6.3.1 D75 6.3.2 Release 3 Validation Report

Document information	
Project Title	Airport ATM Performance (execution phase)
Project Number	06.03.01
Project Manager	EUROCONTROL
Deliverable Name	6.3.1 D75 6.3.2 Release 3 Validation Report
Deliverable ID	D85
Edition	00.01.00
Template Version	03.00.00
Task contributors	
EUROCONTROL, AENA, ENAV	

Abstract

This deliverable is the Validation Report for project 6.3.1 Release 3 step 1 V3 exercises which covered mainly OFA01.02.01 Airport Safety Nets, OFA01.02.02 Enhanced Situational Awareness, OFA04.02.01 Integrated Surface Management and OFA06.01.01 A-CWP Airport, and were performed at Madrid-Barajas and Milano-Malpensa.

This report provides a reminder of the objectives and scenarios that have been played as well as the results of the validation trials using different controller tools.

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Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
00.00.01	18/07/2013	Draft	[redacted]	New Document

00.00.02	25/03/2014	Draft	EUROCONTROL, AENA, ENAV	Integration of EXE614 and EX652 (sections 1 to 5)
00.00.03	25/03/2014	Draft	EUROCONTROL, AENA, ENAV	Correction of English
00.00.04	02/04/2014	Draft	EUROCONTROL, AENA, ENAV	Taken into accounts comments
00.00.05	14/04/2014	Draft	EUROCONTROL, AENA, ENAV	Added recommendations from Safety Nets Workshop
00.00.06	23/04/2014	Draft	EUROCONTROL, AENA, ENAV	Taken into account last internal comments – Document ready for review by other projects
00.01.00	14/05/2015		EUROCONTROL, AENA, ENAV	Final version

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Executive summary

Document purpose:

This document contains the validation report of the integrated validation activities that were conducted by project 6.3.1 for Release 3. Two exercises were performed on two airports: Madrid Barajas and Milano Malpensa.

All the activities concerned Step 1 and V3 E-OCVM lifecycle phase. Their main objective will be the partial validation of OFA01.02.01 Airport Safety Nets, OFA01.02.02 Enhanced Situational Awareness, OFA04.02.01 Integrated Surface Management and OFA06.01.01 A-CWP Airport. The document is focused on the validation results and provides a detailed overview of the exercises in terms of objectives, scenarios, working methods, exercises execution, analysis methodologies. Finally, it presents the conclusions and recommendations that can be drawn from the results.

Validation methods used:

The target maturity level was V3. The validations have been performed through real time simulations, with the addition of shadow-mode for the exercise performed at Milano-Malpensa.

Main results and conclusions:

Here is a summary of the main results also presented in section 5.1.

- Automated assistance to controllers for surface movement planning and routing (only from EXE-614):
    - Controllers indicated that the planning and routing function without data link caused a higher workload and a loss of the Situational Awareness without any improvements in the other areas.
    - Controllers appreciated the different ways of options for modifying a route.
- Provision of surveillance through ground system using enhanced ADS-B (only from EXE-652):
    - Controllers effectively noticed an enhancement of their Situational Awareness thanks to an evident surveillance data quality improvement by means of enhanced ADS-B algorithm.
- Airport safety nets including runways, taxiways and apron:
    - Concept suitable for TWR environment.
    - Controllers appreciated the operational concept.
    - Controllers indicated that the high number of alerts had an impact on the workload and on the Situational Awareness. Nevertheless, controllers asserted that the tool generated mainly real alerts and that there was an increase of the Situational Awareness in low visibility conditions.
    - Controllers indicated that the priority of alerts was quite correct, but this issue needs further investigation.

  - Controllers admitted that Conflicting Clearances, taking into account controllers' possible errors, enhanced the global level of safety.

- Advanced information management and system integration in the ATC tower for step 1:
  - The new HMI functionalities are considered beneficial for the TWR environment.
  - Alerts displayed on a controller's screen should be relevant to their operational responsibilities and easily differentiable.
  - Controllers appreciated the innovative HMI solutions.

1 Introduction

1.1 Purpose of the document

This document provides the Validation Report for the Release 3 V3 integrated validation activities that were performed by project 6.3.1 Airport ATM Performance (execution phase). It describes the results of the validation exercises defined in 6.3.2 Release 3 Validation Plan ([52]) and how they have been conducted.

The document has been written using Data Set 10 in order to remain consistent with [52].

1.2 Intended readership

Intended audience for the 6.3.1 Validation Report is:

- Project P6.3.1 partners
- Project 6.2
- Projects that will collect the outputs of the validation exercises for consolidation (P16.06.0X).
- Project B05
    - Projects members of OFA01.02.01 Airport Safety Nets, OFA01.02.02 Enhanced Situational Awareness, OFA04.02.01 Integrated Surface Management and OFA06.01.01 A-CWP Airport that are concerned with the validation exercises as listed in Table 1:

Project	Project Name
06.03.01	Pre-Operational and Integrated Validations for Airport Operations
06.07.01	Airport safety support tools for pilots, vehicle drivers and controllers
06.07.02	A-SMGCS Routing and Planning functions
06.09.02	Advanced integrated CWP (A-CWP)
12.03.01	Improved Surveillance for surface management
12.03.02	Enhanced Surface Safety Nets
12.03.03	Enhanced Surface Routing
12.05.02	Airport Safety Nets and wind-shear detection and alert for Controllers
12.05.03	Enhance Controller Tools to manage all aspects of 4D trajectories
12.05.04	Integrated Tower Working Position (CWP) Design, Specification Prototyping and Test/Validation
15.04.05.b	Surveillance ground system enhancements for ADS-B (Prototype development)
12.05.07	Performance Based, Monitoring and Decision Support within the HMI of the CWP

Table 1: List of projects

1.3 Structure of the document

This document follows the SESAR JU VALR template version 03.00.00 and it consists of five sections:

- Section 1 - Introduction offers an overview of the whole document.
- Section 2 - Context of the Validation gives the general background of the validation activities that have been performed by P6.3.1 in Release 3.
- Section 3 - Conduct of the Validation Exercises gives some general information about the conduct of the exercises, that are further described in section 6 Validation Exercises reports
- Section 4 - Exercises Results gives consolidated results of the integrated validation activities.
- Section 5 - Conclusions and recommendations gives the overall conclusions.
- Section 6 - Validation Exercises reports presents each exercise separately giving in particular the results obtained by each of them.
- Section 7 - References provides a complete list of the documents used as references.

1.4 Glossary of terms

N/A

1.5 Acronyms and Terminology

Term	Definition
A-CWP	Advanced Controller Working Position
ADS-B	Automatic Dependent Surveillance-Broadcast
AIP	Aeronautical Information Publications
ALM	Arrival Landing Monitoring
ANSP	Air Navigation Service Provider
AO	Airport Operations
AoR	Area of Responsibility
APP	Approach
ASAS	Airborne Separation Assurance Systems
ASAT	Actual Start-up Approval Time
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATCO	Air Traffic Controller
ATC	Air Traffic Control

Term	Definition
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATOT	Actual Take Off Time
ATS	Air Traffic Services
ATSU	Air Traffic Services Unit
BM	Benefit Mechanism
CATC	Conflicting ATC clearances
CDD	Clearance Delivery Dispatcher
CLD	Clearance Delivery
CMAC	Conflicting ATC Clearances
CMON	Conformance Monitoring
CPDLC	Controller Pilot Data-Link Communication
CRWY (*)	Closed Runway
CTWY (*)	Closed Taxiway
CWP	Controller Working Position
CLOR (**)	Closed Runway
CLTWY (**)	Taxi on a closed segment of a taxiway
D	Deliverable
DMAN	Departure Manager
DOD	Detailed Operational Description
D-TAXI	Datalink-TAXI
EASA	European Aviation Safety Agency
E-ATMS	European Air Traffic Management System
EDB	Emission Data Bank
EFF	Efficiency
EFS	Electronic Flight Strip

Term	Definition
ESB	Electronic Strip Board
EIA	Environmental Impact Assessment
EIBT	Estimated In Block Time
ENTW (*)	Enter Wrong Runway
ENV	Environment
E-OCVM	European Operational Concept Validation Methodology
ERWT	Expected Runway Waiting Period
EXE	Exercise
EXOP	Estimated Outbound Taxi
EXOT	Estimated Taxi Out Time
GEC	Ground Executive Controller
GND	Ground
GS	Ground Station
GTG	Ground Traffic Generator
HF	Human Factors
HMI	Human Machine Interface
HP	Human Performance
HSPD (*)	High Speed
KPA	Key Performance Area
KPI	Key Performance Indicator
Kt	Knot
IBP	Industrial Based Platform
ICAO	International Civil Aviation Organisation
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
IVT	International Validation Team

Term	Definition
LU/LA (**)	Landing Clearance/Line-up Clearance
LU/LU (**)	Line-up Clearance/Line-up Clearance
LAWRR (**)	Landing on a wrong runway
LUWRR (**)	Line-up on a wrong runway
MET	Meteorological
MLAT	Multilateration
MSF	Multi Sensor Fusion
NCON (*)	No Contact
NEHP (*)	Nearby / Same Holding Points
NENT (*)	No Enter
NLUP (*)	No Line Up
NPBK (*)	No Push-back
NOCON (**)	Approaching without any TWR contact
NOLND (**)	Landing without clearance
NOLUP (**)	Line-up without clearance
NOPB (**)	Pushback without clearance
NOTOF (**)	Take off without clearance
NOTX (**)	Taxi without clearance
NTOF (*)	No Take-Off
LUPW (*)	Line up Wrong Runway
OCD	Operational Concept Document
OFA	Operational Focus Areas
OI	Operational Improvement
OPHP (*)	Opposite Holding Points
OPPDI (**)	Opposite Direction
OSED	Operational Service and Environment Definition

Term	Definition
PAC	Operation Package
PAPI	Precision Approach Path Indicator
PAS (*)	Prediction Area of Security
PRD	Predictability
QoS	Quality of Service
RBT	Reference Business/Mission Trajectory
R&D	Research and Development
RIMS	Runway Incursion Monitoring System
R	Release
RDM (*)	Runway Departure Monitoring
RT	Real Time
R/T	Radio Telephony
RTS	Real Time Simulation
RUINC (**)	Runway Incursion
RWY	Runway
SA	Situational Awareness
SAF	Safety
SEA	Società per azioni Esercizi Aeroportuali Milano (Milano Malpensa airport services handler)
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.
SME	Subject Matter Expert
SPC	Operational Sub-Package

Term	Definition
SPEL (**)	Speed Limit
SPR	Safety and Performance Requirements
SSN	Surface Safety Nets
STALU (**)	Stationary after line-up clearance
STAPB (**)	Stationary after pushback clearance
STATO (**)	Stationary after take-off clearance
STATX (**)	Stationary after taxi clearance
SUT	System Under Test
TA	Transversal Area
TDOA	Time Difference of Arrival
TEC	Tower Executive Controller
TMA	Terminal Manoeuvre Area
TO	Take off
TOBT	Target Off Block Time
TS	Technical Specification
TSAT	Target Start-up Approval Time
TTOT	Target Take-Off Time
TWR	Tower
TXDEV (**)	Taxi route deviation
TWY	Taxiway
VALP	Validation Plan
VALR	Validation Report
VAS	Violation Area of Security
VEMG	Validation Exercise Management Group
V&V	Validation and Verification
WAM	Wide Area Multilateration

Term	Definition
WL	Workload
WP	Work Package
WPT	Way Point
WRA (*)	Wrong Runway Alert

(*) Acronyms for alert messages in AENA exercise EXE-614

(**) Acronyms for alert messages in ENAV exercise EXE-652

2 Context of the Validation

This section provides the general background of the validation activities that were performed by Project 6.3.1 in Release 3.

2.1 Concept Overview

Project 6.3.1 performs integrated validation only.

Several concepts were validated in Release 3:

- The Safety nets which had an impact on safety providing the following alerts to aircraft/vehicles:
    - Non-conformance to ATC procedures: Algorithms and services to detect non-conformance to aerodrome procedures for example when a mobile taxies at an excessive speed. These situations are detected only with surveillance data.
    - Non-conformance to ATC instructions: Alerts for non-conformance to clearance will be triggered for example when a mobile deviates from its assigned (cleared) trajectory. Conformance monitoring systems need to be assessed in accordance to complex airport layout and new procedures. These situations are detected combining surveillance data with Electronic Flight Strip (EFS) inputs.
    - Conflicting ATC clearances: alerts generated when the controller gives an erroneous authorization or gives conflicting authorizations to different mobiles. These situations are detected combining surveillance data with EFS inputs.

- ADS-B applications which had an impact on both ground and airborne Surveillance systems in terms of safety, performance, interoperability and security.

- Surface Routing and Planning function which allows the controller to use a route which has not been defined previously in the planning or to modify the previously assigned trajectory. Different modes of operation were available to controllers, combined with the route edition panel or the graphical edition map.

- The integration and exploitation of new ATC functions, with current elements into an Advanced Controller Working Position (A-CWP) to enhance the Situational Awareness for ATCOs and flight crews, and to improve safety.

Please note that Runway incursion and Area intrusion alerts were present for completeness and consistency, but were out of the validation scope due to the fact that the related concepts are no longer within SESAR- R&D, but have already been deployed.

Release 3 integrated validations were mainly related to the following Operational Focus Area and Enablers:

- OFA01.02.01 - Surface Airport Safety Nets,

- OFA06.01.01 - CWP Airport,

- OFA01.02.02 Enhanced Situational Awareness.

In addition, they also considered some aspects of OFA04.02.01 Integrated Surface Management.

The table below gives the links between the Operational Package(s), the Sub-Package(s), the Operational Focus Area(s) and the OI(s), with a darker background, the Release 3 project main OFAs. Only the OI steps that have been validated by the exercises are shown here.

Operational Package	Operational Sub-Package	OFA	OI steps
PAC01	SPC01.02 Airport Safety	OFA01.02.01 Airport Safety Nets OFA01.02.02 Enhanced Situational Awareness	AO-0104-A Airport Safety Nets for controllers in Step 1 AO-0201-A Enhanced ground controller Situational Awareness in all weather conditions for step 1
PAC04	SPC04.02 Integrated Surface Management	OFA04.02.01 Integrated Surface Management	AO-0205 Automated Assistance to Controller for Surface Movement Planning and Routing
PAC06	SPC06.01 CWP Airport	OFA06.01.01 CWP Airport	AO-0208-A Advanced Information Management and System Integration in the ATC Tower Step 1

Table 2: P6.3.1 Release 3 Operational packages, OFAs and OI steps

In Release 3, P6.3.1 integrated parts of the following WP6 third-level projects:

- P6.7.1
- P6.7.2
- P6.9.2. This project has participated closely in the EXE614 validation activities and has its own validation objectives [50]. The following table gives the list of the third-level project deliverables that P6.3.1 used as input:

Third-Level Project	Deliverables
P6.7.1	D22 - Preliminary OSED for "Conformance Monitoring"
	D16 - Updated OSED for "Conflicting ATC Clearances
	D17 - Updated SPR for "Conflicting ATC Clearances"
	D23 - Preliminary SPR for "Conformance Monitoring"
	D04 – Operational Concept for the integration of the Safety Support Tools: Updated OCD (second year)
P6.7.2	D73 - Updated OSED
	D74 - Updated SPR
P6.9.2	D105 – OSED (version 1)
	D107 - SPR (version 1)

Table 3: List of the third-level project deliverables used as input

Several WP12 and WP15 projects were as well involved in P6.3.1 Release 3 validation activities as they provided prototypes that were integrated on the platforms used by P6.3.1. The following table gives the list of WP12 and WP15 deliverables that were used by P6.3.1 in Release 3 activities:

WP10 12 and 15projects	Deliverables
P12.03.01	D22 - Phase 2 - Prototype Documentation (INDRA)
P12.03.02	D58 - Phase 2 - Prototype Documentation (INDRA)
	D22 – Phase 2 – Prototype Documentation (SELEX)
P12.03.03	D10 - Phase 2 - Prototype (INDRA)
P12.05.02	D16 - Prototype for Phase 2 (SELEX)
P12.05.03	D07 - INDRA prototype executable and availability note (Phase 2)
P12.05.04	D27 - INDRA prototype availability note - Phase 2
P12.05.07	D08 - Prototype development for Phase 2 (INDRA)
P15.04.05b	D12 - Second Iteration - Provision of ADS-B Ground Station Prototype (for Trajectory Based Operations) (SELEX)

Table 4: List of WP12 and 15 project deliverables used as input

Two exercises were performed:

- EXE-06.03.01-VP-614
- EXE-06.03.01-VP-652.

Table 5 below gives a summary of each of them.

Validation Exercise ID and Title	EXE-06.03.02-VP-614 : Validation of airport surface monitoring, control, and alerts
Leading organisation	AENA
Validation exercise objectives	• Safety improvement by detection of ATC conflicting clearances and aircraft conformance monitoring • Improvement of the controllers' Situational Awareness • Better integration of HMI functionalities (safety nets and surface routing and planning) • Smooth integration of new alerts in the CWP. • Improved in surface routing and planning support given to ground controllers.

	• Support to tower supervisor decision making based on taxiway and runway performance.
	• Objectives from project 06.09.02: analyse the usability requirements and human factors aspects related to the use of an integrated controller working position as a supporting tool for the following ATC functions:
	  ◦ Basic HMI elements (already analysed in R2)
	  ◦ Airport safety support tools for pilots, vehicle drivers and controllers including:
	  ▪ Conflicting ATC clearances (CATC)
	  ▪ Conformance monitoring (CMON)
	  ◦ A-SMGCS Routing and Planning functions.

Rationale	The exercise integrated all the airport safety nets alerts from a functional and HMI point of view. The exercise looked at how the different types of alerts worked jointly for the controller. also it also took the opportunity to validate an improved (regarding the EXE-06.03.01-VP-401) routing and planning function necessary for the conformance monitoring, as well as a tower supervisor decision making support tool.
Supporting DOD / Operational Scenario / Use Case	Airport DOD Step 1-D07/Surface-In and Surface-Out
OFA addressed	Main: • OFA01.02.01 Airport Safety Nets • OFA06.01.01 CWP Airport Auxiliary: OFA04.02.01 Integrated Surface Management
OI steps addressed	• AO-0104-A (partially) • AO-0205 (partially) • AO-0208-A (partially)
Enablers addressed	• AERODROME-ATC-06 (partially) • AERODROME-ATC-07 (partially) • AERODROME-ATC-13 (partially) • AERODROME-ATC-38 (partially) • AERODROME-ATC-50 (partially)
Applicable Operational Context	Airport execution phase
Expected results per KPA	Improved safety (SAF) through detection and alerting of route deviations.

	Improved safety (SAF) through detection and alerting of conflicting ATC clearances. Improved predictability (PRD) of taxi times. Improved efficiency (EFF) through provision of routes in different modes. Improved Human Performance area (HP) through a decreasing or at least maintaining ATCOs' workload.
Validation Technique	Real Time simulation
Dependent Validation Exercises	Joint analysis with EXE-06.03.02-VP-652 Close coordination with P6.9.2

Validation Exercise ID and Title	**EXE-06.03.02-VP-652: Validation of Airport Safety Nets and Enhanced ADS-B**
Leading organization	ENAV
Validation exercise objectives	Safety improvements due to a better surveillance data quality by means of enhanced ADS-B application. Situational Awareness and safety improvements by providing alerts related to: • Non-conformance to ATC procedures • Non-conformance to ATC instructions • Conflicting ATC clearances Assessment of the human performance through usability aspects of the integration and exploitation of surface safety nets functions.
Rationale	The exercise experimented the airport safety nets alerts both in terms of functionalities and of HMI aspects. The exercise aimed to validate the benefits from controllers' point of view. It also took the opportunity to validate an improved enhanced ADS-B application.
Supporting DOD / Operational Scenario / Use Case	Airport DOD Step 1-D07/Surface-In and Surface-Out
OFA addressed	• OFA01.02.01 Airport Safety Nets • OFA01.02.02 Enhanced Situational Awareness • OFA06.01.01 CWP Airport
OI steps addressed	• AO-0104-A (partially) • AO-0201-A (partially) • AO-0208-A (partially)

Enablers addressed	• AERODROME-ATC-06 • AERODROME-ATC-07 • A/C 48a • HUM-AO-0104 • CTE-S5a • CTE-S9a • CTE-S12b
Applicable Operational Context	Airport execution phase
Expected results per KPA	• Safety • Human Performance
Validation Technique	Real Time Simulation and Shadow mode
Dependent Validation Exercises	Joint analysis with EXE-06.03.02-VP-614 Close coordination with P6.9.2

Table 5: P06.03.01 Concept Overview

2.2 Summary of Validation Exercise/s

2.2.1 Summary of Expected Exercise/s outcomes

The expectations of the different stakeholders from the two exercises performed by P6.3.1 in release 3 are given in the table below.

Stakeholder	Validation Expectations	Exercise Identifier
ANSP	To validate the feasibility and usability of different safety support tools working together for controllers. To have evidence of improvements in the ATCOs' Situational Awareness due to the joint assistance of those safety support tools. To measure the improvements in Routing and Planning support given to the controllers, in terms of maintaining or increasing the current level of safety and having a higher predictability and a more stable planning. To demonstrate the feasibility of the new way of working with joint integrated safety tools and routing function in the HMI. To demonstrate the smooth integration in the CWP of the new alerts coming from those tools. To increase the ATCOs' efficiency thanks to the support provided by the integrated CWP (P6.9.2 part). To increase the ATCOs' Situational Awareness resulting in a reduction of runway incursions and restricted area infringements (P6.9.2 part).	EXE-06.03.01-VP-614, EXE-06.03.01-VP-652

Stakeholder	Validation Expectations	Exercise Identifier
Airspace Users	To have evidence of improvements in increasing the safety in their ground movements, having a higher predictability and a more stable planning.	EXE-06.03.01-VP-614, EXE-06.03.01-VP-652
Airport Operator	To have evidence of safety improvements due to the joint assistance of those safety support tools. To have evidence of a better usage of the airport resources giving more accurate and stable times. To have evidence of an increase of the safety level resulting from the reduction of the workload due to high level of usability of the integrated CWP (P6.9.2 part). To have evidence of an increase of the Situational Awareness thanks to the integration of all the information displayed on the CWP (P6.9.2 part).	EXE-06.03.01-VP-614, EXE-06.03.01-VP-652
Manufacturing Industry	To have an evidence of the technological feasibility of the concept and a clear and unambiguous description of the operational requirements. Understand the necessary connections between the systems in order to develop a meaningful integration platform to be deployed in the deployment phase. Possibility to enhance the prototypes. To get feedback on the usability of the prototype as well as on the completeness, readability and meaningfulness of the information displayed (P6.9.2 part).	EXE-06.03.01-VP-614, EXE-06.03.01-VP-652
EUROCONTROL	To improve the performance in airport operations. To consolidate the benefits that the SESAR concept will bring into those operations. To obtain a validated set of A-SMGCS requirements for future implementations.	EXE-06.03.01-VP-614, EXE-06.03.01-VP-652
SESAR JU	Same as EUROCONTROL.	EXE-06.03.01-VP-614, EXE-06.03.01-VP-652

Table 6: Stakeholders expectations

2.2.2 Benefit mechanisms investigated

The benefit mechanisms investigated by P06.03.01 exercises in Release 3 have been presented in Appendix F of D74 – 6.3.2 Release 3 Validation Plan [52]. Please refer to that document.

The benefit mechanisms investigated by P06.09.02 exercises in Release 3 have been presented in Appendix F of D112 – 6.9.2 Release 3 Validation Plan [50]. Please refer to that document.

2.2.3 Summary of the Validation Objectives and success criteria

For all exercises, the results of the scenarios were compared to the results obtained with the reference scenario (same conditions of traffic but without the exercise's operational improvements), as defined in [14].

The following sections 2.2.3.1 and 2.2.3.2 present the validation objectives and the associated success criteria per exercise as defined in [52].

2.2.3.1 Exercise 614 Validation Objectives

The validation objectives defined in Release 3 Validation Plan [52] and used for exercise 614 are listed below.

Identifier	OBJ-06.03.01-VALP-0614.0001
Objective	Assess the safety increase due to the new alerts provided to the ATCOs, working together for hazardous situations in runways, by means of: • Runway incursion • Non-conformance to ATC procedures • Non-conformance to ATC instructions • Conflicting ATC clearances.

Identifier	Success Criterion
CRT-06.03.01-VALP-0614.0101	Enhanced Situational Awareness perceived by ATCOs. • Positive feedback, considering over 75% of the answers describing the combined tools as useful or very useful/beneficial.
CRT-06.03.01-VALP-0614.0102	Smooth coexistence of the new functionalities with previous A-SMGCS Level 2 (surveillance function enabled) alerts. • Over 80% of the answers indicated that joint alerts did not lead to misunderstandings, they provided useful information and did not disturb each other.
CRT-06.03.01-VALP-0614.0103	Correct type of alert is triggered (runway hazardous situations). Confirmed by the ATCOs during the debriefings and by observation during the simulation runs.

Identifier	OBJ-06.03.01-VALP-0614.0002
Objective	Assess the safety increase due to the new alerts provided to the ATCOs, working together for hazardous situations in taxiways and apron by means of system detection of: • Area intrusion • Non-conformance to ATC procedures

	• Non-conformance to ATC instructions.

Identifier	Success Criterion
CRT-06.03.01-VALP-0614.0201	Enhanced Situational Awareness perceived by ATCOs. • Positive feedback, considering over 75% of the answers describing the combined tools as useful or very useful/beneficial.
CRT-06.03.01-VALP-0614.0202	Smooth coexistence of the new functionalities with the previous A-SMGCS Level 2 (surveillance function enabled) alerts. • Over 80% of the answers indicated that the joint alerts do not lead to misunderstandings, provide useful information and do not disturb each other.
CRT-06.03.01-VALP-0614.0203	Correct type of alert is triggered (runway hazardous situations). Confirmed by the ATCOs during the debriefings and by observation during the simulation runs.

Identifier	OBJ-06.03.01-VALP-0614.0003
Objective	Support given by the enhanced safety nets, and the routing function to the ATCOs during the execution of their tasks is positively assessed, taking into account the HMI utility and usability.

Identifier	Success Criterion
CRT-06.03.01-VALP-0614.0301	New tasks and responsibilities introduced by the combined tools in the HMI are satisfactory to the ATCOs. • Positive ATCOs' feedback, considering over 75% of the answers describing the HMI usage and usefulness as adequate or very adequate.
CRT-06.03.01-VALP-0614.0302	ATCOs' workload is reduced or unaltered compared to the reference scenario. • Positive ATCOs' feedback, considering over 75% of the answers describing the workload as acceptable or reduced.
CRT-06.03.01-VALP-0614.0303	Controllers are fully confident in the new tools outputs.

