Safety and Performance Requirements (SPR) for RWSL

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Abstract

This document is the Safety and Performance Requirements (SPR) relating to the SESAR Solution #1, Runway Status Lights (RWSL) application.
This version is based on the results of the V3 trials EXE-06.07.01-VP-232 performed at Paris-CDG and on the RWSL generic safety assessment produced by EUROCONTROL.
It reflects the D10 final Operational Services and Environment Description (OSED).

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Rationale for rejection
None.

Document History

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00.01.00	12/09/2016	Final version		Released version

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

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Executive summary

This document is the consolidated Safety and Performance Requirements document D11 related to SESAR Solution #1 “Runway Status Lights” (RWSL), which is part of the Operational Focus Area (OFA) 01.02.01 (Airport Safety Nets).

The Runway Status Lights system addresses the Operational Improvement AO-0209 "Enhanced Runway Usage Awareness to reduce hazardous situations on the RWY".

It consists of a surveillance driven automatic system that visually indicates to flight crews and vehicle drivers when it is unsafe to enter, use or cross a runway, through new airfield lights which can be composed of Runway Entrance Lights (REL), Take-off Hold Lights (THL) and Runway Intersection Lights (RIL) [14].

The safety and performance requirements are related to the operational process and services defined in the Operational Services and Environment Description (OSED) [15] of the P06.07.01 SESAR project Airport Safety Support Tools for Pilots, Vehicle Drivers and Controllers.

This SPR refers to safety and performance requirements as defined in the RWSL generic safety assessment developed by EUROCONTROL [16]. This RWSL generic guidance uses the validation results from the V3 trials EXE-06.07.01-VP-232 performed at Paris-CDG in 2015-2016 [17]. It also uses the results from the Federal Aviation Administration (FAA) operational evaluations performed at some US airports since 2004. Functional and safety performance requirements are derived from safety performance objectives for each of the following elements:

- Pilots
- Vehicle Drivers
- ATC
- Aeronautical Information
- RWSL Processor
- Field Lighting System
- Surveillance and Network Connections.

1 Introduction

1.1 Purpose of the document

This Safety and Performance Requirements (SPR) document provides the safety and performance requirements for services related to the operational processes defined in the corresponding OSED D10 (RWSL final OSED [15]). The SPR also provides their allocation to Functional Blocks. They shall identify the requirements needed to fulfil each KPA and include, or reference, the sources justifying those requirements. This document is used to provide the basis for ensuring that these safety and performance requirements are applicable during initial implementation and continued operation.

This SPR document provides mainly an introduction to the Safety Assessment of Runway Status Lights (RWSL) document which is a generic guidance "based on the lessons learnt from the CDG RWSL safety assessment together with US experience so far" [16].

1.2 Scope

This document supports the operational services and concept elements identified in the Operational Service and Environment Definition (OSED) [15]. These services will be operational at Paris-CDG in 2016. They are already implemented in several US airports.

