monitoring System fails to detect such non-conformance. The mobile continues to deviate from the given clearance/instruction which might lead to a taxiway conflict.	*** Taxiway conflict prevention** ATCO monitors for potential taxiway conflicts in accordance with current practises (without the support of the conformance monitoring tool). However for induced "taxiway conflict" (e.g. taxi route deviation) the efficiency of this barrier is very low. *** ATC Taxiway collision avoidance** ATCO detects (with or without A-SMGCS) imminent or actual losses of separation and acts to prevent collision	Tinc-SC4

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 001-1	Ground ATC detection of non-conformance to ATC clearances or instructions but with incomplete information during taxiway operation (e.g. alert without the indication of the a/c identification, without the type of non-conformance). Note: This Hazard is a Hz 001 sub-hazard (Hz 001 described above)	SO 002; SO 003; SO 004; SO 006; SO 009; SO 011; SO 012; SO 013; SO 014; SO 017; SO 020; SO 030	An aircraft or a vehicle does not respect the ATC clearance/instruction and the ground ATC conformance monitoring system detects the problem but with missing information. The mobile continues to deviate from the given clearance/instruction until the controller find the missing information and therefore in the worst case such situation might lead to a taxiway conflict Note: When considering this Hazard, one or few information(s) are missing :e.g. alert without the a/c identification, without the a/c type, without the holding point, without the assigned rwy; without the type of non-conformance indicated, etc…	*** Taxiway conflict prevention** ATCO does not react appropriately to the partial alert due to the missing information but ATCO monitors for potential taxiway conflicts in accordance with current practises.. However for induced "taxiway conflict" (e.g. taxi route deviation) the efficiency of this barrier is very low. *** ATC Taxiway collision avoidance** ATCO detects (with or without A-SMGCS) imminent or actual losses of separation and acts to prevent collision	Tinc-SC4

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 001-2	Ground ATC detection of non-conformance to ATC clearances or instructions but with incorrect information during taxiway operation (e.g. alert with wrong indication of the a/c identification, with wrong indication of the type of non-conformance). Note: This Hazard is a Hz 001 sub-hazard (Hz 001 described above)	SO 002; SO 003; SO 004; SO 006; SO 009; SO 011; SO 012; SO 013; SO 014; SO 017; SO 020; SO 024; SO 030	An aircraft or a vehicle does not respect the ATC clearance/instruction and the ground ATC conformance monitoring system detects a problem but with wrong information. The mobile continues to deviate from the given clearance/instruction and it might lead to a taxiway conflict if the controller does not identify the corrupted information. Note: When considering this Hazard, one or few information(s) are incorrect: e.g. alert with wrong a/c identification, with wrong a/c type, with wrong holding point, with wrong assigned rwy, with an erroneous type of non-conformance indicated, etc.…	*** Taxiway conflict prevention** ATCO does not react appropriately to the partial alert due to the incorrect information but ATCO monitors for potential taxiway conflicts in accordance with current practises. However for induced "taxiway conflict" (e.g. taxi route deviation) the efficiency of this barrier is very low. *** ATC Taxiway collision avoidance** ATCO detects (with or without A-SMGCS) imminent or actual losses of separation and acts to prevent collision	Tinc-SC4

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 002	Ground ATC failure to detect the non-conformance to ATC clearances or instructions during runway operation	SO 001; SO 008; SO 010; SO 012; SO 013; SO 015; SO 016; SO 017; SO 018; SO 019; SO 020; SO 021; SO 022; SO 023; SO 025; SO 026; SO 027; SO 028; SO 030; SO 032	An aircraft or a vehicle does not respect the ATC clearance/instruction and the ground ATC conformance monitoring System fails to detect such non-conformance The mobile continues to deviate from the given clearance/instruction which might lead to a runway conflict (Indeed the runway conflict prevention barrier is not efficient for certain non-conformance cases like the landing of take-off without clearances because an ATCO clearance is not needed for conflict).	***Runway Conflict prevention** ATCO monitors for potential runway conflicts in accordance with current practises (without the support of the conformance monitoring tool). This barrier is inefficient for certain non-conformance situations like the landing or take-off without clearances ***ATC runway collision avoidance** ATCO detects (with or without RIMS) the runway conflict and acts to prevent a potential runway collision. RIMS is independent from CMAC and still in operation and the conflict is detected by RIMS	Rinc-SC3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 002-1	Ground ATC detection of non-conformance to ATC clearances or instructions but with incomplete information during runway operation (e.g. alert without the indication of the a/c identification, without the type of non-conformance). Note: This Hazard is a Hz 002 sub-hazard (Hz 002 described above)	SO 008; SO 010; SO 012; SO 013; SO 015; SO 016; SO 017; SO 018; SO 019; SO 020; SO 021; SO 022; SO 023; SO 025; SO 026; SO 027; SO 028; SO 030; SO 032	An aircraft or a vehicle does not respect the ATC clearance/instruction and the ground ATC conformance monitoring system detects the problem but with missing information. The mobile continues to deviate from the given clearance/instruction until the controller find the missing information and therefore in the worst case such situation might lead to a runway conflict (Indeed the runway conflict prevention barrier is not efficient for certain non-conformance cases like the landing of take-off without clearances because an ATCO clearance is not needed for conflict). Note: When considering this Hazard, one or few information(s) are missing: e.g. alert without the a/c identification, without the a/c type, without the type of non-conformance indicated, etc.…	***Runway Conflict prevention** ATCO does not react appropriately to the partial alert due to the missing information but ATCO monitors for potential runway conflicts in accordance with current practises. This barrier is inefficient for certain non-conformance situations like landing or take-off without clearances if the missing information cannot be easily determined by the ATCO ***ATC runway collision avoidance** ATCO detects (with or without RIMS) the runway conflict and acts to prevent a potential runway collision	Rinc-SC3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 002-2	Ground ATC detection of non-conformance to ATC clearances or instructions but with incorrect information during runway operation (e.g. alert with wrong indication of the a/c identification, with wrong indication of the type of non-conformance). Note: This Hazard is a Hz 002 sub-hazard (Hz 002 described above)	SO 008; SO 010; SO 012; SO 013; SO 015; SO 016; SO 017; SO 018; SO 019; SO 020; SO 021; SO 022; SO 023; SO 025; SO 026; SO 027; SO 028; SO 030; SO 032	An aircraft or a vehicle does not respect the ATC clearance/instruction and the conformance monitoring system detects a problem but with wrong information. The mobile continues to deviate from the given clearance/instruction and it might lead to a runway conflict if the controller does not identify the corrupted information (Indeed the runway conflict prevention barrier is not efficient for certain non-conformance cases like the landing of take-off without clearances because an ATCO clearance is not needed for conflict). Note: When considering this Hazard, one or few information(s) are incorrect: e.g. alert with wrong a/c identification, wrong a/c type, wrong holding point, wrong assigned rwy, erroneous type of non-conformance indicated, etc.…	***Runway Conflict prevention** ATCO does not react appropriately to the partial alert due to the incorrect information but ATCO monitors for potential runway conflicts in accordance with current practises. This barrier is inefficient for certain non-conformance situations like the landing or take-off without clearances if the incorrect information cannot be easily identified by the ATCO ***ATC runway collision avoidance** ATCO detects (with or without RIMS) the runway conflict and acts to prevent a potential runway collision	Rinc-SC3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 003	On-board failure to detect the non-conformance to ATC clearances or instructions during taxiway operation	SO 005; SO 007; SO 031	The aircraft does not respect the ATC clearance/instruction and the on-board conformance monitoring System fails to detect such non-conformance. The aircraft continues to deviate from the given clearance/instruction which might lead to a taxiway conflict.	* **Taxiway conflict management (ATC)** ATCO monitors for potential taxiway conflicts in accordance with current practises (with or without the support of the ground ATC conformance monitoring tool). However for induced "taxiway conflict" (e.g. taxi route deviation) the efficiency of this barrier is very low. * **ATC Taxiway conflict management (ATC)** ATCO detects (with or without A-SMGCS) imminent or actual losses of separation and acts to prevent collision	Tinc-SC4

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 003-1	On-board detection of non-conformance to ATC clearances or instructions but with incomplete information during taxiway operation (e.g. alert without indication of the type of non-conformance). Note: This Hazard is a Hz 003 sub-hazard (Hz 003 described above)	SO 005; SO 007; SO 031	The aircraft does not respect the ATC clearance/instruction and the on-board conformance monitoring system detects the problem but with missing information. The aircraft continues to deviate from the given clearance/instruction until the pilot find the missing information and therefore in the worst case such situation might lead to a taxiway conflict Note: When considering this Hazard, one or few information(s) are missing: e.g. alert provided without the type of non-conformance.	Pilot does not react appropriately to the partial alert due to the missing information. * **Taxiway conflict management (ATC)** This barrier is inefficient for induced "taxiway conflict" (e.g. taxi route deviation). * **ATC Taxiway conflict management (ATC)** ATCO detects (with or without A-SMGCS) imminent or actual losses of separation and acts to prevent collision	Tinc-SC4
Hz 003-2	On-board detection of non-conformance to ATC clearances or instructions but with incorrect information during taxiway operation (e.g. alert with wrong indication of the type of non-conformance). Note: This Hazard is a Hz 003 sub-hazard (Hz 003 described above)	SO 005; SO 007; SO 031	The aircraft does not respect the ATC clearance/instruction and the on-board conformance monitoring system detects a problem but with wrong information. The aircraft continues to deviate from the given clearance/instruction and it might lead to a taxiway conflict if the pilot does not identify the corrupted information. Note: When considering this Hazard, one or few information(s) are incorrect: e.g. alert with an erroneous type of non-conformance.	Pilot does not react appropriately to the partial alert due to the incorrect information. * **Taxiway conflict management (ATC)** This barrier is inefficient for induced "taxiway conflict" (e.g. taxi route deviation). * **ATC Taxiway conflict management (ATC)** ATCO detects (with or without A-SMGCS) imminent or actual losses of separation and acts to prevent collision	Tinc-SC4

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 004	On-board failure to detect the non-conformance to ATC clearances or instructions during runway operation	SO 029; SO 031; SO 033; SO 034	The aircraft does not respect the ATC clearance/instruction and the on-board conformance monitoring System fails to detect such non-conformance. The aircraft continues to deviate from the given clearance/instruction which might lead to a runway conflict (Indeed the runway conflict prevention barrier is not efficient for certain non-conformance cases like the landing of take-off without clearances because an ATCO clearance is not needed for conflict).	***Runway Conflict prevention** ATCO monitors for potential runway conflicts in accordance with current practises (with or without the support of the ground ATC conformance monitoring tool). This barrier is inefficient for certain non-conformance situations like the landing of take-off without clearances ***ATC runway collision avoidance** ATCO detects (with or without RIMS) the runway conflict and acts to prevent a potential runway collision	Rinc-SC3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 004-1	On-board detection of non-conformance to ATC clearances or instructions but with incomplete information during runway operation (e.g. alert without indication of the type of non-conformance). Note: This Hazard is a Hz 004 sub-hazard (Hz 004 described above)	SO 029; SO 031; SO 033; SO 034	The aircraft does not respect the ATC clearance/instruction and the on-board conformance monitoring system detects the problem but with missing information. The aircraft continues to deviate from the given clearance/instruction until the pilot find the missing information and therefore in the worst case such situation might lead to a runway conflict Note: When considering this Hazard, one or few information(s) are missing: e.g. alert provided without the type of non-conformance.	*** Runway Conflict prevention (pilot)** Pilot does not react appropriately to the partial alert due to the missing information but Pilot monitors for potential runway conflicts. If needed he/she aborts the take-off or initiates a go-around. ***Runway Conflict prevention (ATC)** ATCO monitors for potential runway conflicts in accordance with current practises (with or without the support of the ground ATC conformance monitoring tool). This barrier is inefficient for certain non-conformance situations like the landing of take-off without clearances ***ATC runway collision avoidance** ATCO detects (with or without RIMS) the runway conflict and acts to prevent a potential runway collision	Rinc-SC3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 004-2	On-board detection of non-conformance to ATC clearances or instructions but with incorrect information during runway operation (e.g. alert with wrong indication of the type of non-conformance). Note: This Hazard is a Hz 004 sub-hazard (Hz 004 described above)	SO 029; SO 031; SO 033; SO 034	The aircraft does not respect the ATC clearance/instruction and the on-board conformance monitoring system detects a problem but with wrong information. The aircraft continues to deviate from the given clearance/instruction and it might lead to a runway conflict if the pilot does not identify the corrupted information. Note: When considering this Hazard, one or few information(s) are incorrect: e.g. alert with an erroneous type of non-conformance.	*** Runway Conflict prevention** Pilot does not react appropriately to the partial alert due to the incorrect information but Pilot monitors for potential runway conflicts. If needed, he/she aborts the take-off or initiates a go-around. ***Runway Conflict prevention (ATC)** ATCO monitors for potential runway conflicts in accordance with current practises (with or without the support of the ground ATC conformance monitoring tool). This barrier is inefficient for certain non-conformance situations like the landing of take-off without clearances ***ATC runway collision avoidance** ATCO detects (with or without RIMS) the runway conflict and acts to prevent a potential runway collision	Rinc-SC3

Table 8: System-Generated Hazards and Analysis

Notes:

In Table 8, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 005	Ground ATC failure to detect the non-conformance to ATC clearances or instructions aiming to prevent runway overrun	SO 012; SO 035	An aircraft initiates a take-off roll from the taxiway and the ground ATC conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during take-off from the taxiway (classified as a runway excursion)	***Pilot avoidance** Pilot detects visually or with the help of displayed information that the take-off roll is from a taxiway and carries out successfully an aborted take-off	SC 2 (no AIM model for Runway Excursion)
		SO 016, SO 019; SO 028	An aircraft initiates a take-off roll from a wrong or a closed runway and the ground ATC conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during take-off from e.g. too short runway	***Pilot avoidance** Pilot detects visually or with the help of displayed information that the take-off roll is from a wrong runway and carries out successfully an aborted take-off	
		SO 026; SO 028	An aircraft initiates a landing on a wrong/closed runway or on a taxiway and the ground ATC conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during landing on e.g. too short runway	*** ATC runway management/monitoring** ATCO monitors for potential take-off or landing on unassigned runway without the support of the ground ATC conformance monitoring tool. ***Pilot avoidance** Pilot detects visually or with the help of displayed information that the landing is established on a wrong runway or on a taxiway and initiates successfully a go around	

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
		SO 030	An aircraft initiates a take-off or a landing on an unsuitable runway (e.g. runway length) and the Ground ATC conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during landing or take-off on e.g. too short runway	*** ATC runway management/monitoring** ATCO monitors for potential take-off or landing on unassigned runway without the support of the ground ATC conformance monitoring tool. ***Pilot avoidance** Pilot detects visually or with the help of displayed information that the take-off or landing is made on an inappropriate runway and carries out successfully an avoidance action (aborted take-off or go around)	
Hz 006	On-board failure to detect the non-conformance to ATC clearances or instructions aiming to prevent runway overrun	SO 029; SO 031	An aircraft initiates a take-off or a landing on an unsuitable or closed runway and the on-board conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during landing or take-off on e.g. too short runway	*** ATC runway management/monitoring** ATCO monitors for potential take-off or landing on unassigned runway with or without the support of the ground ATC conformance monitoring tool. ***Pilot avoidance** Pilot detects visually or with the help of displayed information that the take-off or landing is made on an inappropriate runway and carries out successfully an avoidance action (aborted take-off or go around)	SC 2 (no AIM model for Runway Excursion)
		SO 033	An aircraft initiates a take-off roll from a wrong runway and the on-board conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during take-off from e.g. too short runway	*** ATC runway management/monitoring** ATCO monitors for potential take-off or landing on unassigned runway with or without the support of the ground ATC conformance monitoring tool. ***Pilot avoidance** Pilot detects visually or with the help of displayed information that the take-off roll is from a wrong runway and carries out successfully an aborted take-off	

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
		SO 034	An aircraft initiates a landing on a wrong runway or on a taxiway and the on-board conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during landing on e.g. too short runway	*** ATC runway management/monitoring** ATCO monitors for potential take-off or landing on unassigned runway with or without the support of the ground ATC conformance monitoring tool. ***Pilot avoidance** Pilot detects visually or with the help of displayed information that the landing is established on a wrong runway or on a taxiway and initiates successfully a go around	
		SO 036	An aircraft initiates a take-off roll from the taxiway and the on-board conformance monitoring System fails to detect such non-conformance. This might lead to a runway overrun during take-off from the taxiway (classified as a runway excursion)	***Pilot avoidance** Pilot detects visually or with the help of displayed information that the take-off roll is from a taxiway and carries out successfully an aborted take-off	

Table 9: System-Generated Hazards and Analysis for Runway Overrun

Notes:

In
Table 9, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.

2.8.2 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 Rick Classification Scheme.

SO 101 to SO 104 (relative to Hz 001 to Hz 004) have been derived based on the Risk Classification Schemes (RCS) for the Runway Collision, the Taxiway Collision and the formula proposed to derive the safety objectives in Guidance E in [4].

SO 105 and SO 106 (relative to Hz 005 and Hz 006) have been derived based on existing study on take-off and landing overruns (see Appendix D.3 of [4]). Safety Objectives have been determined considering the most stringent case which is the take-off.

SO ID	Safety Objectives	System Generated Hazard
SO 101	During Taxiway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at ATC level leading to taxiway infringement shall not be greater than 3.3x10-3 per movement	Hz 001(including Hz001-1 and Hz001-2)
SO 102	During Runway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at ATC level leading to runway incursion shall not be greater than 5.0x10-7 per movement	Hz 002(including Hz002-1 and Hz002-2)
SO 103	During Taxiway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at aircraft level leading to taxiway infringement shall not be greater than 3.3x10-3 per movement	Hz 003(including Hz003-1 and Hz003-2)
SO 104	During Runway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at aircraft level leading to runway incursion shall not be greater than 5.0x10-7 per movement	Hz 004(including Hz004-1 and Hz004-2)
SO 105	The frequency of occurrence of an undetected non-conformance to ATC clearances/instruction aiming to prevent runway overrun at ATC level shall not be greater than 1.2x10-7 per movement	Hz 005
SO 106	The frequency of occurrence of an on-board undetected non-conformance to ATC clearances/instruction aiming to prevent runway overrun at aircraft level shall not be greater than 1.2x10-7 per movement	Hz 006

Table 10: Safety Objectives (integrity/reliability)

Notes:
Table 10, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.

2.9 Impacts of aerodrome operations on adjacent airspace or on neighbouring ATM Systems

Ground conformance monitoring is a stand-alone function which is part of A-SMGCS at higher level than 2.

Ground conformance monitoring function applies to apron, taxiway and runway operations and there is no impact on the adjacent airspace which is the approach and TMA except for the last part of the final approach where landing clearances and alignment on correct runway are monitored and where transfer of responsibility between Runway Control and Approach/Departure Control may need to be automatized.

2.10 Achievability of the SAfety Criteria

The general approach to showing that SAC#1 to SAC#3 have the potential to be satisfied has been done through the specification of success and failure Safety Objectives in previous sections.

2.10.1 SAC#1 and SAC#1a

In terms of the Barrier Model the crucial difference from the current system is that the Conformance Monitoring system enables the Runway Monitoring barrier to be strengthened.

The Conformance Monitoring system reduces the number of runway incursion by detecting and solving most of these incursions arising from:

- failure of the landing management
- failure of the take-off management
- induced incursions from aircraft/vehicle whether they are related to unauthorised runway entry or failure to timely exit the runway

For certain non-conformance situations the concept does not prevent the RI but alert about the "start" of an RI even if this is not the case for all situations. Indeed when considering the early detection of a taxi route deviation, of an a/c landing without clearance, of an a/c taxiing to a closed runway, this is a real situation where Runway Incursions are prevented.

Therefore, conformance monitoring reduces the number of Runway Conflicts (RP 2) due to the early detection of runway incursions.

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Thus, if all other barriers remain as effective, and if the runway usage remains the same, there would be fewer runway incursions and consequently a lower risk of accident.

In SESAR and considering the runway usage increase, the potential to improve safety is traded off for other types of benefit: capacity, efficiency/ flexibility or combinations thereof

2.10.2 SAC#2

In terms of the Barrier Model the crucial difference from the current system is that the Conformance Monitoring system enables the Taxiway Conflict Management barrier to be strengthened.

The Conformance Monitoring system reduces the number of taxiway infringement by detecting and solving most of these incursions arising from:

- induced taxiway conflict due to early detection of aircraft/vehicle diverging from conflict free taxi route
- induced pre-tactical taxiway conflict due to early detection of aircraft moving from its gate or from its position after push back without clearance

The Conformance Monitoring system is not in itself designed to change the performance of other barriers.