Identifier	OBJ-06.03.01-VALP-0614.0004
Objective	Assess the validity of the route provided by the Enhanced Routing and Planning function, in Automatic and Semi-automatic modes and the route edition in Manual and Semi-automatic modes.

Identifier	Success Criterion
CRT-06.03.01-VALP-0614.0401	Routes generated in Automatic and Semi-Automatic modes are feasible and useful. • Positive ATCOs' feedback, considering over 75% of the answers describing the routes as adequate or very adequate. • Number of times Automatic route is used as a first option is over 80% from the total. • Number of times Manual route is used is less than 5%, without taking into account the forced situations due to the simulation scenario.
CRT-06.03.01-VALP-0614.0402	The alternative routes proposed by the system in Automatic mode, and modified in Semi-Automatic mode are accepted by the controllers. • Positive ATCOs' feedback, considering over 75% of the answers describing the routes as adequate or very adequate.
CRT-06.03.01-VALP-0614.0403	Manual-Route edition accepted by the ATCOs. • Positive feedback from ATCOs, considering that less than 10% of the answers describing the Manual mode as very inadequate.
CRT-06.03.01-VALP-0614.0404	Enhanced predictability of taxi route times. • Standard deviation of taxi route times decreases, compared with the reference scenario.

Identifier	OBJ-06.03.01-VALP-0614.0005
Objective	Assess a map of the movement area generated by the system, where is reflected the usage category for each taxiway, in terms of movements number.

Identifier	Success Criterion

CRT-06.03.01-VALP-0614.0501	The tower supervisor easily identifies the problematic and overloaded areas or points in the movement area. • Positive feedback with over 80% of the answers considering the map information as adequate or very adequate.

Table 7: Exercise 614 Validation objectives

Additionally, P06.09.02 defined their own validation objectives related to the HMI in R3 Validation Plan [50]. They are listed below.

:Identifier	OBJ-06.02-VALS-0060.0001
Objective	Validate the integration and exploitation of new ATC functions into an A-CWP will result in an enhanced Situational Awareness for ATCOs and flight crews. Consequently validate improvements in safety nets and integration of the Tower with external units such as the TMA and the Network.

Identifier	Success Criterion
CTR-06.09.02-VALP-0001.0001	Controllers confirm that the A-CWP provides a useful support in building and retaining a reliable and accurate overall traffic picture.

Identifier	OBJ-06.09.02-VALP-0001.0001
Objective	Validate that the A-CWP supports controllers in building and retaining an overall traffic picture.

Identifier	Success Criterion
CTR-06.02-VALS-0060.0001	Expected improvements with a big and positive impact on Predictability. Improvements on Safety and Efficiency are also expected.

Identifier	OBJ-06.09.02-VALP-0001.0010
Objective	Validate that the A-CWP supports controllers in building and retaining an overall traffic picture.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0010	Controllers consider the Advanced integrated CWP as a useful support in performing recovery/contingency tasks.

Identifier	OBJ-06.09.02-VALP-0001.0020
Objective	Validate the readability and the meaningfulness of textual information displayed by the A-CWP.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0020	Controllers appreciate the meaning, font type, dimension, colour of the information displayed by the A- CWP.

Identifier	OBJ-06.09.02-VALP-0001.0030
Objective	Validate the readability and the meaningfulness of the graphical objects, symbols and visual representations in the A- CWP.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0030	Controllers appreciate symbols, objects and type displayed on the A-CWP.

Identifier	OBJ-06.09.02-VALP-0001.0040
Objective	Validate consistency and completeness of the information displayed by the A-CWP.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0040	Controllers confirm that the displayed information is coherent and complete to manage the traffic in a safe manner.

Identifier	OBJ-06.09.02-VALP-0001.0050
Objective	Validate timeliness and prioritization of the information displayed by the A-CWP.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0050	The displayed information is timely and correctly prioritised.

Identifier	OBJ-06.09.02-VALP-0001.0060
Objective	Validate the adequacy of information from the A-CWP.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0060	Controllers consider the displayed information to be adequate to perform their tasks

Identifier	OBJ-06.09.02-VALP-0001.0070
Objective	Validate the practicability and intuitiveness of commands on HMI objects.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0070	Controllers consider information finding and sorting quick, easy, practical and intuitive.

Identifier	OBJ-06.09.02-VALP-0001.0080
Objective	Validate the adequacy of feedbacks of commands / actions on HMI objects.

Identifier	Success Criterion

CRT-06.09.02-VALP-0001.0080	HMI objects provide adequate feedbacks for each controller input.

Identifier	OBJ-06.09.02-VALP-0001.0090
Objective	Validate the adequacy of number and sequence of actions on graphical objects needed to accomplish the control tasks.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0090	Controllers confirm that the number and the sequence of actions required to perform their tasks is acceptable.

Identifier	OBJ-06.09.02-VALP-0001.0100
Objective	Validate that the A-CWP supports the controller in the decision making process.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0100	Controllers confirm that the outputs and triggers provided by the different tools and displayed on the HMI support them during the decision making process.

Identifier	OBJ-06.09.02-VALP-0001.0110
Objective	To assess that the A-CWP keeps controllers workload at an acceptable level.

Identifier	Success Criterion
CRT-06.09.02-VALP-0001.0110	Controllers confirm that their workload is kept at an acceptable level.

Table 8: Exercise 614 Validation objectives from P06.09.02

2.2.3.2 Exercise 652 Validation Objectives

The validation objectives identified for EXE-06.03.02-VP-652 are listed in the following tables, together with their associated success criteria.

Identifier	OBJ-06.03.01-VALP-0652.0001
Objective	Validate improvement of the controller Situational Awareness and of the safety on the airport surface, by means of system detection of: • Surface conflict • Runway incursion • Area intrusion • Non-conformance to ATC procedures • Non-conformance to ATC instructions • Conflicting ATC clearances.

Identifier	Success Criterion
CRT-06.03.01-VALP-0652.0101	Correct type of alert is triggered. Confirmed by the ATCOs during the debriefings and by observation during the simulation runs.
CRT-06.03.01-VALP-0652.0102	False alerts are kept to an acceptable level. There should be no false alerts during the exercise. However, should there be an occurrence; it should not prevent the ATCO from continuing the exercise. Confirmed by the ATCOs during the debriefings and by observation during the simulation runs.
CRT-06.03.01-VALP-0652.0103	Answers to questionnaires and debriefings confirm that the Surface Safety nets alerts are beneficial.
CRT-06.03.01-VALP-0652.0104	Surface Safety nets alerts allow preventing unusual events in respect to the reference scenario.
CRT-06.03.01-VALP-0652.0105	System allows improving the controllers' Situational Awareness. Confirmed by the ATCOs during the debriefings and by observation during the simulation runs.

Identifier	OBJ-06.03.01-VALP-0652.0002

Objective	Validate that ADS-B surveillance data quality is enhanced by means of Enhanced ADS-B algorithms.

Identifier	Success Criterion
CRT-06.03.01-VALP-0652.0201	Data quality increase with regard to the current surveillance system by means of ADS-B application.
CRT-06.03.01-VALP-0652.0202	Controller Situational Awareness is improved.

Identifier	OBJ-06.03.01-VALP-0652.0003
Objective	The integration and exploitation of surface safety nets functions with current elements such as surveillance and Electronic Flight Strips into an Advanced Controller Working Position (A-CWP) will result in an enhanced usability and Situational Awareness for ATCOs.

Identifier	Success Criterion
CRT-06.03.01-VALP-0652.0301	Controller Situational Awareness is improved in comparison with the reference scenario.
CRT-06.03.01-VALP-0652.0302	Controller workload is reduced or unaltered in comparison with the reference scenario.
CRT-06.03.01-VALP-0652.0303	Controllers are fully confident in the new tools outputs.
CRT-06.03.01-VALP-0652.0304	Controllers considered the proposed Advanced Integrated Controller Working Position as intuitive and usable.
CRT-06.03.01-VALP-0652.0305	Controllers appreciated timeliness and prioritization of the data displayed by Surface Safety Nets.

Table 9: Exercise 652 Validation Objectives

2.2.3.3 Choice of metrics and indicators

KPA	Area	Metrics/Indicators
Safety	ATM-related Safety Outcome	Coexistence of new functionalities with previous alerts
		Situational Awareness perceived by ATCOs

KPA	Area	Metrics/Indicators
	Situational Awareness	Controllers' perceived Situational Awareness Surface Safety Nets reliability according to controllers opinion Number and type of detected alerts
	Surveillance data quality	Controllers' perceived surveillance data quality. Controllers' perceived Situational Awareness % of validation not executed/valid/not valid tracks respect to the total number of tracks Number and type of notifications
Efficiency	Route provision Outcomes	Number of automatic routes acceptance
		Number of times manual route is used (unforced situations)
		Manual route edition acceptance
		Route proposals accepted by ATCOs
Predictability	Business Trajectory Predictability	Usability of taxiway flow density map
	Taxi time accuracy/stability	Taxi route times; Average and Standard deviation
Human Performance	Human Performance Outcome	ATCO's workload
		HMI utility and usability
	Usability	Controllers' perceived efficiency, effectiveness and satisfaction in accomplishing their work

Table 10: Metrics and indicators

Regarding the validation objectives of P06.09.02, there are no specific quantitative metrics and indicators used for this validation exercise.

The analysis was performed based on a qualitative basis (human performance), collecting the opinion and assessment of the controllers who have the expertise about the real operation.

The sources of information were:

- Questionnaires;
- Debriefing Notes;
- Individual Interviews Notes;

The analysis method is described as following:

The questionnaires are analysed extracting a quantitative measure between 1 and 5 for each question. Then the average value is also obtained by taking into account all questions belonging to one specific objective. These values are converted into coloured symbols that give a visual perception of the status of the validation objective.

With the comments stated in the questionnaires, the debriefing sessions and the personal interviews, each validation objective is reassessed, adding the rationale back of the values determined with the questionnaires.

At this point, the analysis of the results shows the assessment of the requirements which have already been implemented in the platform.

2.2.4 Summary of the Validation Scenarios

2.2.4.1 Exercise 614 Validation Scenarios

The scenarios used in exercise 614 are listed below. They have been extracted from [52].

Identifier	SCN-06.03.01-VALP-0614.0001
Scenario	Reference (Non-Conformance Monitoring and Conflicting ATC Clearances alerts and Surface routing and planning function disabled)

Identifier	SCN-06.03.01-VALP-0614.0002
Scenario	Solution (Non-Conformance Monitoring and Conflicting ATC Clearances alerts and Surface routing and planning function enabled)

Table 11: Exercise 614 validation scenarios

The scenarios planned in P06.09.02 extracted from [50] are aligned with the ones from P06.03.01. Two main scenarios are respectively:

Identifier	SCN-06.09.02-VALP-0001.0001
Scenario	Reference scenario without the use of an integrated controller working position

Identifier	SCN-06.09.02-VALP-0001.0002
Scenario	Solution scenario with the use of an integrated controller working position

Table 12: Exercise 614 validation scenarios (P06.09.02)

2.2.4.2 Exercise 652 Validation Scenarios

The scenarios used in exercise 652 are listed below. They have been extracted from [52].

Identifier	SCN-06.03.02-VALP-0652.0001
Scenario	Reference

Identifier	SCN-06.03.02-VALP-0652.0002
Scenario	Reference + unusual events

Identifier	SCN-06.03.02-VALP-0652.0003
Scenario	Safety Nets + unusual events

Identifier	SCN-06.03.02-VALP-0652.0004
Scenario	ADS-B

Table 13: Exercise 652 Validation Scenarios

2.2.5 Summary of Assumptions

The assumptions valid for each exercise have been described in [52]. The following tables show a recap of them per exercise.

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-06.03.01-VP614-S1-001	RIMS available	Ground tools/Technology	Runway incursion alerts are active.	Existing tool	Airport	Safety; QoS	NA	NA	NA	Medium
ASS-06.03.01-VP614-S1-002	Airport Safety Nets considerations	Human performance	Airport Safety Nets concepts for pilots are out of scope of the exercise.	Scope of exercise	Airport	Safety; Human Performance	NA	NA	NA	Low
ASS-06.03.01-VP614-S1-003	No Data-Link	Procedures in place	Information distributed via R/T.	Scope of exercise	Airport	QoS; Interoperability	NA	NA	NA	Medium
ASS-06.03.01-VP614-S1-004	Normal guidance	Procedures in place	Guidance executed as usual, not using D-L	Scope of exercise	Airport	QoS	NA	NA	NA	Medium
ASS-06.03.01-VP614-S1-005	No Conditional Clearances	Procedures in place	See [52] section 4.1.1.2.2	ICAO recommendations	Airport	Safety	NA	NA	NA	Low
ASS-06.03.01-VP614-S1-006	Transponder usage	Ground tools/Technology	Transponder installed in vehicles crossing/entering runways	Existing tool necessary to assess certain conflicting clearances	Airport	Safety	NA	NA	NA	Medium

Table 14: Exercise 614 Validation Assumptions overview

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-06.03.01-VP652-S1-001	Malpensa TWR	Operational environment	The IBP will be prepared in order to simulate as much as possible the operational environment. The HMI developed will replicate as much as possible the functionalities currently used in Malpensa TWR operational environment. It will reflect current working methods and procedures, but enriched with the operational improvements foreseen for the next years (up to 2017). In particular, it will include Electronic Flight Strips.		Airport	N/A	N/A	N/A	N/A	N/A
ASS-06.03.01-VP652-S1-002	RIMS available	Ground tools/Technology	Runway incursion alerts are active.	Existing tool	Airport	Safety; QoS	NA	NA	NA	Medium
ASS-06.03.01-VP652-S1-003	Airport Safety Nets considerations	Human performance	Airport Safety Nets concepts for pilots are out of the scope of the exercise.	Scope of exercise	Airport	Safety; Human Performance	NA	NA	NA	Low
ASS-06.03.01-VP652-S1-004	No Data-Link	Procedures in place	Information distributed via R/T.	Scope of exercise	Airport	QoS; Interoperability	NA	NA	NA	Medium
ASS-06.03.01-VP652-S1-005	Normal guidance	Procedures in place	Guidance executed as usual, not using D-L	Scope of exercise	Airport	QoS	NA	NA	NA	Medium
ASS-06.03.01-VP652-S1-006	DMAN disabled	Ground tools/Technology	DMAN system is not operative	Existing tool	Airport	QoS	NA	NA	NA	Low
ASS-06.03.01-VP652-S1-007	Route Planner enabled	Ground tools/Technology	DMAN system is operative	Existing tool	Airport	QoS	NA	NA	NA	Medium

Table 15: Exercise 652 Validation Assumptions overview

Next assumptions applicable to the exercise 614 have been extracted from P06.09.02:

- TOBT available in the system is accurate;
- No data link is available. The ATC distribute the information via voice;
- ATFM slots are not modelled;
- No LVPs are activated.

2.2.6 Choice of methods and techniques

The following table shows a recap of the methods and techniques used in the exercises.

KPA	Area	Metrics/Indicators	Data collection method
Safety	ATM-related Safety Outcome	Coexistence of new functionalities with previous alerts	Individual questionnaires Individual interviews Human factors collection data
		Situational Awareness perceived by ATCOs	
	Situational Awareness	• Controllers' perceived Situational Awareness • Surface Safety Nets reliability according to controllers' opinion • Number and type of detected alerts	Questionnaires Debriefings Over the shoulder observations System logs
	Surveillance data quality	• Controllers' perceived surveillance data quality. • Controllers' perceived Situational Awareness • % of validation not executed/valid/not valid tracks respect to the total number of tracks • Number and type of notifications	Questionnaires Debriefings Over the shoulder observations System logs
Efficiency	Route provision Outcomes	Number of automatic routes acceptance	System Data Record
		Number of times manual route is used (unforced situations)	
		Manual route edition acceptance	Individual questionnaires Individual interviews Human factors collection data
		Route proposals accepted by ATCOs	
Predictability	Business Trajectory Predictability	Usability of taxiway flow density map	Individual interviews/ questionnaires
	Taxi time accuracy/stability	Taxi route times; Average and Standard deviation	System Data Record + post processing

KPA	Area	Metrics/Indicators	Data collection method
Human Performance	Human Performance Outcome	ATCO's workload	Individual questionnaires Individual interviews Human factors collection data
		HMI utility and usability	
	Usability	• Controllers' perceived efficiency, effectiveness and satisfaction in accomplishing their work	Questionnaires Debriefings Over the shoulder observations

Table 16: Metrics, indicators and techniques

2.2.7 Validation Exercises List and dependencies

The P06.03.01 validation exercises for Release 3 have been:

- EXE-06.03.01-VP-614 performed at Madrid-Barajas
- EXE-06.03.01-VP-652 performed at Milano-Malpensa.

Both exercises were real-time simulations and a part of the exercise 652 was a shadow mode as well.

The diagram below shows the list of scenarios per exercise. These scenarios have some differences compared with the ones initially provided in the document [52].

The exercise 614 has been performed in close coordination with P06.09.02 and despite the fact that both projects had different validation objectives, joint conclusions and recommendations have been extracted from the simulation. Section 3.3.2.2 contains the scenario deviations for exercise 614.

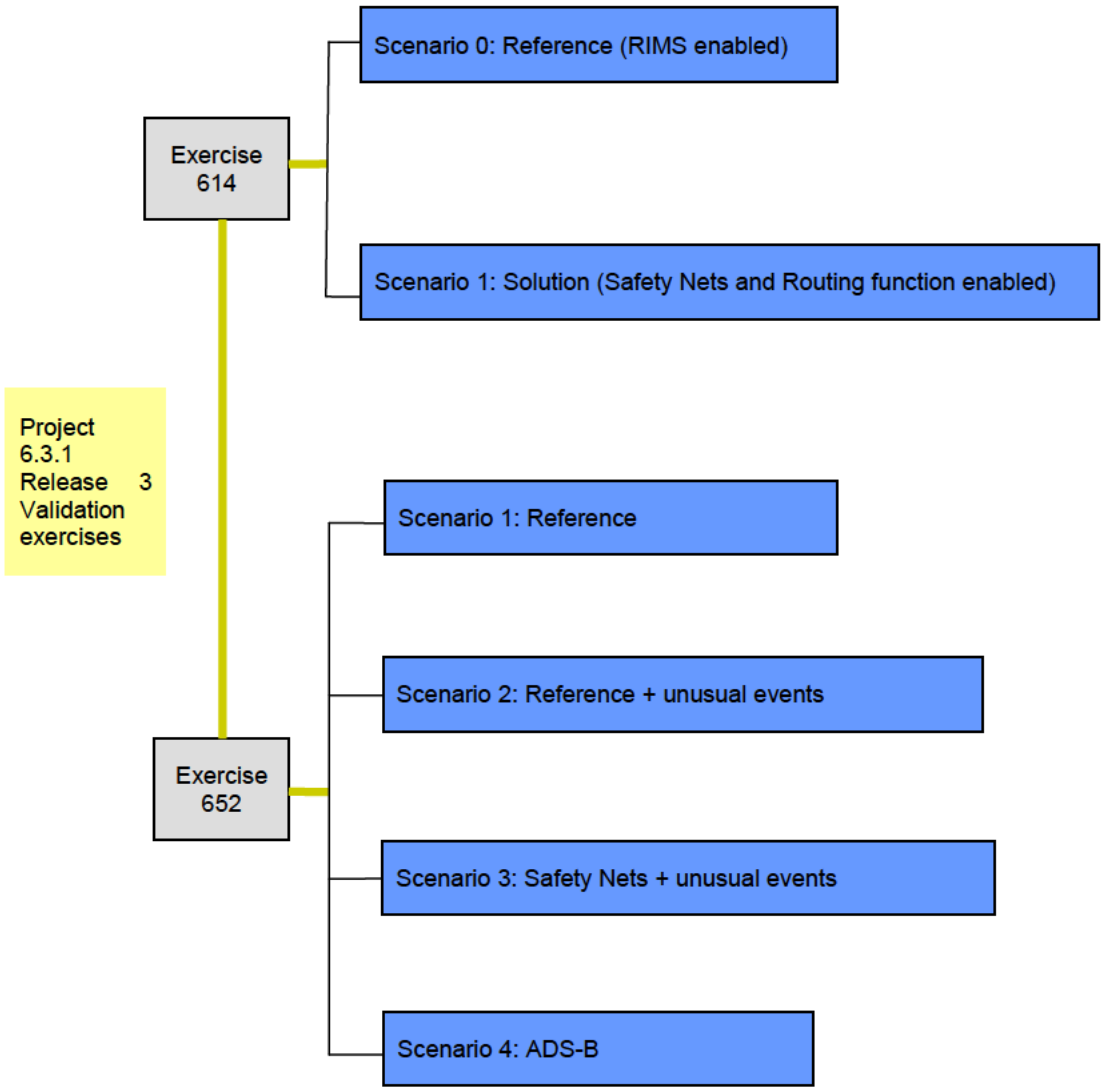


Figure 1: Validation exercises List and dependencies

3 Conduct of the Validation Exercises

This validation report concerns the three exercises conducted by project 6.3.1 in Release 3. The current section presents only a synthesis of the conduct of the exercises, the details being given in section 6.

3.1 Exercises Preparation

The exercise preparation consisted in the following activities, not necessarily performed in the order of the list:

- IBP acceptance: for each exercise, operational staff collaborated with WP03 in the definition of the user needs related to the IBP needed to be able to perform the exercise. The integration of the different prototypes in the pre-operational IBP was performed by WP03. As in release 3 there was an IBP per exercise, for each IBP, the team of the exercise concerned performed acceptance tests and wrote the availability notes following the SJU template.
- Configuration of the platform.
- Preparation of the traffic samples to be used.
- Preparation of the scenarios to be used.
- Training of the controllers, drivers and pseudo-pilots in order to familiarise them with the new system.
- Preparation and test of the data collection method: questionnaires and recording systems.

These activities are further described per exercise in section 6. For both exercises, see the parts 1.2.1 from this section.

3.2 Exercises Execution

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
Exercise 614	Operational Validation of airport safety nets in a A-CWP	27 Jan 2014	30 Jan 2014	31 Jan 2014	21 Mar 2014
Exercise 652	Validation of airport safety nets and enhanced ADS-B	25 Nov 2013	29 Nov 2013	2 Dec 2013	17 Jan 2014

Table 17: Exercises execution/analysis dates

The following experts from the International Validation Team (IVT) participated as independent observers of the exercises:

- Neven Novak, ATCEUC - IVT observer, ATCO (controller at Zagreb Airport) (EXE-06.03.01-VP614)
- Graziano Barbato, ETF – IVT observer, ATCO (controller at Naples Airport) (EXE-06.03.01-VP614)
- Peter Rix European/Cockpit Association-IVT observer, Captain (Lufthansa Pilot) (EXE-06.03.01-VP652)
- Dan Mihaescu,/IFATCA IVT- observer, ATCO (Controller at Bucarest Airport) (EXE-06.03.01-VP652)
- Ulises Martinez/ATC-EUC-IVT observer, ATCO (Controller at Valencia Airport) (EXE-06.03.01-VP652)
- Paul Vissers/European Cockpit Association- IVT trial coordinator, Captain (EasyJet Pilot) (EXE-06.03.01-VP652).

3.3 Deviations from the planned activities

3.3.1 Deviations with respect to the Validation Strategy

There was no deviation regarding the Validation Strategy.

3.3.2 Deviations with respect to the Validation Plan

The validation activities planned to be performed by exercises 614 and 652 were presented in [52].

There were no deviations from the plan for exercise 652.

For exercise 614, the deviations to the plan that occurred during the execution are detailed below.

3.3.2.1 Exercise 614 – Deviations on Operational Concept addressed

In the Validation Plan from P06.03.01 [52] a set of alerts were specified to be active during the exercise. After analysing the scenarios, it was agreed that some of the conflicting ATC clearances would not be triggered at any case. This deviation from the planning does not impact P06.09.02 as its validation plan [50] was delivered later when the scenarios had already been selected.

These alerts are:

- Line-up vs line-up clearances on opposite runway;
- Line-up vs cross or enter Line-up vs take off on opposite runway;
- Line-up vs land on same or opposite runway;
- Line-up vs take-off on opposite runway;
- Cross vs Cross or Enter;
- Take-off vs take-off on opposite or crossing runways;

- Take-off vs land same, opposite or crossing runways;
- Land vs land on opposite or crossing runways;

Take-off or landing from opposite runways is only feasible in Madrid Barajas after a configuration change, when departure runways start to be used for arrivals and vice versa. As a change from North configuration to South configuration was not going to be tested, these alerts had no sense in the selected scenario.

Cross runway alerts were neither considered since Madrid-Barajas has no crossing points.

Although controllers were instructed not to use any conditional clearances, they were issued because controllers are used to them. Observers' reports and controllers' comments in debriefings confirmed that point. This was especially important for runway controllers, since they gave certain conditional clearances for line-up and an alert was triggered.

3.3.2.2 Exercise 614 – Deviations on Scenarios

In P06.03.01 Validation Plan [52] the initial proposal of areas of responsibility under evaluation consisted of two ground controller areas (Central and East) and one runway controller area only for departures. The other areas were not under evaluation and were considered as feeders. Finally, the scenario had three ground controller and two runway controllers, as specified in P06.09.02 Validation Plan [50].

The initial proposal consisted of 13 runs, 3 for the reference scenario and 10 for the solution scenario. Finally the runs were reduced to 7, 2 for the reference and 5 for the solution.

A variation of workload was planned, expressed by means of number of operations per hour, but during the validation all the runs were performed with the same workload (28 departures and 28 arrivals).

3.3.2.3 Exercise 614 – Deviations on Alerts

The first day that all the SESAR functionalities were enabled, controllers indicated a loss of Situational Awareness related to some alerts that were triggered continuously. This entailed that some alerts were modified or switched off the following days. These alerts were:

- No landing (NLND) when there is a miss approach or go around manoeuvre;
- Route deviation (RDEV) information alert when the aircraft has exceed the cleared route;
- No taxi (NTAX) information alert after vacating the runway on the exit taxiway;
- A Runway Incursion alert (ALM) There is an aircraft landing and an aircraft/vehicle is approaching the RPA;
- Stationary (STAT) after Line-up clearance and Stationary after take-off clearance.

4 Exercises Results

4.1 Summary of Exercises Results

As explained in the previous sections, two exercises were conducted in the frame of P06.03.01 in Release 3, on two different airports: Milano-Malpensa and Madrid-Barajas. These airports are classified as shown in the following table extracted from [34] (airports underlined in bold).