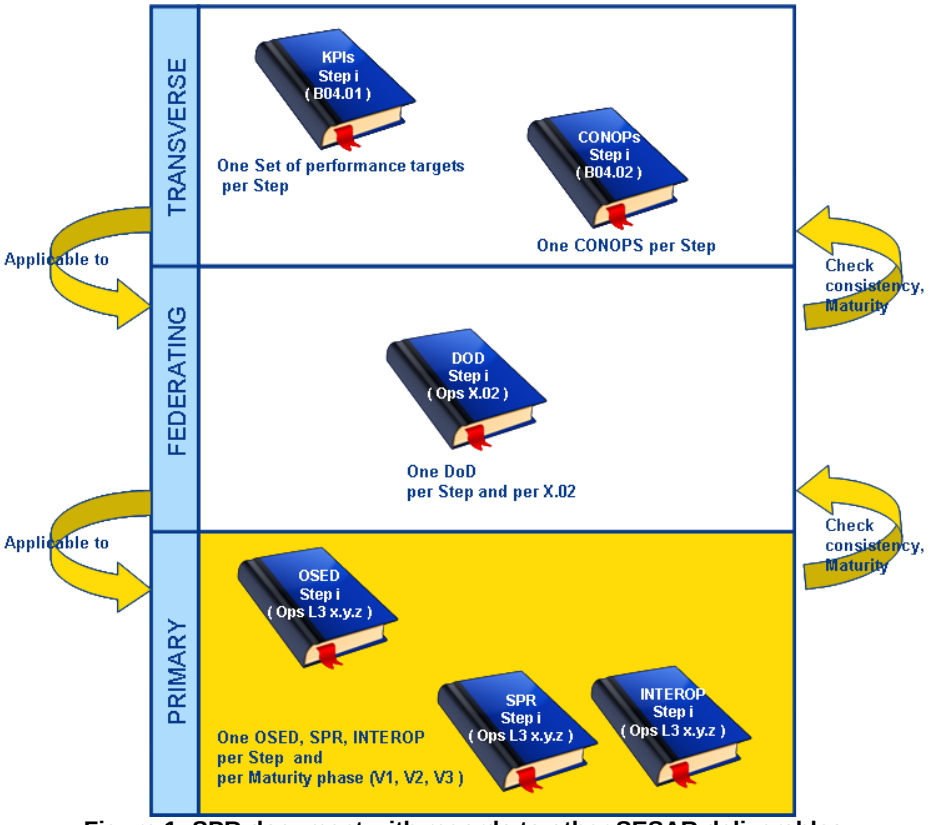

Figure 1: SPR document with regards to other SESAR deliverables

In the figure above, the Steps are driven by the OI Steps addressed by the project in the Integrated Roadmap document [13].

1.3 Intended readership

The main audience for this SPR is:

- Partners contributing to other tasks within project 06.07.01 using the OSED as input, e.g. SPR for RWSL and OCD

- Project 06.09.02 that develops the "A-CWP" (future controller working position) requirements
- Technical project 12.03.01 developing multi-sensor data fusion, which provides surveillance data for RWSL
- Technical project 12.03.02 developing safety nets prototypes
- Project 12.01.07 in charge of the airport systems specification drafting and maintenance
- The transverse project 06.02.
- Project 16.06.01 to ensure that Safety is managed systematically, consistently, timely, with high quality and in accordance with E-OCVM requirements throughout the SESAR development phase.
- Project 16.06.05 to ensure that HP is managed systematically, consistently, timely, with high quality and in accordance with E-OCVM requirements throughout the SESAR development phase.

1.4 Structure of the document

This document is structured in several chapters, based on the SPR template 03.00.00 [19].

- Chapter 1 (this section) introduces the document.
- Chapter 2 addresses what is to be developed and provides the traceability to the relevant OSED. It details in simple terms and plain language the operational concept and scope. Chapter 2.3 describes the operational environment.
- Chapter 3 "Requirements for the Operational Services" refers to the RWSL safety assessment generic guideline.
- Chapter 4 contains the references and applicable documents.

1.5 Background

Runway incursions are one of the most serious safety issues for ATM. One of the ATM safety improvements needed to reduce the number and the severity of runway incursions (and thus the number of runway accidents) consists in warning directly flight crews and vehicle drivers about the potential danger of their situation. Indeed, vehicle drivers and flight crew represent a significant origin for runway incursions.

RWSL has been trialled operationally in some US airports since 2004 with promising results in terms of reduction in the frequency and severity of runway incursions, lack of impact on airport efficiency and acceptance by the flight crews' community.

RWSL is not yet implemented in Europe. Given the concluding results observed in the USA, and CDG offering an opportunity to perform V3 on-site validations, this subject has been included in the scope of P06.07.01 for Step1 as SESAR Solution #1. The objective was to conform as much as possible to the systems already installed in the USA for harmonization purposes.

Live trials where held at CDG in 2015 - 2016. This document is the SPR completed after these trials and taking into account the validation results [17]. It refers to the generic safety case produced in that framework by EUROCONTROL [16].

1.6 Glossary of terms

Term	Definition
Take-off Hold Region	The "Take-off Hold Region" is an area from the runway entrance taxiway to the end of its THL. It is activated when there is an aircraft taking off inside this area.

Term	Definition
THL Safety Region	The "THL Safety Region" is an area associated to a THL. It is defined from the next intersection (included) after the runway entrance point to the end of the runway. It is activated when there is a mobile inside this area.
Closed runway	The runway is not available for aircraft operations.