Thus, if all other barriers remain as effective, and if the taxiway usage remains the same, there would be fewer taxiway infringements and consequently a lower risk of accident.

In SESAR and considering the taxiway movement increase, the potential to improve safety is traded off for other types of benefit: capacity, efficiency/ flexibility or combinations thereof

2.10.3 SAC#3

There is no SESAR AIM Model for runway excursion (e.g. overrun), however a very simplified model is represented in [4] Appendix D.3.

The crucial difference from the current system is that the Conformance Monitoring system enables the Runway Monitoring barrier to be strengthened. The Conformance Monitoring system reduces the number of imminent runway overrun by detecting and solving several pilot induced runway overrun arising from a landing on a closed runway, a take-off or a landing on a wrong runway (runway type) or an attempt to take-off from taxiway.

The Conformance Monitoring system is not in itself designed to change the performance of other barriers.

Thus, if all other barriers remain as effective, and if the runway/taxiway usage remains the same, there would be fewer runways overrun and consequently a lower risk of runway excursion accident.

In SESAR and considering the runway/taxiway usage increase, the potential to improve safety is traded off for other types of benefit: capacity, efficiency/ flexibility or combinations thereof.

2.11 Validation & Verification of the Safety Specification

The consolidated list of the Safety Objectives (functionality and performance) and Safety Objectives (integrity) is listed in appendix A.1A.2 and A.3A.3 respectively.

A V2 validation exercise (EXE-06.07.01-VP-537) was conducted to validate the initial concept defined in the preliminary OSED for the Ground ATC part only and results of this exercise are detailed in the validation report [10].

The conclusion of this report is summarized below:

"*…The fact that simulation generated safety incidents were spotted immediately by the ATCOs when the alerts were triggered and without the alerts some were not noticed or only identified after a short period time, indicates that the implementation of some or all of the alerts would help the ATCOs to perform their tasks more safely and help to maintain the efficiency of the airport operations.*

The majority of the alerts tested by the two controllers were considered as useful and easy to use, but it was seen that during peak periods the ATCOs found it challenging having to deal with the HMI at the same time as they were communicating with the flight crew. The ATCOs do not currently use EFS at CDG and only had a limited period of training and use of the ITWP HMI. It is known that when an ATC unit introduces EFS and new procedures that the training period is long enough for the ATCOs to be able to become totally familiar with the equipment and use it as a second nature without having to think of what they are doing.

The least favoured alerts were; High Speed alert– which was found not to be really suitable for the Paris CDG layout, and the Stationary alert – where certain parameters need to be fine-tuned or removed completely.

The alerts which were considered to be potentially most useful for Paris CDG were Runway Incursion alert (No line up, enter or crossing clearance) and no take-off clearance alert."

Furthermore after having conducted this exercise, it has been recommended in this report that: "The testing of the alerts in several real time simulations has already proved to be very positive. The V3 phase should endeavour to test the alerts in an operational environment either in shadow mode or ideally in live trials to confirm and get quantitative data on the benefits for the safety, human performance and efficiency domains"

3 Safe Design at SPR Level

3.1 Scope

This section addresses the following activities:

- description of the SPR-level model of the Conformance monitoring – sections 3.2.1 and 3.2.2
- derivation, from the Safety Objectives (Functionality and Performance) of section 2, of Safety Requirements for the SPR-level design - section 3.2.4
- analysis of the operation of the SPR-level design under normal operational conditions – section 3.3
- analysis of the operation of the SPR-level design under abnormal conditions of the Operational Environment - section 3.4
- assessment of the adequacy of the SPR-level design in the case of internal failures and mitigation of the system-generated hazards - section 3.5
- justification that the Safety Criteria are capable of being satisfied in a typical implementation - section 3.6
- validation & verification of the Specification - section 3.7

3.2 The Conformance Monitoring SPR-level Model

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

Two SPR-level Models have been developed: relative to taxiway and runways operations respectively.

3.2.1 Description of SPR-level Model for taxiways operations

The SPR-level Model associated to the Taxiway conformance monitoring is shown in Figure 1 below and is extracted from document [1].

The SPR-level Design is the level at which Safety Requirements for Conformance monitoring are specified.

This Model is a subpart of the ATM SPR-level Model for the SESAR Ground Operations (Apron and taxiway).

For the purpose this document only the ground ATC part is considered.

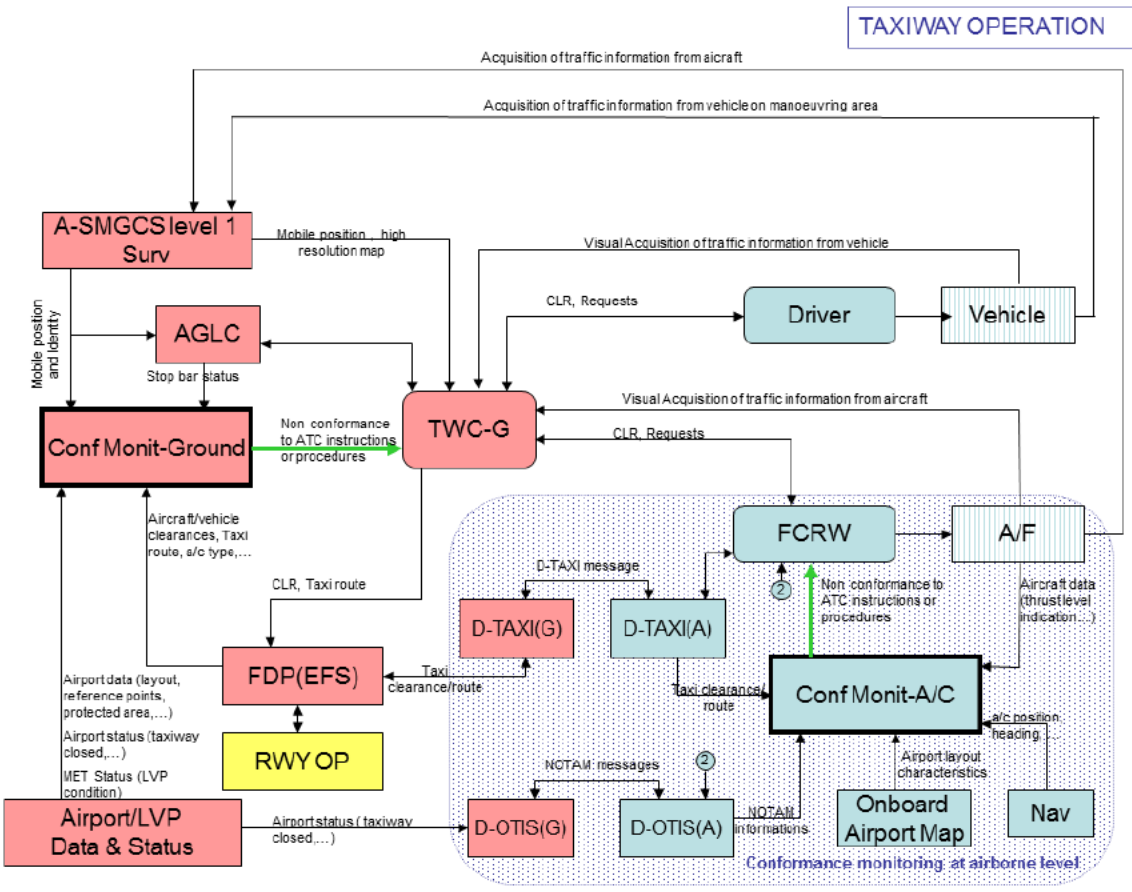


Figure 1: Taxiway conformance monitoring SPR-level Model

3.2.1.1 Elements for the taxiway conformance monitoring at ground level

3.2.1.1.1 Aircraft/ Vehicle Elements

A/F *Airframe:* The (logical) A/F is defined to include also the engines and all other essential Aircraft systems. It responds to track-keeping control inputs received from manual input by the Flight Crew or from the AP/FD system.

The interface to A-SMGCS includes all surveillance (PSR, SSR Mode S) information provided to the ATM ground systems when the aircraft is on the aerodrome surface.

FCRW *Flight Crew*: The Flight Crew remains ultimately responsible for the safe and orderly operation of the flight in compliance with the ICAO Rules of the Air, other relevant ICAO and EASA provisions, and within airline standard operating procedures.

The Flight Crew ensures that the aircraft operates in accordance with ATC clearances and instructions.

The main means of direct communications with the Tower Ground Controller (TWC-G) is (voice) RT for time-critical transactions.

Vehicle: The (logical) Vehicle is defined to include all essential vehicle systems to be driven on the manoeuvring area. It responds to control inputs from the vehicle driver.

The interface to A-SMGCS includes all surveillance (PSR, SSR Mode S) information provided to the ATM ground systems.

Vehicle driver: People who drive vehicles or motorized equipment on airports in accordance with the airport rules. Vehicle driver get permission from the Tower Ground Controller (TWC-G) by radio or advanced coordination with ATC (pre-arranged plan) when entering in the manoeuvring area. The vehicle driver ensures that the vehicle operates in accordance with ATC clearances and instructions

3.2.1.1.2 Ground Elements

TWC-G *Tower Ground Controller:* The principal tasks of the TWC-G are to provide clearances and instructions to aircraft and ground vehicles which will maintain safe and expeditious flow of traffic on the aerodrome apron and taxiway areas.

He/she is also responsible for the transfer of flights to the Runway control function (RWY) on departure and for accepting transfer from the Runway control function (RWY) on arrival.

The main tasks of the TWC-G are to:

- monitor surface movements to detect potentially hazardous situations, and issue avoiding instructions to aircraft and vehicles
- issue taxi instructions to aircraft (including push-back clearances) to ensure safe and expeditious movement on the apron and taxiway areas
- issue instructions to vehicles to ensure separation from aircraft on the airport surface when guidance is not delegated to vehicle drivers

The main means of direct communications with the Flight Crew (FCRW) is (voice) RT for immediate communications and could be supported by data-link for non-time critical communications. Communication with vehicle drivers is done by radio or advanced coordination with ATC.

Conf Monit Ground *Conformance Monitoring Ground*: It detects at ground level situations where the intended aircraft trajectory could lead to taxiway incidents/accidents and it provides an alert to the TWC-G. A number of alerts will be generated at ground level including:

- an aircraft or a vehicle deviates from the assigned taxi route
- an aircraft or vehicle is moving towards or into a closed taxiway
- an aircraft is taxiing at a speed which may indicate an incorrect attempt to take off from a taxiway.
- an aircraft is moving towards or into a taxiway inappropriate/unsuitable for the aircraft type
- an aircraft or a vehicle is remaining stationery on the manoeuvring area for longer than a period of time appropriate to the manoeuvre being undertaken
- an aircraft starts to move from a stand without push back approval
- an aircraft or a vehicle start to move without taxi clearance

A-SMGCS level 1 *Advanced Surface Movement Guidance and Control System:* The A-SMGCS level 1:

- provides a high resolution map of the runways and adjacent manoeuvring areas
- indicates on the airport map the position and identity of all aircraft on the airport surface adjacent to the runways and their destination (runway, stand or other)
- provides the identity and position of cooperating vehicles (those equipped with suitable transponders/ADS-B transmitters)
- provides the position of non-cooperating mobiles and of obstacles.

FDP (EFS) *Flight Data Processing/ Electronic Flight Strip:* FDP(EFS) automates the production, distribution and administrative management of flight plan information including the taxi clearance/route and other air traffic control data and replaces the paper strip systems previously used by TWC-G. With the electronic flight strips all data updates received from an FDP system or by manual inputs are automatically available to all TWC-G.

Airport/MET Data & Status *Airport/Meteorological Data and Status:*

The airport data includes the airport layout (TWY, RWY, etc…), the reference points (holding positions, stop bars, RWY thresholds) and fixed obstacles. The airport status indicates the actual status of the taxiway and runways on a given airport (e.g. open/close). Airport Status is NOTAM information provided by the Aeronautical Information Service (AIS).

Meteorological Status indicates, inter alia, if Low Visual Procedures (LVP) are applied to the aerodrome.

AGLC *Airfield Ground Lighting Control:* AGLC controls, inter alia, taxiway stops bar lighting. Stop bar command could be manually selected by TWC-G. The Stop bar status (illuminated or not) is provided to the Conformance Monitoring Ground.

3.2.1.2 External Entities

RWY OP *Runway operations:* Aerodrome Runway Control function is responsible for operations on the runway and aircraft flying within the area of responsibility of the Tower Runway controller (TWC-R).

Conformance monitoring alerts triggered at the boundary of the taxiway operation shall be also provided to the Tower Runway controller (TWC-R) in order to solve more efficiently any infringement.

3.2.2 Description of SPR-level Model for runway operations

The SPR-level Model associated to the Runway conformance monitoring is shown in Figure 2 below and is extracted from document [1].

The SPR-level Design is the level at which Safety Requirements for Conformance monitoring are specified.

This Model is a subpart of the ATM SPR-level Model for the SESAR Runways Operations (Landing/take off phases of flight).

For the purpose this document only the ground ATC part is considered.

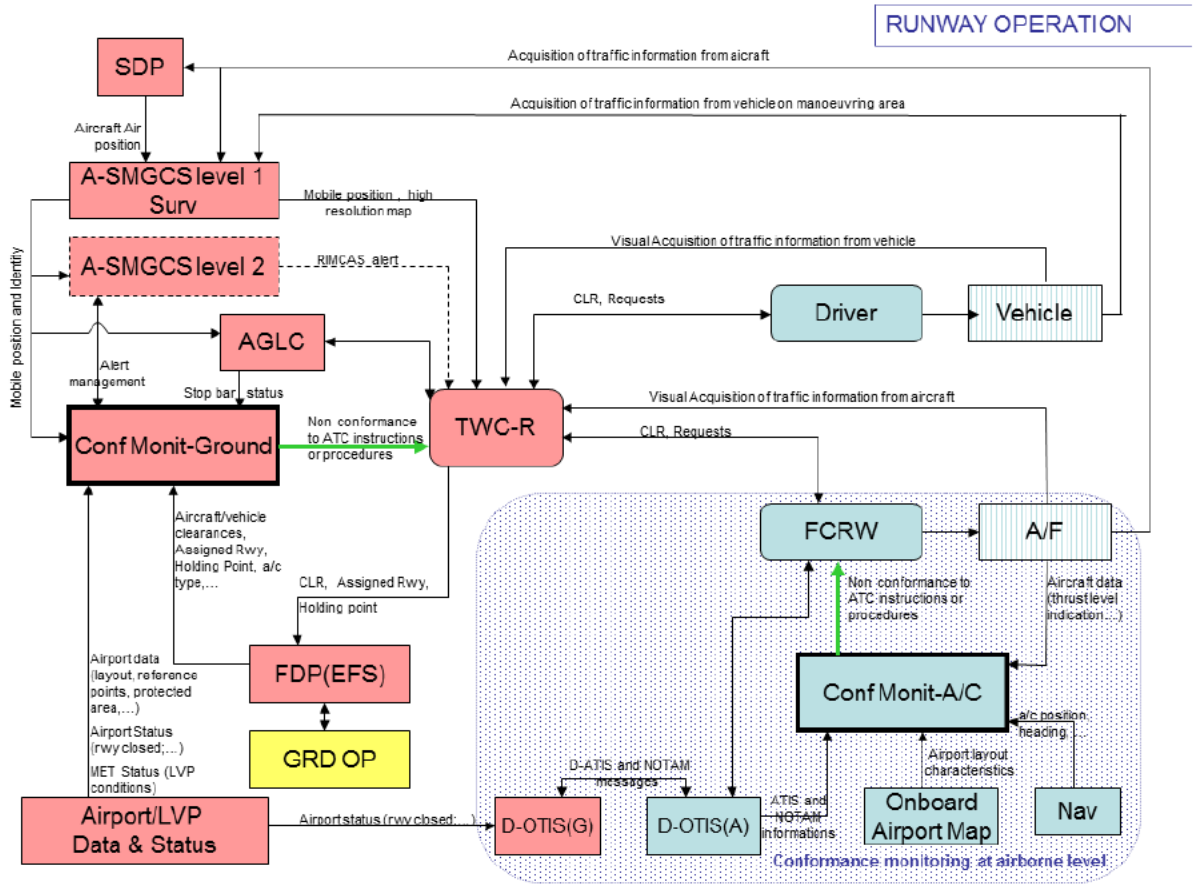


Figure 2: Runway conformance monitoring SPR-level Model

3.2.2.1 Elements for the runway conformance monitoring at ground level

3.2.2.1.1 Aircraft/ Vehicle Elements

A/F *Airframe:* Description identical to the taxiway operation.

FCRW *Flight Crew:* Description identical to the taxiway operation except that Tower Runway Controller (TWC-R) replaces the Tower Ground Controller (TWC-G).

Vehicle: Description identical to the taxiway operation.

Vehicle driver: Description identical to the taxiway operation except that Tower Runway Controller (TWC-R) replaces the Tower Ground Controller (TWC-G) for the runway operations

3.2.2.1.2 Ground Elements

TWC-R *Tower Runway Controller:* The principal tasks of the TWC-R are to provide clearances and instructions to aircraft and vehicles which will maintain exclusive use of the runway for a given movement, to separate aircraft after Take-off, and to maintain separation of aircraft on Final Approach from other aerodrome traffic.

He/she is also responsible for the transfer of flights to the Tower ground controller (TWC-G) on arrival and to the appropriate downstream sector immediately after Take-off.

Considering runway operations and the conformance monitoring aspects, the main

tasks of the TWC-R are to:

- assure exclusive access to the runway(s) in use by monitoring the runway protected area using visual surveillance and A- SMGCS level 1
- issue landing clearances to aircraft when the Runway Protected Area is unoccupied or there is a very high probability that it will be unoccupied
- issue runway vacating instructions to aircraft
- issuing go-around instructions where a landing clearance cannot be provided or must be cancelled due to failure of previous aircraft to vacate the RPA or to an actual or possible runway incursion
- issuing line-up and take-off clearances to departing aircraft
- issuing crossing clearances for aircraft and vehicles
- monitoring the runway environment and taking action to avoid hazards

The main means of direct communications with the Flight Crew (FCRW) is (voice) RT for immediate communications and could be supported by data-link for non-time critical communications.

Communication with vehicle drivers is done by radio or advanced coordination with ATC.

Conf Monit Ground *Conformance Monitoring Ground:* It detects at ground level situations where the intended aircraft trajectory could lead to runway incident/accidents and it provides an alert to the TWC-R. A number of alerts will be generated at ground level when:

- actual or potential aircraft or vehicle incursion into an active runway
- an aircraft is lining up on the runway without clearance or on a wrong runway
- an aircraft or a vehicle is crossing a red stop bar
- an aircraft or vehicle is crossing/entering an active runway without clearance
- an aircraft or vehicle is moving towards or into a closed runway (other than the active runway)
- an aircraft is moving towards or into a runway inappropriate/unsuitable for the aircraft type
- an aircraft or a vehicle is remaining stationery on the runway for longer than a period of time appropriate to the manoeuvre being undertaken
- a landing aircraft in final approach has not transferred to the tower frequency
- an aircraft is landing without a landing clearance
- an aircraft is landing or attempting to land on a wrong runway

A-SMGCS-level 2 alerts shall have higher priority than those triggered by CONF MONIT (G).

A-SMGCS level 1 **Advanced Surface Movement Guidance and Control System:** Description identical to the taxiway operation

SDP *Surveillance Data Processing:* SDP correlates the various available sources of (independent and dependent) surveillance data – e.g. primary and secondary radar, ADS-B, ADS-C and Wide-area Multilateration (WAM), and provides (at least) the following information relevant to final approach and runway operations: Identification; Position; Altitude

A-SMGCS level 2 *Advanced Surface Movement Guidance and Control System level 2:* At Level 2, A-SMGCS consists in the introduction of automated surveillance (identical to Level 1) complemented by an automated service capable of detecting conflicts and infringements of some ATC rules involving aircraft or vehicles on runways and

restricted areas. Whereas the detection of conflicts identifies a possibility of a collision between aircraft and/or vehicles, the detection of infringements focuses on dangerous situations because one or more mobiles infringed ATC rules.

A-SMGCS level 2 is shown as being logically separate from CONF MONIT (G) since it can be regarded as a safety net rather than a continuously-acting control system and furthermore CONF MONIT (G) could be implemented without A-SMGCS Level 2.

A-SMGCS-level 2 alerts shall have higher priority than those triggered by CONF MONIT (G).

FDP (EFS) *Flight Data Processing/ Electronic Flight Strip:* Description identical to the taxiway operation except that the runway controller (TWC-R) replaces the Ground controller (TWC-G).