Parameter Values	Intercontinental Hub	European Hub	Primary Node	Secondary Node	Tertiary Node	General / Business Aviation	Military Aerodrome
Multiple Ind runways, complex Surface Layout	**MAD**, FCO,	PMI					
Multiple Dep. Runways, Complex Surface Layout	LHR, CDG, AMS, FRA, ZRH,	CPH, HEL, VIE, BRU, **MXP**, BCN, ORY, ARN	BUD, DUS, LIS, TXL, PRG, LYS	SXF, CGN		RKE, LBG	
Single Runway, Complex Surface Layout	LGW		WAW, OPO, LIS	LTN, LBA, FNC, LCY, OPO			
Multiple Ind runways, non-complex Surface Layout	MUC	OSL	ATH				
Multiple Dep. Runways, non-complex Surface Layout			HAM	HAJ, LEJ			
Single Runway, non-complex Surface Layout			STN, STR, VLC	NUE, GOT, BGY, CIA, SOF, BUH, LUX, CRL, HHN, LIN	DTM, AAR, RTM, GRO, BRE, DRS, LJU	BRN, FAB, QEF	EIN, TOJ

Table 18: Airport classification

The difference in the classification leads to some differences between the results obtained for the same function according to the airport. These different results prevent from regrouping all the outputs obtained by the exercises. Where possible, a consolidation of the results has been made and is presented in the current section. Otherwise, the results are presented per airport, in section 6.

In addition, the two exercises did not evaluate all the same functions. It has to be considered that some functions were evaluated only by one exercise. They are:

- A-SMGCS routing function evaluated by exercise 614.
- Enhanced ADS-B evaluated by exercise 652.

The rest of the functions were performed by both exercises, but the results are not always the same. The reasons that can be given for these differences are:

- The difference in airport classification.

- Malpensa and Barajas layouts are very different and, as a consequence, the ways of working of controllers as well.

- The controllers who participated in the exercises did not have the same profile. At Barajas, there was a mix of controllers from the airport and some coming from other airports. At Malpensa, the controllers were from Milano Malpensa and Rome Fiumicino airports.

The summary per exercise is presented in the following table:

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
Exercise 614 (06.03.01 part)	OBJ-06.03.01-VALP-0614.0001	Validate the safety improvements for runways.	CRT-06.03.01-VALP-0614.0101	Enhanced Situational Awareness perceived by ATCOs. • Positive feedback, considering over 75% of the answers describing the combined tools as useful or very useful/beneficial	**Success criterion not achieved** Qualitative assessment: The major part of ATCOs' feedback highlights the fact that the new tools do not increase Situational Awareness - 2 out of 4 questions with over 75% of positive feedback from runway controllers - even if the general feedback was positive.	NOK
			CRT-06.03.01-VALP-0614.0102	Smooth coexistence of new functionalities with previous A-SMGCS Level 2 (surveillance function enabled) alerts. • Over 80% of the answers indicate that joint alerts do not lead to misunderstandings, provide useful information and do not disturb each other	**Success criterion not achieved** Qualitative assessment: Controllers considered it easy to identify mobiles involved in conflicting situations from the rest of the traffic (95% of answers considered it easy or very easy). There were 52% of answers considering that different types of alerts sometimes misled the controllers, this assessment is based mainly on traffics assumed in other positions.	
			CRT-06.03.01-VALP-0614.0103	Correct type of alert is triggered (runway hazardous situations). • Confirmed by the ATCOs during debriefing and observation during the simulation runs	**Success criterion achieved** Qualitative assessment: ATCOs considered the alert type, priority and time of mobiles involved as adequate. Some alert parameters were modified during simulation as a result of controllers' comments.	
	OBJ-06.03.01-VALP-0614.0002	Validate the safety improvements for taxiways/apron.	CRT-06.03.01-VALP-0614.0201	Enhanced Situational Awareness perceived by ATCOs. • Positive feedback, considering over 75% of the answers describing the combined tools as useful or very useful/beneficial	**Success criterion not achieved** Qualitative assessment: The major part of ATCOs' feedback highlights the fact that the new tools do not increase Situational Awareness (2 out of 4 questions with over 70% of positive feedback from ground controllers) even if the general feedback was positive.	NOK
			CRT-06.03.01-VALP-0614.0202	Smooth coexistence of new functionalities with previous A-SMGCS Level 2 (surveillance function enabled) alerts. • Over 80% of the answers indicate that	**Success criterion not achieved** Qualitative assessment: Controllers considered it easy to identify mobiles involved in conflicting situations from the rest of the traffic (95% of answers	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				joint alerts do not lead to misunderstandings, provide useful information and do not disturb each other	considered it easy or very easy). There were 52% of answers considering that different types of alerts sometimes misled the controllers, this assessment is based mainly on traffics assumed in other positions.	
			CRT-06.03.01-VALP-0614.0203	Correct type of alert is triggered. • Confirmed by the ATCOs during debriefing and observation during the simulation runs	**Success criterion achieved** Qualitative assessment: ATCOs considered the alert type, priority and time of mobiles involved as adequate. Nevertheless, some alert parameters were modified during simulation as a result of controllers' comments.	
	OBJ-06.03.01-VALP-0614.0003	Validate the tools adaptation to the ATCOs' procedures.	CRT-06.03.01-VALP-614.0301	New tasks and responsibilities introduced by the combined tools in the HMI are satisfactory to the ATCOs. • Positive ATCOs' feedback, considering over 75% of the answers describing HMI usage and usefulness as adequate or very adequate	**Success criterion not achieved** Qualitative assessment: ATCOs assessed the new tools irregularly. The support provided was considered with the 56% of answers as quite beneficial or very beneficial and the easiness of usage was reported with the 80% of answers as easy or very easy.	NOK
			CRT-06.03.01-VALP-0614.0302	ATCOs' workload is reduced or unaltered compared to the reference scenario. • Positive ATCOs' feedback, considering over 75% of the answers describing the workload as acceptable or reduced	**Success criterion not achieved** Qualitative assessment: ATCOs assessed the new tools irregularly. 72% of answers considered the workload associated as acceptable, with barely any significant effect or even improved compared with current TWR workload. Nevertheless, the workload worsened compared with the reference scenario and the ATCOs' feedback reported that new tools increased their workload.	
			CRT-06.03.01-VALP-0401.0303	Controllers are fully confident in new tools outputs.	**Success criterion not achieved** Qualitative assessment: ATCOs reported the information provided by the SSN and Routing function as correct with a 64% and a 45% of answers respectively. It should be noted the high percentage of answers I don't know (36% and 40%)	
	OBJ-06.03.01-	Validate the suitability of	CRT-06.03.01-	Routes generated in Automatic and Semi-	**Success criterion not achieved**	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
	VALP-0614.0004	the updated Surface Routing and Planning function.	VALP-0614.0401	Automatic modes are feasible and useful. • Positive ATCOs' feedback, considering over 75% of the answers describing the routes as adequate or very adequate • Number of times Automatic route is used as first option is over 80% from the total • Number of times Manual route is used is less than 5%, without taking into account forced situations due to the simulation scenario	Quantitative assessment: Routes proposed as first option were positively assessed, with a score of 2.8 out of 4 (70%). Nevertheless, this value is less than the limit established for the success criteria. **Success criterion not achieved** Quantitative assessment: System recordings indicate up to a 74% of times in the average along all the runs that controllers accepted the initial proposed route. **Success criterion achieved** Quantitative assessment: System recordings indicate up to a 2% of times in the average along all the runs that controllers modified the route entering the whole path.	
			CRT-06.03.01-VALP-0614.0402	The alternative routes proposed by the system in Automatic mode, and modified in Semi-Automatic mode are accepted by the controllers. • Positive ATCOs' feedback, considering over 75% of the answers describing the routes as adequate or very adequate	**Success criterion partially achieved** Qualitative assessment: The edition panel of routes opened by the controllers led to new alternative routes reported as adequate or very adequate with a 78% of answers. Likewise, the graphic map was reported with a 89% of answers considering the tool as intuitive or very intuitive. The 3 routes proposed by default as alternative options were assessed with the 65% of answers as adequate or very adequate.	
			CRT-06.03.01-VALP-0614.0403	Manual Route edition accepted by the ATCOs. • Positive ATCOs' feedback, considering less than 10% of the answers describing the Manual mode as very inadequate	**Success criterion achieved** Qualitative assessment: Graphic map edition was assessed by controllers up to 3.2 up to 4 (80%) and there was no answer considering it as not intuitive at all; 89% of answers considered the editor as quite or very intuitive. Route edition panel was assessed by controllers up to 2.9 out to 4 (72%) and there was no answer considering it as not adequate at all; 78% of answers considered the panel as adequate or very adequate.	
			CRT-06.03.01-	Enhanced predictability of taxi route times.	**Success criterion partially achieved**	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
			VALP-0614.0404	• Standard deviation of taxi route times decreases, compared with the reference scenario.	Quantitative assessment: Standard deviation decreases for outbound flights from 4.4 to 4.3, but increases for inbound flights from 4.8 to 5.2.	
	OBJ-06.03.01-VALP-0614.0005	Validate the usability and utility of the "taxiway usage map".	CRT-06.03.01-VALP-0614.0501	The tower supervisor easily identifies problematic and overloaded areas or point in the movement area. • Positive feedback with over 80% of the answers considering the map information as adequate or very adequate	**Success criterion achieved** Qualitative assessment: The airport metric map of overloaded areas was assessed as easy to understand. Nevertheless it should be noted that the supervisor considered the information useful for the post-operation phase but not during the execution phase. The tool was presented only to 2 controllers who have supervisor profile; no percentage is provided.	OK
Exercise 614 (06.09.02 part)	OBJ-06.09.02-VALP-0001.0001	Building of reliable traffic picture	CRT-06.09.02-VALP-0001.0001	Controllers confirm that the A- CWP provides an useful support in building and retaining a reliable and accurate overall traffic picture	**Success criterion achieved** Controllers confirmed that the A-CWP proved useful to build and retain an overall traffic picture. Average score 4.0.	OK
	OBJ-06.09.02-VALP-0001.0010	Validate that the A-CWP supports controllers in case of recovery/contingency situations	CRT-06.09.02-VALP-0001.0010	Controllers consider the Advanced integrated CWP as an useful support in performing recovery/contingency tasks	Not Evaluated. No contingency was simulated	
	OBJ-06.09.02-VALP-0001.0020	Readability and meaningfulness of displayed textual information	CRT-06.09.02-VALP-0001.0020	Controllers appreciate meaning, fonts type, dimension, colour of the information displayed by the A-CWP	**Success criterion not achieved** Font's type, dimension and colour OK. The meaning of the textual information was not easily identified. Average score 3.4.	NOK
	OBJ-06.09.02-VALP-0001.0030	Readability and meaningfulness of displayed graphical objects and symbols	CRT-06.09.02-VALP-0001.0030	Controllers appreciate symbols, objects and type displayed on the A- CWP	**Success criterion achieved** Graphical objects and symbols were easily identified by the controllers. Average score 3.6.	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
	OBJ-06.09.02-VALP-0001.0040	Consistency and completeness of the displayed information	CRT-06.09.02-VALP-0001.0040	Controllers confirm that the displayed information are coherent and complete to manage the traffic in a safe manner	**Success criterion not achieved** The way information was displayed didn't help to manage the traffic in a safe manner. The information was complete and coherent. Average score 3.1.	NOK
	OBJ-06.09.02-VALP-0001.0050	Timeliness and prioritization of the displayed information	CRT-06.09.02-VALP-0001.0050	The displayed information is timely and correctly prioritised	**Success criterion achieved** The HMI presented the information in the adequate moment. Average score 3.6.	OK
	OBJ-06.09.02-VALP-0001.0060	Adequacy of information	CRT-06.09.02-VALP-0001.0060	Controllers consider the displayed information to be adequate to perform their tasks	**Success criterion achieved** Average score 3.7.	OK
	OBJ-06.09.02-VALP-0001.0070	Practicability and intuitiveness of commands	CRT-06.09.02-VALP-0001.0070	Controllers consider information finding and sorting quick, easy, practical and intuitive	**Success criterion achieved** Average score 3.7.	OK
	OBJ-06.09.02-VALP-0001.0080	Adequate HMI feedbacks	CRT-06.09.02-VALP-0001.0080	HMI objects provide adequate feedbacks for each controller input	**Success criterion achieved** Average score 3.6.	OK
	OBJ-06.09.02-VALP-0001.0090	Number and sequence of actions required to accomplish control tasks	CRT-06.09.02-VALP-0001.0090	Controllers confirm that the number and the sequence of actions required to perform their tasks is acceptable.	**Success criterion not achieved** Average score 3.2.	NOK
	OBJ-06.09.02-VALP-0001.0100	Controllers effort in the decision making process	CRT-06.09.02-VALP-0001.0100	Controllers confirm that the outputs and triggers provided by the different tools and displayed on the HMI support them during the decision making process.	**Success criterion achieved** Average score 3.5.	OK
	OBJ-06.09.02-	Controllers workload	CRT-06.09.02-	Controllers confirm that their workload is	**Success criterion not achieved**	NOK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
	VALP-0001.0110		VALP-0001.0110	kept at an acceptable level	Average score 3.2.	
Exercise 652	OBJ-06.03.01-VALP-0652.0001	Surface Safety Nets	CRT-06.03.01-VALP-0652.0101	Correct type of alert is triggered. Confirmed by the ATCOs during debriefing and observation during the simulation runs.	**Success criterion achieved** Correct type of alert was triggered even if new type of safety net could be implemented and some of them could be enhanced.	OK
			CRT-06.03.01-VALP-0652.0102	False alerts are kept to an acceptable level. There should be no false alerts during the exercise. However, should there be an occurrence; it should not prevent the ATCO from continuing the exercise. Confirmed by the ATCOs during debriefing and observation during the simulation runs.	**Success criterion achieved** False alerts occurred but they were kept to an acceptable level that did not prevent the ATCO from continuing the exercise. It should be noted that the major part of false alerts were linked to threshold to be well tuned for future implementations.	
			CRT-06.03.01-VALP-0652.0103	Answers to questionnaires and debriefings confirm that the Surface Safety Nets alerts are beneficial.	**Success criterion achieved**	
			CRT-06.03.01-VALP-0652.0104	Surface Safety Nets alerts allow preventing unusual events in respect to reference scenario.	**Success criterion partially achieved** In general, ATCOs confirmed that SSN helped them respect to reference scenario where no SSN were used especially in case of adverse weather condition where they are not supported by aerodrome view. Even if, for particular SSNs type, it could be better to have a "preventing" advice that warns them to not give a wrong clearance in order to not warn/alert them when a clearance has been already given.	
			CRT-06.03.01-VALP-0652.0105	System allows improving controllers' Situational Awareness. Confirmed by the ATCOs during debriefing and observation during the simulation runs.	**Success criterion achieved** In general, the use of SSN allows improving SA.	
	OBJ-06.03.01-	ADS-B	CRT-06.03.01-	Data quality increase with regards to the current surveillance system by means of	**Success criterion achieved**	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
	VALP-0652.0002		VALP-0652.0201	ADS-B application.	Since scenario reference 1 and solution 4 were compared, ATCOs effectively noticed a data quality increase by means of ADS-B application with regards to the current surveillance system. Confronting the type of data regarding the state of validation (i.e. valid, not valid, validation not executed) it has been possible to demonstrate that not valid data were excluded from the system improving data quality.	
			CRT-06.03.01-VALP-0652.0202	Controller Situational Awareness is improved.	**Success criterion achieved** ATCOs asserted ADS-B is useful to improve their Situational Awareness especially in case of low visibility conditions.	
	OBJ-06.03.01-VALP-0652.0003	Advanced Controller Working Position (A-CWP)	CRT-06.03.01-VALP-0652.0301	Controller Situational Awareness is improved in comparison with reference scenario.	**Success criterion achieved** Globally the Situational Awareness in solution scenario was higher than in the reference one.	OK
			CRT-06.03.01-VALP-0652.0302	Controller workload is reduced or unaltered in comparison with reference scenario.	**Success criterion achieved** Globally the workload in solution scenario was lower than in the reference.	
			CRT-06.03.01-VALP-0652.0303	Controllers are fully confident in new tools outputs.	**Success criterion achieved** Controllers were confident in new tools outputs.	
			CRT-06.03.01-VALP-0652.0304	Controllers considered the proposed Advanced Integrated Controller Working Position as intuitive and usable.	**Success criterion achieved** Controllers considered the proposed Advanced Integrated Controller Working Position quite intuitive and usable.	
			CRT-06.03.01-VALP-0652.0305	Controllers appreciated timeliness and prioritization of data displayed by Surface Safety Nets.	**Success criterion partially achieved** Controllers in general appreciated timeliness and prioritization of data displayed by Surface Safety	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					Nets. Nevertheless, they gave some suggestions to improve them. ATCOs asserted that thresholds of alarm / information alerts need to be tuned better in order to avoid some unwanted alerts. Moreover, especially for conflicting clearances safety nets, they would prefer a more preventing function in the sense to have a preventing advice that warns them not to give a wrong clearance instead of having an information alert that alerts after they give a clearance.	

Table 19: Summary of Validation Exercise Results

4.1.1 Results on concept clarification

In all exercises, the controllers appreciated the new functions and related HMI solutions, but they all criticised the display of all alerts on all the positions.

4.1.2 Results per KPA

Both exercises focused on the following common KPAs/TA:

- Human Performance
- Safety

The following sections present the main results per KPAs/TA.

For the results particular to one exercise only, please refer to section 6.

4.1.2.1 Human Performance

Human Performance transversal area was assessed through controllers' workload and tools utility and usability.

At Malpensa airport, controllers appreciated the new functions and related HMI solutions, but they all concluded for a need to reduce manual, schematic and complex operations and would prefer to filter alerts per controller working position.

Barajas controllers had an inconsistent assessment as all of them appreciated the new tools utilities but they considered there is room for improvements, especially in the display of alerts and in the support provided by the routing. Regarding the workload, although it remained within acceptable limits during the simulation it worsened compared with the reference scenario. Despite all of these considerations, the new functionalities had, in general, a good impact on this transversal area from the HMI point of view.

4.1.2.2 Safety

Safety KPA was assessed through Situational Awareness and provision of information.

Safety was improved at Malpensa airport by means of a better Situational Awareness on the airport surface due to the combination of the different Safety Nets with enhanced ADS-B. The provision of information was also evaluated as very useful.

Barajas controllers reported the provision of information as very positive, about the identification of mobile involved in conflicting situations. Some problems appeared with misleading alerts, mainly due to non-conformance monitoring alerts related with the routing functionality and with the amount of alerts displayed even if they were not in that area of responsibility. Due to this, it was also concluded that Situational Awareness was not increased even if there was a general positive feedback.

4.1.3 Results impacting regulation and standardisation initiatives

The Surface Safety Nets tool, strictly related to safety aspects and notifying about short-term critical situations, should be appropriately standardized. Moreover, as controllers will always be ultimately responsible for the conflict resolution, they should be adequately trained about the behaviour to follow in case of alert.

4.2 Analysis of Exercises Results

4.2.1 Unexpected Behaviours/Results

For unexpected behaviours or results experienced during one exercise, please refer to section 6 of the document.

4.3 Confidence in Results of Validation Exercises

4.3.1 Quality of Validation Exercises Results

The exercise results are based on different validation means to collect all the qualitative and quantitative data:

- Controllers' subjective opinions (qualitative data) on the concept collected by means of questionnaires and debriefings
- Feedback provided by controllers (qualitative data) through personal interviews
- Observation collected (qualitative data) by different observers who attended to the simulation runs
- Objective data collected by means of system recording (quantitative data).

The combination of all these techniques ensures the correctness and reliability of the results obtained.

The execution of the exercise in different airports, involving different controller leads to high quality of results, in particular for those that are similar between the exercises.

4.3.2 Significance of Validation Exercises Results

The techniques used in these exercises, real time simulation and shadow mode, are suitable to test mature concepts allowing to put the end-user in a realistic operational environment, representative of the operational and technical constraints and interfaces. These techniques obtain results with a very high precision and provide a high confident feedback on the applicability of the operational concept under test.

The drawbacks of these techniques are the limited capability for performance assessment (due to the limited number of runs, no statistical analysis is possible) and the local contexts where the proposed solutions are analysed. These drawbacks have been partially mitigated in the project thanks to the application of the concepts in two different airports, each one with operational significance with regard to the concepts addressed.

However, the number of experimental runs and participants were considered as not large enough to perform statistical tests. Where applicable the mean of the subjective measurements was calculated in order to show tendencies.

Significant effort was spent to ensure that the simulations would seem realistic to the controllers involved. For further data about the realism of the simulations, refer to sections 6.1.3.3 and 6.2.3.3.

5 Conclusions and recommendations

5.1 Conclusions

The main conclusions that can be drawn from the two exercises are given in the table below, per OI step. The results from one exercise only can be found in section 6.

Operational concept	Main results	Aspects to be better investigated
Surface Safety Nets	• Concept suitable for TWR environment. • Controllers appreciated the operational concept. • Controllers admitted that Conflicting Clearances, taking into account controllers' possible errors, enhanced the global level of safety. • Controllers asserted that the tool has generated mainly real alerts and provided benefits in terms of safety, especially increasing Situational Awareness in low visibility conditions.	• Surface Safety Nets HMI to be improved in order to have a filtering of alerts per controller working position. • The need of a new option in the CWP to indicate conditional clearances. • Surface Safety Nets need further tuning actions to better satisfy controllers' expectations and needs. • Controllers asserted that other kinds of alarm/information alerts (especially for Conflicting Clearance SSN) should be defined and implemented in order to cover all possible situations and so to assure a good level of safety. • Controllers asserted that some SSNs, especially ATC Conflicting Clearances, should improve their "preventing" function in order to further enhance safety level. • Controllers indicated that the priority of alert was quite correct, but it needs further investigation.
A-CWP	• The new HMI functionalities are considered beneficial for the TWR environment but they suggested some additional refinement e.g. reducing the number of actions to enter information in the system. • Alerts displayed to a controller should be relevant to their operational responsibilities (alerts useful for his/her work and not far from the AoR and easily differentiable between them).	• Confirm the alerts that each controllers' position want to see and if only alarm/information alerts related to flights under the own control should be displayed on a controller's HMI. • Investigate other command options to be implemented, like a preventing feature for alerts before they are triggered and other options for local implementation. • Need to reduce schematic and complex operations by means of minimising the number of manual inputs to the HMI required to perform a task. • Investigate the trade-off between acronyms and full names for alerts to be displayed to the controllers.

Table 20: P06.03.01 Release 3 exercises main results

5.2 Recommendations

The recommendations common to the two exercises are given in this section. They concern only the Surface Safety Nets (5.2.1) and the controller interface (5.2.2).

Section 5.2.3 will present all the recommendations indicating if current version of the OSEDs already takes them into account or if an update is necessary.

The following sections take also into account the outputs of the workshop that took place on 8th April 2014 about the results of the two exercises.

5.2.1 Recommendations regarding the Surface Safety Nets

The main recommendations on Surface Safety Nets are

- The triggering threshold of the alerts, in terms of the values of the parameters which trigger the alert (times and/or distances to a specific point or another mobile), must be finely tuned to avoid unnecessary alerts that would overload the controllers.
- The prioritisation of the alerts needs to be further investigated.
- The preventing feature of SSN conflicting clearances must be improved in the sense to have a preventing advice that warns them not to give a wrong clearance.
- Cases specific to each airport must be carefully considered prior to local implementation.
- The requirement aircraft taxiing with high speed should be amended to exclude the rapid exit taxiway.

5.2.2 Recommendations regarding the A-CWP

The main recommendations on HMI are:

- When acronyms are used, they should be as similar as possible to the ones used in the aeronautical domain.
- The alerts displayed on a CWP must only be the ones relevant to that controller position.
- The number of manual inputs required to perform a specific task must be minimised in order to avoid a schematic utilization of HMI and to decrease the controller workload.

5.2.3 Recommendations from Release 3 exercises versus current version of the OSEDs

The exercises were based on the OSEDs available at the time when the Validation Plan ([52]) was produced. Between that time and the current Validation Report, the OSEDs used have been amended and some of the recommendations given in sections 5.2.1, 5.2.2, 6.1.4.2 and 6.2.4.2 have already been taken into account.

Table 21 gathers all the recommendations in the sections previous mentioned. The last column indicates whether the recommendation has been already taken into account or not in the current version of the OSED ([59]).

Not all the recommendations included in the current OSED version have been translated to the operational requirements. A recommendation has been considered as covered if it appears in the OSED ([59]), nevertheless it is

recommended to review the operational requirements of the document to ensure the traceability.

The routing recommendations (and the HMI recommendations related with the Routing and Planning function) have been checked against the corresponding OSED ([60]) for P06.07.02. Following the same criteria as Safety Nets, a recommendation has been considered as covered if it appears in its OSED.

Recommendations common to both exercises	**Safety Nets**	The triggering threshold of the alerts must be finely tuned to avoid unnecessary alerts that would overload the controllers.	**Covered** in last version of OSED
		The prioritisation of the alerts needs to be further investigated.	**Covered** in last version of OSED
		The preventing feature of SSN conflicting clearances must be improved.	**Covered** in last version of OSED
		Cases specific to each airport must be carefully considered prior to local implementation.	**Covered** in last version of OSED
		The triggering condition related to the “aircraft taxiing with high speed” alert should be amended to exclude the rapid exit taxiway.	**Covered** in last version of OSED
	Airport Controller Working Position	The use of acronyms to characterise the alerts should be preferred and use of full names should be minimized when possible. When acronyms are used, they should be as similar as possible to the ones used in the aeronautical domain.	**Not Covered** The new OSED does not provide information about acronyms.
		The alerts displayed on a CWP must only be the ones relevant to that controller position.	**Partially Covered** The new OSED contains this concept but it does not analyse it alert by alert.
		The number of manual inputs required to perform a specific task must be minimised in order to avoid a schematic utilization of HMI and to decrease the controller workload.	**Covered** in last version of OSED
Recommendations from Exercise 614	**Surface Safety Nets**	The triggering condition related to the "no taxi clearance" information alert should be modified to exclude the arrival aircraft on taxiways vacating the runway.	**Not Covered**
		The cancellation condition related to the "no landing" alert should be amended to include that, if the	**Partially Covered**

		aircraft is labelled as "miss approach" or "go around", the "no landing" alert should not be triggered or cancelled if the alert is triggered first.	The concept in the new OSED still has not included the “miss approach” procedure
		The cancellation condition related to the "no take-off clearance" alert should be amended to exclude aborted take-offs.	**Covered** in last version of OSED
		The severity condition related to the "taxi route deviation" alert should be amended to have a information alert only when the aircraft deviated from the assigned route, not from the cleared route if this is coherent with the operational procedure if the airport.	**Covered** in last version of OSED Covered by the “no taxi approval” instruction
		If a runway has a displaced threshold, the RPA may be defined in the AIP accordingly without covering the whole runway. Nevertheless, controllers may expect that an alert is always triggered when a vehicle enters a runway. This should be clarified when defining parameters of the alerts.	**Not Covered**
	Routing and planning function	If needed by the mode of operation, the routing modification and clearances should be able to be issued for other areas of responsibility.	**Partially covered** Section 4.2.1.1 REQ-06.07.02-OSED-RGGE.0009 considers modification of planned routes under ATCOs coordination. REQ-06.07.02-OSED-RGGE.0010 considers route validation only in the own AoR.
		The function should allow the modification of the route even if during its edition the aircraft has moved to a new taxiway segment and the initial point of the route differs from the original one.	**Partially Covered** REQ-06.07.02-OSED-RGIN.0001 indicates that the

			routing function used the surveillance data (for aircraft position) as an input, but does not indicate anything if the aircraft has moved during the edition period.
		Need of higher flexibility at the beginning of the route, related to the pushback direction. The default route may need to include a short taxi in non-nominal direction.	**Covered**
	Airport Controller Working Position	After a route modification, only the modified part should be highlighted (instead of the whole route). And this highlight should be only shown on the position of the controllers affected by the change.	**Not Covered**
		Remaining taxi time shall not be displayed in the label. The same applies to any information reported as unnecessary by the controllers. The A-CWP HMI shall be configurable to the point of allowing different information configurations for each airport and position implementation.	**Not Covered** There is no requirement in the OSED related to labels.
		Textual routing information should be kept to a minimum with only meaningful parts.	**Not Covered** There is no requirement regarding textual display of the routing
		Routing and Planning Function should allow the controllers to see the routes of more than one mobile at the same time	**Covered** REQ-06.07.02-OSED-RGHM.0016 has this recommendation implicit when it indicates that in case of intersecting routes the last one

			interacted with shall be on top.
Recommendations from Exercise 652	**Surface Safety Nets**	Adjust the tool by making a control on altitude variable in order to improve some Surface Safety Nets (e.g. RUINC, Speed limit on Taxiways).	**Not Covered** in last version of OSED since it is a recommendation for further refinement in system prototypes.
		Enrich the conflicting clearances Surface Safety Net tool by integrating or introducing as much as possible controllers' source of error (e.g. LINE-UP AND WAIT BEHIND, TAKE OFF AFTER, LANDING AFTER, CROSS/LINE-UP, CROSS/TAKE-OFF, CROSS/LANDING, TAKE-OFF/LANDING).	**Covered** in last version of OSED fro crossing CATC. **Not Covered** in last version of OSED for conditional clearances.
	Advanced Controller Working Position	In case of closed taxiway and runway, consider contrasting colours for taxiways, runways and aircraft.	**Not Covered** in last version of OSED.