1.7 Acronyms and Terminology

Term	Definition
A-CWP	Advanced Controller Working Position
AGL	Aerodrome Ground Lighting
AIP	Aeronautical Information Publication
ANSP	Air Navigation Services Provider
ATC	Air Traffic Control
ATIS	Automated Terminal Information Service
ATM	Air Traffic Management
CAT	Category
CDG	Paris Charles-de-Gaulle airport
CWP	Controller Working Position
DSNA	Direction des Services de la Navigation Aérienne (French ANSP)
ECTL	EUROCONTROL (European Organisation for the Safety of Air Navigation)
E-OCVM	European Operational Concept Validation Methodology
FAA	Federal Aviation Administration
FLS	Field Lighting System
GPS	Global Positioning System
Groupe ADP	Groupe Aéroports de Paris (corporate brand)
HMI	Human Machine Interface
HP	Human Performance
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization

Term	Definition
IFR	Instrument Flight Rules
LED	Light Emitting Diode
LVP	Low Visibility Procedures
MET	Meteorological
MITRE	Massachusetts Institute for Technology, Research and Engineering
MLAT	Multilateration
NOTAM	Notices To Airmen
OCD	Operational Concept Description
OI	Operational Improvement
OSED	Operational Services and Environment Description
REL	Runway Entrance Lights
RET	Rapid Exit Taxiway
RFFS	Rescue and Fire Fighting Services
RI	Runway Incursion
RIL	Runway Intersection Lights
RIMS	Runway Incursion Monitoring System (replaced by RMCA)
RMCA	Runway Monitoring and Conflict Alert
RWSL	Runway Status Lights
RWY	Runway
SNA-RP	Service de la Navigation Aérienne – Région Parisienne
SMR	Surface Movement Radar
THL	Take-off Hold Lights
THR	Threshold
TWR	Tower
TWY	Taxiway
US(A)	United States (of America)

2 Summary of Operational Concept (from OSED)

2.1 Description of the Concept Element

The RWSL provides a fully automatic system that uses aerodrome core surveillance data to dynamically switch ON and OFF some new airfield lights to directly inform the flight crews and the vehicle drivers about current runway usage. This runway status indication informs the flight crews and the vehicle drivers when the runway is unsafe for entering, crossing or taking off.

The objective of this concept is the reduction of hazardous situations on the runway, i.e. the number of the most severe runway incursions (A and B as defined in chapter 6 of the ICAO Manual on the Prevention of Runway Incursions [18]).

2.2 Description of Operational Services

Operational services are not part of the DOD [14].

2.3 Description of Operational Environment

This section provides a brief description of the service operational environment for RWSL. For a more comprehensive description of the operational environment, please refer to the RWSL final OSED [15].

2.3.1 Operational Characteristics

2.3.1.1 Airport Characteristics

RWSL consists of the following new airfield lights:

Runway Entrance Lights (REL): Sets of red lights illuminating runway entrances when it is not safe to enter or cross the runway.