Airport/MET Data & Status *Airport Meteorological Data and Status:* Description identical to the taxiway operation

AGLC **Airfield Ground Lighting Control:** Description identical to the taxiway operation except that Runway stop bar shall be considered instead of Taxiway Stop bar.

3.2.2.2 External Entities

GRD OP *Ground Control operations:* Aerodrome Ground Movements Control function is responsible for traffic on the manoeuvring area with the exception of runways.

Conformance monitoring alerts triggered at the boundary of the Runway operation shall be also provided to the Tower Ground controller (TWC-G) in order to solve more efficiently any infringement.

3.2.3 Operation of the SPR-level Models – Overview

This section describes the operation of the SPR-level models for typical airport operations when considering the scope of the conformance monitoring. The following sections describe the conformance monitoring associated with taxiway and runway operations

3.2.3.1 Ground ATC Conformance monitoring for taxiway operation

3.2.3.1.1 Push back

Flight Crew contacts the Tower Ground Controller (TWC-G) and requests approval for pushback. The Tower Ground Controller, after proper identification of the aircraft via ground surveillance (A-SMCGS level 1) or visual confirmation, issues the approval for start-up and push-back and entered such information in the Flight Data Processing System (FDP(EFS))

If Aircraft starts pushback without ATC approval, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Ground Controller of such situation via an alert.

I004: Availability of A-SMGCS level 1 on apron area is essential for the push back conformance element. Lack of A-SMGCS coverage on apron leads to an inefficient push back conformance monitoring.

3.2.3.1.2 Taxi approval

The Tower Ground Controller (TWC-G) issues a taxi clearance to the aircraft by voice or by data link (D-TAXI) whenever possible and keyed such information in the Flight Data Processing System

(FDP(EFS)). The Flight Crew acknowledges the taxi clearance. In a similar way, the Tower Ground Controller issues taxi clearance to vehicle when required.

If Aircraft or vehicle starts taxiing without ATC approval, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Ground Controller of such situation via an alert.

When a clearance is limited to a point at which the Tower Ground Controller requires the aircraft or vehicle to stop (Taxi Clearance Limit), the Flight Crew or vehicle driver should stops at the clearance limit position and awaits further clearance. The Ground ATC Conformance Monitoring monitors the progress of the aircraft or vehicle with respect to the taxi clearance issued and automatically alerts the Tower Ground Controller if the Aircraft or vehicle proceeds across the clearance limit.

When the clearance limit is a runway holding point, the Tower Ground Controller (TWC-G) instructs the Flight Crew or vehicle driver to contact the Controller responsible for Runway operations (TWC-R via RWY OP). If the mobile is not transferred to the runway controller, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects this problem and informs the Tower Ground Controller (TWC-G) of such situation via an alert.

3.2.3.1.3 Taxi route deviation

The Flight Crew or the vehicle driver proceeds to taxi following the designated route specified in the taxi clearance. The taxi route from FDP(EFS) is provided to the Ground ATC Conformance Monitoring. The Tower Ground Controller (TWC-G) uses the A-SMGCS level 1 to monitor the aircraft or vehicle movement and track its progress against the issued taxi route. If Aircraft or vehicle starts to deviate from the taxi route which has been cleared by the controller, the Ground ATC Conformance Monitoring detects such non-conformance and informs the Tower Ground Controller of such situation via an alert.

3.2.3.1.4 Taxiway Stationary situation

When an aircraft or a vehicle doesn't move within a certain time frame following a Tower Ground Controller (TWC-G) instruction/clearance the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Ground Controller of such situation via an alert. The stationary duration before triggering the alert is a parameter defined within the Ground ATC Conformance Monitoring element.

3.2.3.1.5 Taxi Type

When a taxi route is not appropriate for a given aircraft because part of the route is unsuitable for the aircraft type (e.g. size and/or weight), the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance and informs the Tower Ground Controller (TWC-G) of such situation via an alert. The aircraft type and the taxi route from the FDP(EFS) is provided to the Ground ATC Conformance Monitoring.

The taxiway limitation (e.g. in width, weight,…) from the Airport/MET data & status is provided to the Ground ATC Conformance Monitoring and the A-SMCGS level 1 provides mobile's position to the Ground ATC Conformance Monitoring.

3.2.3.1.6 Closed Taxiway

When an aircraft or a vehicle move towards a taxiway which has been closed after the clearance has been given, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Ground Controller (TWC-G) of such situation via an alert.

The taxi route from the FDP(EFS) is provided to the Ground ATC Conformance Monitoring. The closed taxiway information is provided from the Airport/MET data & status to the Ground ATC Conformance Monitoring.

3.2.3.1.7 Attempt to take-off from Taxiway

When an aircraft is exceeding a speed limit when taxiing, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Ground Controller (TWC-G) of such situation via an alert [SR GG 013]. The taxi route from FDP(EFS) is provided to the Ground ATC Conformance Monitoring. The speed limit on taxiway for triggering the alert is a parameter defined within the Ground ATC Conformance Monitoring element.

3.2.3.1.8 Red Stop bar crossed

A taxiing aircraft or vehicle which reaches a red stop bar at an intermediate holding point or at the limit between control positions areas of responsibility shall stop. If an Aircraft or vehicle crosses the red stop bar, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data, the Airport/MET data & status reference points (holding positions, stop bars) and the Airfield Ground Lighting Control System (AGLC).

In such case, the Ground ATC conformance monitoring informs the Tower Ground Controller (TWC-G) of such situation via an alert. The holding point(s) information from FDP(EFS) are provided to the Ground ATC Conformance Monitoring.

3.2.3.2 Ground ATC Conformance monitoring for runway operation

3.2.3.2.1 Red Stop bar crossed

A taxiing aircraft or vehicle which reaches a red stop bar at a runway holding point, at an intermediate holding point or at the limit between control positions areas of responsibility shall stop. If an Aircraft or vehicle crosses the red stop bar, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and the Airfield Ground Lighting Control System (AGLC).

In such case the Conf-Monit-Ground informs the Tower Runway Controller (TWC-R) of such situation via an alert. The reference points (holding positions, stop bars) from Airport/MET data & status are provided to the Ground ATC Conformance Monitoring.

3.2.3.2.2 No Line Up or Crossing Clearance

Line Up

The Tower Runway Controller (TWC-R) verifies that the runway approach area is clear, that the aircraft will meet arrival/departure separation requirements and that the departing aircraft will comply with its Take Off Time prior to providing the line-up instruction to the aircraft.

If an Aircraft is lining up on an active runway without clearance, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert.

Crossing/Entering

If the Taxi Clearance Limit is an active runway, the Tower Ground Controller (TWC-G via GRD OP) instructs the Flight Crew or vehicle driver to contact the Tower Runway Controller (TWC-R) who will issue clearance to cross/enter. If the mobile is not transferred to the runway controller, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects this problem and informs the Tower Ground Controller (TWC-R) of such situation via an alert.

For crossing clearance, the Tower Runway Controller verifies, either visually or using the Ground Surveillance System (A-SMGCS level 1), that the aircraft or vehicle is crossing the runway and once vacated, he instructs the Flight Crew or vehicle driver to contact the Tower Ground Controller responsible for this ground surface area (TWC-G via GRD OP).

If the mobile is not transferred to the ground controller, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects this problem and informs the Tower Runway Controller (TWC-R) of such situation via an alert.

If an Aircraft or vehicle is crossing/entering an active runway without clearance, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert.

3.2.3.2.3 Lining up on wrong runway

When an aircraft is lining up on a wrong runway, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data [and informs the Tower Runway Controller (TWC-R) of such situation via an alert. The assigned runway information from FDP(EFS) is provided to the Ground ATC Conformance Monitoring.

3.2.3.2.4 Runway type

When a runway is not appropriate for an aircraft type due to its length, width or pavement resistance, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance and informs the Tower Runway Controller (TWC-R) of such situation via an alert. The assigned runway from the FDP (EFS) is provided to the Ground ATC Conformance Monitoring .

The runway limitation for the different aircraft types is provided by the Airport/MET data & status to the Ground ATC Conformance Monitoring. The A-SMCGS level 1 provides mobile's position to the Ground ATC Conformance Monitoring.

3.2.3.2.5 Runway closed

When an aircraft or a vehicle move/flight towards a runway which has been closed after the clearance has been given, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller (TWC-R) of such situation via an alert.

The assigned runway information from FDP (EFS) is provided to the Ground ATC Conformance Monitoring. The closed runway information is provided from the Airport/MET data & status to the Ground ATC Conformance Monitoring.

3.2.3.2.6 No Take-Off Clearance

The Tower Runway Controller (TWC-R) by visual reference and using the Ground Surveillance System (A-SMGCS level 1) verifies that the runway is free of obstacles for the take-off of the aircraft. The Tower Runway Controller issues the take-off clearance to the Flight Crew. The Flight Crew acknowledges the take-off clearance, initiates the take-off roll and lifts-off.

If an Aircraft initiates the take-off roll without a take-off clearance, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert.

3.2.3.2.7 Runway Stationary

<u>For arriving aircraft:</u>

The flight crew advises the Tower Runway Controller (TWC-R) that he has vacated the runway. The Tower Runway Controller verifies, either visually or(else) using the Ground Surveillance System (A-SMGCS level 1), that the aircraft has vacated the runway and transfers the control of the flight to the Tower Ground Controller in charge of related area on the airport (TWC-G via GRD OP).

If the aircraft is not transferred to the ground controller, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects this problem and informs the Tower Runway Controller (TWC-R) of such situation via an alert.

If an Aircraft does not vacate the runway protected area within a certain time frame, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert. The stationary duration before triggering the alert is a parameter defined within the Ground ATC Conformance Monitoring element.

For departing aircraft:

If an aircraft is lined up on the runway and doesn't receive a take-off clearance within a certain time frame, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert.

Similarly, an aircraft which has received a take-off clearance but remaining stationary for a certain period of time will trigger a Ground ATC Conformance Monitoring alert. The stationary duration before triggering the alert is a parameter defined within the Ground ATC Conformance Monitoring element.

For vehicles:

If a vehicle does not vacate the runway protected area within a certain time frame, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert. The stationary duration before triggering the alert is a parameter defined within the Ground ATC Conformance Monitoring element.

3.2.3.2.8 No Landing Clearance

The Tower Runway Controller (TWC-R) issues to the Flight Crew the "Landing Clearance" and the Flight Crew acknowledges the landing clearance.

If an aircraft is at a distance of 2 NM from the runway and doesn't receive a landing clearance, the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert. The distance at which the alert is triggered is a parameter defined within the Ground ATC Conformance Monitoring element.

3.2.3.2.9 Landing on wrong runway

If an aircraft is aligned to a runway that differs to the runway assigned by the FDP (EFS) the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert.

3.2.3.2.10 Runway incursion

Visually and supported by the Ground Surveillance System (A-SMGCS level 1) the Tower Runway Controller (TWC-R) monitors the landing runway and adjacent traffic to ensure that the traffic complies with instructions and that the runway remains clear.

If an aircraft or vehicle is within the Runway Protected Area (RPA) without a clearance entered in the FDP (EFS), the Ground ATC Conformance Monitoring (Conf Monit-Ground) detects such non-conformance with the support of the A-SMCGS level 1 surveillance data and informs the Tower Runway Controller of such situation via an alert.

The Runway Protected Area (RPA) encompasses the ILS/MLS Critical and Sensitive areas (CSA) which are provided from Airport/MET data & status to the Ground ATC Conformance Monitoring.

Note: The "No Line up/Crossing clearance" and "Red Stop bar crossed" alerts are also classified as runway incursions but they give the precise reason for such incursion in order to solve the problem as soon as possible.

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

Table 11 shows how the Safety Objectives (Functionality and Performance), presented in section 2 of the present document, 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.

Table 12 provides the formalisation of the Safety Requirements (functionality and performance) which have been identified in Table 11.

Table 13 provides a list of assumptions made in deriving the Safety requirements.

Safety Objectives ***(Functionality and Performance from success approach)***	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
SO 001 All air traffic control clearances related to aircraft and vehicles operations on the movement area shall be timely entered in the Conformance Monitoring System	TWC-G shall enter all clearances given to aircraft relative to their push-back, taxi-out and taxi-in in the FDP(EFS) (SR GG 001)	TWC-G → FDP(EFS)
	TWC-G shall enter all clearances given to vehicles relative to their taxi clearances in the FDP(EFS) (SR GG 002)	TWC-G → FDP(EFS)
	TWC-G shall enter clearances given to aircraft or vehicle in the FDP(EFS) as soon as possible and not more than 3 seconds (SR GG 003)	TWC-G → FDP(EFS)
	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System all clearances which have been entered by TWC-G (SR GG 004)	FDP(EFS) → Conf Monit Ground
	TWC-R shall enter all clearances given to aircraft relative to their line-up, take-off, landing and runway crossing in the FDP(EFS) (SR GR 001)	TWC-R → FDP(EFS)
	TWC-R shall enter all clearances given to vehicles relative to the runway crossing in the FDP(EFS) (SR GR 002)	TWC-R → FDP(EFS)
	TWC-R shall enter clearances given to aircraft or vehicle in the FDP(EFS) as soon as possible and not more than 3 seconds (SR GR 003)	TWC-R → FDP(EFS)
	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System all clearances which have been entered by TWC-R (SR GR 004)	FDP(EFS) → Conf Monit Ground
SO 002 The Conformance Monitoring System shall detect and notify the aerodrome	*Following safety requirements derived for SO 01 and relevant for taxiway operations are applicable: SR GG 001, GG 003 and SR GG 004*	*See relevant elements identified for SO 01*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
control tower when an aircraft is being pushed back or is under tow without a pushback clearance (only applicable if engine start is accomplished at the gate and a push is required to taxi-out).	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	A/F →A-SMGCS level 1 → Conf Monit Ground Vehicle -> A-SMGCS L1→ Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft is moving and has not received a push back approval (SR GG 005)	Conf Monit Ground → TWC-G
SO 003 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to taxi-out without a taxi clearance	*Following safety requirements derived for SO 01 and relevant for taxiway operations are applicable: SR GG 001, GG 003 and SR GG 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	A/F →A-SMGCS level 1 → Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft starts to move on the taxiway or any designated protected area without taxi approval (SR GG 006)	Conf Monit Ground → TWC-G
SO 004 The Conformance Monitoring System shall ensure that aircraft and vehicles conform to their taxiing instructions and surface trajectory	*Following safety requirements derived for SO 01 and relevant for taxiway operations are applicable: SR GG 001, GG 003 and SR GG 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft is deviating from its cleared taxi route (SR GG 007)	Conf Monit Ground → TWC-G

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
SO 006 The Conformance Monitoring System shall detect and notify the aerodrome control tower when the taxi (in or out) clearances includes designator(s) of taxiway(s) that are actually closed	*Following safety requirements derived for SO 01 and relevant for taxiway operations are applicable: SR GG 001, GG 002, GG 003 and SR GG 004*	*See relevant elements identified for SO 01*
	The Airport/MET Data & status shall provide to the Ground ATC Conformance Monitoring System the list of closed taxiway (SR GG 008)	Airport/MET Data & status → Conf Monit Ground
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a taxi route includes a closed taxiway area or when the mobile is already on that closed taxiway area (SR GG 009)	Conf Monit Ground → TWC-G
SO 008 The Conformance Monitoring System shall detect and notify the aerodrome control tower when a movement is likely to enter an active runway (runway strip), or any designated protected area as required by airport authorities, without a clearance	*Following safety requirements derived for SO 01 and relevant for runway operations are applicable: SR GR 001, GR 002, GR 003 and GR 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the LVP activation in case of Low Visibility Operation (SR Gx 002)	Airport/MET data & status → Conf Monit Ground
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the description of the airport layout (TWY, RWY, etc…), the reference points (holding positions, stop bars, RWY thresholds) and fixed obstacles. (SR Gx 006)	Airport/MET data & status → Conf Monit Ground

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the location of the ILS/MLS Critical and Sensitive area (SR GR 005)	Airport/MET data & status → Conf Monit Ground
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile enters the runway protection area or any designated protected area without a clearance (SR GR 006)	Conf Monit Ground → TWC-R
SO 009 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to make positioning movements without a clearance irrespective of whether the movement is executed under the aircraft's own power or by means of a tug	*All safety requirements derived for SO 01 are applicable: SR GG 001 to SR GG 004 for taxiway and SR GR 001 to SR GR 004 for runway operations*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a mobile starts to make positioning movements on the apron/taxiway without a clearance (SR GG 010)	Conf Monit Ground → TWC-G
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile starts to make positioning movements on the runway protected area without a clearance (SR GR 007)	Conf Monit Ground → TWC-R
SO 010 The Conformance Monitoring System shall detect and notify the aerodrome control tower if the aircraft crosses a holding position marking without a clearance	*All safety requirements derived for SO 01 are applicable: SR GG 001 to SR GG 004 for taxiway and SR GR 001 to SR GR 004 for runway operations*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the description of the airport layout (TWY, RWY, etc…), the reference points (holding positions, stop bars, RWY thresholds) and fixed obstacles. (SR Gx 006)	*Airport/MET data & status → Conf Monit Ground*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
	AGLC shall provide the status of the stop bar (turned-off/turned-on) to the ground ATC Conformance Monitoring System (SR GR 008)	AGLC → Conf Monit Ground
	The ATCO must input the holding point and FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the holding points for a given taxi-route (SR GG 011)	FDP(EFS)→ Conf Monit Ground
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft crosses a holding position marking without a clearance (SR GG 012)	Conf Monit Ground → TWC-G
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile is crossing a stop bar turned-on (red) (SR GR 009)	Conf Monit Ground → TWC-R
SO 011 The Conformance Monitoring System shall detect and notify the aerodrome control tower if an instructed aircraft to take immediate action to stop at any intermediate positions on the taxiway that may be required does not stop.	*Following safety requirements derived for SO 01 and relevant for taxiway are applicable: SR GG 001, GG 003 and GG 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the description of the airport layout (TWY, RWY, etc…), the reference points (holding positions, stop bars, RWY thresholds) and fixed obstacles. (SR Gx 006)	*Airport/MET data & status → Conf Monit Ground*
	The ATCO must input the holding point and FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the holding points for a given taxi-route (SR GG 011)	*FDP(EFS)→ Conf Monit Ground*
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft crosses a holding position marking without a clearance (SR GG 012)	*Conf Monit Ground → TWC-G*
SO 012 The Conformance Monitoring System shall detect and notify the aerodrome control tower in the following hazardous situations:	*All safety requirements derived for SO 01 are applicable: SR GG 001 to SR GG 004 for apron/taxiway and SR GR 001 to SR GR 004 for runway operations*	*See elements for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
• an aircraft attempting to use a closed taxiway or other closed surface area	*The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the list of closed taxiway (SR GG 008)*	*Airport/MET Data & status → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a taxi route includes a closed taxiway area or when the mobile is already on that closed taxiway area (SR GG 009)	*Conf Monit Ground → TWC-G*
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the list of closed runway (SR GR 010)	Airport/MET data & status → Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile is assigned to use a closed runway or when the mobile is already on that closed runway (SR GR 011)	Conf Monit Ground → TWC-R
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft on the taxiway exceed a speed to be defined locally which indicates an attempt to take-off from a taxiway (SR GG 013)	Conf Monit Ground → TWC-G
SO 013 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft or vehicle infringes the holding position limit defined by a clearance bar, stop bar or taxiway intersection marking without a clearance	*All requirements derived for SO 010 and SO 011 are applicable for SO 013*	*See elements for SO 010 and SO 011*
SO 014 The Conformance Monitoring System shall detect and notify the aerodrome	*A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)*	*A/F →A-SMGCS level 1 → Conf Monit Ground*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
control tower when, in LV conditions, the longitudinal separation on taxiways as specified for each particular aerodrome by the appropriate ATS authority is infringed	*The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the LVP activation in case of Low Visibility Operation (SR Gx 002)*	*Airport/MET data & status → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when the longitudinal separation between two aircraft on a taxiway in LVC is smaller than a value specified by the appropriate ATS authority (SR GG 014)	Conf Monit Ground → TWC-G
SO 015 The Conformance Monitoring System shall detect and notify the aerodrome control tower when the aircraft passes the runway-holding position without a clearance	*All requirements derived for SO 010 are applicable for SO 015*	*See elements for SO 010*
SO 016 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft attempt to take-off from a wrong runway	The ATCO must input the runway for departure and FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft assigned runway for departure (SR GR 012)	FDP(EFS)→ Conf Monit Ground
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is lining up on a runway that differs from the runway assigned (SR GR 013)	Conf Monit Ground → TWC-R
SO 017 The Conformance Monitoring System shall detect and notify the aerodrome control tower if the control of the flight has not been transferred from/to Apron/Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the condition/status of the different flights (Arrival, Departure, flight assumed, flight transferred,…) (SR Gx 003)	FDP(EFS)→ Conf Monit Ground
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
Control, from Approach to Runway and from Runway to Departure controls, when the aircraft proceeds past a point for which further authority is required	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a taxi-out aircraft proceeds past a point without having been transferred to the runway controller. This point shall be made available to the Ground ATC Conformance Monitoring System by Airport/MET data. (SR GG 015)	Conf Monit Ground → TWC-G Airport/MET data → Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an arriving aircraft proceeds past a point without having been transferred by the approach controller or when a departing aircraft proceeds past a point without having been transferred to the approach controller by TWC-R These points shall be made available to the Ground ATC Conformance Monitoring System by Airport/MET data. (SR GR 015)	Conf Monit Ground → TWC-R Airport/MET data → Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a taxi-in aircraft or a vehicle crossing/entering the runway proceeds past a point without having been transferred to the ground controller. This point shall be made available to the Ground ATC Conformance Monitoring System by Airport/MET data. (SR GR 016)	Conf Monit Ground → TWC-R Airport/MET data → Conf Monit Ground Ground
SO 018 The Conformance Monitoring System shall detect and notify the aerodrome control tower if an aircraft enters the runway to line up without instructions	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft enters the runway to line up without instructions (SR GR 017)	Conf Monit Ground → TWC-R
SO 019 The Conformance Monitoring System	*FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft assigned runway for departure (SR GR 012)*	*FDP(EFS)→ Conf Monit Ground*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
shall detect and notify the aerodrome control tower if an aircraft lines up for a runway for which the designator differs from the designator of the intended departure runway.	*A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)*	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is lining up on a runway that differs from the runway assigned (SR GR 013)	*Conf Monit Ground → TWC-R*
SO 020 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft for which a clearance has been issued remains stationary for a period of time exceeding a predetermined value. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc..) and the local operational procedures.	*All safety requirements derived for SO 01 are applicable: SR GG 001 to SR GG 004 for taxiway and SR GR 001 to SR GR 004 for runway operations*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a mobile, having receive a clearance to move, remains stationary on the taxiway for a period of time exceeding a predetermined value (to be defined locally) (SR GG 016)	Conf Monit Ground → TWC-G
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile, having receive a clearance to move, remains stationary on the runway protected area for a period of time exceeding a predetermined value (to be defined locally) (SR GR 018)	Conf Monit Ground → TWC-R
SO 021 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft for which a line-up clearance has been issued does not receive a take-off clearance	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004,*	*See relevant elements identified for SO 01*
	The Ground ATC Conformance Monitoring system shall provide an alert to TWC-R when a mobile, having received a line-up clearance, does not receive a take-off clearance within a period of time exceeding a predetermined value" (SR GR 030)	Conf Monit Ground → TWC-R