Table 21: Summary of the recommendations of P6.3.1 release 3 exercises

6 Validation Exercises reports

6.1 Exercise 614 Validation Report

This section provides detailed information about the exercise in terms of execution and related results.

6.1.1 Exercise Scope

EXE-06.03.01-VP-614 was a real time simulation related to the validation of Surface Safety Nets and Routing and Planning function in an Advanced Controller Position, A-CWP. Reference and Solution scenarios were simulated to cover the validation objectives proposed in the P06.03.01 Validation Plan [52]

P06.09.02 analysed the HMI integration of the different functionalities, as indicated in the P06.09.02 Validation Plan [50].

The exercise took place in Madrid at AENA HQ Pre-operational IBP, TWR segment, from 27th to 30th of January 2014.

6.1.2 Conduct of Validation Exercise

6.1.2.1 Exercise Preparation

Preparation steps for the Exercise 614 were:

- High level definition of exercise including selection of functionalities available in the prototype, traffic samples, validation scenarios, special events, etc
- Updating of the V&V platform
- Prototype testing/acceptance
- Writing of the availability notes document
- Preparation of the exercise. This activity includes, amongst other:
    - Definition of physical scenario
    - Adaptation of the traffic
    - Definition of the data gathering methods
- Preparation of the training material including presentations, user manual and training scenarios.
- Selection and invitation of ATCOs to be involved as experimental subjects
- Selection and training of the pseudo-pilots
- Preparation of the site and room hosting the exercise

The configuration and testing took place15th, 16th and 17th of January. The training of the controllers and final refinements of the scenarios and platforms took place from the 22nd to the 24th of January.

During the whole week of the validations several people from different organisations where involved in different levels (as mere observers or actively participating in the simulation).

The main activities carried out during the preparation phase are collected in the following table and mapped with the staffs/actors in charge of performing them.

Staffs	Actors	Activities
Simulation Staff	• Exercise Operational Coordinator	• Managed and monitored all the activities included in the preparation process in order to ensure the execution of the exercise is in line with the validation objectives and timeline • Coordinated the selection of the Operational Staff to guarantee the ATCOs' and pseudo-pilots availability • Defined a detailed exercise planning • Coordinated the preparation of the training material and sessions.
Simulation Staff	• Experts at the concept under analysis; • Simulation Experts (RTS technique and data analysis);	• Prepared the simulation scenarios, including airspace and traffic samples. • Defined the Operations Room Layout. • Defined the ATCOs seating plan for each run. • Prepared the training material, including ATCOs' presentations, user manual and training scenarios. • Defined the material needed to collect validation results such as questionnaires and outlines of the individual interviews and debriefing sessions.
Technical Staff	• Platform experts.	• Coordinated the provision of the prototypes and their integration in the IBP according to the project requirements and schedule. • Performed the Technical Tests of the platform. • Ensured the recording of the data needed for post-analysis. • Collaborated in the training material, including ATCOs' presentations, user manual and training scenarios.
Support Operational Staff	• Air Traffic Controllers with wide experience; • Pseudo-pilots with experience in simulations.	• Supported the preparation of the simulation scenarios, including airspace and traffic samples, and validated them • Supported the definition of the ATCOs' and working methods • Performed the Operational Tests of the platform.
Operational Staff	• Air traffic Controllers executing the exercise • Pseudo-pilots	• ATCOs performed the theoretical and practical training prior to the beginning of the validation exercises. ATCOs were active Spanish airport controllers. • Pseudo-pilots performed the practical training in the use of the platform. Pseudo-pilots were licensed pilots. • Pseudo-pilots acted as vehicle drivers when necessary.

Table 22: EXE 614 - Preparatory activities

6.1.2.1.1 IBP acceptance

The IBP used to perform the validation activity was AENA HQ Pre-operational IBP, TWR segment version SACTA.TWR.R3. The IBP is a real-time validation platform with eight configurable tower working positions, a 360º visual simulator that simulates the visual view of the airport system, and a communication subsystem to simulate air-ground and ground-ground voice communications with up to 16 pseudo-pilot positions.

A description of the IBP and the evolution performed for the execution of the exercise can be found in [57].

The integration test activities performed by AENA and INDRA, to confirm that IBP was ready to begin the validation, reviewed the following services/ functions:

- Air traffic generator function
- Session Control Position function
- Flight data Processing service
- Correlated Tracks, Flight Plans and auxiliary presentation in the CWP
- Transfer and coordination functions
- 360º Visual simulator provision
- Tower CWP functions
- Simulated scenarios and exercises
- Voice Communication System (controller-controller and controller-pilot)
- Pseudo-pilot functions
- A-SMGCS including:
    - Surface Surveillance
    - SNETS – Safety Nets alerts service integrated and presented in CWP:
        - Non-conformance to ATC procedures
        - Non-conformance to ATC instructions
        - Conflicting ATC clearances
        - Runway Incursion
        - Area Intrusion
    - Surface Routing and planning function is integrated
    - Surface Routing and planning presentation in the CWP
- Recording functionality
- Analysis functions.

The IBP integration was declared as successful once all scenarios and simulation exercises were tested with technical and operational assessment. The availability notes document was produced [53].

Next figures present a general view of the simulator.

Figure 2: EXE 614 - Simulation facilities general view 1

Figure 3: EXE 614 - Simulation facilities general view 2

6.1.2.1.2 Architecture and system specifications

This section is aimed to briefly describe the prototypes used during the simulation. The operational description of the requirements implemented by the system projects come from P06.07.01 and P06.07.02.

Prototypes	Technical WP
Improved surveillance for surface management	12.03.01
Enhanced Surface Safety Nets	12.03.02
Enhanced Surface Routing	12.03.03
Enhanced Controller Tools to manage all aspects of 4D trajectories	12.05.03
Controller Working Position	12.05.04
Performance Based, Monitoring and Decision Support within the HMI of the A-CWP	12.05.07

Table 23: EXE 614 - Prototypes

The exercise and the prototypes used seek validating part of the A-SMGCS system, specifically, the surface safety nets defined in SESAR together with surveillance and routing functions and their presentation to the controller.

6.1.2.1.2.1 Improved Surveillance for Surface Management

Project 12.03.01 Phase 2 prototype used in the exercise as system enabler aims at improving the A-SMGCS surveillance function including Mono/Multi Sensor Tracking (sensor's reliability), improved data fusion of the tracking (position accuracy and integrity) and classification/identification of the target.

These functionalities improve current A-SMGCS Level 2 and pave the way to introduce A-SMCGS higher levels in later stages.

6.1.2.1.2.2 Enhanced Surface Safety Nets

Project 12.03.02 develops a Surface Safety Nets prototype able to alert controllers when an aircraft or a vehicle using the aerodrome movement area makes an unauthorised or hazardous manoeuvre, or when a controller gives conflicting instructions. The area of detection is composed by the runways, taxiways and aprons. The main sources of conflict situations covered by the prototype are:

- **Conformance Monitoring:** It measures and reports on deviations between the actual and expected positions of mobiles with respect to their assigned taxi route and given clearance. It also detects an aircraft taxiing with excessive speed.

- **Conflicting ATC clearances**: Runway alert generation when ATC provides a mobile with a clearance that is in conflict with another clearance already given to another mobile.

Next conflicting situations have been also integrated, coming from an already existing prototype:

- **Runway incursion**: alerts of the incorrect presence of an aircraft or vehicle on the protected area of runway.

- **Area intrusion**: alerts of the detection of an aircraft in a restricted taxing area.

Information and alarm alerts have acoustic support that was not enabled during this simulation due to the high number of incidents simulated.

Table 24 provides the list of available alarm/information alerts that Surface Safety Nets tool detects and alerts with the relative thresholds

that were used during the exercise. There were other alerts available in the prototype that were not tested due to the validation scenario, thus are not included in the table, e.g. alert due to one approaching aircraft and another aircraft taking off in opposite direction on the same runway.

Regarding the acronyms that appear on the label, the Runway Incursion and Area Intrusion alerts already tested in EXE-06.03.02-VP-401 keep the same acronym. The other acronyms are a proposal from WP12 following the same principle (3 or 4 letters that relates to the name of the alert) as there was not any indication in either the OSEDs or the VALPs from the operational projects.

SSN EXE 614		INFORMATION	ALARM	LABEL
Runway Incursion	There is an approaching aircraft in an active runaway and another aircraft or vehicle is in the runway Protection Area, RPA	Approaching aircraft is at less than 45 sec from runway threshold	Approaching aircraft is at less than 25 sec from runway threshold or separation distance between 2 landing aircraft is less than 0.5 NM	ALM ALM
	There is an aircraft landing and an aircraft/vehicle is approaching the RPA	Time to reach the RPA is less than 10 sec	N/A	ALM
	There is a taking off aircraft and another aircraft or vehicle is in the RPA and ahead the taking-off one	Departure aircraft speed is higher than 30kt	Departure aircraft speed is higher than 80kt	RDM RDM
	There is a lining-up or taking-off aircraft on a closed runway (in both directions)	N/A	The aircraft lines-up/takes-off on the runway	WRA
	There is an aircraft in the RPA of a closed runway	Aircraft in the RPA	N/A	WRA
	There is a vehicle in the RPA of a runway(closed or open)	Vehicle in the RPA	N/A	WRA
Area Intrusion	An aircraft enters an area defined as Restricted Area	Prediction: Time to reach the area is less than 10 sec	Violation: The aircraft enters the area	PAS VAS
Non-conformance to ATC procedures	Aircraft taxiing with high speed, beyond the limits defined for the taxiways	The aircraft overcomes 42 knots	N/A	HSPD
Non-conformance to ATC instructions	Take off without clearance	N/A	The aircraft is taking off without take-off clearance	NTOF
	Landing without clearance	N/A	Time to runway threshold is less than 25 sec and it has not received landing clearance	NLND
	Landing on wrong runway	N/A	Time to runway threshold is less than 25 sec and the landing clearance is not to the one in the FPL	LNDW
	Taxi route deviation (aircraft on the assigned route but on a no t cleared segment of the route)	The surveillance function detects the aircraft in a not cleared taxiway segment	N/A	RDEV

SSN EXE 614		INFORMATION	ALARM	LABEL
	Taxi route deviation (aircraft not on the assigned route)	N/A	The surveillance function detects the aircraft in a taxiway segment outside the assigned route	RDEV
	Taxi authorised on closed segment of taxiway. (The aircraft has not entered the segment)	A taxiway segment is closed in the cleared route of an aircraft.	N/A	CTWY
	Approaching aircraft that has not contacted TWR ATC	The aircraft is at less than 90sec from runway threshold and the related flight plan has been released by the TMA position	N/A	NCON
	Pushback without clearance. Aircraft is in a stand that requires push-back	The aircraft is moving without push-back clearance	N/A	NPBK
	Taxi without clearance	The aircraft is taxiing without taxi clearance	N/A	NTAX
	Line-up without clearance	N/A	The aircraft is lining up without clearance	NLUP
	Enter without clearance	N/A	The aircraft/vehicle is entering the runway without clearance	NENT
	Line-up in wrong runway	The aircraft is lining up on wrong runway (according to FPL)	N/A	LUPW
	Entering in wrong runway	N/A	A vehicle is entering a runway which is not the authorised one	ENTW
	Closed runway (line-up/take-off/land)	The aircraft is authorised to line-up/take-off/land on a closed runway	N/A	CRWY
	Stationary after pushback/taxi/line-up/take-off clearance	The aircraft is stationary after 120sec of pushback/taxi/line-up/take-off clearance	N/A	STAT
Conflicting ATC clearances	Line-up vs. line-up on same runway at opposite holding points	N/A	Two line-up clearances on same runway at opposite positions	OPHP
	Line-up vs. Enter on same runway at opposite holding points	N/A	Line-up and Enter clearances on same runway at opposite positions	OPHP
	Enter vs Enter on same runway at opposite holding points	N/A	Two enter clearances on same runway at opposite positions	OPHP
	Line-up vs. line-up on same runway at same or nearby entry point	N/A	Two line-up clearances on same runway at same positions	NEHP

Table 24: EXE 614 - Safety Nets conflict types and parameters

The next table presents the priority within each group implemented. A label with yellow letters corresponds to an INFORMATION alert and a label with red letters corresponds to an ALARM alert.

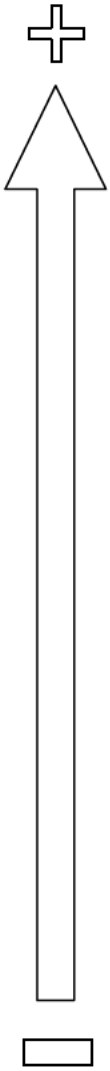
Priority	Conformance Monitoring	Conflicting ATC Clearance	Runway Incursion	Area Intrusion
	No Landing Clearance	Opposite Runways	Runway Crossing Monitoring	Violation Area of Security
	Landing on Wrong Runway	Same Runway	Opposite Traffic Alert	Prediction Area of Security
	No Contact	Crossed Runways	Runway Departure Monitoring	
	No Take-off Clearance	Converging Runways	Arrival Landing Monitoring	
	No Line-up Clearance	Opposite Holding Points	Wrong Runway Alert	
	Lining-up on Wrong Runway	Same/Nearby Holding Points		
	No Cross Clearance	Parallel Runways		
	No Enter Clearance			
	Entering Wrong Runway			
	Red Stop bar			
	No Taxi Clearance			
	No Push-back Clearance			
	Taxi Route Deviation			
	High Speed Movement			
	Closed Runway			
	Closed Taxiway			
	Stationary After Clearance			

Table 25: EXE 614 - Priority of Alerts

Priorities were defined following this approach:

- ALARM alerts have preference over INFORMATION alerts.
- Exception if one alert had both states, the INFORMATION alert is just before the ALARM, e.g. "lining-up on wrong runway" and then "no line-up Clearance"
- It was taken into account that the alerts depend on the state of the flight or location of the aircraft. Thus, some of the alerts are not compatible on the same aircraft, label, e.g. having the alerts related to landing with higher priority than the alerts related to taking-off is not a real priority rule.

- The exercise had the planning and routing function which would not provide a route through a closed taxiway or to a closed runway.

6.1.2.1.2.3 Enhanced Surface Routing

Project 12.03.03 Enhanced Surface Routing prototype aims to support the A-SMGCS Routing service by developing a tool (Surface Routing Server) to assist controllers in determining optimal taxi routes for aircraft using the aerodrome manoeuvring area. The objective is to reduce taxi times and time spent in holds, and to improve the efficiency of surface movement operations.

The routing service provides information to the system regarding the next logical owner of the object of responsibility (aircraft) according to the route; it will facilitate the transfer of the aircraft to the next ground or runway controller.

The improvements in the prototype used in the exercise with respect to the previous version are the route generator using a more complete calculator algorithm, the calculation of alternative routes according to the constraints given through a path selected by the controller and the remaining taxi time calculation (using standard aircraft velocity and current position).

6.1.2.1.2.4 Enhanced Controller Tools to manage all aspects of 4D trajectories

Project 12.05.03 prototype enhances the controller tools managing 4D trajectories in the airport context. It is directly related to the HMI for routing, flight plan edition and route clearances.

The prototype used in the exercise supports the Routing and Planning function management. By improving the HMI interaction for route generation through the introduction of two additional ways of to produce them, a graphical route edition and a panel route edition that allows introducing the final point and intermediate ones using the keyboard. It also displays the remaining taxi time calculated by the Enhanced Surface Routing, on the label.

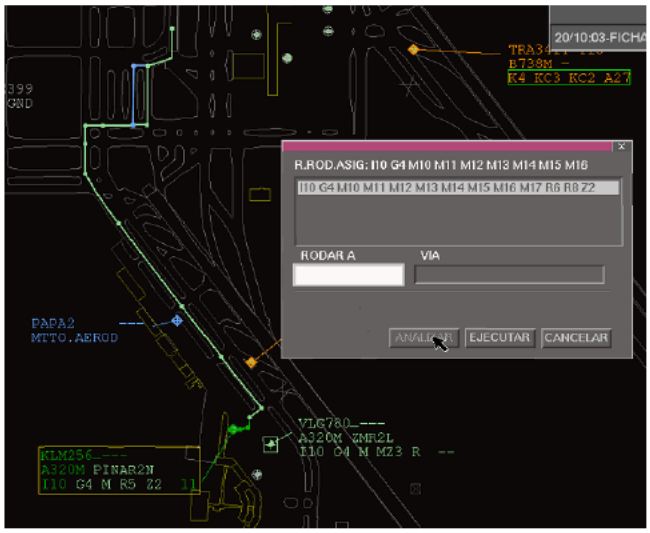


Figure 4: EXE 614 - Panel Route edition

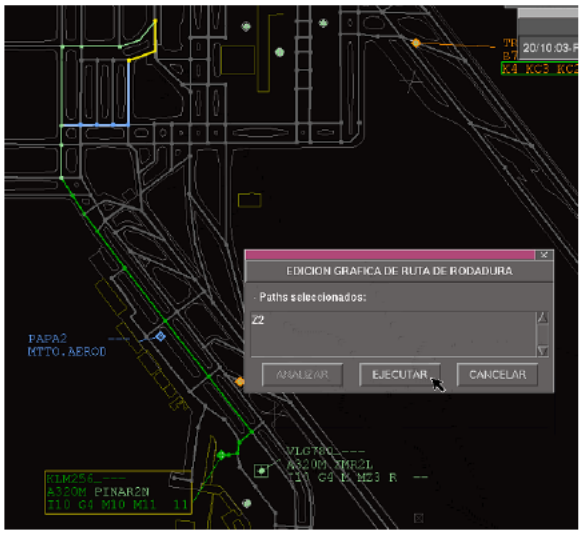


Figure 5: EXE 614 - Graphical route edition

Other functionalities incorporated by this prototype are the possibility to perform clearances directly on the route and an indication of the part of the graphical route that has been cleared and the pending one.

The HMI details of this functionality are explained in detail in section 6.1.2.1.2.7.2.1

6.1.2.1.2.5 Performance Based, Monitoring and Decision Support within the HMI of the A-CWP

Project 12.05.07 develops different prototypes of decision support tools to the tower ATC based in performance indicators. The prototype displays Airport Metrics and Maps to the supervisor with graphical information about taxiways and runway utilization, classified by departure, arrival and total movements performed during a configurable period of time.

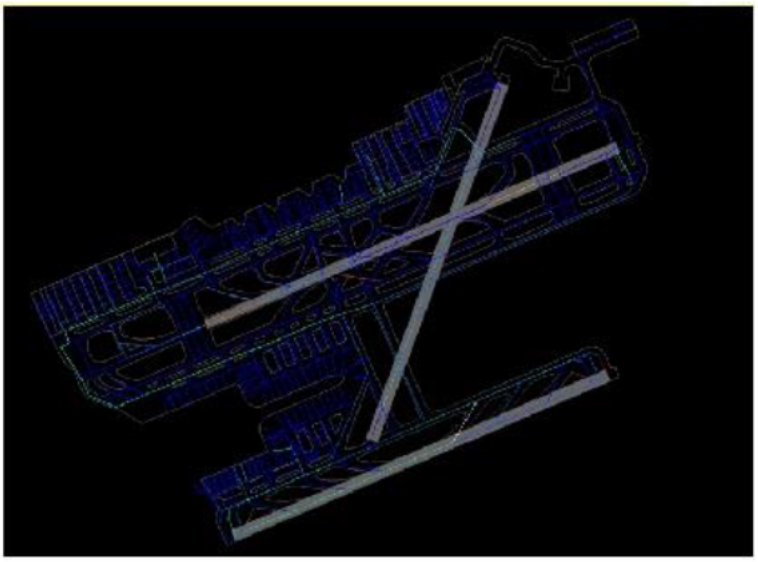


Figure 6: EXE 614 - Density map example from [58]

6.1.2.1.2.6 Controller Working Position

Project 12.05.04 prototype improves the controller working position integrating all the functionalities developed and available for the exercise. The CWP uses electronic flight strips, a radar screen with interactive radar labels and a controller's communication touch screen.

This prototype centres on the integration of airport safety nets, conflicting ATC clearances, conformance monitoring and A-SMGCS routing and planning functions.

The next sections describe the new HMI functionalities.

6.1.2.1.2.7 HMI Description

The HMI used in this validation is an evolution of the one used in EXE-06.09.02-VP-567, thus in this section only the new functionalities will be described. More information about the baseline HMI can be found in section 3.3 of the VP-567 Validation Report [51].

All the information in this section is for information purposes only, for further details on the prototype refer to 12.05.04 documentation.

6.1.2.1.2.7.1 Summary of the HMI

In the HMI, the controllers had Electronic Flight Strips and information labels on the screen thanks to the correlation of the flight plans with the use of multilateration surveillance and surface radar tracks. Also in the label, they had a control/clearances action window just for annotations and conformance monitoring purposes.

Basic airport information (layout, closed taxiways), meteorological information, status of the system (error windows) were also available on the position.

The display of the different windows (size, position) was configurable, and some of them also changed based on the role of the ATCO using that specific CWP.

6.1.2.1.2.7.2 New functionalities

6.1.2.1.2.7.2.1 Routing and planning HMI

The new routing HMI included includes routing information on the label such as taxi route and remaining taxi time from current position.

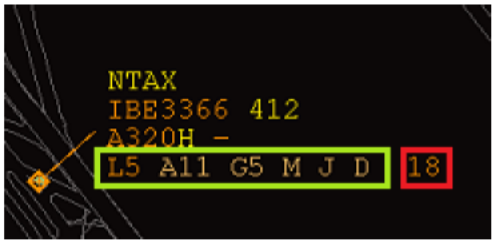


Figure 7: EXE 614 - Label for an arrival

The figure above presents the label with the taxi route information (highlighted in green) and the remaining taxi time (highlighted in red)[1]

The taxi route information on the label consisted on the next 5 or 6 segments of the route. The cleared segments had a darker colour (green for departures and orange for arrivals) and the pending segments were displayed in a brighter colour.

The total taxi time is shown in the Flight Plans window in the clearance delivery position.

The routing HMI also provided the possibility for the ATCOs to see the route of one aircraft displayed in the airport layout. In this case, the colours used are the same as the ones used on the label.

[1] the green and red boxes have been added in this document

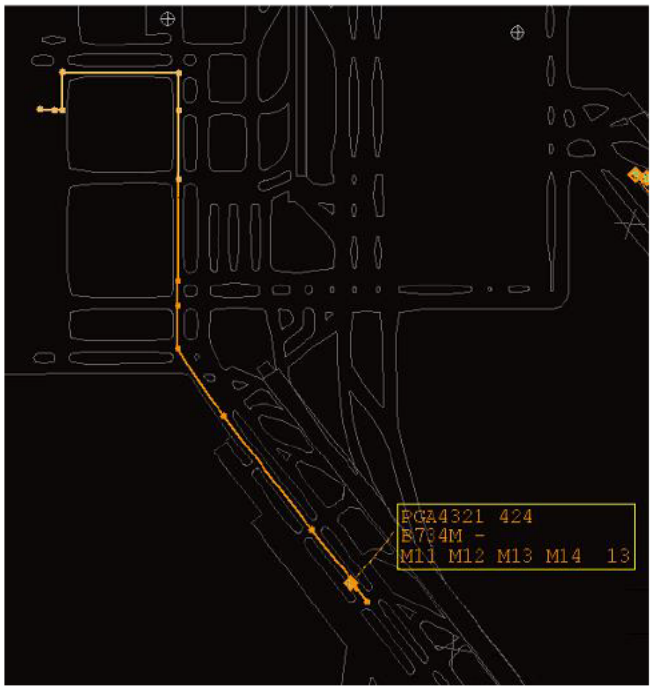


Figure 8: EXE 614 - Graphical display of the ground route

The figure above presents an example of an arrival aircraft with the cleared route in dark orange and the pending route in light orange.

For clearing a route inside their AoR controllers had to click on the route information displayed on the label and select the last segment of the route they want to clear.

Route edition

For modifying the routes, the controllers had two options:

Textual edition:

Taxi route edition panel displays three alternative taxi routes for the selected flight plan and allows introducing user constraints, such as the destination (RODAR A) and intermediate points (VIA).

When the Analyse option is selected, up to three new alternative routes are calculated according to the introduced values. Clicking on each alternative the corresponding taxi route is displayed on the airport layout in blue colour. When the Execute option is selected, the new route is assigned to the flight plan.