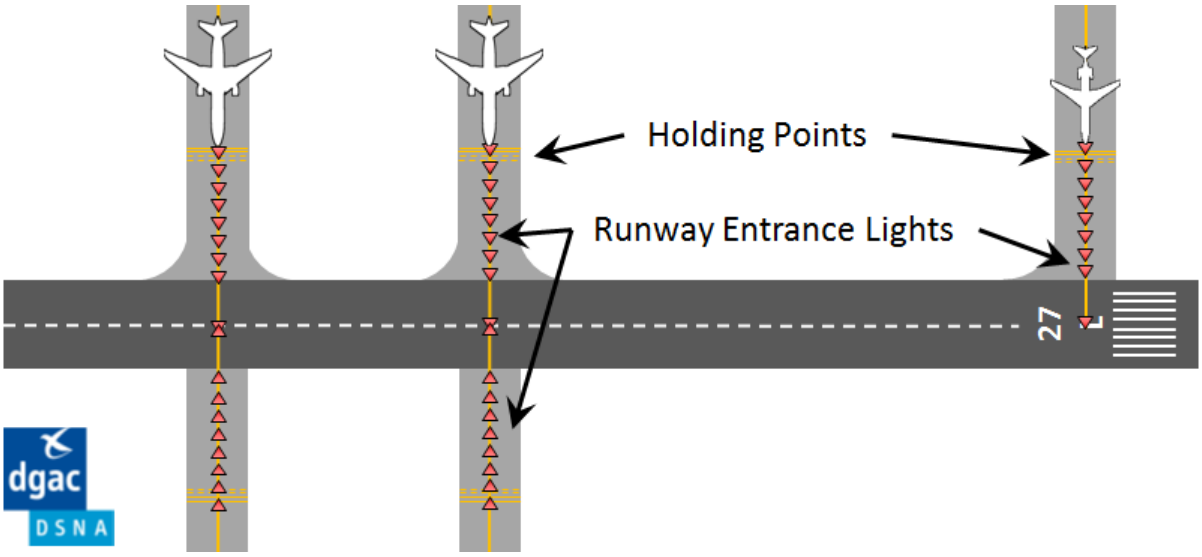

Figure 2: REL implementation

Take-off Hold Lights (THL): Sets of red lights illuminating along the axis of a runway in front of a departing aircraft when it is unsafe to take off from that runway due to an obstacle (vehicle or aircraft) already occupying the runway ahead.

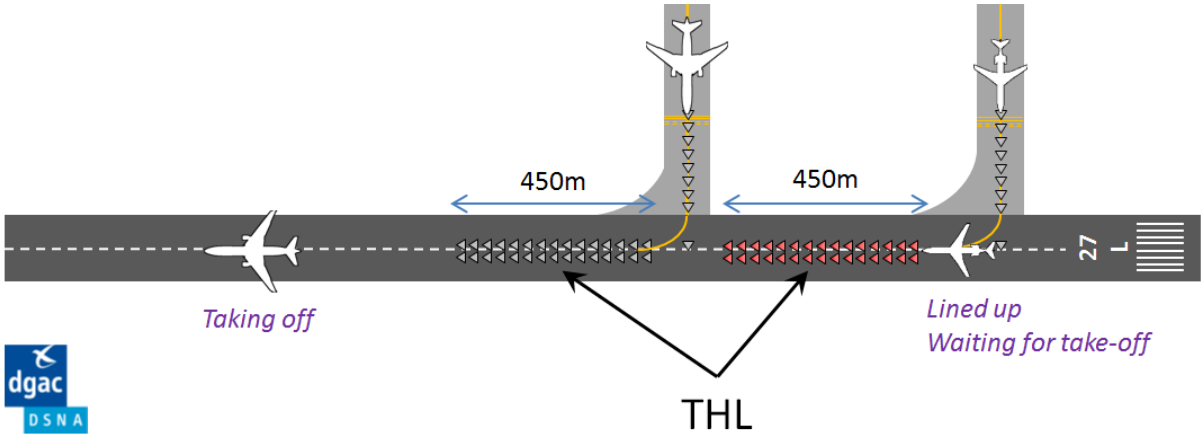

Figure 3: THL implementation

Runway Intersection Lights (RIL): sets of red lights illuminating along the axis of a runway near the intersection with another runway (crossing runways only) when it is not safe to go through the intersection.