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
within a period of time exceeding a predetermined value even though appropriate separation exists. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc..) and the local operational procedures.	*A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)*	*A/F →A-SMGCS level 1 → Conf Monit Ground*
SO 022 The Conformance Monitoring System shall detect and notify the aerodrome control tower if the aircraft starts the take-off roll without a clearance	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is starting to Take off without clearance (SR GR 019)	Conf Monit Ground → TWC-R
SO 023 The Conformance Monitoring System shall detect and notify the aerodrome control tower if a clearance to land or any alternative clearance has not been entered in the Conformance Monitoring System before the aircraft reaches a distance of 4 km (2 NM) from touchdown.	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft reaches a point to be defined locally (e.g. 2 Nm from the touchdown) and has not received a landing clearance (SR GR 020)	Conf Monit Ground → TWC-R

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
SO 024 The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to taxi-in from the runway exit point without a taxi clearance	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See applicable elements for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Airport/MET data shall provide to the Ground ATC Conformance Monitoring System the list of runway exit points for the landing aircraft (SR GR 021)	Airport/MET data → Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft starts to taxi-in from the runway exit point without a taxi clearance (SR GR 022)	Conf Monit Ground → TWC-R
SO 025 When category II/III approaches are in use, the Conformance Monitoring System shall detect and notify the aerodrome control tower when sensitive and/or critical areas are infringed.	*The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the LVP activation in case of Low Visibility Operation (SR Gx 002)*	*Airport/MET data & status → Conf Monit Ground*
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the location of the Critical and Sensitive area (SR GR 005)	*Airport/MET data & status → Conf Monit Ground*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile enters any Critical or Sensitive area. (SR GR 026)	Conf Monit Ground → TWC-R
SO 026 The Conformance Monitoring System shall detect and notify the aerodrome control tower when the runway alignment of an	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See applicable elements for SO 01*
	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the assigned runway for landing aircraft (SR GR 023)	FDP(EFS)→ Conf Monit Ground

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
approaching aircraft differs from the designator of the landing runway the landing clearance includes	*A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)*	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an arriving aircraft is aligned to a runway which differs from the assigned runway landing clearance (SR GR 024)	Conf Monit Ground → TWC-R
SO 027 The Conformance Monitoring System shall detect and notify the aerodrome control tower if a landed aircraft becomes stationary for a period of time exceeding a predetermined value in the critical portion of the runway strip including the runway in use, the area surrounding it within the distance outlined by taxi-holding positions, the take-off/approach surfaces in addition to any areas established for the protection of navigation and landing aids. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc.) and the local operational procedures.	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See relevant elements identified for SO 01*
	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B (SR Gx 001)	*A/F →A-SMGCS level 1 → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile, having receive a clearance to move, remains stationary on the runway protected area for a period of time exceeding a predetermined value (to be defined locally) (SR GR 018)	*Conf Monit Ground → TWC-R*

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations SR Gx yy = applicable to **G**round ATC monitoring for **G**round and **R**unway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
SO 028 The Conformance Monitoring System shall detect and notify the aerodrome control tower when a take-off or landing-clearance indicates the runway designator of a closed runway.	*Following safety requirements derived for SO 01 and relevant for runway are applicable: SR GR 001, GR 003 and SR GR 004*	*See relevant elements identified for SO 01*
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the list of closed runway (SR GR 010)	*Airport/MET data & status → Conf Monit Ground*
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile is assigned to use a closed runway or when the mobile is already on that closed runway (SR GR 011)	*Conf Monit Ground → TWC-R*
SO 030 The Conformance Monitoring System shall detect and notify the aerodrome control tower if the type of aircraft for which a clearance to operate on the manoeuvring area has been issued exceeds the limitations of this area (e.g. aircraft all-up mass exceeding pavement resistance).	*Following safety requirements derived for SO 01 are applicable: SR GG 001, GG 003 and GG 004 for taxiway and SR GR 001, GR 003 and GR 004 for runway operations*	*See relevant elements identified for SO 01*
	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft type for each departing and arriving aircraft (SR Gx 004)	FDP(EFS)→ Conf Monit Ground
	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the suitability of the different runway and taxi route for the different aircraft type (SR Gx 005)	Airport/MET data & status → Conf Monit Ground
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft is assigned to use an unsuitable taxiway considering the aircraft type or is already on that unsuitable taxiway (SR GG 017)	Conf Monit Ground → TWC-G
	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is assigned to use an unsuitable runway considering the aircraft type or is already on that unsuitable runway (SR GR 025)	Conf Monit Ground → TWC-R

Safety Objectives *(Functionality and Performance from success approach)*	**Safety Requirements (SR xx)** SR GG yy = applicable to Ground ATC monitoring and for Ground operations SR GR yy = applicable to Ground ATC monitoring and for Runway operations SR Gx yy = applicable to Ground ATC monitoring for Ground and Runway operations SR in italics indicates that this SR has been derived from a previous SO mapping.	**Maps on to / Interface flow**
SO 032 •The Conformance Monitoring System shall detect and notify the aerodrome control tower if a vehicle enters a Runway Protected Area without having received a clearance	*All requirements derived for SO 008 and relevant for mobiles are applicable for SO 032*	*See elements for SO 008*

Table 11: Mapping of Safety Objectives to SPR-level Model Elements

Ref. **[SPR-level Model Element]**	**Safety Requirement (functionality & performance) for normal operations**	**Related SO**
Ground ATC conformance monitoring safety requirements equally applicable to taxiway and runway operations		
SR Gx 001 A/F →A-SMGCS level 1 → Conf Monit Ground	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B	SO 02 to SO 04, SO 06, SO 08 to SO 12, SO 13 to SO 28, SO 30, SO 32
SR Gx 002 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the LVP activation in case of Low Visibility Operation	SO 08, SO 14, SO 25, SO 32
SR Gx 003 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the condition/status of the different flights (Arrival, Departure, flight assumed, flight transferred,…)	SO 01
SR Gx 004 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft type for each departing and arriving aircraft	SO 30
SR Gx 005 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the suitability of the different runway and taxi route for the different aircraft type	SO 30
SR Gx 006 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the description of the airport layout (TWY, RWY, etc…), the reference points (holding positions, stop bars, RWY thresholds) and fixed obstacles.	SO 08, SO 10, SO 11, SO 13, SO 15, SO 32

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
Ground ATC conformance monitoring safety requirements applicable to taxiway operations		
SR GG 001 TWC-G → FDP(EFS)	TWC-G shall enter all clearances given to aircraft relative to their push-back, taxi-out and taxi-in in the FDP(EFS)	SO 01, SO 02, SO 03, SO 04, SO 06, SO 09, SO 10, SO 11, SO 12, SO 13, SO 20, SO 30, SO 32
SR GG 002 TWC-G → FDP(EFS)	TWC-G shall enter all clearances given to vehicles relative to their taxi clearances in the FDP(EFS)	SO 01, SO 06 SO 09, SO 10, SO 12, SO 13, SO 15, SO 20, SO 32
SR GG 003 TWC-G → FDP(EFS)	TWC-G shall enter clearances given to aircraft or vehicle in the FDP(EFS) as soon as practicable and within less than 3 seconds	SO 01, SO 02, SO 03, SO 04, SO 06 SO 09, SO 10, SO 11, SO 12, SO 13, SO 15, SO 20, SO 30, SO 32
SR GG 004 FDP(EFS) → Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System all clearances which have been entered by TWC-G	SO 01, SO 02, SO 03, SO 04, SO 06 SO 09, SO 10, SO 11 SO 12, SO 13, SO 15, SO 20, SO 30, SO 32
SR GG 005 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft is moving and has not received a push back approval	SO 02
SR GG 006 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft starts to move on the taxiway without taxi approval	SO 03
SR GG 007 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft is deviating from its cleared taxi route	SO 04
SR GG 008 Airport/MET Data & status → Conf Monit Ground	The Airport/MET Data & status shall provide to the Ground ATC Conformance Monitoring System the list of closed taxiway	SO 12
SR GG 009 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a taxi route includes a closed taxiway area or when the mobile is already on that closed taxiway area	SO 06, SO 12
SR GG 010 Conf Monit Ground → TWC-G	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a mobile starts to make positioning movements on the apron/taxiway without a clearance	SO 09
SR GG 011 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the holding points for a given taxi-route	SO 10, SO 11, SO 13, SO 15, SO 32

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GG 012 Conf Monit Ground → TWC-G	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft crosses a holding position marking without a clearance	SO 10, SO 11, SO 13, SO 15, SO 32
SR GG 013 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft on the taxiway exceed a speed to be defined locally which indicates an attempt to take-off from a taxiway	SO 12
SR GG 014 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when the longitudinal separation between two aircraft on a taxiway in LVC is lower than a value specified by the appropriate ATS authority	SO 14
SR GG 015 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a taxi-out aircraft proceeds past a point without having been transferred to the runway controller	SO 17
SR GG 016 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when a mobile, having received a clearance to move, remains stationary on the taxiway for a period of time exceeding a predetermined value (to be defined locally)	SO 20
SR GG 017 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft is assigned to use an unsuitable taxiway considering the aircraft type or is already on that unsuitable taxiway	SO 30
Ground ATC conformance monitoring safety requirements applicable to runway operations		
SR GR 001 TWC-R → FDP(EFS)	TWC-R shall enter all clearances given to aircraft relative to their line-up, take-off, landing and runway crossing in the FDP(EFS)	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 18, SO 20 to SO 24, SO 26, SO 27, SO 28, SO 30, SO 32
SR GR 002 TWC-R → FDP(EFS)	TWC-R shall enter all clearances given to vehicles relative to the runway crossing in the FDP(EFS)	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 20, SO 22, SO 23, SO 24, SO 32
SR GR 003 TWC-R → FDP(EFS)	TWC-R shall enter clearances given to aircraft or vehicle in the FDP(EFS) as soon as practicable and within less than 3 seconds	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 18, SO 20 to SO 24, SO 26, SO 27, SO 28, SO 30, SO 32

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GR 004 FDP(EFS) → Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System all clearances which have been entered by TWC-R	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 18, SO 20 to SO 24, SO 26, SO 27, SO 28, SO 30, SO 32
SR GR 005 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the location of the ILS/MLS Critical and Sensitive area	SO 08, SO 25, SO 32
SR GR 006 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile enters the runway protected area or any designated protected area without a clearance	SO 08, SO 25, SO 32
SR GR 007 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile starts to make positioning movements on the runway protected area without a clearance	SO 09
SR GR 008 AGLC → Conf Monit Ground	AGLC shall provide the status of the stop bar (turned-off/turned-on) to the ground ATC Conformance Monitoring System	SO 10, SO 13 SO 15, SO 32
SR GR 009 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile is crossing a stop bar turned-on (red)	SO 10, SO 13 SO 15, SO 32
SR GR 010 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the list of closed runway	SO 12, SO 28
SR GR 011 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile is assigned to use a closed runway or when the mobile is already on that closed runway	SO 12, SO 28
SR GR 012 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft assigned runway for departure	SO 16, SO 18
SR GR 013 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is lining up on a runway that differs from the runway assigned	SO 16, SO 18
SR GR 014 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a departing aircraft proceeds past a point without having been transferred to the departure controller	SO 17
SR GR 015 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an arriving aircraft proceeds past a point without having been transferred by the approach controller to TWC-R or when a departing aircraft proceeds past a point without having been transferred to the approach controller by TWC-R	SO 17

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GR 016 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a taxi-in aircraft or a vehicle crossing/entering the runway proceeds past a point without having been transferred to the ground controller	SO 17
SR GR 017 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft enters the runway to line up without instructions	SO 18
SR GR 018 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile, having received a clearance to move, remains stationary on the runway protected area for a period of time exceeding a predetermined value (to be defined locally)	SO 20, SO 21, SO 27
SR GR 019 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is starting to Take off without clearance	SO 22
SR GR 020 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft reaches a point to be defined locally (e.g. 2 Nm from the touchdown) and has not received a landing clearance	SO 23
SR GR 021 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the runway exit point for the landing aircraft	SO 24
SR GR 022 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft starts to taxi-in from the runway exit point without a taxi clearance	SO 24,
SR GR 023 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the assigned runway for landing aircraft	SO 26
SR GR 024 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an arriving aircraft is aligned to a runway which differs from the assigned runway landing clearance	SO 26
SR GR 025 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an aircraft is assigned to use an unsuitable runway considering the aircraft type or is already on that unsuitable runway	SO 30
SR GR 026 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile enters any Critical or Sensitive area.	SO 25

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

ID	Assumptions
A Gx 001	The A-SMGCS level 1 accuracy (mobile position and speed) is compliant with EUROCAE MASPS Standard ED 87B

Table 13: Assumptions made in deriving the above Safety Requirements

Traceability

Table 14 shows the mapping between the relevant OI steps and the SPR-level Models

OI step code	OI step title	Operation /Accident type	Related Barrier in AIM	Related SPR-level Model Element(s)
AO-0104-A	Airport Safety Nets including Taxiway and Apron:	Apron and Taxiway / Taxiway Collision	Taxiway conflict Management barrier (B3) addressing induced pre-tactical taxiway conflict (TP4A) and induced taxiway conflict (TP3A)	*Taxiway Model/ Ground conformance monitoring:* [A-SMGCS level 1]; [Conf-Monit-Ground]; [TWC-G]; [FDP(EFS)]; [Airport/MET Data & Status]
		Runway / Runway Collision	Runway Monitoring (B3A)	*Runway model/ Ground conformance monitoring:* [A-SMGCS level 1]; [SDP]; [Conf-Monit-Ground]; [TWC-R]; [FDP(EFS)]; [Airport/MET Data & Status]
		Runway / Runway excursion	No AIM model	*Runway model/ Ground conformance monitoring:* [A-SMGCS level 1]; [Conf-Monit-Ground]; [TWC-R]; [FDP(EFS)]; [Airport/MET Data & Status]

OI step code	OI step title	Operation /Accident type	Related Barrier in AIM	Related SPR-level Model Element(s)
AO-0102	Automated Alerting of Controller in Case of Runway Incursion or Intrusion into Restricted Areas	Apron and Taxiway / Taxiway Collision	Taxiway conflict Management barrier (B3) addressing induced pre-tactical taxiway conflict (TP4A) and induced taxiway conflict (TP3A)	*Taxiway Model/ Ground conformance monitoring only* [A-SMGCS level 1]; [Conf-Monit-Ground]; [TWC-G]; [FDP(EFS)]; [Airport/MET Data & Status]
		Runway / Runway Collision	Runway Monitoring (B3A)	*Runway model/ Ground conformance monitoring only* [A-SMGCS level 1]; [SDP]; [Conf-Monit-Ground]; [TWC-R]; [FDP(EFS)]; [Airport/MET Data & Status]
		Runway / Runway excursion	No AIM model	*Runway model/ Ground conformance monitoring only* [A-SMGCS level 1]; [Conf-Monit-Ground]; [TWC-R]; [FDP(EFS)]; [Airport/MET Data & Status]

Table 14: Traceability between OI steps and SPR-level Model Elements

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

3.3.1 Scenarios for Normal Operations

The Normal Operational Scenarios are extracted from the OSED [2] and captured in Table 15

ID	Scenario	Rationale for the Choice
Use Case 1	Conformance Monitoring functions for an Arrival Flight	Use Case as identified in the OSED [2]
Use Case 2	Conformance Monitoring functions for a Departure Flight	Use Case as identified in the OSED [2]

Table 15: Operational Scenarios – Normal Conditions

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

This section provides only one thread analysis of use case 2 of Table 15 with a focus on taxi route deviation and it includes the ground monitoring aspects

However conclusion of this thread analysis (safety requirement derivation) has been extended to all non-conformance situations for taxiway operations but also for runway operations

3.3.2.1 Departure Flight- Aircraft Taxi route deviation

This scenario considers the taxi-out phase from the taxi clearance to the short holding point for a take-off. Figure 3 describes the thread analysis and the attached tables (continuous flows and actions) identify the necessary requirements or assumptions to support such operation considering the given situation. Requirements/assumptions which have been already identified during the SPR level model analysis are labelled SR00x whereas new requirements/ assumptions are labelled SR00x and detailed in section 3.3.5.