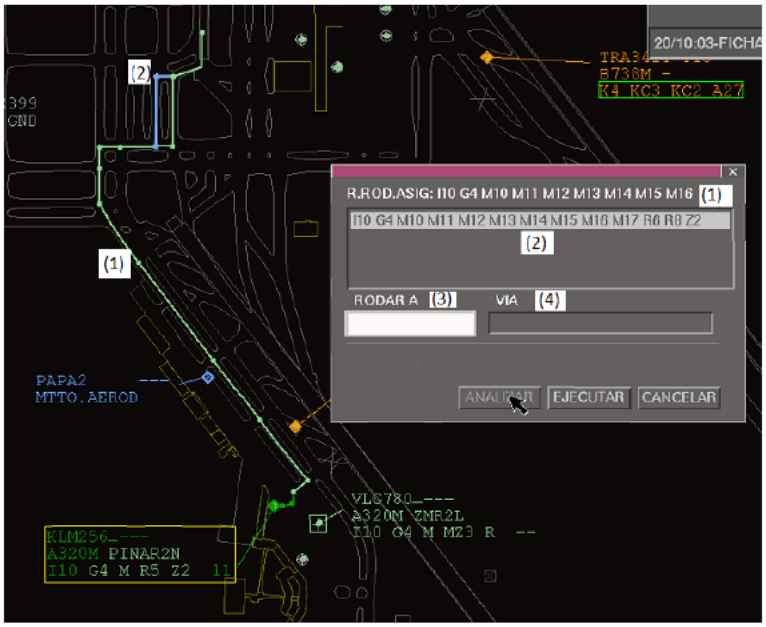


Figure 9: EXE 614 - Taxi route edition panel

The figure above shows the display with the route edition window with the actual route (1), the proposed route (2) the “Destination” field (3) and the “Via” field (4)

Graphical edition:

When selecting the graphical edition all the segments of the layout available for the aircraft are displayed in grey. Closed segments and segments forbidden to the aircraft type are filtered and not shown in the selection map. The controller can then select the segments he/she wants to choose for the alternative route (no rubber-band implementation). These segments are yellow. After selecting the desired segments the ATCO has the same options as in the textual mode (Analyse or Execute).

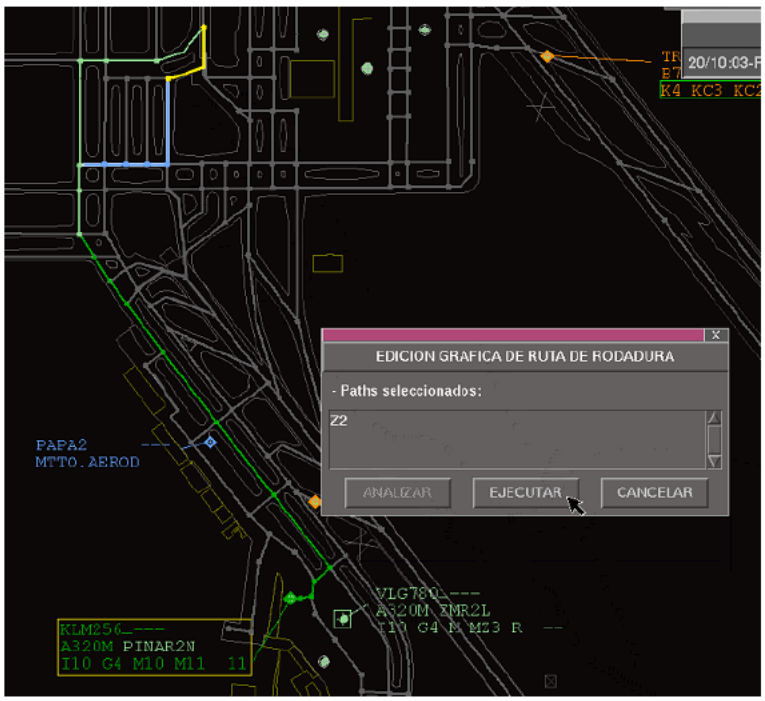


Figure 10: EXE 614 - Route graphical edition

After a route is modified (either by the system or by a controller), the route information in the label is highlighted via a green blinking box (as it is shown on the top right corner of Figure 9). Each controller will have to click on it to acknowledge it and hide the highlight.

6.1.2.1.2.7.2.2 Alerts HMI

The alerts are configured to be displayed in two places of the A-CWP: on the label of the affected aircraft and on a dedicated Alert Window.

The alerts are divided in two groups regarding their severity: INFORMATION (displayed in yellow) and ALARM (displayed in red). Each alert has a unique acronym used to identify it. Note that these acronyms have been defined in this prototype for 614 validation purposes only and are not 06.09.02 or 06.07.01 decisions. The conformance monitoring acronyms are based on the exercise EXE-06.09.02-VP-653, while Runway incursion and area intrusion acronyms are based on the ones used in VP-06.03.01-VP401. Table 24 lists the alerts and acronyms used.

When a new alert is generated, its acronym appears, blinking, in the label of the aircraft involved. To acknowledge the alert in a specific A-CWP the controller of that position has to click on the alert. All controllers had to perform this action for the alerts displayed in their position.

The alert also appears in the alert window of every A-CWP of the airport.

The alert will disappear only when the situation is solved (i.e. there is no way to hide an alert neither on the label nor on the window regardless of the type or place where it was generated).

It is possible to disable all the alerts of one type of safety net locally in a position (indicated in the HMI in yellow), globally for all the positions (done by the supervisor, indicated in red). It is indicated in the position in the status of the system area.

Figure 11: EXE 614 - Alert Inhibition

It is also possible to disable them for a flight plan. This would be indicated in the flight radar label with a letter -R for runway incursion, S for area intrusion, C for non-conformance, and A for conflicting ATC clearances.

Alerts on the label

The alerts are situated on top of the label, following the colour rules explained above.

It is possible to see in Figure 7 an information alert on the top left corner of the label.

Alerts window

The alert window shows the alerts identified by their acronym, the identifier of the aircraft that is causing the alert and additional information depending on the type of alert (usually their destination: runway number or gate number). In this window, the information does not blink and it doesn't follow the colouring rules either (all the text is shown in grey).

The window is divided into four sections, one per each alert type: Runway Incursion (RW), Area Intrusion (AS), Non-Conformance Monitoring (CMON) and Conflicting ATC Clearances (ATC). Each

controller can hide or display the alert window.

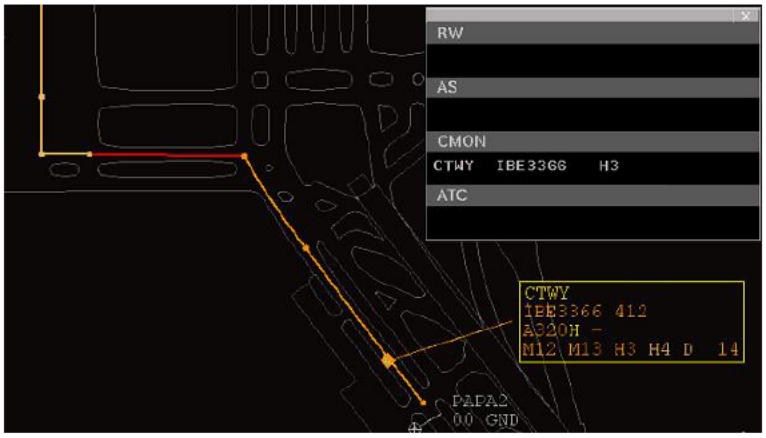


Figure 12: EXE 614 - Alert window and CTWY alert on the label

6.1.2.1.2.7.2.3 Vehicle HMI

The A-CWP also presented the option to create "Vehicle Plans" for vehicles operating on the airport and equipped with a transponder. Clicking on the Vehicle Plan button when a track is selected displays a window to introduce the identifier and the vehicle type. The plans associated to vehicles were much simpler than the flight plans, but had some clearances associated to comply with CMON alerts.

This vehicles had an associated label, similar to the one used for the aircraft. Using that label, the controllers could see the alerts related to the vehicle and input some instructions (e.g. runway crossing clearances).

Figure 13: EXE 614 - Vehicle Plan window

6.1.2.1.3 Training

Controller's training sessions combined theoretical class followed by practical simulation exercises in the simulation room.

The training sessions were divided into the following activities:

- Introduction with validation objectives and exercise scope
- training on Madrid-Barajas airport operation and paperless environment
- training on Runaway incursion and Area intrusion alerts
- training on Conformance Monitoring and Conflicting ATC Clearances
- training on Routing and Planning function
- Reference Scenario training runs
- Safety Nets + Routing and Planning function scenario training runs

Seven controllers received this training. Five were controllers that evaluated the functionalities, one was a support controller and another acted as supervisor. Four of the five controllers in roles under evaluation had previous experience with the paperless environment, RIMS, and Routing and Planning function due to their participation in exercises EXE-06.03.01-VP-401 & EXE-06.09.02-VP-567. The other controller did not have this experience, but she works in a paperless environment.

The supervisor controller also had experience from last year.

6.1.2.2 Exercise execution

The execution of the exercise was performed from 27th to 30th of January 2014.

The following simulation scenarios were used:

Scenario 0 – Reference: The reference scenario had the alerts of Runway Incursion and Area Intrusion (RIMS) enabled.

Scenario 1 – Solution: The solution scenario had these alerts enabled plus the conformance monitoring alerts, conflicting ATC instructions alerts and the Routing and Planning function. The incidents provoked by the pseudo-pilots and asked to perform to the controllers varied from one session to another. Taxiways and runways were closed and opened to test the alerts and routing functions.

In both cases, controllers used a paperless CWP and radio communication (R/F), i.e. no data link.

The activities performed were:

	Monday 27th	Tuesday 28th	Wednesday 29th	Thursday 30th
09:00 - 09:15	Presentation of activities	Presentation of activities	Presentation of activities	Presentation of activities

09:15 – 10:15 (Session P1)	Scenario 0	Scenario 1	Scenario 1	Scenario 1
10:15 – 11:00	Debriefing	Debriefing	Debriefing	Debriefing
11:00 – 11:30	Break			
11:30 – 12:30 (Session P2)	Scenario 0	Scenario 1	Scenario 1	Final Debriefing
12:30 – 13:30	Debriefing	Debriefing	Debriefing	
13:30 – 14:00	Wrap-up	Wrap-up	Wrap-up	Wrap-up
14:00 – 15:00	Lunch			
15:00 – 18:00	System Change	Contingency	Personal interviews	-

Table 26: EXE 614 - Runs calendar

The scenario represented Madrid-Barajas airport layout in north configuration. Five controlling positions were simulated operating from the same tower (North Tower). This is slightly different from real life operations as apron managers give service to terminals T1, T2 and T3 from the South Tower and to T4 from the West Tower. The exercise had three ground controllers - South, Central and East-, two runway controllers - one for departures, and another one for arrivals- all of them under evaluation and one auxiliary controller that managed the parking area of the terminal T4 – West - and the clearances of the entire airport. In this configuration RWYs 36 L & R are used for departures and RWYs 32 L & R for arrivals.

Please note that due to representation the North of the Figure 14 is on the right.

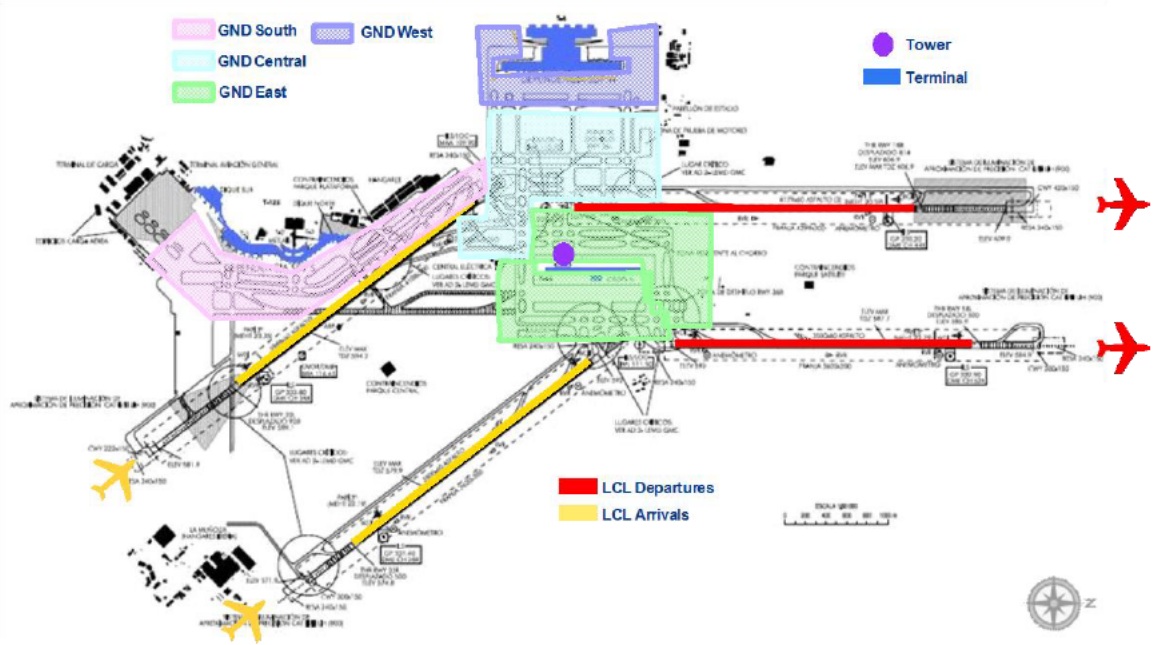


Figure 14: EXE 614 - airport layout

Figure 15 presents the operations room layout used during the validation exercise. Controllers under evaluation rotated between the different positions. Table 27 presents the controller's rotation during the different simulation runs.

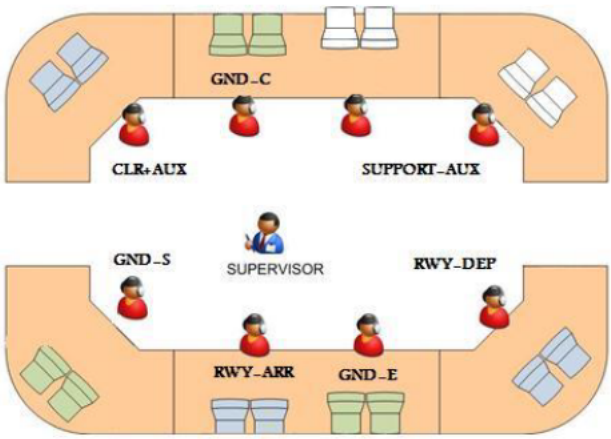


Figure 15: EXE 614 - Operations room layout

Run		GND South	GND Central	GND East	Runway Departures (36L & 36R)	Runway Arrivals (32L & 32R)	CLD + GND West
Day	Session						
27th	P1	1	2	3	4	5	6
	P2	5	1	4	2	3	6
28th	P1	3	5	2	1	4	6
	P2	4	3	1	5	2	6
29th	P1	2	4	5	3	1	6
	P2	1	2	3	4	5	6
30th	P1	5	1	4	2	3	6

Table 27: EXE 614 - Controller's rotation

Regarding the ATCOs involved in the simulation, they are active Spanish controllers with wide experience (all over 5 years). Some of them are controller instructor, which was considered an asset as they provide useful comments not just about their performance but also on the training.

There were six pseudo-pilots supporting the exercise, one per radio frequency, plus two support pseudo-pilots (one coordinator and one back-up). Pseudo-pilots were provided with a list of incidents they had to provoke.

The responsibilities of the different roles were:

- Ground Controller (South, Central, East, and West) who was responsible for:
  - traffic movements on the manoeuvring area with the exception of the runways;
  - aircraft movements on the Apron (except for Central controller);
  - management of push-back (except for Central controller);
  - coordination of GND movements on the taking-off/landing area with the RWY controller;
  - providing the departure controller a pre-sequencing of the flights in order to enable him/her to define an optimal departure sequence to minimise delay;
  - modification of aircraft route if necessary;
  - provision of taxi instructions and advices.
- Runway Controller (Departure, and Arrival) who was responsible for:
  - operations on the active runways and aircraft flying within the area of responsibility of

the TWR;

- management of the runway occupancy;
- provision of take-off/landing clearances to departing/arriving aircraft;
- sequencing of aircraft on the runway for take-off;
- coordination of RWY movements on the landing/taking-off area with the GND controller;
- Modification of arrival flight routes if necessary.

- Clearance Delivery Controller who was responsible for provision of:
  - start-up clearance;
  - ATC route clearances to departing IFR flights.
- Supervisor Controller who was responsible for:
  - the safe and efficient provision of air traffic services by the Tower crew;
  - opening and closing taxi segments and runways;
  - staffing and managing controllers working positions;
- Flight crew who were responsible for:
  - executing the flight according to the current flight plan;
  - complying with clearances given by ATC except when simulating an incident.
- Vehicle driver who was responsible for:
  - complying with instructions given by ATC when on the manoeuvring area except when simulating an incident.

6.1.2.3 Deviation from the planned activities

There were some deviations from the planned activities associated to the following aspects:

- **OPERATIONAL CONCEPT ADDRESSED:**

In the Validation Plan from P06.03.01 [52] a set of alerts were specified to be active during the exercise. After analysing the scenarios, it was agreed that some of the conflicting ATC clearances would not be triggered at any case. This deviation from the planning does not impact P06.09.02 as the validation plan [50] was delivered later when the scenarios had already been selected.

These alerts are:

- Line-up vs line-up clearances on opposite runway;
- Line-up vs cross or enter Line-up vs take off on opposite runway;

- Line-up vs land on same or opposite runway;
- Line-up vs take-off on opposite runway;
- Cross vs Cross or Enter;
- Take-off vs take-off on opposite or crossing runways;
- Take-off vs land same, opposite or crossing runways;
- Land vs land on opposite or crossing runways;

Take-off or landing from opposite runways is only feasible in Madrid Barajas after a configuration change, when departure runways start to be used for arrivals and vice versa. As there was not going to be tested a change from North configuration to South configuration these alerts had no sense in the selected scenario.

Cross runway alerts were neither considered since Madrid-Barajas has no crossing points.

Although controllers were instructed not to use conditional clearances, they were issued because they are used to them. Observers' reports and controllers' comments in debriefings confirmed that point. This was especially important for runway controllers, since they gave certain conditional clearances for line-up and an alert was triggered.

- **SCENARIOS:**

In P06.03.01 Validation Plan [52], the initial proposal of areas of responsibility under evaluation consisted on two ground controller areas (Central and East) and one runway controller area only for departures. The other areas were not under evaluation and would be considered as feeders. Finally, the scenario had three ground controller and two runway controllers, as specified in P06.09.02 Validation Plan [50].

- **ALERTS:**

The first day that all the SESAR functionalities were enabled, controllers indicated a loss of Situational Awareness related to some alerts that were triggered continuously. This provoked that some alerts were modified or switched off the following days. These alerts were:

- No landing (NLND) when there is a miss approach or go around manoeuvre;
- Route deviation (RDEV) information alert when the aircraft has exceed the cleared route;
- No taxi (NTAX) information alert after vacating the runway on the exit taxiway;
- A Runway Incursion alert (ALM) There is an aircraft landing and an aircraft/vehicle is approaching the RPA;
- Stationary (STAT) after Line-up clearance and Stationary after take-off clearance.

6.1.3 Exercise Results

EXE-06.03.01-VP614 was performed from January 27th to 30th 2014.

P06.03.01 and P06.09.02 look to SESAR concepts from two different perspectives. P06.03.01 looks to the integration of concepts from the functionality point of view and P06.09.02 looks to them from the HMI point of view. Although both points of view are connected, they are studied differently. Due to this reason, each project developed a validation plan and a questionnaire with their own objectives.

The simulation exercise was designed to cover both necessities, and it was planned that each project had a separate report. However, during the gate of P06.09.02, 18th of February 2014, it was decided to have one unique report for the exercise.

Due to the differences during planning phase, results are presented in the document following a different structure. P06.03.01 results are structured per KPA while P06.09.02 results are structured per validation objective.

A joint analysis of the results is provided in section 6.1.3.2 Analysis of Exercise Results.

A table (Table 19) showing the summary of the exercise results per validation objectives and per success criteria as identified within P06.03.01 and P06.09.02 Validation Plans can be found in section 4.1.

6.1.3.1 Summary of Exercise Results

The results should be read taking into account current mode of operation in Madrid - Barajas which was used as reference mode of operations during the exercise.

In current mode of operations, aircraft taxiing through the main taxiways have preference over all the other aircraft and are cleared by the first ground controller from the gate to the runway/ runway exit to the gate. It is a common procedure that if one ground controller is saturated, part of his area of responsibility is transferred to an adjacent controller. This is agreed verbally between the controllers and the supervisor.

Conditional clearances for line-up are used when the visibility is good and the runway queue is high.

The validation objectives addressed by Exercise 614 in P06.03.01 were:

1. OBJ-06.03.01-VALP-0614-0001 – Assess the safety increase due to new alerts provided to the ATCOs working together for hazardous situations in runways, by means of:
    - Runway incursion
    - Non-conformance to ATC procedures
    - Non- conformance to ATC instructions
    - Conflicting ATC clearances
2. OBJ-06.03.01-VALP-0614-0002 – Assess the safety increase due to new alerts provided to the ATCOs working together for hazardous situations in taxiways, by means of:
    - Area intrusion
    - Non-conformance to ATC procedures
    - Non- conformance to ATC instructions
3. OBJ-06.03.01-VALP-0614-0003 – Support given by enhanced safety nets, and routing function to the ATCOs during the execution of their tasks is positively assessed, taking into

account the HMI utility and usability.

4. OBJ-06.03.01-VALP-0614-0004 – Assess the validity of the route provided by the updated Routing and Planning function, in Automatic and Semi-automatic modes and the route edition in Manual and Semi-automatic modes.

5. OBJ-06.03.01-VALP-0614-0005 – Assess a map of the movement area generated by the system, where is reflected the usage category of each taxiway, in terms of movements number.

The validation objectives addressed by Exercise 614 in P06.09.02 were:

1. OBJ-06.09.02-VALP-0001.0001 – Validate that the A-CWP supports controllers in building and retaining an overall traffic picture.

2. OBJ-06.09.02-VALP-0001-0020 – Validate the readability and meaningfulness of textual information displayed by the A-CWP.

3. OBJ-06.09.02-VALP-0001-0030 – Validate the readability and meaningfulness of graphical objects, symbols and visual representations in the A- CWP.

4. OBJ-06.09.02-VALP-0001.0040 – Validate consistency and completeness of the information displayed by the A-CWP.

5. OBJ-06.09.02-VALP-0001.0050 – Validate timeliness and prioritization of the information displayed by the A-CWP.

6. OBJ-06.09.02-VALP-0001.0060 – Validate the adequacy of information from the A-CWP.

7. OBJ-06.09.02-VALP-0001.0070 – Validate the practicability and intuitiveness of commands on HMI objects.

8. OBJ-06.09.02-VALP-0001.0080 – Validate the adequacy of feedbacks of commands / actions on HMI objects.

9. OBJ-06.09.02-VALP-0001.0090 – Validate the adequacy of number and sequence of actions on graphical objects needed to accomplish control tasks.

10. OBJ-06.09.02-VALP-0001.0100 – Validate that the A-CWP supports the controller in the decision making process.

11. OBJ-06.09.02-VALP-0001.0110 – To assess that the A-CWP keeps controllers workload at an acceptable level.

6.1.3.1.1 Results on concept clarification

The analysis addressed especially the validation of particular surface safety nets combined with enhanced routing functionalities impacting different Key Performance Areas.

In section 6.1.3.1.2, the results will be presented per key performance and transversal areas pointing out also aspects about concept clarification and implementation from the point of view of P06.03.1.

In section 6.1.3.1.3, the results will be presented per objective from the point of view of P06.09.02.

6.1.3.1.2 Results per KPA from P06.03.01

This section reports the results of **06.03.01** for each KPAs/TA and for each validation objective, obtained by means of the integration and analysis of data collected during the exercise.

Exercise 614 focused on the following KPAs/TA:

- Human Performance
- Safety
- Efficiency
- Predictability

Despite the fact that Validation Objectives included a set of success criteria with their respective positive percentage, as results have been analysed by KPA, the KPA approach shall be analysed not only from the number of answers' point of view but also from the weighted average an mean values of these answers.

This analysis can be identified by a visual sign which shows the global status of that specific item:

● Positive perception of the statement [70% - 100%]

● Conditional positive perception (This means that additional modifications are required before valuating positively this statement) [50% - 70%)

● Negative perception of the statement [0% - 50%)

The different questions proposed have different types of answers. Most of the answers analysed using the weighted average have four (4) or five (5) possible answers, scaled from very negative (what will be weighted using one) to very positive (weighted using four of five, depending on the number of possibilities). The visual signs presented above have different scale intervals based on the number of possibilities:

	Four possible answers	Five possible answers
●	[2,8 -4]	[3,5 – 5]
●	[2 – 2,8)	[2,5 – 3,5)
●	[1 – 2)	[1 – 2,5)

Table 28: EXE 614 – Weighted Average values measure

6.1.3.1.2.1 Human Performance

Human Performance Transversal Area was investigated in terms of the impact of integrated and enhanced features on controllers' workload and the confidence in tool outputs.

Controllers' workload is focused on the tasks they have to perform and the "*memory and recall effort needed"* for that. Controllers' confidence in tool outputs is focused on the "*tool utility and usability*".

This KPA is related to the objective:

OBJ-06.03.01-VALP-0614-0003 – Support given by enhanced safety nets, and routing function to the ATCOs during the execution of

their tasks is positively assessed, taking into account the HMI utility and usability.

6.1.3.1.2.1.1 Workload and recall effort

Controllers reported that the workload remained within acceptable limits, but it worsens when compared to the Reference scenario.

The questions directly addressing the workload and system usage were:

- *Q1.1 How do you consider the workload associated when using the system?*

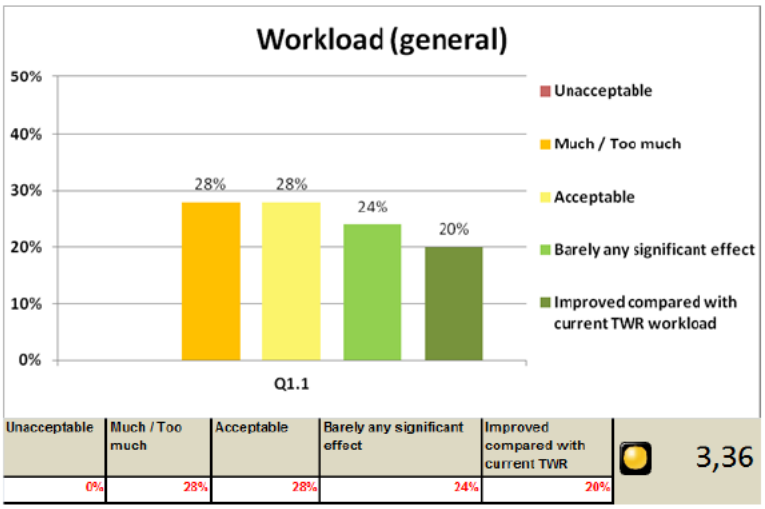


Figure 16: EXE 614 – General Workload weighted average

The percentage of controllers that reported the general workload with positive feedback, regarding acceptable of barely workload is of 72%. The weighted average indicates that the feedback is within the intermediate area with an average under 3.5.