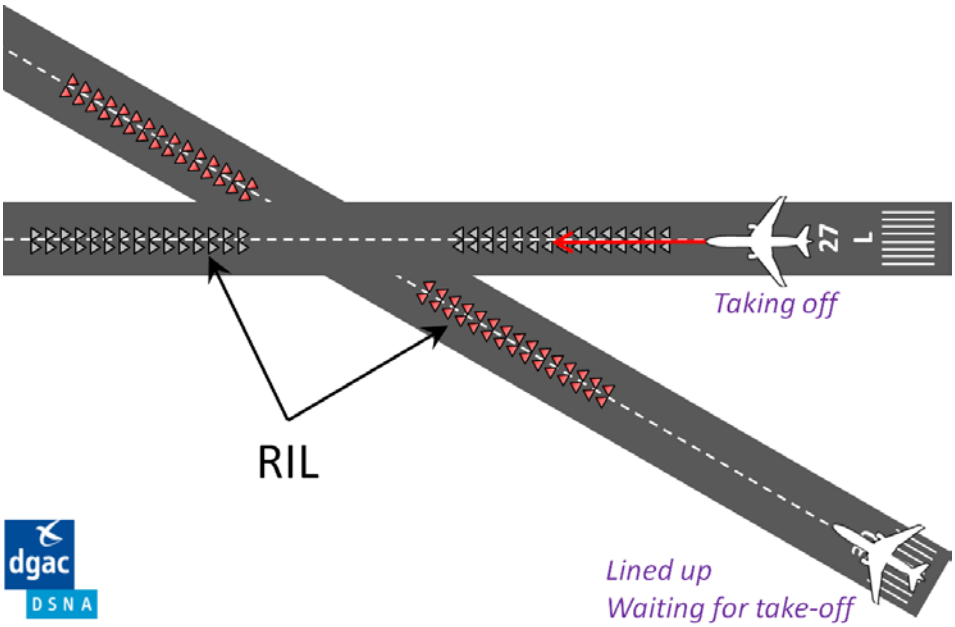

Figure 4: RIL implementation

From the ATC side, the only need is to have RWSL information displayed on the tower runway controller working position (A-CWP) in case of a query from a flight crew or vehicle driver concerning RWSL lights contradicting a clearance or being inconsistent with visible traffic. The whole RWSL system shall also be able to be deactivated from the control tower if required.

RWSL will be used in all visibility conditions. During LVP operations, the system will be used in conjunction with stop bars. In case of heavy rain, the system will be able to be deactivated if ATC considers surface movement radar performances are too degraded to be usable.

RWSL functions shall be applied to all mobiles that are moving on the equipped runways of an airport. RWSL service will be delivered for all aircraft and vehicles with or without transponders.

2.3.2 System Characteristics

REL – activation / deactivation principle

REL related to an intersection shall be ON when an aircraft moving on the runway is less than a certain distance or a certain time away from this intersection.

Time and distance are configurable for each REL and linked to aircraft speed ranges.

Above a certain speed, all REL of a runway in front of an aircraft shall be switched ON.

REL ahead of an aircraft taking off shall be OFF as soon as it is regarded to have taken off by surveillance system. REL extinction shall be able to be anticipated (i.e. REL shall be able to be OFF just before the departure goes through the intersection).

THL – activation / deactivation principle

For each runway entrance point, there are:

- A THL line (approximately 450 meters of lights) is composed of one or several segments of lights (segmentation is due to multiple line-ups). Each segment shall be controllable separately.
- Two associated Take-off Hold Regions (one defined for non-LVP conditions and one for LVP conditions).
- Two associated THL Safety Regions (one defined for non-LVP conditions and one for LVP conditions).

Once the speed of the aircraft has exceeded a certain limit, the “Take-off Hold Region” is activated:

- If there is no other mobile (aircraft, non-cooperative target or vehicle) in the associated THL Safety Region, THL lights are OFF.
- If there is at least one other mobile (aircraft, non-cooperative target or vehicle) in the THL Safety Region beyond the Take-off Hold Region, all segments of the THL line shall be switched ON.
- If there is another mobile (aircraft, non-cooperative target or vehicle) that is both in the THL Safety Region and the Take-off hold Region, only THL segments between the aircraft and the mobile shall be switched ON.

THL lights are switched OFF as soon as:

- The THL Safety Region is not active anymore. The system shall enable to anticipate the THL Safety Region deactivation (change of course, or prediction of the position using its speed and course…),

  OR

- The Take-off Hold Region is not active anymore.

RIL – activation / deactivation principle

The RIL activation logic differs according to the status of the aircraft (on approach, landed, departing or taxiing):

- In departure vs. departure conflicts, RIL will be illuminated only if one of the aircraft is below a maximum velocity (the value has to be a parameter of the system) and can stop. No RIL will be illuminated if a departure is projected to be above the maximum velocity more than a certain time before the intersection. That time has to be a parameter of the system. RIL will be extinguished once either aircraft is airborne.
- In landed vs. departure aircraft conflicts, RIL are activated for the departure if it is below a maximum velocity and can stop. Otherwise, if it cannot stop or fails to slow in response to the

lights, they are illuminated for the arriving aircraft whether or not it can stop. RIL will be extinguished once the departing aircraft is airborne.

- In arriving vs arriving aircraft conflicts, RIL are illuminated only if one arriving aircraft can stop. RIL will be extinguished once the first aircraft has passed the intersection.
- No RIL will be illuminated for a on approach vs. on approach conflict.
- No RIL will be illuminated for a taxiing vs. taxiing conflict.

2.3.3 Roles and Responsibilities

The RWSL system is a support tool for the tower runway controller who is responsible for managing the runway and for the flight crews and vehicle drivers who are using the runway.