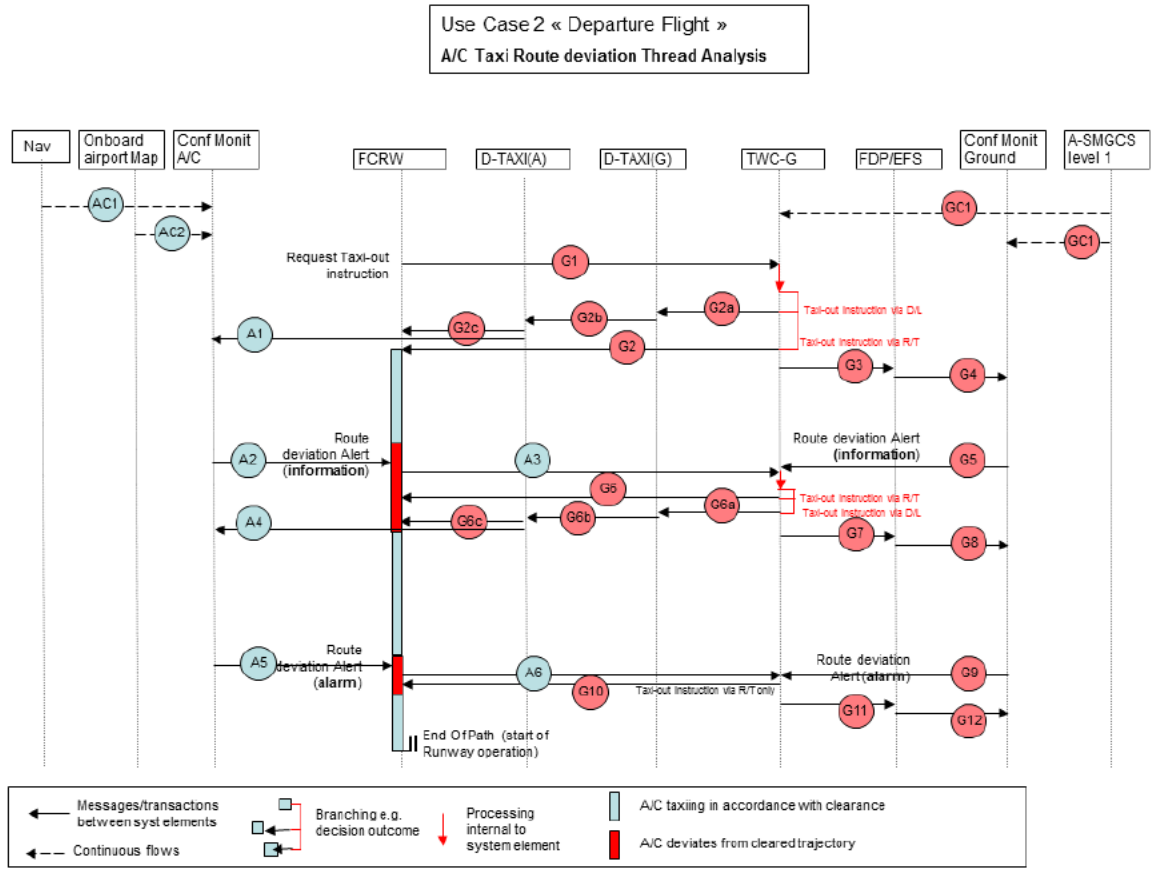


Figure 3: Thread analysis for Use case#2 (departing Flight) Scenario 1 (Taxi route deviation)

Continuous flows	
GC1	A-SMGCS level 1 passes continuous ground position data of a/c and vehicles to Tower Ground Controller (TWC-G) and to the Ground Conformance Monitoring System (Conf Monit- Ground) (SR Gx 001)
Actions	
G1	The flight crew (FCRW) request via R/T the Taxi-out instructions to the Tower Ground Controller (TWC-G)
G2	The Tower Ground Controller (TWC-G) delivers via R/T the Taxi-Out instructions to the flight crew (FCRW)
G3	The Tower Ground Controller (TWC-G) informs the Flight Data Processing system (FDP(EFS)) of the Taxi-out instructions given to the Flight Crew (FCRW) (SR GG 001; SR GG 003)
G4	The Flight Data Processing system(FDP(EFS)) informs the Ground Conformance Monitoring System (Conf Monit- Ground) of the Taxi-out instructions given to the Flight Crew (FCRW) (SR GG 004)
FCRW deviates from cleared Taxi-Out route without immediate danger (e.g. far from the RPA of an active runway or route deviation on a taxiway which is suitable for the a/c and not closed)	
G5	The Ground Conformance Monitoring System (Conf Monit- Ground) alert the Tower Ground

	Controller (TWC-G) of the Route deviation through an "Information Alert" (SR GG 007; SR GG0018)
G6	The Tower Ground Controller (TWC-G) delivers via R/T the updated Taxi-Out instructions to the Flight Crew (FCRW)
G7	The Tower Ground Controller (TWC-G) informs the Flight Data Processing system (FDP(EFS)) of the updated Taxi-out instructions given to the Flight Crew (FCRW) (SR GG 001; SR GG 003)
G8	The Flight Data Processing system(FDP(EFS)) informs the Ground Conformance Monitoring System (Conf Monit- Ground) of the updated Taxi-out instructions given to the Flight Crew (FCRW) (SR GG 004)
FCRW deviates from cleared Taxi-Out route with an immediate danger (e.g. near the RPA of an active runway or route deviation on a taxiway which is unsuitable for the a/c or closed)	
G9	The Ground Conformance Monitoring System (Conf Monit- Ground) alert the Tower Ground Controller (TWC-G) of the Route deviation through an "ALARM Alert" (SR GG 007; SR GG019)
G11	The Tower Ground Controller (TWC-G) informs the Flight Data Processing system (FDP(EFS)) of the updated Taxi-out instructions given to the Flight Crew (FCRW) (SR GG 001; SR GG 003)
G12	The Flight Data Processing system(FDP(EFS)) informs the Ground Conformance Monitoring System (Conf Monit- Ground) of the updated Taxi-out instructions given to the Flight Crew (FCRW) (SR GG 004)
End of Path *Start of Runway operation (Line Up and Take-Off)*	

3.3.2.2 Design analysis to support identified False Alert objectives

Performance Objectives PO 01 and PO 02 specify the false alert rate of the Ground ATC Conformance Monitoring System respectively for runway operations and taxiway operations and such false alert rate shall not be greater than 10^{-4} per movement.

A false alert is defined as the indication of a non-conformance situation when such situation has not occurred (result of false detection). A false alert would cause a conformance monitoring alert.

The objective of this analysis consists in determining how the system architecture can be made to support this performance requirement. For that purpose, the method consists in apportioning the performance requirement into lower level requirements to elements of the system.

Fault tree is used to identify the causes of the false alerts and quantitative lower level requirements are the means to express requirements for elements/parts of the system that will be subject to more in-depth assessment in further lifecycle steps.

False alerts occur by definition at any time during the airport operations whereas no non-conformance situation exists.

The following causes leading to false alerts have been captured into the fault tree.

- Ground Conformance Monitoring System detects a non-conformance situation due to corrupted data inputs (Grd_Data_Spur) which could be either Surveillance data, Airport/MET Data & Status, AGLC or FDP(EFS)
- Ground Conformance Monitoring System detects a non-conformance situation without corrupted inputs (Grd_Conf_Spur). This cause is linked to Ground Conformance Monitoring function corruption (e.g. algorithm) or to missing or excessively delayed input clearance from controller.

The false alert requirements listed in
Table **16** below have been derived from the above fault trees to support the false alert performance requirement:

ID [SPR-level Model element]	False Requirements PR Gx yy = applicable to Ground ATC monitoring for Ground and Runway	Performance objectives

	operations	
PR Gx 01 [Conf Monit-Ground], [FDP(EFS)]	The ground conformance monitoring System shall not generate false alert with a probability greater than 5.0x10-5 when no corrupted data inputs are present at the entry of the system.	PO 01, PO 02
PR Gx 02 [A-SMGCS], [Airport/MET Data & Status], [AGLC], [FDP(EFS)]	The ground conformance monitoring System shall not generate false alert with a probability greater than 5.0x10-5 due to corrupted data input (Surveillance data, Airport/MET Data & Status, AGLC or FDP(EFS))	PO 01, PO 02

Table 16: False Alert Requirements

3.3.3 Effects on Safety Nets – Normal Operational Conditions

The ground conformance monitoring system will generate alerts and therefore could impact the efficiency of other alerting systems like A-SMGCS level 2, Conflicting ATC clearance, etc... It is therefore necessary that the Ground ATC Conformance Monitoring System alerts and other airport safety net alerts are compatible each other to facilitate Controller recognition and problem resolution. If necessary an alert priority scheme between these systems should be defined. Two safety requirements have been derived to address this concern: SR GG 020 for taxiway operations and SR GR 028 for runway operations.

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

V3 validation exercise has not been conducted yet.

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

ID **[SPR-level Model element]**	**Safety Requirements (SR xx)** SR GG yy = applicable to **G**round ATC monitoring and for **G**round operations SR GR yy = applicable to **G**round ATC monitoring and for **R**unway operations	**Thread Action Number/Scenario # xx** **[SO Reference]**
SR GG 018 [Conf Monit-Ground; TWC-G]	The Ground ATC Conformance Monitoring System shall provide an Information alert (caution) to the Tower Ground Controller for non-conformance situations requiring immediate controller awareness but not necessarily immediate response. E.g. for a route deviation not in the proximity of the runway protected area, for a movement without push-back or taxi approval, for a detected stationary situation but without traffic in the immediate vicinity, for an aircraft not yet on the unsuitable taxiway type or on a closed taxiway, for an aircraft having a taxiing speed important but not yet considered excessive.	Derived considering Scenario 1 and extended to taxiway operations Scenario 1 Taxi route deviation (Use case# 002:departure flight) [SO 02, SO 03, SO 04, SO 06, SO 09, SO 10, SO 11, SO 12, SO 13, SO 14, SO 17, SO 20, SO 30]

ID [SPR-level Model element]	Safety Requirements (SR xx) SR GG yy = applicable to Ground ATC monitoring and for Ground operations SR GR yy = applicable to Ground ATC monitoring and for Runway operations	Thread Action Number/Scenario # xx [SO Reference]
SR GG 019 [Conf Monit-Ground; TWC-G]	The Ground ATC Conformance Monitoring System shall provide an Alarm alert (warning) to the Tower Ground Controller for non-conformance situations requiring immediate controller awareness and immediate response. E.g. for a taxi route deviation near the runway protected area, for a detected stationary situation with traffic in the vicinity, for an aircraft on the unsuitable taxiway type or on the closed taxiway, for an aircraft taxiing with an excessive speed or for a red stop bar which has been crossed.	Derived considering Scenario 1 and extended to taxiway operations Scenario 1 Taxi route deviation (Use case# 002:departure flight) [SO 04, SO 06, SO 09, SO 10, SO 11, SO 12, SO 13, SO 14, SO 17, SO 20, SO 30]
SR GR 026 [Conf Monit-Ground; TWC-R]	The Ground ATC Conformance Monitoring System shall provide an Information alert (caution) to the Tower Runway Controller for non-conformance situations requiring immediate controller awareness but not necessarily immediate response. E.g. for situations where aircraft/vehicle are moving from their position without having received line-up, crossing, take-off, landing clearance but without other traffic foreseen in the RPA within a specified time; for an aircraft not yet on the unsuitable runway type or on the closed runway; for an aircraft landing or lining up on wrong runway but without other traffic foreseen in the RPA within a specified time or for a runway incursion without other traffic in the RPA.	Derived considering SR GG018 and extended to runway operations Scenario 1 Taxi route deviation (Use case# 002:departure) [SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 16 to SO 28, SO 30, SO 32]
SR GR 027 [Conf Monit-Ground; TWC-R]	The Ground ATC Conformance Monitoring System shall provide an Alarm alert (warning) to the Tower Runway Controller for non-conformance situations requiring immediate controller awareness and immediate response. E.g. for situations where aircraft/vehicle are moving from their position without having received line-up, crossing, take-off, landing clearance and with other traffic foreseen in the RPA within a specified time; for an aircraft on the unsuitable runway type or on a closed runway; for an aircraft landing or lining up on wrong runway with other traffic foreseen in the RPA within a specified time; for a runway incursion with other traffic foreseen on the RPA or for a red stop bar crossed.	Derived considering SR GG019 and extended to runway operations Scenario 1 Taxi route deviation (Use case# 002:departure) [SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 16 to SO 28, SO 30, SO 32]
SR GG 020 [Conf Monit-Ground; TWC-G]	The Ground ATC Conformance Monitoring System alerts and other airport safety net alerts (A-SMGCS level 2 RIMS) shall be compatible each other to facilitate Tower Ground Controller recognition and problem resolution. CMAC functionality shall be totally independent from RIMS. RIMS alerts shall have higher priorities that CMAC alerts.	Effects on safety net.

ID [SPR-level Model element]	Safety Requirements (SR xx) SR GG yy = applicable to Ground ATC monitoring and for Ground operations SR GR yy = applicable to Ground ATC monitoring and for Runway operations	Thread Action Number/Scenario # xx [SO Reference]
SR GR 028 [Conf Monit-Ground; TWC-R]	The Ground ATC Conformance Monitoring System alerts and other airport safety net alerts (A-SMGCS level 2 RIMS, Conflicting ATC clearances,..) shall be compatible each other to facilitate Tower Runway Controller recognition and problem resolution. CMAC functionality shall be totally independent from RIMS. RIMS alerts shall have higher priorities that CMAC alerts.	Effects on safety net

Table 17: Additional SR from Thread Analysis – Normal Operational Conditions

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

This section shows that the SPR-level Design is complete, correct and internally coherent with respect to the Safety Requirements (Functionality and Performance) derived for the abnormal operating conditions that were used to derive the corresponding Safety Objectives (success approach) in section 2.7

3.4.1 Scenarios for Abnormal Conditions

ID	Scenario
1	Speed of an aircraft on the taxiway exceeds the speed limitations in a proportion that indicates that the aircraft may intend to take-off from the taxiway in use
2	Unplanned closure of section(s) of the movement area

Table 18: Operational Scenarios – Abnormal Conditions

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

Table 19 below lists, for the two abnormal conditions previously identified:

- the Safety Objectives (Functionality and Performance) to mitigate the consequences of the abnormal conditions as identified in 2.7
- the corresponding Safety Requirements (Functionality and Performance) considering the high-level design (SPR level-Model).

Scenario ID	Abnormal Conditions / SO (*Functionality and Performance*)	Safety Requirements (SR 0x) SR GG yy = applicable to Ground ATC monitoring and for Ground operations SR GR yy = applicable to Ground ATC monitoring and for Runway operations SR Gx yy = applicable to Ground ATC monitoring for Ground and Runway operations SR in italics indicates that this SR has been derived from a previous activity.
1	Excessive speed / SO 035 The Conformance	*SR Gx 001: A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B*

	Monitoring System shall detect and notify the aerodrome control tower if the speed of the aircraft on the taxiway exceeds the speed limitations in a proportion that indicates that the aircraft may intend to take-off from the taxiway in use.	*SR GG 013: Ground ATC Conformance Monitoring System shall provide an alert to TWC-G when an aircraft on the taxiway exceed a speed to be defined locally which indicates an attempt to take-off from a taxiway*
2	Sudden closure of section(s) of movement area / SO 37 In the event of sudden closure of section(s) of the movement area, ATC shall revert back to standard practices for coordination of unplanned runway/taxiway closures and suspend further aircraft operations on the section(s) until the airport advises the runway or taxiway is open	SR GG 021 In the event of sudden closure of section(s) of the movement area, the Tower Ground Controller shall revert back to standard practices for coordination of unplanned taxiway closure and suspend further aircraft operations on the section(s) until the airport advises the taxiway is open SR GR 029 In the event of sudden closure of section(s) of the movement area, the Tower Runway Controller shall revert back to standard practices for coordination of unplanned runway closure and suspend further aircraft operations on the section(s) until the airport advises the runway is open.

Table 19: Safety Requirements to mitigate abnormal conditions

Table 20 below shows additional safety requirements (functionality and performance) that have been revealed by the above analyses for abnormal conditions.

ID **[SPR-level Model element]**	**Safety Requirements**	**Abnormal condition/ Relevant SO**
SR GG 021 [Conf Monit-Ground; TWC-G]	In the event of sudden closure of section(s) of the movement area, the Tower Ground Controller shall revert back to standard practices for coordination of unplanned taxiway closure and suspend further aircraft operations on the section(s) until the airport advises the taxiway is open	Sudden closure of section(s) of movement area / SO 037
SR GR 029 [Conf Monit-Ground; TWC-R]	In the event of sudden closure of section(s) of the movement area, the Tower Runway Controller shall revert back to standard practices for coordination of unplanned runway closure and suspend further aircraft operations on the section(s) until the airport advises the runway is open.	Sudden closure of section(s) of movement area / SO 037

Table 20: Additional Safety Requirements from abnormal Operational Conditions

3.5 Design Analysis – Case of Internal System Failures

The objective of this analysis consists in determining how the Conformance Monitoring System architecture (encompassing people, procedures, equipment) designed for airport operations can be made safe. For that purpose, the method consists in apportioning the Failure-case Safety Objectives of each hazard into Failure-case 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 (failure case) 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 (e.g. to transmit Safety Requirements to ANSP (procedure design, AIS, ATS) and to Aircraft manufacturer(e.g. TC/STC holder).

The probability of the "failure to detect the non-conformance situation" allocated from the different Safety Objectives (SO 101 to SO 106) is more demanding for runway incursion compared to Taxiway infringement or runway overrun when considering the frequency of occurrence of having a non-conformance situation in the operational environment.

Therefore safety requirements for the design of the conformance monitoring will be derived quantitatively from the most demanding case which is, for the Ground ATC system, the hazard relative to runway operations (SO102/Hz 002).

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 (equipment failure rates and human errors probability).

3.5.1 Causal Analysis

The hazard 002 occurs during runway operations when the system fails to detect the non-conformance to ATC clearances or instructions.

The associated SO (SO 102) specifies that the frequency of occurrence of an undetected non-conformance to ATC clearances/instructions leading to runway incursion shall not be greater than 5.0x10-7 per movement.

The causes leading to Hz 002 have been captured into a fault tree as explained below.

The non-conformance to ATC clearances/instructions during runway operation is not detected when:

- There is a non-conformance situation (e.g. e.g. Take-Off or Landing without clearances). It is assumed that probability of having such situation is 4.15x10-4/movement (corresponding to 1 non-conformances per 3 operational days for an airport with 800 movements per day)

And

- There is a failure to detect the non-conformance to ATC clearances/instructions when using the ground ATC conformance monitoring due to:
  - Non-conformance to ATC clearances/instructions not detected by the Ground conformance monitoring System due to:
    - Loss of ground conformance monitoring system

    Or

    - Loss or corrupted data necessary for the conformance monitoring (Surveillance data, Airport/MET data & status, AGLC data or FDP(EFS) data)

  Or

  - Non-conformance to ATC clearances/instructions not properly detected (missing information displayed) by the Ground conformance monitoring System due to:
    - Data not provided to the ground conformance monitoring System leading to partial detection of the non-conformance (Surveillance data, Airport/MET data & status, AGLC data or FDP(EFS) data) **or** Corruption of the ground conformance monitoring System leading to a detection with missing

information (e.g. type of non-conformance not provided, non-conformance information missing,…)

and

- Runway controller does not identify the missing information and therefore does not react appropriately against the partial ground conformance monitoring alert

Or

- Non-conformance to ATC clearances/instructions not properly detected (incorrect information displayed) by the Ground conformance monitoring System due to:
  - Incorrect data provided to the ground conformance monitoring System leading to partial detection of the non-conformance (Surveillance data, Airport/MET data & status, AGLC data or FDP(EFS) data, missing or wrong controller's input) or Corruption of the ground conformance monitoring System leading to a detection with incorrect information (e.g. incorrect type of non-conformance, incorrect non-conformance information ,…)

  and

  - Runway controller does not identify the incorrect information and therefore does not react appropriately against the partial ground conformance monitoring alert

Or

- Runway controller does not timely react against a valid ground conformance monitoring alert or he/she misses the alert (e.g. alert not seen/not heard)

And

- Runway controller does not detect the non-conformance by his/her normal visual scanning (external visual scanning and/or monitoring supported by tools like A-SMGCS level 1) with a faulty ground conformance monitoring system.

And

- Pilot does not detect his/her non-conformance by normal visual scanning and by listening VHF runway frequency. It has been assumed for this Hazard that on board conformance monitoring is not fitted.

This hazard occurs only in case of a non-conformance situation therefore this "initiation factor" should be considered in the fault tree.

When considering runway operations, the non-conformance situation is relative to mobiles which deviate from clearance/instruction like: No line-up or crossing clearance, red stop bar crossed, lining up on wrong runway, runway incursion, Take-Off or landing from closed runway, no take-off clearance, no landing clearance or landing on wrong runway.

It is estimated that the probability of having such situation is 4.15x10-4/movement (corresponding to 1 non-conformances per 3 operational days for an airport with 800 movements per day)

Considering this initiation factor (Non_Conf_Sit), the following table describes the different causes leading to this hazard with the associated quantification.