The conclusion is that the workload is not reduced but remains within acceptable limits which is aligned with the expected result according to the benefit mechanisms identified in P06.03.01 validation plan,[52]: "*the new functionalities shall contribute to reduce or at least to not increase controller workload which impacts directly on human performance area*"

Controllers indicated in questionnaires and debriefings that problems with workload had come in terms of time spent and attention paid when they have had to update the routes and to recognize all the new alerts.

The answers for this questions has been also analysed for the Reference scenario, where the Conformance Monitoring alerts, the Conflicting ATC Clearance alerts and the routing function were disabled. The general workload has been evaluated more positively than in the Validation scenario as seen in Figure 17, with a weighted average up to 3.80.

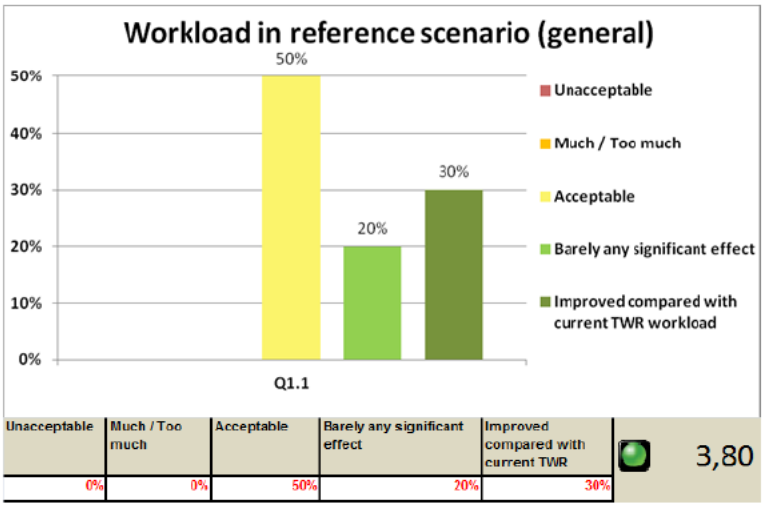


Figure 17: EXE 614 – Reference Workload weighted average

Other important aspect that generated workload pointed out by controllers are the pseudo pilots' activities: intentional mistakes to provoke special situations have contributed to generate additional work for controllers, in terms of rerouting mobiles and resolving alerts.

Indicate if you agree with the next statements:

- *Q1.2 I felt more tired than usual.*
- *Q1.3 I have the impression that I have to be more aware.*
- *Q1.4 I have ignored other important tasks.*
- *Q1.5 I have not been able to coordinate in a proper way.*
- *Q1.6 I have made a special effort to memorize.*
- *Q1.7 I have needed help*

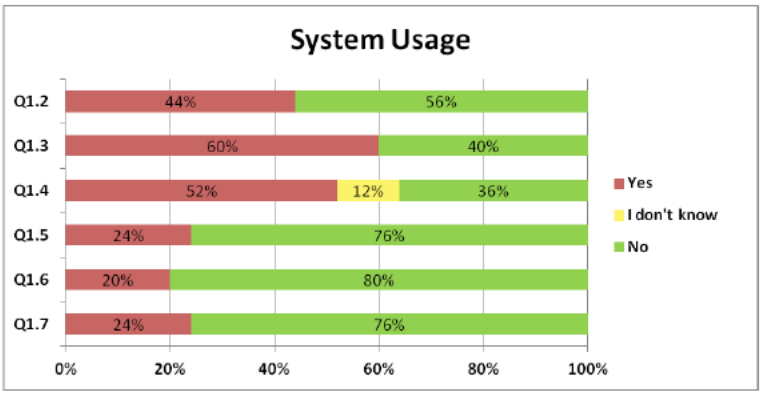


Figure 18: EXE 614 - System Usage

When controllers indicated that they had high workload or have not been comfortable they were asked to indicate which they considered was the reason(s). The answers are depicted in next figure:

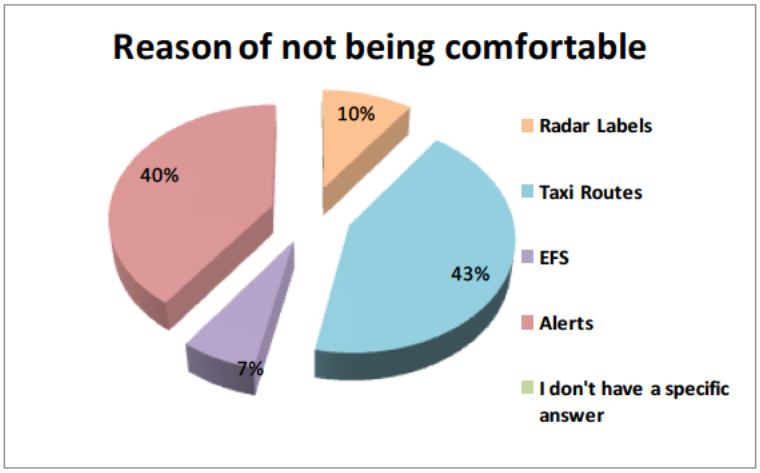


Figure 19: EXE 614 - High workload reasons

As seen on Figure 18 main problems come from the work requirements to the controllers with questions Q1.2, Q1.3 and Q1.4 (related with fatigue, awareness and tasks ignorance). Main reasons for that are the new tools deployed, specifically the Alerts and the Routing system as radar labels and EFS mean only the 17% of the total.

When these questions are analysed for the reference scenario, the results are quite better than in the Validation scenario, although controllers report also negatively about the effort to memorize (Q1.6) and the impression that they have to be more aware (Q1.3), as seen on Figure 18 and Figure 34. The effort to memorize has been reported as negative in both scenarios but it was even worse in the reference, this can be attributed to the learning effect which enhances the subjective perception. Such perceptions in Reference scenario are attributed to the paperless environment.

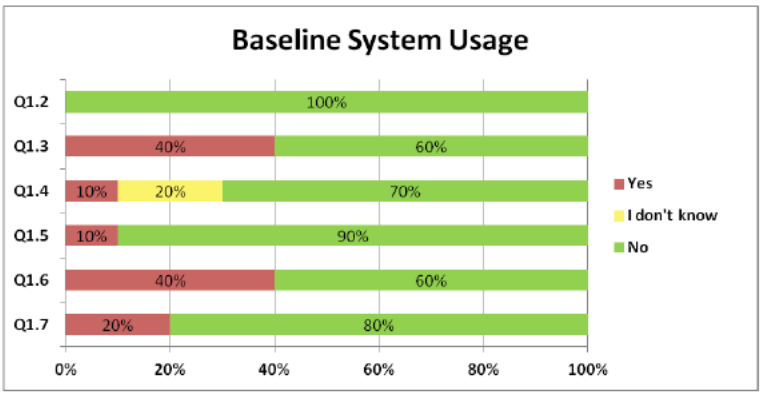


Figure 20: EXE 614 – Reference System Usage

When analysed by controller role, the assessment was more positive on runway controller than on ground controllers.

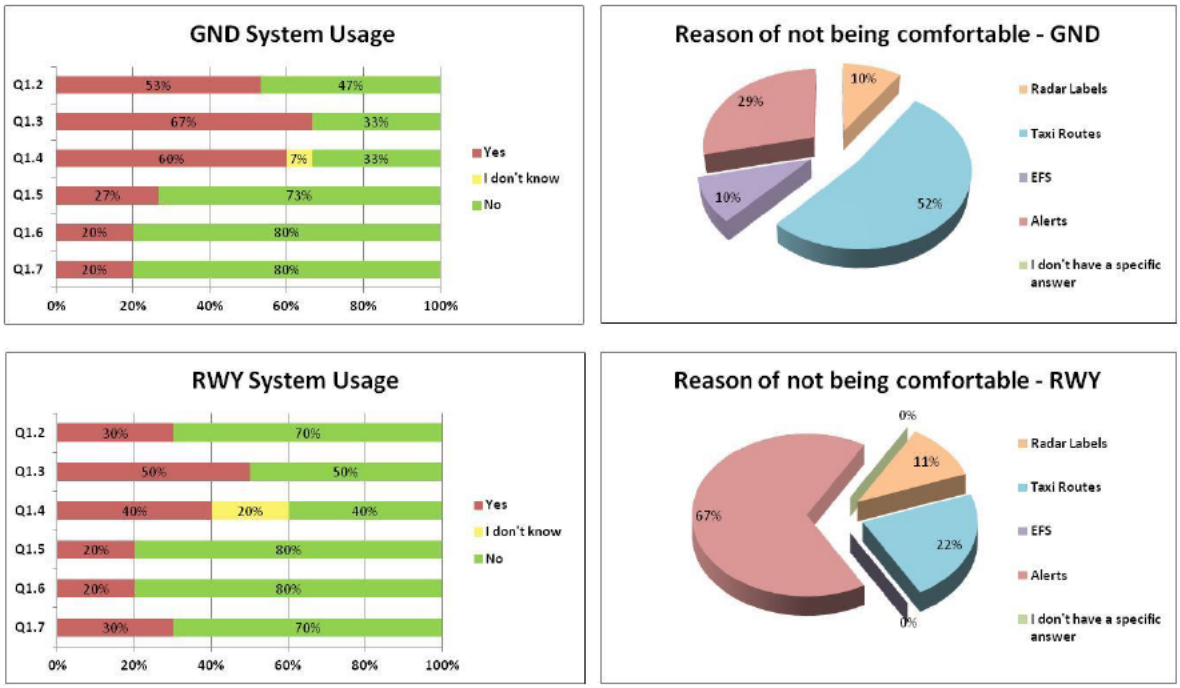


Figure 21: EXE 614 - System Usage and reasons per role

It is very relevant that, while 70% of answers for runway controllers indicated that they did not feel more tired than usual, only 47% of answers for ground controllers showed the same opinion. On similar way, the rate of answers is better for runway controllers, when talking about awareness (Q1.3) and tasks ignorance (Q1.4). In addition, main reason for not being comfortable differs between ground and runway controllers. While the ground controller considered the Taxi Routes as the first reason for the discomfort, the runway controller considers the Alerts as first reason.

Regarding the workload in general, the role which required higher workload was the ground controller, as seen on figures below:

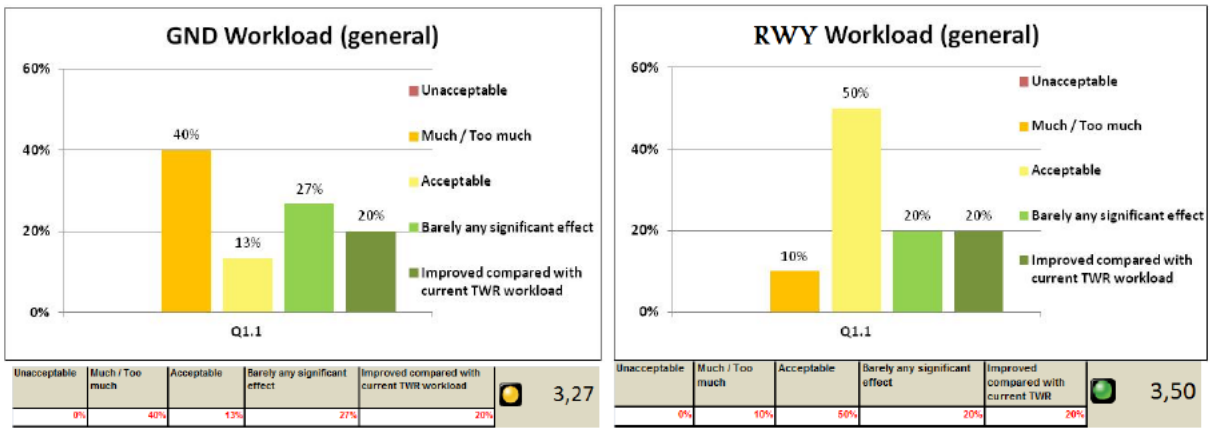


Figure 22: EXE 614 - Workload per role and weighted average

Runway controllers have assessed the general workload as acceptable or unaltered over the 90% of the answers.

The weighted average calculated for both questions points out that workload has been better assessed for runway controllers that for ground controllers. Connecting these considerations with the

previous part of system usage and reasons for not being comfortable it seems that problems with routing penalize worse the controllers than problems with alerts.

To assess the impact of alerts and routing next questions were performed separately about both functionalities:

- *Q1.8 Generate new tasks that complicate the existing ones*
- *Q1.9 Increase my workload*

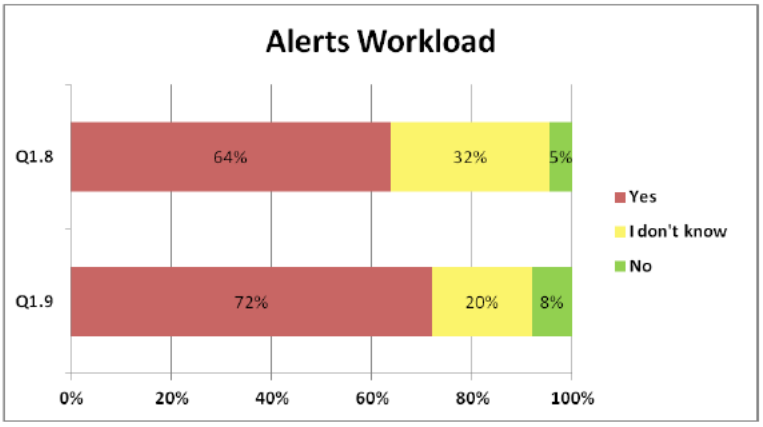


Figure 23: EXE 614 - Alerts Workload

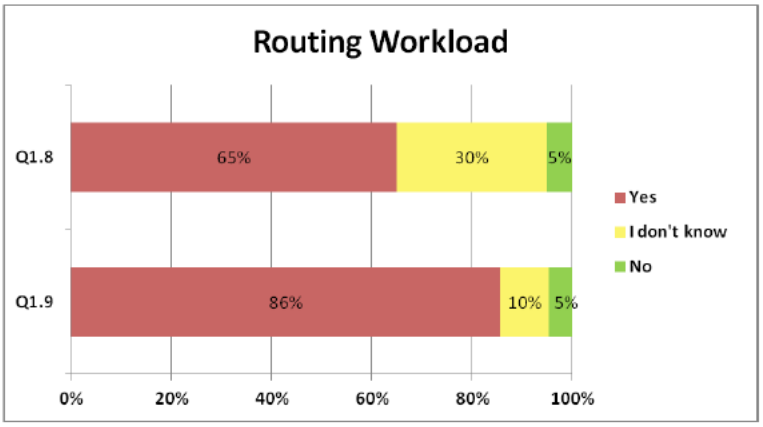


Figure 24: EXE 614 - Routing Workload

As seen on Figure 23 and Figure 24, workload and new tasks created have been very negatively evaluated, in terms of alert and routing features respectively. These results are in consonance with the reasons of not being comfortable shown on Figure 21. The amount of positive answers is minimum, not greater than 8%, but it has to be taken into account that question related with new tasks generated has a certain amount of indecisive answers. These questions will not be analysed for ground and runway controllers separately, as only few deviations were appreciated.

These negative answer in the case of alerts were related to:

- The fact that all the alerts were presented to all controllers. Observers reported that controllers were very saturated with the alerts. Controllers have difficulty distinguishing the alerts under their responsibility. Debriefings revealed that such amount of alerts were a nuisance more than a support.

It should be noted that the number of alerts during each run was high as there were ten alerts per run provoked intentionally by the pseudo-pilots, plus the ones that controllers provoked intentionally to test the system, and plus the ones that were not intentional due to the procedures used in Madrid-Barajas (explained below).

- During the first day there were some alerts that were directly pointed out by controllers as nuisance, so they were turned off during the next runs:
    - "No taxi" information alert (NTAX) after a landing when the aircraft was vacating the runway. The exit taxiway is considered the beginning of the route, but the ground controller had not assumed the aircraft and thus had not issued any clearance, which provoked the warning.
    - "Route deviation" information alert (RDEV) because, although the aircraft was in the assigned route, it had exceeded the cleared route. Due to current operations in Madrid-Barajas, it is usual that aircraft are cleared most of the route on the airport.
    - Missed approach manoeuvres provoked a "no landing" alert (NLND). In this case, the alert was changed and, if the controller indicated it was a missed approach, the alert was not triggered.
- Misunderstanding generated by:
    - Alerts triggered by overflights. Initially it was not planned to include overflights, but a controller wanted to test them so they were created ad-hoc, provoking "no landing" alerts. The simulation events were updated the next day to amend the situation and allow overflights.
    - Reasons about why alerts were triggered or not, e.g. a vehicle entered the runway but no alert was triggered. The reason was that the runway threshold was displaced and the RPA had been defined taking into account that. Following controllers' indication, the parameters were changed to make the whole runway a protection area. A review of the type of alert, and how they would be triggered, was performed the next day.
    - There were some ATC Clearance alerts because controllers had not entered in the system the clearance provided verbally to the aircraft.
    - Runway Incursion alarm alerts (ALM) that appeared and disappeared very fast.

During the analysis of system recordings, it was detected that there were information alerts related to high speed (HSPD) in the rapid exit taxiway. The runway incursions alarm alerts were produced because the system detected the same aircraft twice in different positions.

Positive answers in the case of alerts were related to:

- Alerts related to runway were assessed very positively by all the runway controllers, specially the Runway Incursion type.
- Stationary information alerts were differently assessed by the controllers, as some indicated that they had focused their attention on flights that should be moving, and other indicated that if the flight crew is not moving the aircraft, it is because they are probably checking the different systems of the aircraft and should not be disturbed.

Negative answers in the case of Routing and Planning function were related to:

- Controllers considered that updating the aircraft route required attention that took time from looking out of the window without a direct benefit, as no datalink was used.

- The fact that a ground controller could only clear a route within his area of responsibility. It should be noted that this clearance is not coherent with Madrid-Barajas procedures; however, it could be useful in other scenarios with different procedures.

- When a route changed, it was highlighted to all the controllers including controllers that were not going to have the aircraft under their responsibility and the one that had changed it.

6.1.3.1.2.1.2 Utility and Usability

Another important subject is the perception of the usability and utility of the new tools by the controllers. Questions directly addressing this matter were:

- *Q2.1 How do you consider the support given by the new tools, when fulfilling the commanded tasks?*

- *Q2.2 In terms of using the new HMI functions, how do you consider the easiness of usage of these ones?*

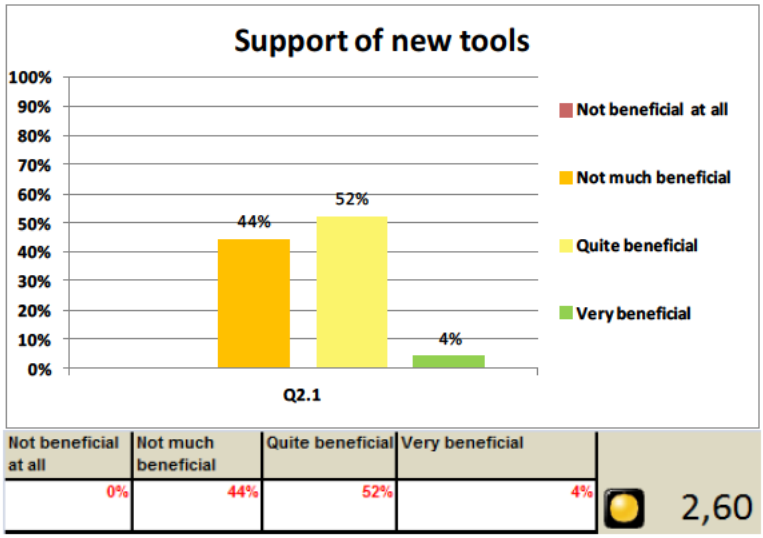


Figure 25: EXE 614 - Support of new tools

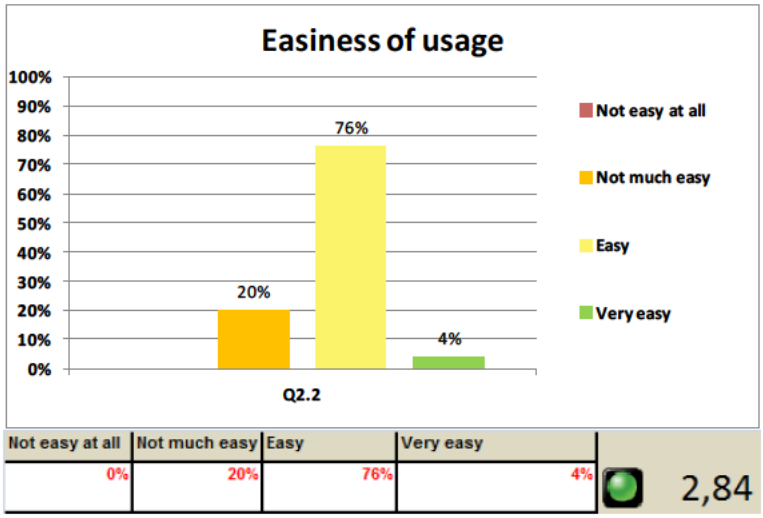


Figure 26: EXE 614 - Easiness of usage

The usability of the new functionalities was inconsistently assessed by every controllers, with 1 answer out of 2 questions had positive feedback perception (weighted average over 2.80). The answer with worst feedback is related with support of new tools. Controllers indicated that some alerts are useful but the ones not related with their positions or AoR are a nuisance in general, worsening the work environment. Other possible reasons pointed out are related to a lack of practice with the new tools; also, that they sensed that the new tools are not completely developed and do not allow them to perform the new tasks as desired; and the feeling that the tools contribution is redundant in some aspects with the current work methodology, i.e. when controllers have to issue instructions via R/T and input to the HMI after that.

Despite the controllers' general opinion about an increase of the number of inputs to the system, which is directly related with higher workload (see also de HMI feedback), it is reflected in question Q2.2 that easiness of usage has been widely accepted. Controllers considered that this will even be improved with more practice.

Another important block of questions is the one related with alerts display and appearance on the screen. Although some of the following questions will be further considered in the HMI section, they have been presented as a general issue that impacts the perception of the controllers:

- *Q2.3 Do you consider adequate the priority of alerts within each group?*
- *Q2.4 Do you consider adequate the severity level of the different alerts? Information or alarm*
- *Q2.5 Do you consider the acronyms used adequate?*
- *Q2.6 Are all the alerts displayed in all the positions. Do you consider it adequate?*

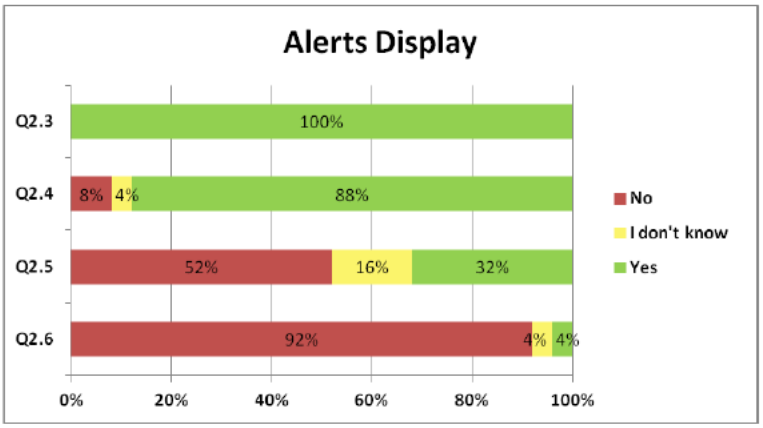


Figure 27: EXE 614 - Alerts Display

As seen on previous figure, controllers have assessed priority of alerts within each group and severity level very positively.

The alerts were implemented for visualisation in four groups – Runway Incursion, Conformance monitoring, Conflicting ATC clearances, Area intrusion. It was possible to have for one aircraft one alert from each group at the same time, though this happened only once and because it was created on purpose to test it.

Regarding the level of severity, some controllers indicated that all the ground alerts should be INFORMATION alert, and ALARM alert should be used only in the runway.

Controllers indicated that a simplification and reduction of acronyms would reduce the recall effort and improve Situational Awareness, see HMI section 6.1.3.1.3. Finally, the question regarding all the alerts displayed in all the positions has been evaluated very negatively. General opinion in this matter is that controllers have been very affected as a result of the great amount of alerts on their screen. It confirms what had been previously introduced by the workload of new tools. Controllers indicated that they only want to visualize alerts affecting their positions. The description provided was:

- All controllers want to see the alerts of mobiles under their responsibility (in R/T) regardless of whether they are under their area or have moved to another one, e.g. vehicles assumed by ground controllers that perform a runway incursion. This is also linked to the mode of operation where ground controllers assume temporarily, part of the AoR of the adjacent controller.

- Runway controllers want to see the alerts of mobiles that are on the runway, on the area of protection of the runway, or that may perform a runway incursion, even if they are not under their responsibility.

- Ground controllers want to see the alerts of aircraft that are in the previous ground/runway position if their route enters in their area of responsibility and are about to enter their area of responsibility, e.g. they want to see a "route deviation" information alert if an aircraft takes a runway exit different from the expected one but not a "no contact" alert.

- Some ground controllers with the area of responsibility limiting with a runway want to see the alert of mobiles on the runway. This was not shared by all the controllers, thus could be configurable by each controller.

Section related with Efficiency will provide further information regarding routing display, which is connected with this part of visualization as well.

The last point related with the controllers' interaction with the system is the order for the actions when working with the system. It was confirmed by the observers that most of the inputs related to the controllers' clearances were made at the same time during the R/T transmission or immediately after that, without receiving the read back confirmation from flight crew's position. Some observers reported also that the input process depended on the current workload and that certain controllers waited until after receiving the acknowledge message.

These variations agree with controllers' questionnaires and debriefings where there is no uniform conclusion, which indicates that most of controllers proceed without receiving read back confirmation, but it is a work method based more on a personal option than on a procedure.

Conclusion from the Human Performance Transversal Area is that workload remains within acceptable limits, but the new tools demanded high interaction from the controllers. Although the alerts have been positively assessed in terms of information provided and priority, several improvements have been identified. The routing and planning function did not provide an improvement in other area that compensated the workload invested.

6.1.3.1.2.2 Safety

Safety KPA was investigated in terms of the impact of integrated features on the safety on airport surface. This task is focused on the indicators *"provision of information and coexistence with previous alerts"* and *"controller Situational Awareness"*.