The airport duty officer and the airfield ground lighting maintenance service are also involved in the use of the RWSL system in case of failure / malfunctioning or of any planned unavailability of one or several functions of the RWSL system. In any of these cases, they inform the tower supervisor and/or the tower runway controller.

2.3.4 Constraints

RWSL system requires the availability of the aerodrome core surveillance data.

In order to support aerodrome core surveillance performances, vehicle positioning systems and aircraft transponders shall be turned ON and kept ON while on the manoeuvring area.

The accuracy of horizontal and vertical positions and trends information from the airport core surveillance system together with its integrity shall be adequate for RWSL.

The RWSL processor shall receive aerodrome core surveillance data in a timely manner.

All future deployment should consider the following elements as local constraints:

- **Nature of the mobiles (aircraft and vehicles, cooperative or not):** should the system detect all mobiles? What are the local regulations about these mobiles equipment level (Mode S, reported Mode C accuracy, vehicle positioning system for airside vehicles, etc.?)
- **Nature and performances of the surveillance:** what are the sensors feeding the aerodrome core surveillance, their coverage and performances, their contribution to the overall surveillance performances?
    - As a generic example of the way to proceed, about altitude, it should be clarified what sensors provide Mode C data, at what update rate, is it a raw, smoothed, or extrapolated aircraft data, what is the time offset between reality and data collection, etc. and what are the consequences on other subsequent data such as vertical velocity?
    - It should also be highlighted that the expected needs about aircraft vertical position information differs from one sub-system to another (REL, THL, RMCA, A-CWP display, etc.)
    - In the same way, RWSL provides indications about runway usage directly to pilots and vehicle drivers, without any human-in-the-loop to detect inconsistencies with real situation.
- **Characteristics of the runway layout and operations:** parallel dependent runways, hotspots positions, local procedures (multiple line-ups, etc.). RWSL is a new system that has to deal with the existing operational methods without degrading the airport capacity or interfering with normal operations. Thus, RWSL has to take as a constraint the need to avoid inconsistencies between operational clearances and its own lights statuses so that these lights are never ON when a valid (not erroneous) clearance is issued by the controller.

- **Physical characteristics of the lights and their infrastructure:** latencies (both ways), lighting and brightness level, orientation and aperture of lights, composition with pre-existing infrastructure and lights, and their supervision have to be studied carefully.

3 Requirements

The safety and performance requirements are described in the safety assessment of RWSL system generic guideline produced by EUROCONTROL in the framework of the live trials held at CDG in 2015 - 2016 and making use of the US experience [16]. Initially a safety case was built in coordination with Groupe ADP and the SNA-RP for CDG. It was then made generic to assist all the airports wishing to implement the RWSL system to conduct a safety assessment.

In this RWSL generic guidance, functional and safety performance requirements are developed for each of the following elements:

- Pilots
- Vehicle Drivers
- ATC
- Aeronautical Information
- RWSL Processor
- Field Lighting System
- Surveillance and Network Connections.

4 References and Applicable Documents

4.1 Applicable Documents

[1] Template Toolbox 03.01.03
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

[4] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

4.2 Reference Documents

[5] ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[1]

[6] B.4.1 Performance Framework (validation targets, influence diagrams)

[7] B.4.3 Architecture Description Document

[8] SESAR Safety Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[9] SESAR Security Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[10] SESAR Environment Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[11] SESAR Human Performance Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[12] SESAR Business Case Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[13] WPB.01 Integrated Roadmap Latest version

[14] 06.02 Step 1 Airport DOD 2014 Update D122

[15] 06.07.01 D10 RWSL final OSED; 09/2016

[16] Safety Assessment of Runway Status Light (RWSL) System – Generic Guidance, EUROCONTROL, V1.1, 09/2016[2]

[17] 06.07.01 D09 RWSL V3 Validation Report, 09/2016

[1] The EUROCAE ED-78A has been used as an initial guidance material. ED-78A is useful, but is not an applicable document, because it mostly addresses the V4-V5 phases, whilst the SESAR R&D programme is focussed on development (V1-V2-V3, and because of its partial compliance with safety regulatory requirements).
[2] This document is not publicly available, but upon request to EUROCONTROL (ATM/RDS/APT).

[18]Manual on the Prevention of Runway Incursions, DOC 9870 AN/463, ICAO, First edition

[19]SESAR Safety and Performance Requirements template, 03.00.00, 05/2012

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