Hz 002 Basic Causes [SPR-level Model Element]	Failure Causes description	Safeguards	Quantification
Non-conformance not detected at all by the Ground conformance monitoring system			
Grd_Data_Loss [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	Loss or corrupted Ground Data leading to an absence of detection by the ground conformance monitoring. These loss/corrupted data could be either surveillance data, Airport/MET status data, AGLS data or FDP(EFS) data	*Possible detection of the ground data loss/corruption by the ATCO due to their impact on other ATC systems (no mobiles displayed on the A-SMGCS screen, electronic flight strip not available) * If failure is detected, the ATCO should be aware that he cannot rely anymore on the conformance monitoring tool *The conformance monitoring System shall indicate to the ATCO its unavailability in case of a detected loss/corruption of the data (SR-Gx-007)	This cause is considered as a common cause (CCF2.1) with other causes relevant for this hazard (Grd_Data_Miss and Grd_Data_Inc) therefore the following quantification is accounting for this common cause CCF2.1: Probability of ground data loss/corruption leading to a non-detection of the non-conformance situation by the conformance monitoring system shall be less than 1.0x10-4 (SR-I_Gx-001)
Grd_Conf_Loss [Conf Monit-Ground]	The ground conformance monitoring function is lost. In case of a non-conformance situation, this will not be detected by the system.	*The conformance monitoring System should indicate to the ATCO its unavailability in case of a detected loss (SR-Gx-008)	Probability of an undetected loss of the ground conformance monitoring system shall be less than 1.0x10-4 (SR-I_Gx-002)
Non-conformance not identified due to a Ground conformance monitoring detection with missing information			
Grd_Data_Miss [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	Missing Ground Data leading to a partial detection by the ground conformance monitoring. These missing data could be either surveillance data, Airport/MET status data, AGLS data or FDP(EFS) data	*Possible detection of the missing ground data by the ATCO due to their impact on other ATC systems (no a/c ID displayed on the A-SMGCS screen, electronic flight strip information missing on the display,…) * If failure is detected, the ATCO should be aware that the conformance monitoring tool detection will be only partial	This cause is considered as a common cause (CCF2.1) with other causes relevant for this hazard (Grd_Data_Loss and Grd_Data_Inc) therefore the following quantification is accounting for this common cause CCF2.1: Probability of missing data leading to a partial detection of the non-conformance situation shall be less than 1.0x10-4 (SR-I_Gx-003)
Grd_Conf_Miss [Conf Monit-Ground]	There is a corruption of the ground conformance monitoring function (e.g. algorithm, display interface,…) which leads to a detection with missing information provided to the ATCO.	None	This cause is considered as a common cause (CCF2.3) with another cause relevant for this hazard (Grd_Conf_Inc) therefore the following quantification is accounting for this common cause CCF2.3: Probability of a partial detection with missing information due to the

Hz 002 Basic Causes [SPR-level Model Element]	Failure Causes description	Safeguards	Quantification
			conformance monitoring function (e.g. algorithm) shall be less than 1.0x10-4 (SR-I_Gx-004)
Atco_Fail_Conf_Miss [TWC-R]	The ATCO cannot identify the missing information following the partial detection and therefore cannot react appropriately against this alert	None	This cause is considered as a common cause (CCF2.2) with other causes relevant for this hazard (Atco_Fail_Conf_Inc and Atco_Fail_Wo_Conf) . It has been estimated that ATCO will not be able to identify in due time the missing information in 50% of the cases.
Non-conformance not identified due to a Ground conformance monitoring detection with incorrect information			
Grd_Data_Inc [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	Incorrect Ground Data leading to a partial detection by the ground conformance monitoring. These incorrect data could be either surveillance data, Airport/MET status data, AGLS data or FDP(EFS) data	*Possible detection of the incorrect ground data by the ATCO due to their impact on other ATC systems (wrong a/c ID displayed on the A-SMGCS screen, incorrect electronic flight strip information on the display,…) * If failure is detected, the ATCO should be aware that the conformance monitoring tool detection will be only partial	This cause is considered as a common cause (CCF2.1) with other causes relevant for this hazard (Grd_Data_Loss and Grd_Data_Miss) therefore the following quantification is accounting for this common cause CCF2.1: Probability of incorrect data leading to a partial detection of the non-conformance situation shall be less than 1.0x10-4 (SR-I_Gx-005)
Grd_Conf_Inc [Conf Monit-Ground]	There is a corruption of the ground conformance monitoring function (e.g. algorithm, display interface,…) which leads to a detection with incorrect information provided to the ATCO.	None	This cause is considered as a common cause (CCF2.3) with another cause relevant for this hazard (Grd_Conf_Miss) therefore the following quantification is accounting for this common cause CCF2.3: Probability of a partial detection with incorrect information due to the conformance monitoring function (e.g. algorithm) shall be less than 1.0x10-4 (SR-I_Gx-006)
Atco_Fail_Conf_Inc [TWC-R]	The ATCO cannot identify the incorrect information following the partial detection and therefore cannot react appropriately against this alert	None	This cause is considered as a common cause (CCF2.2) with other causes relevant for this hazard (Atco_Fail_Conf_Miss and Atco_Fail_Wo_Conf) . It has been estimated that ATCO will not be able to identify in due time the incorrect information in 90% of the cases.
ATCO does not react appropriately against a Non-conformance monitoring alert			

Hz 002 Basic Causes [SPR-level Model Element]	Failure Causes description	Safeguards	Quantification
Atco_Fail_Conf [TWC-R]	ATCO does not react appropriately against a valid ground conformance monitoring alert	*The conformance monitoring alert shall be appropriately located within the ATCO working position (SR-Gx-009) *The ATCO shall be trained on the conformance monitoring concept and especially on the importance of reacting promptly against alert. SR-Gx-010	Probability that ATCO does not react appropriately against a valid ground conformance alert shall be less than 4.0x10-3. This corresponds to not responding appropriately to 1 valid alert when considering 250 valid alerts. Considering this quantification which cannot be used directly , it will be necessary to derive qualitative requirements at physical level relative to: *man-machine interface (visual, aural,..), * ATCO procedural aspects * Training aspect (SR-I_Gx-007)
ATCO fails to detect the non-conformance situation with a faulty conformance monitoring system			
Atco_Fail_Wo_Conf [TWC-R]	ATCO does not detect, with a faulty ground conformance monitoring system, the non-conformance situation using standard procedure e.g. through visual scanning of the runway surface supported or not by surveillance indication.	*The ATCO shall continue to monitor the runway surface to detect any non-conformance situation through visual scanning when a conformance monitoring is implemented (SR-Gx-011)	This cause is considered as a common cause (CCF2.2) with other causes relevant for this hazard (Atco_Fail_Conf_Miss and Atco_Fail_Conf_Inc) . It has been estimated that ATCO will not be able to identify in due time the non-conformance situation with a faulty ground conformance system in 50% of the cases.
Pilot fails to detect his/her non-conformance situation			
Pilot_Fail_Det [FCRW]	Pilot does not detect, his/her non-conformance situation using standard procedure e.g. through visual scanning of the runway surface and by listening VHF runway frequency. It is recalled that for this hazard the aircraft is not equipped with an on board conformance monitoring	*The Pilot shall monitor the runway surface to detect his/her non-conformance situation through visual scanning and by listening VHF frequency	It has been estimated that pilot will not detect in due time his/her non-conformance situation in 50% of the cases.

3.5.2 Common Cause Analysis

3.5.2.1 Within Fault Tree

Within Fault Trees, a number of internal fault tree dependencies have been identified in chapter 3.5.1and are represented in each fault tree figure by “CCFx” indication.

For Hazard 002 (Ground ATC detection during Runway operation), there are three main common causes:

- the ground data necessary to detect the non-conformance situation (CCF2.1)
- the ground ATC conformance monitoring system (CCF2.3)
- the controller (CCF2.2)

Regarding the ground data (surveillance, FDP (EFS), Airport/Met status, AGLC), loss/corrupted data could lead to either absence of detection of a non-conformance situation or detection with missing information or detection with incorrect information. The quantitative apportionment for this failure cause duly accounts of this Common Cause CCF2.1.

Regarding the ground ATC conformance monitoring system, corruption of the system (algorithm, interface to the display) could lead to either detection of a non-conformance situation with missing information or detection with incorrect information. The quantitative apportionment for this failure cause duly accounts of this Common Cause CCF2.2. It should be noted that the loss of the ground ATC conformance monitoring system is not considered as a corruption and therefore cannot be considered as a CCF 2.2 common cause.

Regarding the controller who has a central role for the conformance monitoring, a controller deficiency could lead to a situation where he/she does not react against a conformance monitoring alert and he/she does not detect the non-conformance using normal procedures (visual scanning of the movement area supported or not by surveillance indication).

The dependency level is not “High” but “Moderate” considering that controller’s decision is based on two different detection mechanism (alerting versus visual scanning). Without the consideration of this common cause, controller’s failure to detect the conflicting situation is around 40% but considering this CCF and using the THERP Dependency Modelling it leads to a failure rate of 50%.

Therefore the ATCO deficiency to detect non-conformance using normal procedures has a probability of 0.50 instead of 0.40.

One internal fault tree dependency has been identified between Hazards and AIM Runway Collision Barrier. Indeed loss or corruption of the surveillance data (A-SMGCS level 1) could lead to Hazards as already described in 3.5.2.1 above but also could impact the ATC Runway Collision avoidance barrier (B2) if such barrier relies on A-SMGCS level 2. The availability/reliability of the surveillance data determined for the conformance monitoring system does not take into account this impact.

I006: The required availability/reliability performance of A-SMGCS level 1 has been determined by considering only the impact on the conformance monitoring function (Safety Requirement SR-I_GR-003 and SR-I_GR-003) and not by considering the possible impact on the ATC runway collision avoidance if supported by A-SMGCS level 2. The project should determine if availability/reliability performance of A-SMGCS level 1 has to be re-enforced when considering the impact on the runway monitoring barrier (Conformance Monitoring Function) and on the ATC Runway Collision avoidance barrier.

3.5.3 Formalization of Mitigations

Considering the outcome of the causal analysis (see 3.5.1) and more particularly the “Safeguards” identified in the table accompanying the hazard fault trees,

Table 21 below formalizes the system generated hazard (Hz) mitigations which have not been already captured in previous tables for the success-case safety requirements.

Reference	Mitigation to System Generated Hazards SR Gx yy = applicable to ATC Ground monit for Ground and Runway operations	Hz ref
SR Gx 007 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The Ground ATC Conformance Monitoring System shall indicate to the controller its unavailability when data (A-SMGCS-level 1, Airport/MET data & status, AGLC or FDP(EFS)) required for the conformance monitoring function have been detected to be lost or corrupted	Hz 002 And also Hz 001 and 005
SR Gx 008 [Conf Monit-Ground]	The controller shall be informed about the unavailability of the ground ATC conformance monitoring function	Hz 002 And also Hz 001 and 005
SR Gx 009 [Conf Monit-Ground]	The ground ATC conformance monitoring alert shall be appropriately located within the controller working position to ease quick controller response to the alert	Hz 002 And also Hz 001 and 005
SR Gx 010 [TWC-R], [TWC-G]	The controller shall be trained on the ground ATC conformance monitoring system and on the importance of reacting promptly against a triggered alert to solve the non-conformance situation	Hz 002 And also Hz 001 and 005
SR Gx 011 [TWC-R], [TWC-G]	The controller shall continue to monitor the manoeuvring area to detect any non-conformance situation through visual scanning whether or not a ground ATC conformance monitoring is fitted.	Hz 002 And also Hz 001 and 005

Table 21: Additional success-case safety requirements to mitigate system generated hazards

3.5.4 Safety Requirements (integrity/reliability)

Considering the outcome of the causal analysis (see 3.5.1) the following Table 22 defines the safety requirements to limit the frequency with which each identified system failure could be allowed to occur, taking account of the above mitigations such that the residual risk is within the specified Safety Objectives.

Reference	Safety requirements (integrity/reliability) SR-I_Gx yy = applicable to ATC Ground monit for Ground and Runway operations	Hz ref
SR-I_Gx-001 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The probability of corrupted or loss of data (Surveillance, Airport/MET data & status, AGLC or FDP(EFS)) leading to a non-conformance situation not detected by the ground ATC conformance monitoring system shall be not greater than 1.0x10-4.	Hz 002 And also Hz 001 and 005
SR-I_Gx-002 [Conf Monit-Ground]	The probability of an undetected loss of the ground ATC conformance monitoring system shall be not greater than 1.0x10-4.	Hz 002 And also Hz 001 and 005

Reference	Safety requirements (integrity/reliability) SR-I_Gx yy = applicable to ATC Ground monit for Ground and Runway operations	Hz ref
SR-I_Gx-003 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The probability of loss of data (Surveillance, Airport/MET data & status, AGLC or FDP(EFS)) leading to a partial ground ATC conformance monitoring detection with missing information shall be not greater than 1.0x10-4.	Hz 002 And also Hz 001 and 005
SR-I_Gx-004 [Conf Monit-Ground]	The probability of a conformance monitoring partial detection with missing information due to failure of the ground ATC conformance monitoring function shall be not greater than 1.0x10-4.	Hz 002 And also Hz 001 and 005
SR-I_Gx-005 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The probability of corrupted data (Surveillance, Airport/MET data & status, AGLC or FDP(EFS)) leading to a partial ground ATC conformance monitoring detection with incorrect information shall be not greater than 1.0x10-4.	Hz 002 And also Hz 001 and 005
SR-I_Gx-006 [Conf Monit-Ground]	The probability of a conformance monitoring partial detection with incorrect information due to failure of the ground ATC conformance monitoring function shall be not greater than 1.0x10-4.	Hz 002 And also Hz 001 and 005
SR-I_Gx-007 [TWC-R], [TWC-G]	• The probability that the controller does not react appropriately against a valid ground ATC conformance alert shall be not greater than 4.0x10-3. • This corresponds to not responding appropriately to 1 valid alert when considering 250 valid alerts. • This quantification should be used indirectly to derive qualitative requirements at physical level to design/define: • * the man-machine interface (visual, aural,..), • * the ATCO procedures • * the training aspect	Hz 002 And also Hz 001 and 005

Table 22: Safety Requirements (integrity/reliability)

3.6 Achievability of the SAfety Criteria

In section 2.10 of the present document the assessment of the achievability of the Safety Criteria defined in section 2.4 has been performed in through specifications safety objectives.

For both the given SACs (#1 to #3) it has been proven that the Conformance Monitoring System is not itself designed to change the performances of others barriers of the SESAR AIM models where safety objectives are applied.

At SPR-design level, SOs have been mapped versus safety requirements for both the cases of normal and abnormal conditions and new functional and integrity/reliability safety requirements have defined and mapped to all previously identified hazards.

Therefore for each of the input SAC, the same conclusions can be derived as reported in sections 2.10.1, 2.10.2, 2.10.3 for SAC#1, SAC#2 and SAC#3 respectively.

3.7 Validation & Verification of the Safe Design at SPR Level

The consolidated lists of safety requirements are reported in Appendix B for the functional and integrity.

The testing of the alerts in several real time simulations has already proved to be very positive. The V3 phase should endeavour to test the alerts in an operational environment either in shadow mode or ideally in live trials to confirm and get quantitative data on the benefits for the safety, human performance and efficiency domains.

4 Detailed Safe Design at Physical Level

The design of the system at physical level is out the scope of the present document version.

Appendix A Consolidated List of Safety Objectives

A.1 Safety Criteria (SAC)

ID	Description
SAC#1	The number of Runway incursion arising from inefficient entry/exit management, Take-Off management or Landing management shall be reduced when ATM is supported by the conformance monitoring tool.
SAC#1a	The number of Runway Conflicts shall be reduced when ATM is supported by the conformance monitoring tool due to the early detection of runway incursions.
SAC#2	The number of Taxiway infringement arising from induced taxiway conflict and from induced pre-tactical taxiway conflict shall be reduced by 15% when ATM is supported by the conformance monitoring tool.
SAC#3	Risk of runway overrun during take-off or landing shall be decreased when ATM is supported by the conformance monitoring tool

A.2 Safety Objectives (Functionality and Performance)

ID	Description	SAC
SO 001	All air traffic control clearances related to aircraft and vehicles operations on the movement area shall be timely entered in the Conformance Monitoring System. Timely means that the detection of the non-conformance to ATC clearances/instructions is not impaired (miss-detection, late detection) by any delay to enter clearances in the Conformance Monitoring System. This also implies an adaptation of the controllers' working method in order to ensure that the clearances are input into the system when they are given by voice.	SAC#1, SAC#1a, SAC#2, SAC#3
SO 002	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft is being pushed back or is under tow without a pushback clearance (only applicable if engine start is accomplished at the gate and a push is required to taxi-out).	SAC#2
SO 003	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to taxi-out without a taxi clearance	SAC#2
SO 004	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft or vehicles do not conform to their taxiing instructions and surface trajectory	SAC#2
SO 005	The On-board Conformance Monitoring System shall detect and notify the flight crew if the aircraft does not conform to its taxiing instructions and surface trajectory.	SAC#2
SO 006	The Conformance Monitoring System shall detect and notify the aerodrome control tower when the taxi (in or out) clearances includes designator(s) of taxiway(s) that are actually closed	SAC#2
SO 007	The On-board Conformance Monitoring System shall detect and notify the flight crew when the taxi (in or out) clearances includes designator(s) of taxiway(s) that are actually closed	SAC#2

ID	Description	SAC
SO 008	The Conformance Monitoring System shall detect and notify the aerodrome control tower when a movement is likely to enter an active runway (runway strip), or any designated protected area as required by airport authorities, without a clearance	SAC#1, SAC#1a
SO 009	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to move without a clearance irrespective of whether the movement is executed under the aircraft's own power or by means of a tug	SAC#1, SAC#1a, SAC#2
SO 010	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the aircraft crosses a holding position marking without a clearance	SAC#1, SAC#1a, SAC#2
SO 011	The Conformance Monitoring System shall detect and notify the aerodrome control tower if an instructed aircraft to take immediate action to stop at any intermediate positions on the taxiway that may be required does not stop.	SAC#2
SO 012	The Conformance Monitoring System shall detect and notify the aerodrome control tower in the following hazardous situations: • an aircraft attempting to use a closed taxiway or other closed surface area	SAC#1, SAC#1a, SAC#2, SAC#3
SO 013	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft or vehicle infringes the holding position limit defined by a stop bar or stop markings without a clearance	SAC#1, SAC#1a, SAC#2
SO 014	The Conformance Monitoring System shall detect and notify the aerodrome control tower when, depending on visibility conditions (VIS-1- VIS-4), the longitudinal separation on taxiways if any and as specified for each particular aerodrome by the appropriate ATS authority is infringed	SAC#2
SO 015	The Conformance Monitoring System shall detect and notify the aerodrome control tower when the aircraft passes the runway-holding position without a clearance	SAC#1, SAC#1a
SO 016	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft attempt to take-off from a wrong runway	SAC#1, SAC#1a, SAC#3
SO 017	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the control of the flight has not been transferred from/to Apron/Ground Control, from Approach to Runway and from Runway to Departure controls, when the aircraft proceeds past a point for which further authority is required	SAC#1, SAC#1a, SAC#2
SO 018	The Conformance Monitoring System shall detect and notify the aerodrome control tower if an aircraft enters the runway to line up without instructions	SAC#1, SAC#1a,
SO 019	The Conformance Monitoring System shall detect and notify the aerodrome control tower if an aircraft lines up for a runway for which the designator differs from the designator of the intended departure runway.	SAC#1, SAC#1a, SAC#3

ID	Description	SAC
SO 020	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft for which a clearance has been issued remains stationary for a period of time exceeding a predetermined value. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc..) and the local operational procedures.	SAC#1, SAC#1a, SAC#2
SO 021	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft for which a line-up clearance has been issued does not receive a take-off clearance within a period of time exceeding a predetermined value even though appropriate separation exists. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc.) and the local operational procedures.	SAC#1, SAC#1a,
SO 022	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the aircraft starts the take-off roll without a clearance	SAC#1, SAC#1a,
SO 023	The Conformance Monitoring System shall detect and notify the aerodrome control tower if a clearance to land or any alternative clearance has not been entered in the Conformance Monitoring System before the aircraft reaches a certain distance from touchdown.	SAC#1, SAC#1a,
SO 024	The Conformance Monitoring System shall detect and notify the aerodrome control tower when an aircraft starts to taxi-in from the runway exit point without a taxi clearance	SAC#2
SO 025	When category II/III approaches are in use, the Conformance Monitoring System shall detect and notify the aerodrome control tower when sensitive and/or critical areas are infringed.	SAC#2
SO 026	The Conformance Monitoring System shall detect and notify the aerodrome control tower when the runway alignment of an approaching aircraft differs from the designator of the landing runway the landing clearance includes	SAC#1, SAC#1a, SAC#3
SO 027	The Conformance Monitoring System shall detect and notify the aerodrome control tower if a landed aircraft becomes stationary for a period of time exceeding a predetermined value in the critical portion of the runway strip including the runway in use, the area surrounding it within the distance outlined by taxi-holding positions, the take-off/approach surfaces in addition to any areas established for the protection of navigation and landing aids. The predetermined value shall be defined considering the local environment (aerodrome layout, traffic density, etc.) and the local operational procedures.	SAC#1, SAC#1a,
SO 028	The Conformance Monitoring System shall detect and notify the aerodrome control tower when a take-off or landing-clearance indicates the runway designator of a closed runway.	SAC#1, SAC#1a, SAC#3
SO 029	The On-board Conformance Monitoring System shall detect and notify the flight crew when a take-off or landing-clearance indicates the runway designator of a closed runway.	SAC#1, SAC#3
SO 030	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the type of aircraft for which a clearance to operate on the manoeuvring area has been issued exceeds the limitations of this area (e.g. aircraft all-up mass exceeding pavement resistance).	SAC#1, SAC#1a, SAC#2, SAC#3

ID	Description	SAC
SO 031	The On-board Conformance Monitoring System shall detect and notify the flight crew if the aircraft type exceeds the limitations of the runway or taxiway (e.g. aircraft all-up mass exceeding pavement resistance, runway length, aircraft size versus taxiway width, etc.) for which a taxiing, landing or take-off clearance has been issued.	SAC#1, SAC#2, SAC#3
SO 032	The Conformance Monitoring System shall detect and notify the aerodrome control tower if a vehicle enters a Runway Protected Area without having received a clearance	SAC#1, SAC#1a,
SO 033	The On-board Conformance Monitoring System shall detect and notify the flight crew when the aircraft initiates a take-off from a wrong runway	SAC#1, SAC#3
SO 034	The On-board Conformance Monitoring System shall detect and notify the flight crew when the aircraft deviates from the localizer axis indicating an attempt to land on a wrong runway or on a taxiway	SAC#1, SAC#2 SAC#3
SO 035	The Conformance Monitoring System shall detect and notify the aerodrome control tower if the speed of the aircraft on the taxiway exceeds the speed limitations in a proportion that indicates that the aircraft may intend to take-off from the taxiway in use.	SAC#1, SAC#1a, SAC#2 SAC#3
SO 036	The On-board Conformance Monitoring System shall detect and notify the flight crew if the throttle position or speed of the aircraft on the taxiway indicates that the aircraft may intend to take-off from the taxiway in use.	SAC#1, SAC#2 SAC#3
SO 037	In the event of sudden closure of section(s) of the movement area, ATC shall revert back to standard practices for coordination of unplanned runway/taxiway closures and suspend further aircraft operations on the section(s) until the airport advises the runway or taxiway is open	SAC#1, SAC#1a, SAC#2

Notes:

In the above table, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.