This KPA is related to the objectives:

OBJ-06.03.01-VALP-0614-0001 – Assess the safety increase due to new alerts provided to the ATCOs working together for hazardous situations in runways, by means of:

- Runway incursion
- Non-conformance to ATC procedures
- Non- conformance to ATC instructions
- Conflicting ATC clearances

OBJ-06.03.01-VALP-0614-0002 – Assess the safety increase due to new alerts provided to the ATCOs working together for hazardous situations in taxiways, by means of:

- Area intrusion
- Non-conformance to ATC procedures
- Non- conformance to ATC instructions

6.1.3.1.2.2.1 Provision of information and alerts coexistence

Controllers reported very positively about identification of mobiles involved in conflict situations and to distinguish them from the rest of the traffic (over 95% of answers considering easy or very easy and a weighted average up to 3.34). Comments in questionnaires were focused on how decisive and useful were the blinking alerts on the radar label for the runway controllers when a mobile penetrates the runway with no authorization. The presence of the alert on the radar screen is determinant even on ground controller positions. The problem with this point comes out due to the high amount of alerts simulated, which sometimes provoked that some alerts were covered up by others, when the screen had zoomed out. This impacted specially on runway controller positions where the screen has to display the length of the runway. This problem is also addressed in the HMI comments related with the alerts display.

Regarding the alerts misleading due to the coexistence of different types of alerts, there was an irregular assessment as it is shown in the weighted average (with less than 2.60). Regarding the number of answers, there is a 52% considering that different types of alerts have sometimes misled the controllers, against 48% of

answers considering that different types never or almost never misled them. Reasons for that assessment are based on ideas previously discussed, like alerts covering up each other when zoom out, alerts for traffics assumed in other positions or AoRs which disturb more than help and the lack of familiarization with certain acronyms even after the training period which led into the acknowledge of the event by analysing the context. Special emphasis was made by runway controllers who consider unnecessary alerts of mobiles not assumed in their positions and very far from the runways, becoming quite distracting for normal operations.

Questions directly addressing these matters were:

- *Q3.1 Was it easy to identify the mobile/s involved in the incidents?*
- *Q3.2 Have the different types of alerts misled you instead of helping you?*

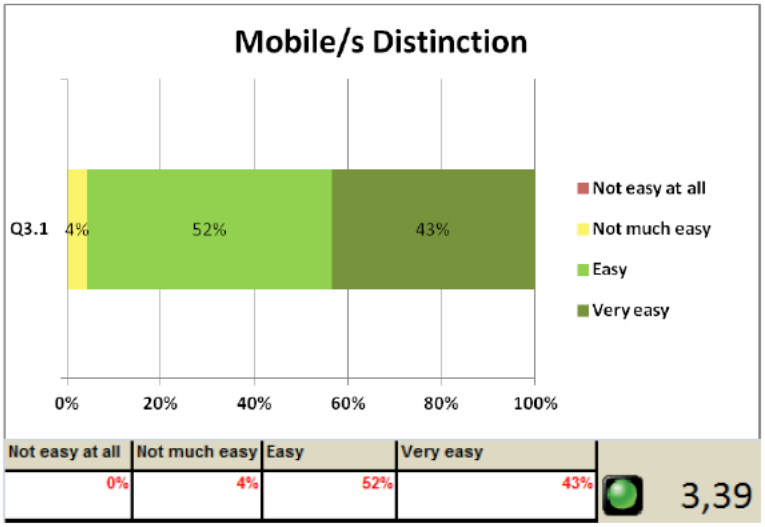


Figure 28: EXE 614 - Mobile/s Distinction and weighted average

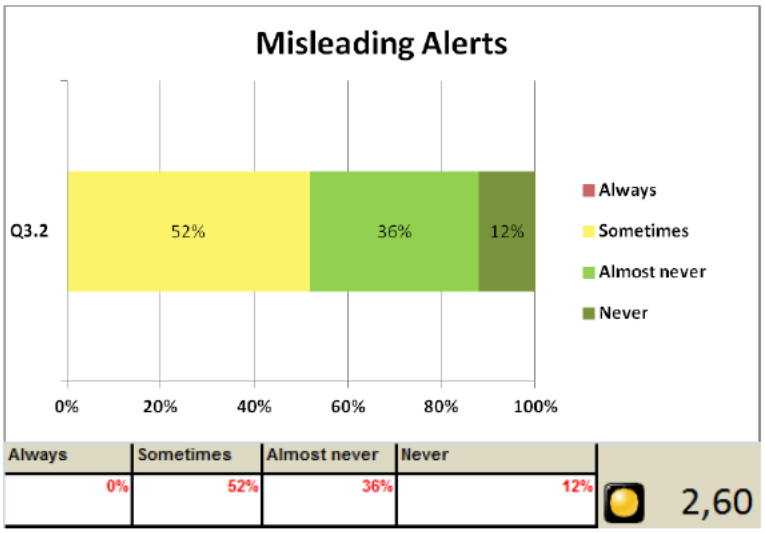


Figure 29: EXE 614 - Misleading Alerts and weighted average

Another important fact related with the alerts is the conditional clearances. Although controllers had been instructed not to issue them, observers reported that controllers used them. On runways when two conditional clearances were transmitted unintended (not deliberately to test the alert) and they

were input to the system, a NEHP or OPHP alert was triggered, which provoked a distraction of the controller. A recommendation could be to consider a conditional clearance option in the system in order to avoid those situations.

Two controllers reported the same misunderstanding: one vehicle entered the runway without a clearance at the far end of the runway. The vehicle had an INFORMATION alert (runway incursion) when it entered in the runway (they had it regardless of whether it was cleared to enter or not). When an aircraft was cleared to take-off there was no alert on the aircraft. The runway incursion alert was not triggered until the aircraft has reached a certain speed. Controllers expected an earlier information alert by means of a conflicting ATC Clearance.

Finally they understood the logic of the different alerts, and decided that the vehicle runway incursion could be reinforced with the runway highlighted (see section *6.1.3.1.3.7.2 Briefing analysis* for HMI)

Comparing these results with the ones in the Reference scenario it is deducted from the next figures that:

- Mobiles Distinction is better in the Solution scenario (although weighted average is 3.13 against 3.39, in the Reference controllers have reported that mobile distinction is not easy at all in a 13% and in the Solution scenario there is no such negative impression). It is here worth mentioning that some of the incidents provoked were detected by the new tools during the Solution scenario but not during the Reference.

- Alerts Misleading is better in the Reference scenario, as obviously less alerts tend to not be misunderstood by the controllers (weighted averages are 3.38 against 2.60).

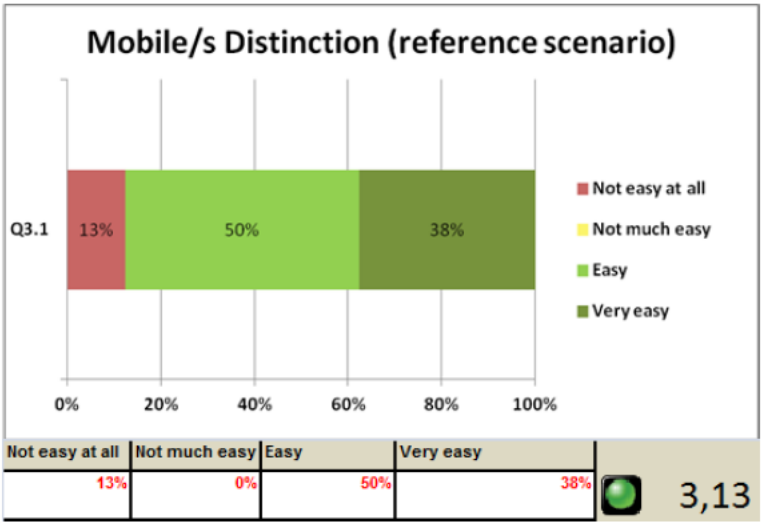


Figure 30: EXE 614 - Mobile/s Distinction weighted average in Reference

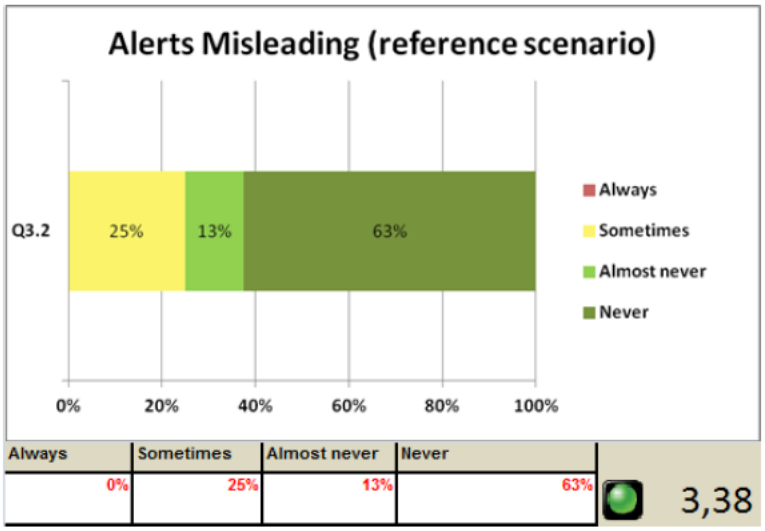


Figure 31: EXE 614 - Misleading Alerts weighted average in Reference

Conclusions for *"provision of information and alerts coexistence"* are directly related with *"Situational Awareness"*. Both indicators cannot be independently understood or addressed. The higher provision of useful information the controllers receive, the better Situational Awareness they have. The next section contains more results regarding the utility of the information provided.

6.1.3.1.2.2.2 Situational Awareness

It has been observed that questions regarding Situational Awareness have a certain amount of indecisive answers (24 to 36%) but, in general, controllers that reported positively about Situational Awareness during the exercise are under the 70%. The main reasons for indecision are directly related to comments and conclusions from the previous section; besides, it can be a determinant factor considering also a lack of familiarity with new features.

Questions directly addressing these matters were the following ones, and have been addressed and reported considering alerts and routing features separately from each other:

- *Q3.3 The Alerts / Routing help me to carry out my work*
- *Q3.4 The Alerts / Routing provide useful information*
- *Q3.5 The information provided by the Alert / Routing is correct*

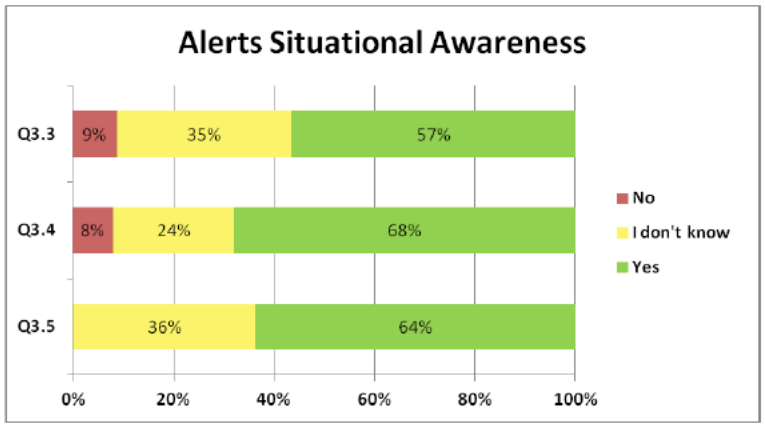


Figure 32: EXE 614 - Alerts Situational Awareness

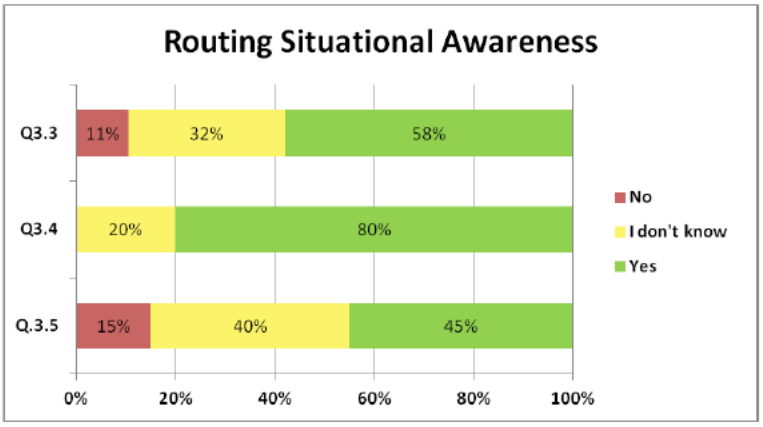


Figure 33: EXE 614 - Routing Situational Awareness

On one side, routing information has been considered very useful even more than alerts (80% against 68%); in some cases, it has balanced out the lack of familiarisation with the airport layout when the controllers came from other facilities different from the scenario (not from Barajas airport). On the other side, information provided by alerts is considered more reliable than information provided by routing. This conclusion seems like a contradiction but limitations with routing functionalities, further explained in section related to Efficiency KPA, will reaffirm that.

If Situational Awareness is compared per tool and role, it is clear in Figure 34 that new features contribute to a better Situational Awareness for runway controllers.

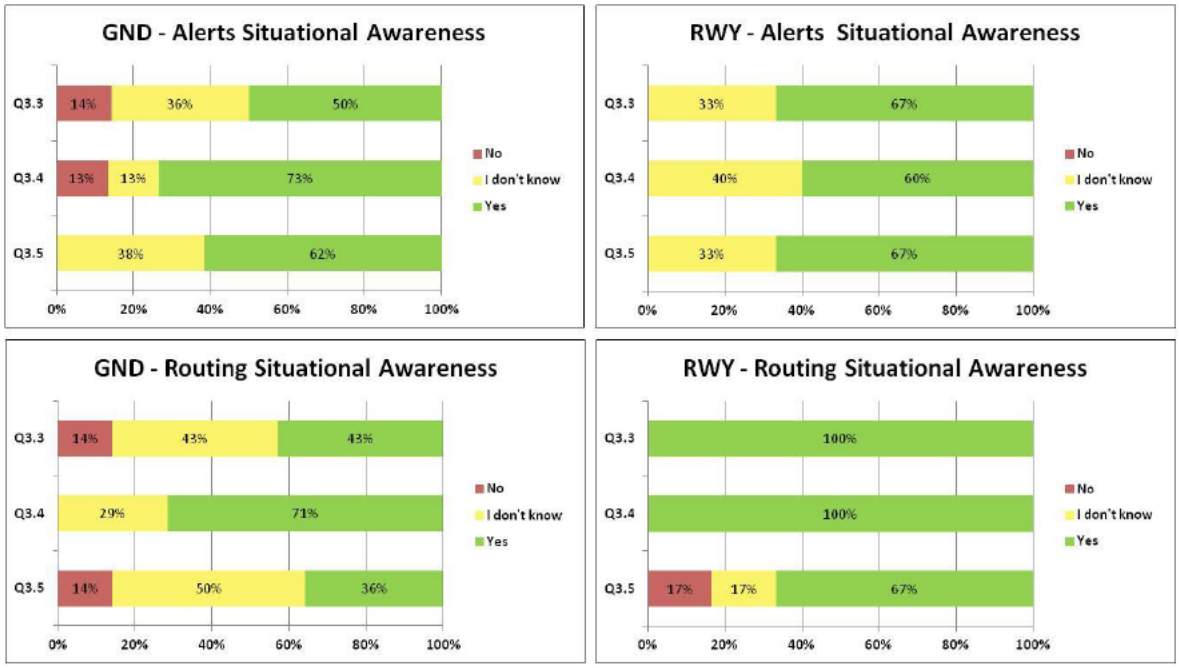


Figure 34: EXE 614 - Situational Awareness per tool and role

Last conclusions for Safety KPA are based on two more generic questions:

- *Q3.6 Do you feel comfortable with the proportion of time spent looking out of the window and the amount of time spent looking at the screen?*

- *Q3.7 Do you consider useful the alerts triggered in your position?*

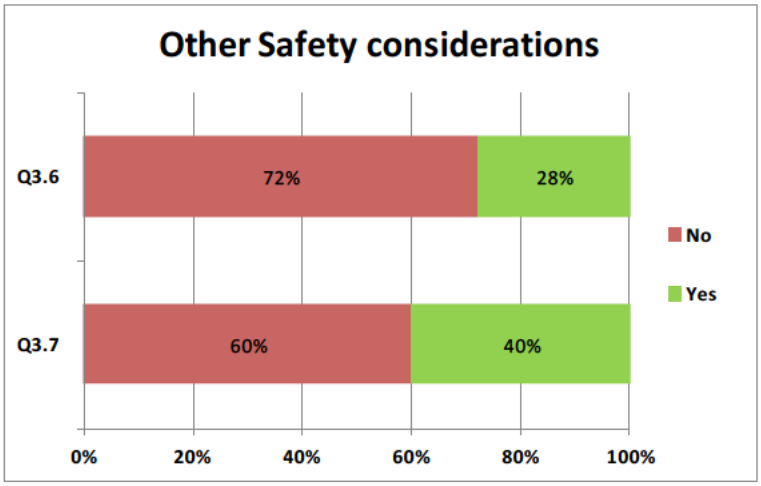


Figure 35: EXE 614 - Other safety considerations

Controllers reported that they have looked out of the window a few times, as the rest of the time they were saturated by the new tools features (up to 72% of negative answers). This assessment has been corroborated by the observers who have notified that controllers have looked out of the window in specific moments, but they were not able to do it always in conflict situations. It has been admitted that, when functionalities were working together and all the alerts from different positions were blinking on the screen, it was very difficult to look away from the screen. Even although some controllers looked out more often, they were making an additional effort, entirely conditioned by the workload on the screen.

During the debriefings, it was confirmed by controllers that they would have wanted to spend more time looking out of the window.

The results for question Q3.6 in the Reference scenario show that controllers consider much more useful the alerts triggered in their positions than in the Solution scenario (88% against 40% of positive answers). As already indicated, this can be linked to the high number of alerts displayed in all the positions.

Controllers consider also in the Reference that they were not comfortable with the time looking out of the window (question Q3.7). In this case, it is linked to the paperless environment.

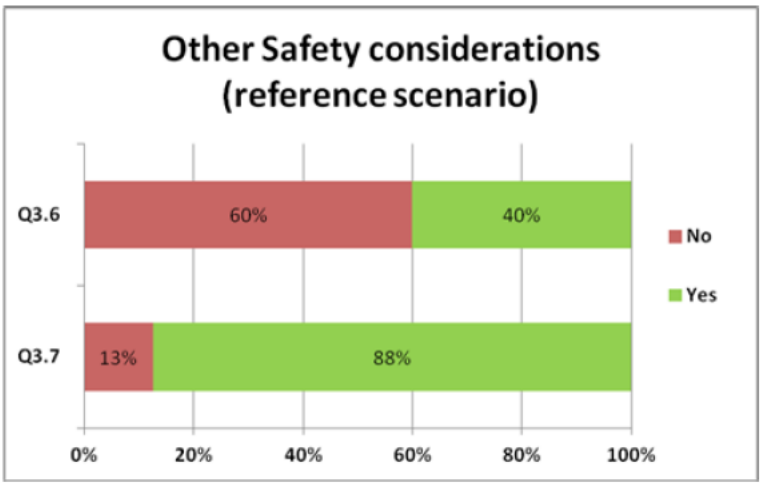


Figure 36: EXE 614 - Other safety considerations in Reference scenario

Controllers also pointed out the low utility of all the alerts triggered in their positions (up to 60% of negative answers). This is directly connected with question Q2.6 and its answers (negative over 90%). Controllers have assessed in several comments that they do not want all the alerts and it would be a positive modification to limit the visualization of alerts to the ones affecting their own positions or about to affect them.

Conclusion from the safety KPA is that it has not been improved as expected.

Alerts were triggered correctly following the aircraft and vehicles incidents provoked. The tool supported controllers in identifying incidents and mobiles involved, but the display of alerts in all positions has deeply impacted the Situational Awareness. The Routing and Planning function provided Situational Awareness to the controllers not familiarised with the airport layout, but the general feeling is that it subtracted time from looking out of the window, which was not compensated by other means.

Runway controllers provide a better feedback than ground controllers. Alerts are more positively assessed than routing.

6.1.3.1.2.3 Efficiency

Efficiency KPA was validated using qualitative and quantitative indicators in terms of the impact of the routing activity outcomes.

The qualitative indicators are the *"suitability of the routes provided by the system"*. The quantitative indicators are the:

- *Number of automatic routes acceptance as first option*
- *Number of times manual route is used*
- *Route alternatives (Automatic Mode) accepted by ATCOs*
- *Route proposals (Semi-Automatic Mode) accepted by ATCOs*
- *Graphical route edition vs Panel route edition*

This KPA is related to the objective:

OBJ-06.03.01-VALP-0614-0004 – Assess the validity of the route provided by the updated Routing Planning function, in Automatic and Semi-automatic modes and the route edition in Manual and Semi-automatic modes.

Out of scope of the exercise is to repeat the validation of the surface Routing and Planning function performed in release 2. The focus of the exercise regarding this function is on the improvements included: adequateness of the route proposed, improvement on the semi-automatic and manual modes HMI. Due to this reason, during the simulation priority was given to the modification of routes using the different tools available over possible improvements on taxi time efficiency or predictability. The quantitative indicator has been analysed to have a better insight of the exercise development but should not be considered the outcome of the validation of the surface Routing and Planning function, which was given in release 2 in [54].

6.1.3.1.2.3.1 Routes Suitability

The routes proposed automatically by the routing function were considered as adequate or very adequate in over the 65% of the answers and the weighted average improves even more these values considering a positive perception (up to 2.80).There were no routes automatically proposed which were considered as not adequate at all. In case of the alternative routes proposed by the function, when the automatic route was not used, only 6% of answers considered them not adequate at all. Despite this interpretation, the assessment was not as positive as expected because the weighted average does not show a positive perception (below 2.80).

Observers reported that sometimes controllers checked the Taxi Route Edition Panel not to select a different route but also to see the alternatives provided and to test the different edition functionalities.

The questions directly addressing adequacy of Automatic routes were:

- *Q4.1 Do you consider adequate the routes automatically generated and allocated by the system?*
- *Q4.2 In case of having requested to the system an alternative route for any flight, do you think alternative routes proposed by the system are adequate? (three alternatives)*

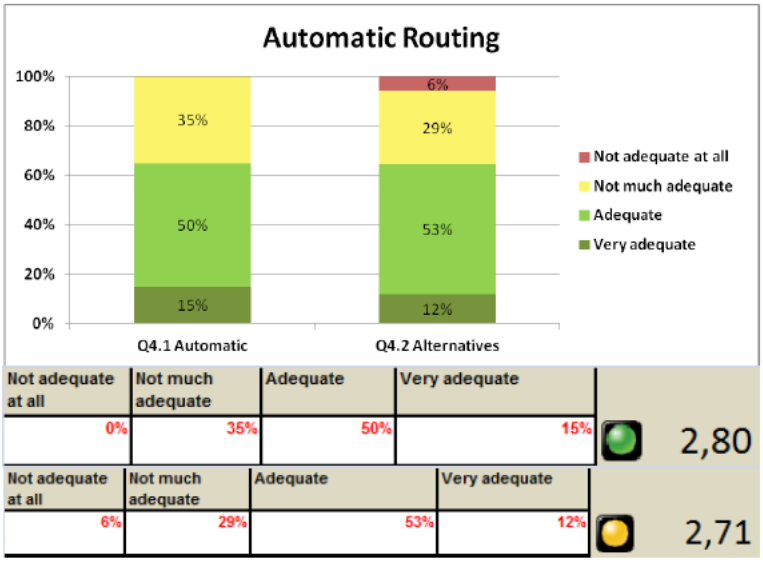
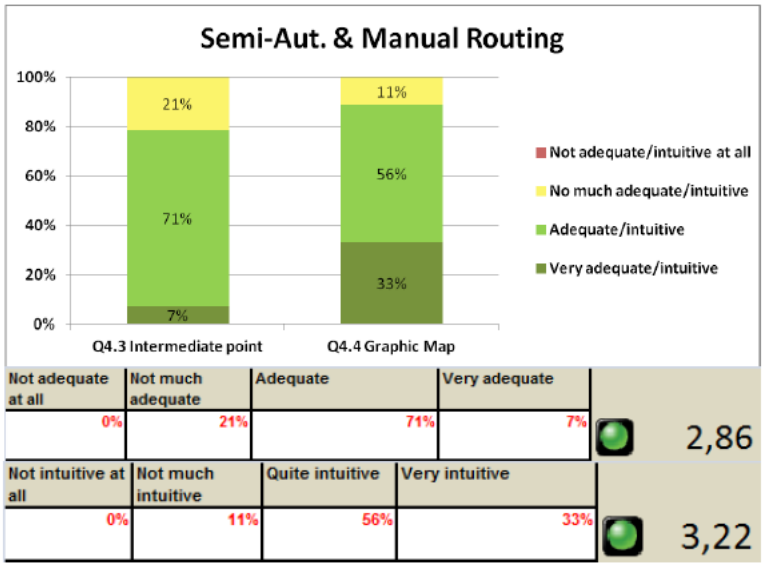


Figure 37: EXE 614 - Automatic Routing adequacy and weighted average

The questions directly addressing adequacy of Semi-Automatic or Manual routes were:

- *Q4.3 In case of having requested to the system an alternative route for any flight, do you think alternative routes when entering an intermediate point via keyboard are adequate?*

- *Q4.4 Do you consider easy and intuitive the route generation system in manual mode? (taxiways map)*



Not adequate at all	Not much adequate	Adequate	Very adequate	
0%	21%	71%	7%	2,86

Not intuitive at all	Not much intuitive	Quite intuitive	Very intuitive	
0%	11%	56%	33%	3,22

Figure 38: EXE 614 - Semi-Automatic and Manual Routing Adequacy and weighted average

The questions related with routing edition have been evaluated quite positively as the weighted average is over 2.80 (up to 3.22 in the question referred to the graphic map).

The main problem detected by the controllers is that the prototype did not allow the aircraft to be routed using opposite directions of the taxiways, which is usual in the apron depending on the push-back direction and the aircraft final destination or when some specific taxiway segments of Barajas are closed. That is the reason controllers reported that they could offer better routing options that the ones provided by the system.

Observers agreed that controllers opened the panel to modify the route when they did not agree with the proposed route or due to temporary restrictions. The panel was opened a few times by certain controllers, simply to test the tool. In addition, they confirmed that, in certain cases, controllers needed support because, after selecting another route, writing a waypoint ("Taxi To" option) and trying to analyse it, the system indicated that it was not available, since the aircraft was taxiing and the start point had already changed (it is required to close the panel and reopen it). In other cases, controllers just considered a shorter path to the destination as a better option, but sometimes these routes used opposite taxiway directions and the routing system was configured only to follow directions defined in the airfield charts from AIP documents.

There was a comment regarding that the prototype could be improved if the taxi routes proposed were checked by the airport operative controller who will indicate which ones had higher priorities, as in most of the cases, the standard route is the preferred route but, depending on the location of the aircraft, a shortcut would be the preferred one.