A.3 Safety Objectives (Integrity)

SO ID	Safety Objectives	System Generated Hazard
SO 101	During Taxiway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at ATC level leading to taxiway infringement shall not be greater than 3.3x10-3 per movement	Hz 001(including Hz001-1 and Hz001-2)
SO 102	During Runway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at ATC level leading to runway incursion shall not be greater than 5.0x10-7 per movement	Hz 002(including Hz002-1 and Hz002-2)
SO 103	During Taxiway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at aircraft level leading to taxiway infringement shall not be greater than	Hz 003(including Hz003-1 and Hz003-2)

	3.3x10-3 per movement	
SO 104	During Runway operations, the frequency of occurrence of an undetected non-conformance to ATC clearances/instruction at aircraft level leading to runway incursion shall not be greater than 5.0x10-7 per movement	Hz 004(including Hz004-1 and Hz004-2)
SO 105	The frequency of occurrence of an undetected non-conformance to ATC clearances/instruction aiming to prevent runway overrun at ATC level shall not be greater than 1.2x10-7 per movement	Hz 005
SO 106	The frequency of occurrence of an on-board undetected non-conformance to ATC clearances/instruction aiming to prevent runway overrun at aircraft level shall not be greater than 1.2x10-7 per movement	Hz 006

Notes:

In the above table, the greyed cells report the safety objectives relevant to the On-board Conformance Monitoring as reported in [1]. These objectives correspond to a service which is out of the scope of the present document. However for reasons of compatibility with IDs of objectives relevant to ATC Ground Conformance Monitoring document, the original numeration has been maintained.

Appendix B Consolidated List of Safety Requirements

B.1 Safety Requirements (Functionality and Performance)

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
Ground ATC conformance monitoring safety requirements equally applicable to taxiway and runway operations		
SR Gx 001 A/F →A-SMGCS level 1 → Conf Monit Ground	A-SMGCS level 1 shall provide an accurate position and speed of aircraft and vehicles to the Ground ATC Conformance Monitoring System in accordance to EUROCAE ED-87B	SO 02 to SO 04, SO 06, SO 08 to SO 12, SO 13 to SO 28, SO 30, SO 32, SO 35
SR Gx 002 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the Low Visibility Procedure (LVP) activation in case of Low Visibility Operation	SO 08, SO 14, SO 25, SO 32
SR Gx 003 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the condition/status of the different flights (Arrival, Departure, flight assumed, flight transferred,…)	SO 01
SR Gx 004 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft type for each departing and arriving aircraft	SO 30
SR Gx 005 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the suitability of the different runway and taxi route for the different aircraft type	SO 30
SR Gx 006 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the description of the airport layout (TWY, RWY, etc…), the reference points (holding positions, stop bars, RWY thresholds) and fixed obstacles.	SO 08, SO 10, SO 11, SO 13, SO 15, SO 32
SR Gx 007 • [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The Ground ATC Conformance Monitoring System shall indicate to the Tower Controller its unavailability when data (A-SMGCS-level 1, Airport/MET data & status, AGLC or FDP(EFS)) required for the conformance monitoring function have been detected to be lost or corrupted	SO 101(Hz 01), SO 102 (Hz 02) and SO 105 (Hz 05)
SR Gx 008 [Conf Monit-Ground]	The Tower Controller shall be informed about the unavailability of the ground ATC conformance monitoring function	SO 101(Hz 01), SO 102 (Hz 02) and SO 105 (Hz 05)
SR Gx 009 [Conf Monit-Ground]	The ground ATC conformance monitoring alert shall be appropriately located within the controller working position to facilitate a quick controller response to the alert	SO 101(Hz 01), SO 102 (Hz 02) and SO 105 (Hz 05)

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR Gx 010 [TWC-R], [TWC-G]	The Tower Controller shall be trained on the ground ATC conformance monitoring system and on the importance of reacting promptly against a triggered alert to solve the non-conformance situation	SO 101(Hz 01), SO 102 (Hz 02) and SO 105 (Hz 05)
SR Gx 011 [TWC-R], [TWC-G]	The Tower Controller shall continue to monitor the manoeuvring area to detect any non-conformance situation through visual scanning whether or not a ground ATC conformance monitoring is fitted.	SO 101(Hz 01), SO 102 (Hz 02) and SO 105 (Hz 05)
Ground ATC conformance monitoring safety requirements applicable to taxiway operations		
SR GG 001 TWC-G → FDP(EFS)	The Tower Ground Controller shall enter all clearances given to aircraft relative to their push-back, taxi-out and taxi-in in the FDP(EFS)	SO 01, SO 02, SO 03, SO 04, SO 06, SO 09, SO 10, SO 11, SO 12, SO 13, SO 20, SO 30, SO 32
SR GG 002 TWC-G → FDP(EFS)	The Tower Ground Controller shall enter all clearances given to vehicles relative to their taxi clearances in the FDP(EFS)	SO 01, SO 06 SO 09, SO 10, SO 12, SO 13, SO 15, SO 20, SO 32
SR GG 003 TWC-G → FDP(EFS)	The Tower Ground Controller shall enter clearances given to aircraft or vehicle in the FDP(EFS) as soon as practicable and within less than 3 seconds	SO 01, SO 02, SO 03, SO 04, SO 06 SO 09, SO 10, SO 11, SO 12, SO 13, SO 15, SO 20, SO 30, SO 32
SR GG 004 FDP(EFS) → Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System all clearances which have been entered by the Tower Ground Controller	SO 01, SO 02, SO 03, SO 04, SO 06 SO 09, SO 10, SO 11 SO 12, SO 13, SO 15, SO 20, SO 30, SO 32
SR GG 005 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when an aircraft is moving and has not received a push back approval	SO 02
SR GG 006 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when an aircraft starts to move on the taxiway without taxi approval	SO 03
SR GG 007 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when an aircraft is deviating from its cleared taxi route	SO 04
SR GG 008 Airport/MET Data & status → Conf Monit Ground	The Airport/MET Data & status shall provide to the Ground ATC Conformance Monitoring System the list of closed taxiway	SO 12
SR GG 009 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when a taxi route includes a closed taxiway area or when the mobile is already on that closed taxiway area	SO 06, SO 12
SR GG 010 Conf Monit Ground → TWC-G	The Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when a mobile starts to make positioning movements on the apron/taxiway without a clearance	SO 09

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GG 011 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the holding points for a given taxi-route	SO 10, SO 11, SO 13, SO 15, SO 32
SR GG 012 Conf Monit Ground → TWC-G	The Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when an aircraft crosses a holding position marking without a clearance	SO 10, SO 11, SO 13, SO 15, SO 32
SR GG 013 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when an aircraft on the taxiway exceed a speed to be defined locally which indicates an attempt to take-off from a taxiway	SO 12, SO 35
SR GG 014 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when the longitudinal separation between two aircraft on a taxiway in Low Visibility Conditions is lower than a value specified by the appropriate ATS authority	SO 14
SR GG 015 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when a taxi-out aircraft proceeds past a point without having been transferred to the Tower Runway Controller	SO 17
SR GG 016 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when a mobile, having received a clearance to move, remains stationary on the taxiway for a period of time exceeding a predetermined value (to be defined locally)	SO 20
SR GG 017 Conf Monit Ground → TWC-G	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Ground Controller when an aircraft is assigned to use an unsuitable taxiway considering the aircraft type or is already on that unsuitable taxiway	SO 30
SR GG 018 [Conf Monit-Ground; TWC-G]	The Ground ATC Conformance Monitoring System shall provide an Information alert (caution) to the Tower Ground Controller for non-conformance situations requiring immediate controller awareness but not necessarily immediate response. E.g. for a route deviation not in the proximity of the runway protected area, for a movement without push-back/taxi approval or a stationary situation but without traffic in the immediate vicinity, for an aircraft not yet on the unsuitable taxiway type or on the closed taxiway, for an aircraft having a taxiing speed important but not yet considered excessive.	SO 02, SO 03, SO 04, SO 06, SO 09, SO 10, SO 11, SO 12, SO 13, SO 14, SO 17, SO 20, SO 30
SR GG 019 [Conf Monit-Ground; TWC-G]	The Ground ATC Conformance Monitoring System shall provide an Alarm alert (warning) to the Tower Ground Controller for non-conformance situations requiring immediate controller awareness and immediate response. E.g. for a taxi route deviation near the runway protected area, for a detected stationary situation with traffic in the vicinity, for an aircraft on the unsuitable taxiway type or on the closed taxiway, for an aircraft taxiing with an excessive speed or for a red stop bar which has been crossed.	SO 04, SO 06, SO 09, SO 10, SO 11, SO 12, SO 13, SO 14, SO 17, SO 20, SO 30

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GG 020 [Conf Monit-Ground; TWC-G]	The Ground ATC Conformance Monitoring System alerts and other airport safety net alerts (A-SMGCS level 2, RIMS) shall be compatible each other to facilitate Tower Ground Controller recognition and problem resolution. CMAC functionality shall be totally independent from RIMS. RIMS alerts shall have higher priorities that CMAC alerts.	None
SR GG 021 [Conf Monit-Ground; TWC-G]	In the event of sudden closure of section(s) of the movement area, the Tower Ground Controller shall revert back to standard practices for coordination of unplanned taxiway closure and suspend further aircraft operations on the section(s) until the airport advises the taxiway is open	SO 37
Ground ATC conformance monitoring safety requirements applicable to runway operations		
SR GR 001 TWC-R → FDP(EFS)	The Tower Runway Controller shall enter all clearances given to aircraft relative to their line-up, take-off, landing and runway crossing in the FDP(EFS)	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 18, SO 20 to SO 24, SO 26, SO 27, SO 28, SO 30, SO 32
SR GR 002 TWC-R → FDP(EFS)	The Tower Runway Controller shall enter all clearances given to vehicles relative to the runway crossing in the FDP(EFS)	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 20, SO 22, SO 23, SO 24, SO 32
SR GR 003 TWC-R → FDP(EFS)	The Tower Runway Controller shall enter clearances given to aircraft or vehicle in the FDP(EFS) as soon as practicable and within less than 3 seconds	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 18, SO 20 to SO 24, SO 26, SO 27, SO 28, SO 30, SO 32
SR GR 004 FDP(EFS) → Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System all clearances which have been entered by the Tower Runway Controller	SO 01, SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 18, SO 20 to SO 24, SO 26, SO 27, SO 28, SO 30, SO 32
SR GR 005 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the location of the ILS/MLS Critical and Sensitive area	SO 08, SO 25, SO 32
SR GR 006 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when a mobile enters the runway protected area or any designated protected area without a clearance	SO 08, SO 25, SO 32
SR GR 007 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when a mobile starts to make positioning movements on the runway protected area without a clearance	SO 09
SR GR 008 AGLC → Conf Monit Ground	Airfield Ground Lighting Control (AGLC) shall provide the status of the stop bar (turned-off/turned-on) to the ground ATC Conformance Monitoring System	SO 10, SO 13 SO 15, SO 32
SR GR 009 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when a mobile is crossing a stop bar turned-on (red)	SO 10, SO 13 SO 15, SO 32

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GR 010 Airport/MET data & status → Conf Monit Ground	The Airport/MET Data & Status shall provide to the Ground ATC Conformance Monitoring System the list of closed runway	SO 12, SO 28
SR GR 011 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when a mobile is assigned to use a closed runway or when the mobile is already on that closed runway	SO 12, SO 28
SR GR 012 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the aircraft assigned runway for departure	SO 16, SO 18
SR GR 013 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an aircraft is lining up on a runway that differs from the runway assigned	SO 16, SO 18
SR GR 014 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when a departing aircraft proceeds past a point without having been transferred to the departure controller	SO 17
SR GR 015 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to TWC-R when an arriving aircraft proceeds past a point without having been transferred by the approach controller to TWC-R or when a departing aircraft proceeds past a point without having been transferred to the approach controller by TWC-R	SO 17
SR GR 016 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when a taxi-in aircraft or a vehicle crossing/entering the runway proceeds past a point without having been transferred to the Tower Ground Controller	SO 17
SR GR 017 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an aircraft enters the runway to line up without instructions	SO 18
SR GR 018 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when a mobile, having received a clearance to move, remains stationary on the runway protected area for a period of time exceeding a predetermined value (to be defined locally)	SO 20, SO 27
SR GR 019 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an aircraft is starting to Take off without clearance	SO 22
SR GR 020 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an aircraft reaches a point to be defined locally (e.g. 2 Nm from the touchdown) and has not received a landing clearance	SO 23

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GR 021 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the runway exit point for the landing aircraft	SO 24
SR GR 022 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an aircraft starts to taxi-in from the runway exit point without a taxi clearance	SO 24,
SR GR 023 FDP(EFS)→ Conf Monit Ground	FDP(EFS) shall provide to the Ground ATC Conformance Monitoring System the assigned runway for landing aircraft	SO 26
SR GR 024 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an arriving aircraft is aligned to a runway which differs from the assigned runway landing clearance	SO 26
SR GR 025 Conf Monit Ground → TWC-R	Ground ATC Conformance Monitoring System shall provide an alert to the Tower Runway Controller when an aircraft is assigned to use an unsuitable runway considering the aircraft type or is already on that unsuitable runway	SO 30
SR GR 026 [Conf Monit-Ground; TWC-R]	The Ground ATC Conformance Monitoring System shall provide an Information alert (caution) to the Tower Runway Controller for non-conformance situations requiring immediate controller awareness but not necessarily immediate response. E.g. for situations where aircraft/vehicle are moving from their position without having received line-up, crossing, take-off, landing clearance but without other traffic foreseen in the runway protected area (RPA) within a specified time; for an aircraft not yet on the unsuitable runway type or on the closed runway; for an aircraft landing or lining up on wrong runway but without other traffic foreseen in the RPA within a specified time or for a runway incursion without other traffic in the RPA.	SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 16 to SO 28, SO 30, SO 32
SR GR 027 [Conf Monit-Ground; TWC-R]	The Ground ATC Conformance Monitoring System shall provide an Alarm alert (warning) to the Tower Runway Controller for non-conformance situations requiring immediate controller awareness and immediate response. E.g. for situations where aircraft/vehicle are moving from their position without having received line-up, crossing, take-off, landing clearance and with other traffic foreseen in the runway protected area (RPA) within a specified time; for an aircraft on the unsuitable runway type or on a closed runway; for an aircraft landing or lining up on wrong runway with other traffic foreseen in the RPA within a specified time; for a runway incursion with other traffic foreseen on the RPA or for a red stop bar crossed	SO 08, SO 09, SO 10, SO 12, SO 13, SO 15, SO 16 to SO 28, SO 30, SO 32
SR GR 028 [Conf Monit-Ground; TWC-R]	The Ground ATC Conformance Monitoring System alerts and other airport safety net alerts (A-SMGCS level 2, RIMS, Conflicting ATC clearances,..) shall be compatible each other to facilitate Tower Runway Controller recognition and problem resolution. CMAC functionality shall be totally independent from RIMS. RIMS alerts shall have higher priorities that CMAC alerts.	None

Ref. [SPR-level Model Element]	Safety Requirement (functionality & performance) for normal operations	Related SO
SR GR 029 [Conf Monit-Ground; TWC-R]	In the event of sudden closure of section(s) of the movement area, the Tower Runway Controller shall revert back to standard practices for coordination of unplanned runway closure and suspend further aircraft operations on the section(s) until the airport advises the runway is open	SO 37
SR GR 030 Conf Monit Ground → TWC-R	The Ground ATC Conformance Monitoring system shall provide an alert to TWC-R when a mobile, having received a line-up clearance, does not receive a take-off clearance within a period of time exceeding a predetermined value"	SO 21

B.2 Safety Requirements (Integrity)

Reference	Safety requirements (integrity/reliability)	SO/Hz ref
SR-I_Gx-001 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The probability of corrupted or loss of data (Surveillance, Airport/MET data & status, AGLC or FDP(EFS)) leading to a non-conformance situation not detected by the ground ATC conformance monitoring system shall be not greater than 1.0x10-4.	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)
SR-I_Gx-002 [Conf Monit-Ground]	The probability of an undetected loss of the ground ATC conformance monitoring system shall be not greater than 1.0x10-4.	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)
SR-I_Gx-003 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The probability of loss of data (Surveillance, Airport/MET data & status, AGLC or FDP(EFS)) leading to a partial ground ATC conformance monitoring detection with missing information shall be not greater than 1.0x10-4.	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)
SR-I_Gx-004 [Conf Monit-Ground]	The probability of a conformance monitoring partial detection with missing information due to failure of the ground ATC conformance monitoring function shall be not greater than 1.0x10-4.	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)
SR-I_Gx-005 [Airport/Met status], [A-SMGCS level 1 Surv], [FDP(EFS)], [AGLC]	The probability of corrupted data (Surveillance, Airport/MET data & status, AGLC or FDP(EFS)) leading to a partial ground ATC conformance monitoring detection with incorrect information shall be not greater than 1.0x10-4.	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)
SR-I_Gx-006 [Conf Monit-Ground]	The probability of a conformance monitoring partial detection with incorrect information due to failure of the ground ATC conformance monitoring function shall be not greater than 1.0x10-4.	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)
SR-I_Gx-007 [TWC-R], [TWC-G]	• The probability that the Tower Controller does not react appropriately against a valid ground ATC conformance alert shall be not greater than 4.0x10-3. • This corresponds to not responding appropriately to 1	SO 101(Hz 01) , SO 102 (Hz 02) and SO 105 (Hz 05)

	valid alert when considering 250 valid alerts. • This quantification should be used indirectly to derive qualitative requirements at physical level to design/define: • * the man-machine interface (visual, aural,..), • * the ATCO procedures • * the training aspect	

ID [SPR-level Model element]	False Alert Requirements	Performance objectives
PR Gx 01 [Conf Monit-Ground]	The ground conformance monitoring System shall not generate false alert with a probability greater than 5.0x10-5 when no corrupted data inputs are present at the entry of the system.	PO 01, PO 02
PR Gx 02 [A-SMGCS], [Airport/MET Data & Status], [AGLC], [FDP(EFS)]	The ground conformance monitoring System shall not generate false alert with a probability greater than 5.0x10-5 due to corrupted data input (Surveillance data, Airport/MET Data & Status, AGLC or FDP(EFS))	PO 01, PO 02

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 Gx 001	The A-SMGCS level 1 accuracy (mobile position and speed) is compliant with EUROCAE MASPS Standard ED 87B	
A Gx 002	The probability that the Tower Controller does not react appropriately against a valid ground ATC conformance alert shall be not greater than 4.0x10-3	

C.2 Safety Issues log

The following Safety Issues were necessarily raised during the safety assessment:

Ref	Safety issue	Resolution
I001	Since Conformance Monitoring Systems in the Control Tower and on board the aircraft to ensure that all movements are being conducted as directed are developed and operate independently, they can produce a reaction that degrades the effectiveness of both in the event of a conflict.	
I002	The following Safety Objectives (success approach) are not supported by the Conformance monitoring concept as described in the current OSED [2]: SO 012, SO 014, SO 016, SO 017, SO 021, SO 025. SAC achievability might be difficult without such SO satisfied.	
I003	Determine if Ground ATC conformance monitoring function is part of A-SMGCS level 2.	
I004	Availability of A-SMGCS level 1 on apron area is essential for the push back conformance element. Lack of A-SMGCS coverage on apron leads to an inefficient push back conformance monitoring.	
I005	The current conformance monitoring concept described in the OSED does not support the implementation of following Safety Requirements: SR Gx 03, SR GG 010, SR GG 014, SR GR 007, SR GR 014, SR GR 015, SR GR 021 and SR GR 022.	
I006	The required availability/reliability performance of A-SMGCS level 1 has been determined by considering only the impact on the conformance monitoring function (Safety Requirement SR-I_GR-003 and SR-I_GR-003) and not by considering the possible impact on the ATC runway collision avoidance if supported by A-SMGCS level 2. It should be determined if availability/reliability performance of A-SMGCS	

	level 1 has to be re-enforced when considering the impact on the runway monitoring barrier (Conformance Monitoring Function) and on the ATC Runway Collision avoidance barrier	

C.3 Operational Limitations log

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

Ref	Operational Limitations	Resolution
L001		
L002		

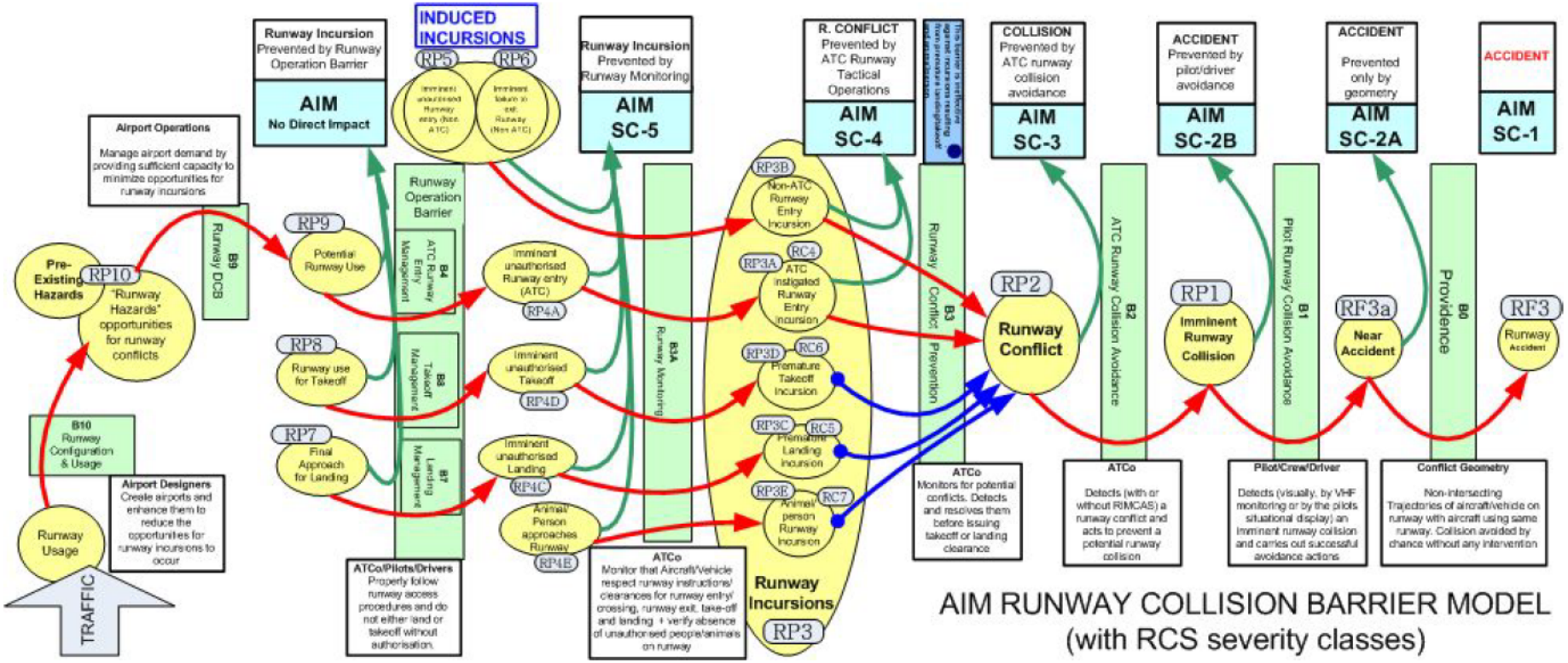
C.4 Recommendations log

The following Recommendations were necessarily raised during the safety assessment:

Ref	Recommendations	Resolution
REC001		
REC002		

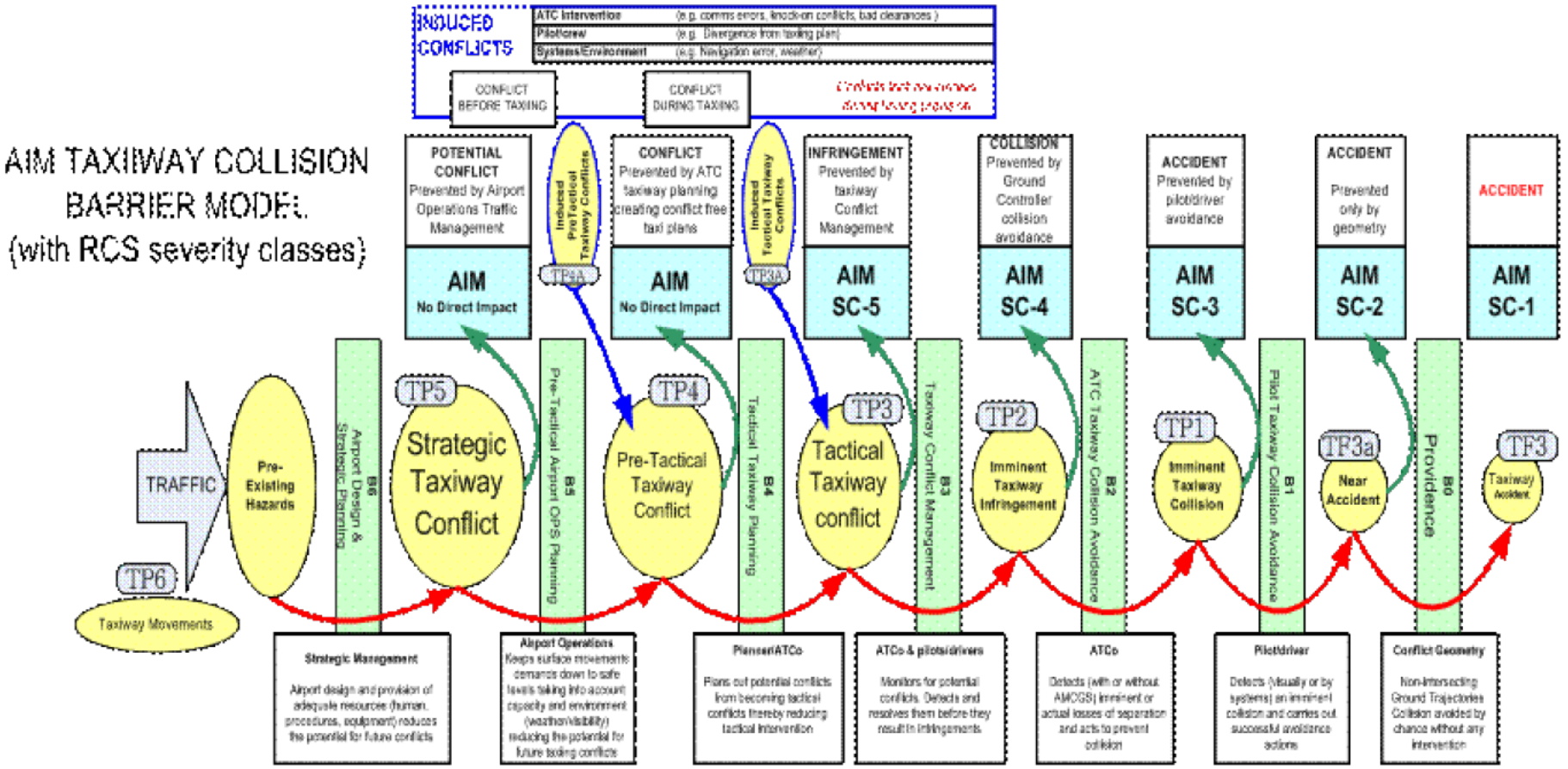
Appendix D: AIM Runway Collision Barrier Model

The following picture reports the AIM Runway Collision Barrier Model used for developing this document.

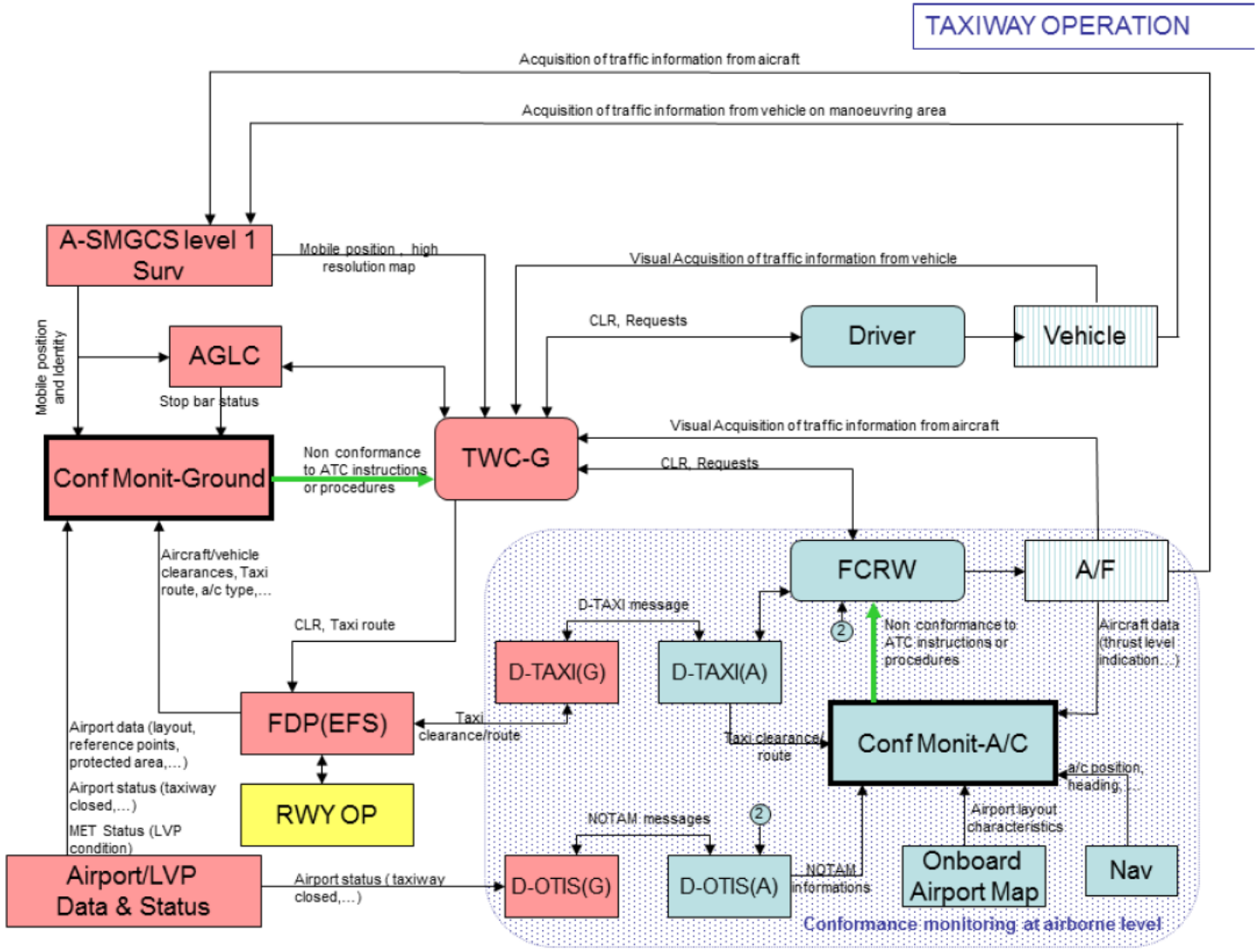


Appendix E: AIM Taxiway Collision Barrier Model

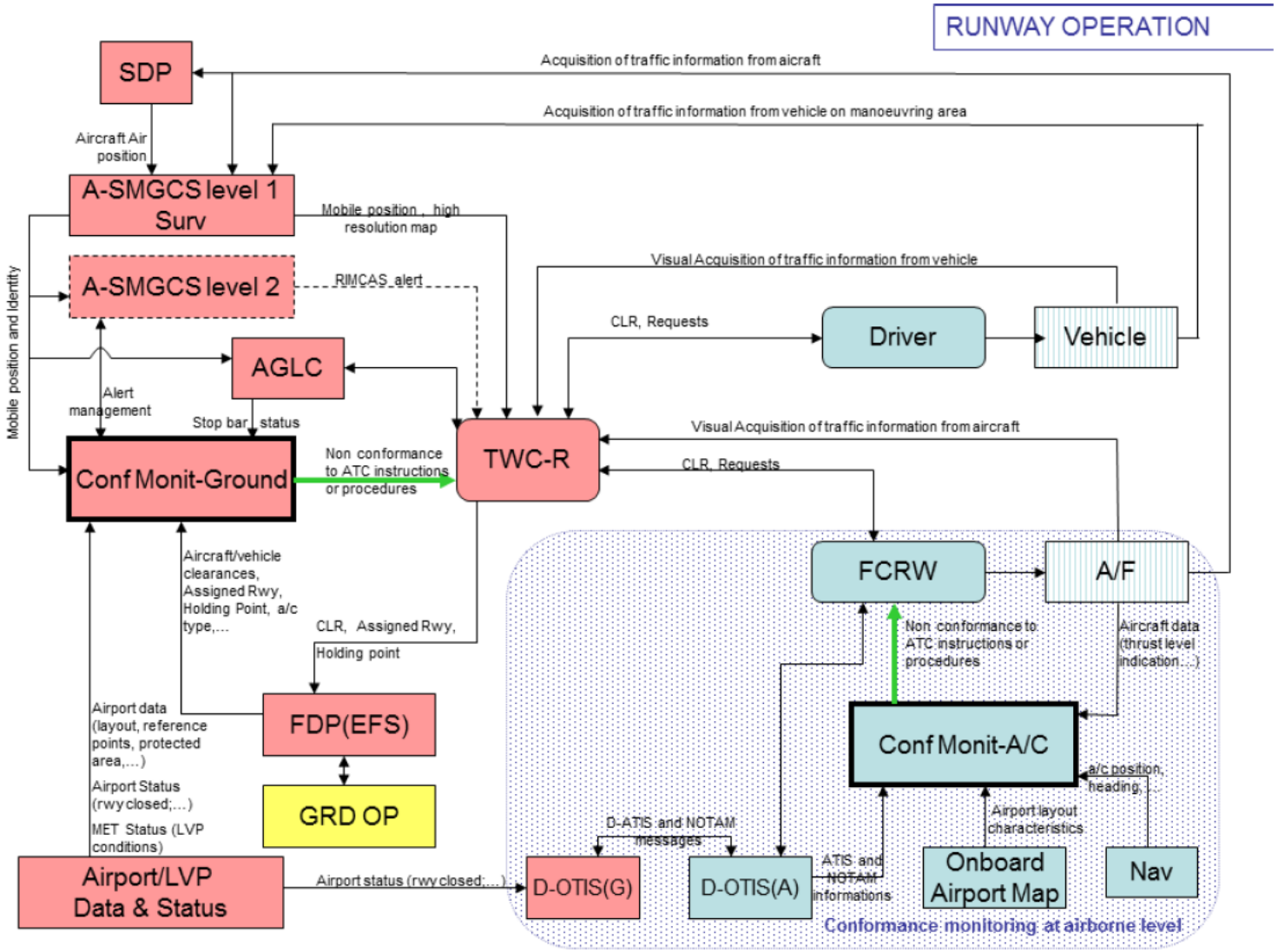
The following picture reports the AIM Taxiway Collision Barrier Model used for developing this document.



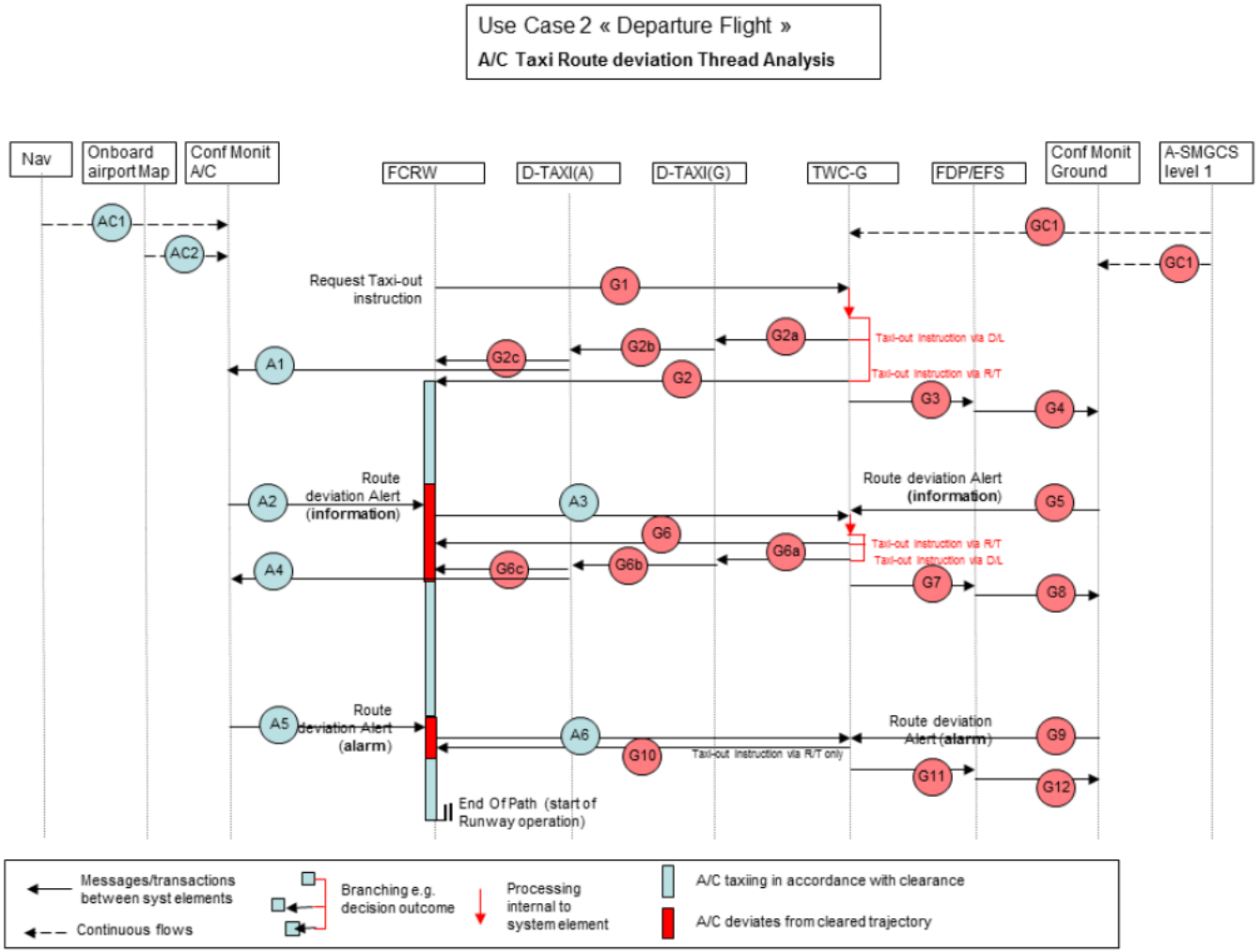
Appendix F: Taxiway conformance monitoring SPR level Model



Appendix G: Runway conformance monitoring SPR Level Model



Appendix H Thread analysis for Use Case #2 (Departing Flight) Scenario 1



1 **END OF DOCUMENT**