One conclusion extracted from debriefings was the routing edition was not flexible. There should be a way to disable the direction restrictions. Especially important when there is a closed taxiway as controllers usually reroute aircraft using nearby paths. Another problem appeared when the system did not provide alternative routes when a runway or a taxi path was closed as all the options were through opposite direction, so the route could not be modified. The system has to be designed to provide solutions under unexpected

events (i.e. if an aircraft had aborted take-off, was blocking the runway and had to vacate it, the system did not support the use of the nearby entering taxiways and was proposed to taxi along the runway and vacate using the opposite threshold).

The requirements of the operational project indicate that there should be a mode to enter a complete route that allows total flexibility when designing the route. This was not implemented in the prototype. When controllers were presented with this option during the debriefings, they disregarded it. They indicated that if a taxiway segment is closed they already have a lot of work and cannot define all the segments of the routes.

Finally, observers reported that after assuming a flight, the route automatically assigned was checked or not depending on the controller. Some of them checked routes at the beginning of the run with less workload. Other controllers checked the routes only when they needed to give indications via voice.

6.1.3.1.2.3.2 Quantitative Indicators

The following tables summarize the actions performed by controllers on the routes and recorded by the system.

The recordings of the system presented in Table 29 indicates that controllers accepted the initial proposed route over a 74% of the times in average, but used the routing tool to analyse the alternative routes proposed by the functionality for over a 49% of the flights (51% of the flights whose route edition was not open).

The "manual mode" entering the whole route was rarely used. This can be related to the feedback from the controllers that it was very time consuming and that this mode was designed to override constraints but this was not possible in the current implementation.

	28-P1	28-P2	29-P1	29-P2	30-P1
Percentage of flights whose route edition was not open	61%	59%	43%	50%	43%
Percentage of flights whose initial route was accepted	75%	73%	82%	70%	68%
Percentage of flight modified entering the whole path	0%	10%	0%	0%	0%

Table 29: EXE 614 - ATCOs route acceptance

The recordings of the system presented in Table 30 indicate that controllers tested both ways of modifying routes. In the last run, the preferred method was the panel. Observers reported that the preferences about one method or other depended on the controllers, but that all tested both ways.

	28-P1	28-P2	29-P1	29-P2	30-P1
Percentage of actions using the panel	85%	76%	33%	45%	78%
Percentage of actions using the graphical edition	15%	24%	67%	55%	22%

Table 30: EXE 614 - ATCOs route edition preference

The recordings of the system presented in Table 31 indicate that the functionality provided a feasible

route (analysis reply) over the 70% of the request for analysis and execution.

The percentage is lower on January 29th because the segment of taxiway closed was in one taxiway whose best alternative was via an opposite direction.

The lower percentage in the graphical edition on the 30th was because the runway controller tried to use this method to route an aborted take-off out of the runway though an entry taxiway.

	28-P1	28-P2	29-P1	29-P2	30-P1
Percentage of times that the function was able to propose a route after a request using the panel	72%	86%	60%	45%	77%
Percentage of times that the function was able to propose a route after a request using the graphical edition	80%	89%	70%	83%	36%

Table 31: EXE 614 - Viable routes proposed by the function

Conclusion from Efficiency is that the routes provided by the system were adequate and their modification using the different edition modes was easy and intuitive with some clear exceptions:

- The lack of flexibility because the tool did not allow to go against the AIP direction.
- The need of higher flexibility at the beginning of the route, related to the pushback direction.
- The function should allow the modification of the route even if, during its edition, the aircraft has moved to a new taxiway segment and the initial point of the route differs from the original one.

6.1.3.1.2.4 Predictability

Predictability KPA was validated using qualitative and quantitative indicators in terms of the impact of the time accuracy and stability.

The qualitative indicator is the *"problematic and overloaded areas identification"*. The quantitative indicators are the:

- *Taxi times*
- *Average and Standard deviation*

This KPA is related to the objectives:

OBJ-06.03.01-VALP-0614-0004 – Assess the validity of the route provided by the updated Routing Planning function, in Automatic and Semi-automatic modes and the route edition in Manual and Semi-automatic modes.

OBJ-06.03.01-VALP-0614-0005 – Assess a map of the movement area generated by the system, where is reflected the usage category of each taxiway, in terms of movements number.

As indicated in the previous version, it is out of scope of the exercise to repeat the validation of the surface Routing and Planning function performed in release 2. The quantitative indicator has been analysed to have a better insight of the exercise development but should not be considered the outcome of the validation of the surface Routing and Planning function, which was given in release 2 in [54].

6.1.3.1.2.4.1 Overloaded Areas identification

One of the improvements in this validation exercise was the presentation on the supervision position of information regarding runway and taxiway utilization and airport airside performance metrics to support the supervisor controller in decision-making processes. The information was presented both by table and through a graphical map. In this graphical representation the whole route of each flight is recorded in terms of the runway used and taxiways gone across, so it is used to present on the map the flow density for each taxiway sequence by terms of a colour ranking.

The tool was presented to the supervisor of the exercise and to another controller who is also supervisor. They indicated that the information displayed on the map would be more useful if, instead of colours related to percentages, colours related to absolute movements per interval of time were used. They evaluated positively that the interval of time was configurable.

Finally, they commented the tool would be useful for elaborating performance reports of the tower shifts, but they already have access to offline tools that provide similar information.

They indicated that the tool would be very interesting and useful in the supervisor position if it were a predictive tool that provides the information regarding foreseen runway and taxiway utilisation and airport performance metrics for the next hour (or configurable period). These enhancements would support configuring the positions and would be used for short-term planning. Another improvement proposed was to relate the movements with the different configuration of areas of responsibility.

6.1.3.1.2.4.2 Quantitative Indicators

Average taxi-times and waiting-time with the engines on are very similar in the solution and the reference scenarios. No general conclusion can be extracted.

Average taxi-out time worsens a 5% with the routing function enabled but improves a 17% in the taxi-in. On the contrary, standard deviation improves a 2% in the taxi-out but worsens a 5% on the taxi-in. A similar trend can be observed in the waiting-time with engines on as expected due to the operational procedure used.

As indicated in the validation plan, improving the taxi-time's predictability was not the objective of the simulation. Preference was given to the feedback on the different ways of modifying the route, and suitability of alternative routes provided by the tool. This indicator has been measured to ensure that the execution of the simulation was similar in all the runs.

Unlike in the EXE-06.03.01-VP-401 exercise, in this simulation standard Barajas operational procedure was followed[2].

During the debriefings, controllers from Palma de Mallorca and Malaga indicated that this is also the standard procedure in their airports. The Barcelona controller indicated that this is not the standard procedure in El Prat.

[2] The standard operational procedure in Barajas is that the aircraft taxiing through the main taxiways have preference over all the other aircraft and are cleared by the first ground controller from the gate to the runway/ runway exit to the gate.

Next figures present average and standard deviation of the taxi time for arrival and departures.

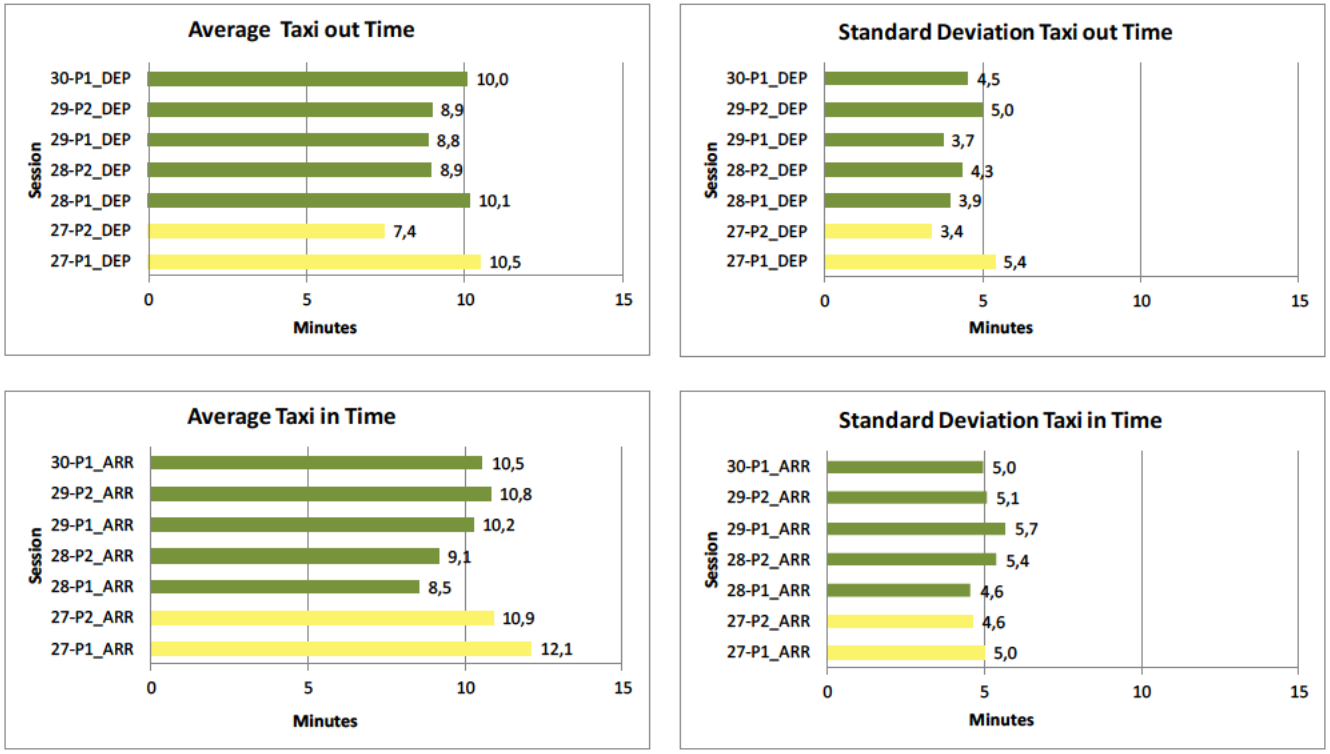
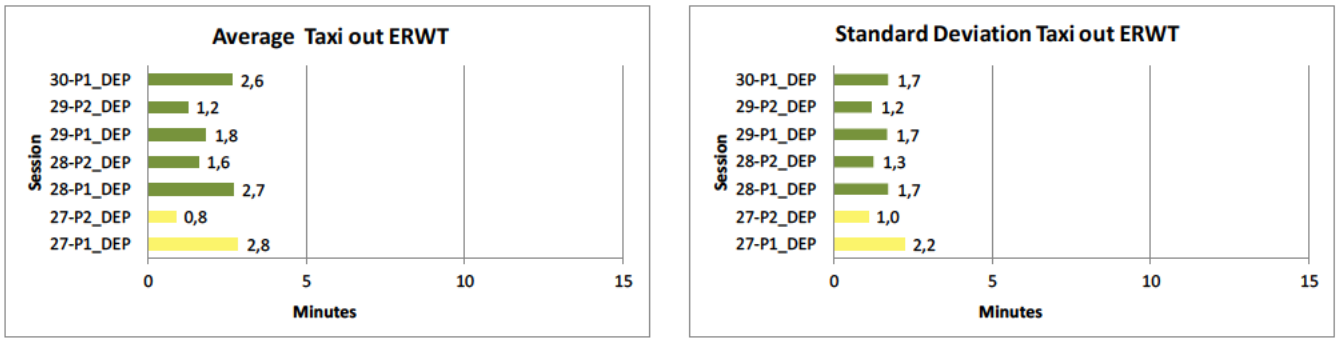


Figure 39: EXE 614 - Taxi time average and standard deviation

The average waiting time with the engines on (ERWT) are presented in next figures.



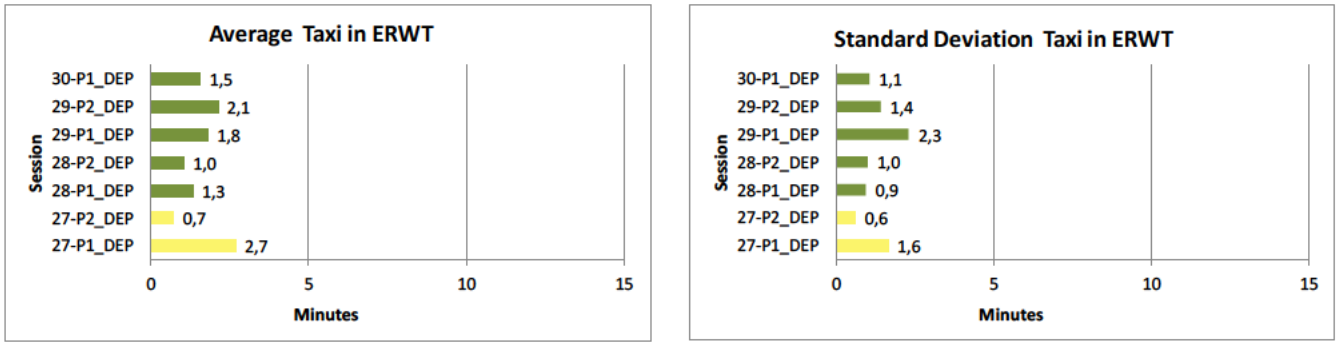


Figure 40: EXE 614 - Waiting time with engines on average and standard deviation

6.1.3.1.3 Results per objective from P06.09.02

The following sections address the assessment of each validation objective of **06.09.02** following this structure:

- Survey results: it is done using the questionnaires information. The format of the answers facilitates the translation in numerical values obtaining an objective view of the controllers' assessment.
    - Graphical information: graphs which are built with the quantifiable information of the questionnaires. They show the results in a visual manner for all consolidated roles (GND+RWY ATCOs) and also per role, when relevant differences between them arose in the answer of the questionnaires.
    - Textual information: text based on the information collected from the comments of the questionnaires,
    - Summary of questionnaire results table: This table shows the mean values for each question and the total average in order to support the decision about the compliance of one validation. For each question (except for 1.4), five answers where available to the ATCOs with a value from 1 to 5 related to the level of acceptance with the statement.: "Strongly Disagree" (1), "Disagree" (2), "Neither agree nor disagree" (3), "Agree" (4) "Strongly agree" (5). This assessment does not include the analysis of the comments performed during the debriefing sessions and interviews. It includes a visual sign which shows the global status of that specific item:
        - ● positive perception of the statement [3,5 - 5]
        - ● conditional positive perception [2,5 - 3,5). This means that additional modifications are required before valuating positively this statement
        - ● negative perception of the statement [1 - 2,5)
- Briefing analysis: it is done with the open comments that validation team collected during the validation exercises.
    - Textual information: text based on the debriefing sessions and the individual interviews. It describes the rationale for the graphical information and also additional comments and suggestions to improve and detail the aspect being analysed.
    - Global assessment of the compliance of the objective taking into account the functionalities valuated

6.1.3.1.3.1 OBJ-06.02-VALS-0060.0001

NOTE: Even though this is not a validation objective defined in 06.09.02 as part of the Validation Plan [50], some of the questions were formulated having it in mind. It is considered that giving feedback on this objective could be beneficial even if it is out of P06.09.02 responsibilities to assess the status of the objective itself.

Objective description: to validate that the integration and exploitation of new ATC functions into an A-CWP results in enhanced Situational Awareness for ATCOs and flight crews.

Success Criteria: improvements with big and positive impact on Predictability, improvements on Safety and Efficiency.

6.1.3.1.3.1.1 Survey results

The questions addressing this validation objective are:

- *Q1.1 The new Alerts HMI improves the capacity of focusing on the right moment and place by identifying dangerous situations.*
- *Q1.2 The new routing HMI improves the Situational Awareness.*
- *Q1.3 The signal of activation and deactivation of the alerts functions was adequate.*

The figure below shows the distributions of the answers of all the controllers (in the case of Q1.2, only the answers from the GND controllers are shown, as they are the only ones that use this tool extensively.

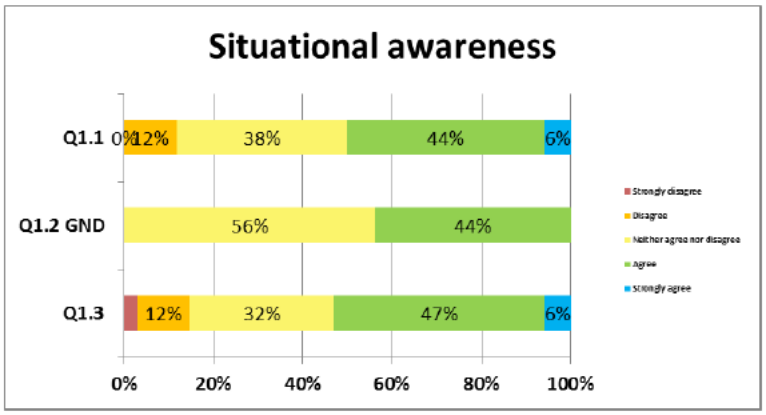


Figure 41: EXE-614 - HMI Questionnaire Results – Situational Awareness

Statistically, it should be remarked that almost 50% of the answers did not perceive any improvement in the Situational Awareness.

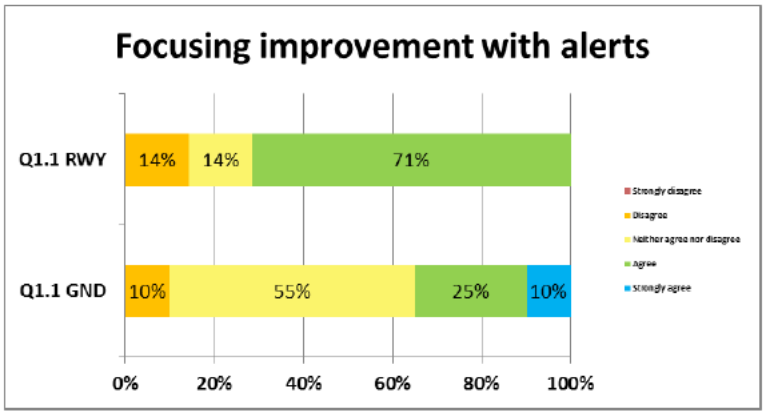


Figure 42: EXE-614 Questionnaire Results– Q1.1

Looking in particular at question 1.1, regarding the capacity of focus the attention and identify dangerous situations, it is much better valued by RWY controllers than GND controllers. It should be noted than the workload in the simulation is lower for the RWY controllers, allowing them to focus on the alerts.

Question	Scale	Average score	Status
Q1.1	[1-5]	3.4	●
Q1.2 GND	[1-5]	3.4	●
Q1.3	[1-5]	3.4	●
Average	[1-5]	3.4	●

Table 32: EXE 614 - Global assessment of the questionnaire – Situational Awareness

In the table above, the average of all the answers is showed; it should be noted that the results in numerical terms for the three questions are very similar and indicates than the new functionalities do not improve enough the Situational Awareness, leaving the door open to upgrades to obtain a full benefit from them.

6.1.3.1.3.1.2 Briefing analysis

The new functionalities added a lot of traffic information, most of the ATCOs found all of this information useful, especially in the last rounds when they were more used to the system. Nevertheless, the high number of alerts that were displayed reduced the overall Situational Awareness and make it difficult to focus or identify the most important ones. The main feedback on this was the general feeling that “less is more”, less alerts (only the ones inside the assigned AoR, only the ones leading to dangerous situations...).

6.1.3.1.3.2 OBJ-06.09.02-VALP-0001.0001

Objective description: to validate that the A-CWP supports controllers in building and retaining an

overall traffic picture.

Success Criteria: controllers confirm that the A- CWP provides useful support in building and retaining a reliable and accurate overall traffic picture.

6.1.3.1.3.2.1 Survey results

The question addressing this validation objective is:

- *Q1.4 In overall, the use of the new A-CWP helps to create and maintain a global image of the traffic.*

The Q1.4 is weighted on a different scale than the rest of the questions of the questionnaire (with 4 possible values instead of 5).

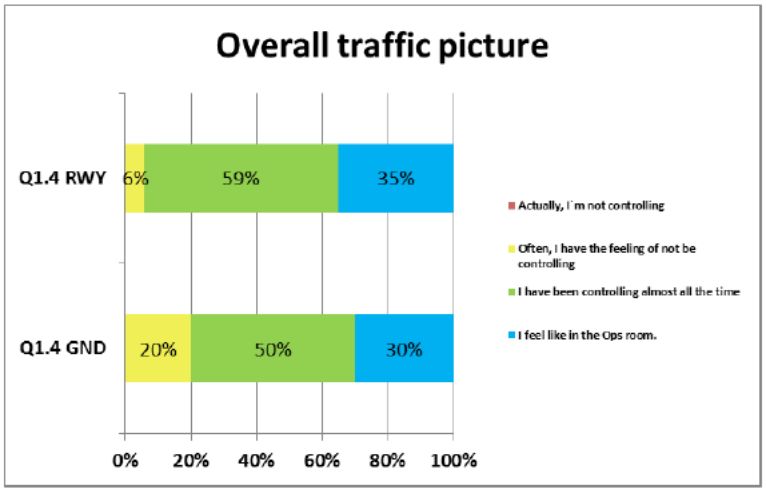


Figure 43: EXE-614 - HMI Questionnaire Results – Overall traffic picture

At the time of scoring this question, for coherence purposes, the same scale and status assessment has been maintained, from 1 to 5, keeping 3.5 as the threshold for a positive view.

The assessment is rather positive (more than 50% of positive answers). It is worth to highlight than more than 30 % of the ATCOs in both roles, feel like they have been in the Ops room.

Question	Scale	Average score	Status
Q1.4 GND	[1-5]	3.9	●
Q1.4 RWY	[1-5]	4.1	●
Average	[1-5]	4.0	●

Table 33: EXE 614 - Global assessment of the questionnaire – Overall Traffic picture

Numerically, the average score of this question is well overall the threshold for considering the assessment as positive.

6.1.3.1.3.2.2 Briefing analysis

The comments on this matter are the same regarding Situational Awareness mentioned in 6.1.3.1.3.1 (it is difficult to distinguish these two concepts when evaluating comments).

One interesting comment was that, when having low workload in the RWY controller position, one controller liked to have all the alerts in his position. This gave him a better picture of the situation of the traffic at the airport and what to expect. It is worth to say that the same controller gave negative feedback on the alerts outside his AoR under different circumstances.

6.1.3.1.3.2.3 Validation Objective Status

OK: the new information provided by the HMI helps the controllers to create and maintain an overall traffic picture.

The possibility of checking the routes of upcoming traffic and the alerts on the labels helped the controllers to have a picture of what was going on and what to expect in the near future. Also, the information was generally received as realistic and close to what they would expect in real life operations.

6.1.3.1.3.3 OBJ-06.09.02-VALP-0001.0020

Objective description: to validate the readability and meaningfulness of textual information displayed by the A-CWP.

Success criteria: controllers appreciate meaning, font's type, dimension, colour of the information displayed by the A-CWP.

6.1.3.1.3.3.1 Survey results

The questions addressing this validation objective are:

- *Q2.1 The presentation of textual information related to alerts enables the identification and understanding of the conflict.*
- *Q2.2 The readability, fonts, type, colours and size used in the texts related to the routing functions (menus, information...) are adequate.*

The figure below presents the graphical distribution of the answers for all controllers for Q2.1 and for GND controllers for Q2.2 (as they are the ones who do an extensive use of the routing tool):

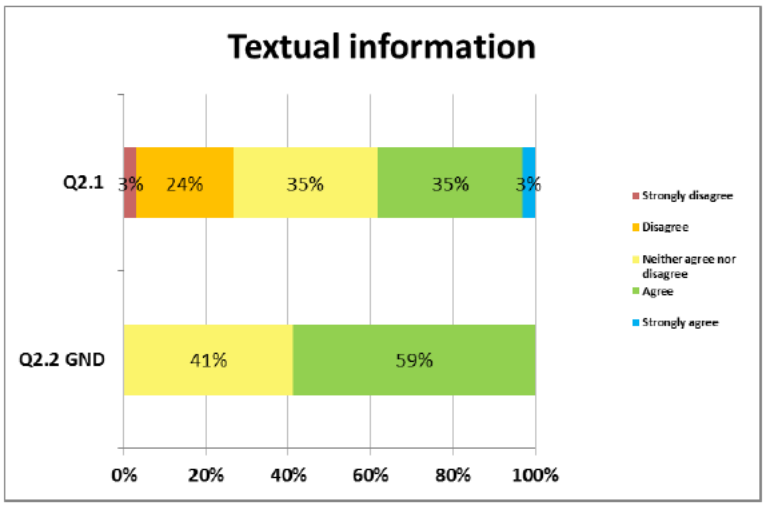


Figure 44: EXE-614 - HMI Questionnaire Results – Textual Information

The perception with respect the two different aspects assessed here (identification and readability), the second (Q2.2) is considered in a much more positive manner; meanwhile, in the first one the percentage of negative assessment is almost as significant as the positive one.

For this objective, as the results are almost identical for both roles, there are not represented here.

Question	Scale	Average score	Status
Q2.1	[1-5]	3.1	●
Q2.2 GND	[1-5]	3.6	●
Average	[1-5]	3.4	●

Table 34: EXE 614 - Global assessment of the questionnaire – Textual information

The low rating of question 2.1 makes that in a numerical manner the assessment of this objective could not be totally positive; some improvements should be made mainly in the area of identification and understanding of the conflicts.

6.1.3.1.3.3.2 Briefing analysis

The way textual information is displayed received good feedback. Especially the colours used to distinguish arrivals, departures and vehicles and information and alarm alerts. The different tones for cleared and pending route on the text in the label were well received also.

The only place where the textual representation received bad feedback was on the Alerts Window. In this window, all the information show in the window is displayed in grey with no highlight whatsoever.

Although the way textual information was displayed was well received (readability, fonts, colours…). The high amount of information (all intermediate segments of each route and all the alerts of the entire airport) made difficult to the users to use the textual information in time. Also, the high number of acronyms make difficult for the controllers to understand their meaning. At the end, most of them didn't find useful at all that the type of alert was displayed using an acronym.

6.1.3.1.3.3.3 Validation Objective Status

NOK: font's type, dimension and colour used for the textual information was well received in most of the cases, but controllers weren't able to appreciate the meaning of most of the acronyms used for identifying the different alerts. In the future, the numbers of acronyms should be reduced or even not used at all, and their meaning should be easily identifiable (similar acronyms should be avoided).

6.1.3.1.3.4 OBJ-06.09.02-VALP-0001.0030

Objective description: to validate the readability and meaningfulness of graphical objects, symbols and visual representations in the A-CWP.

Success criteria: controllers appreciate symbols, objects and type displayed on the A- CWP.

6.1.3.1.3.4.1 Survey results

The questions addressing this validation objective are:

- *Q3.1 The graphical representation of alerts is adequate.*
- *Q3.2 The graphical representation of the taxi routes is adequate.*
- *Q3.3 The alert highlights are adequate.*

The figure below presents the graphical distribution of the answers for all controllers in questions Q3.1 and Q3.3, and only the GND controllers in 2.2:

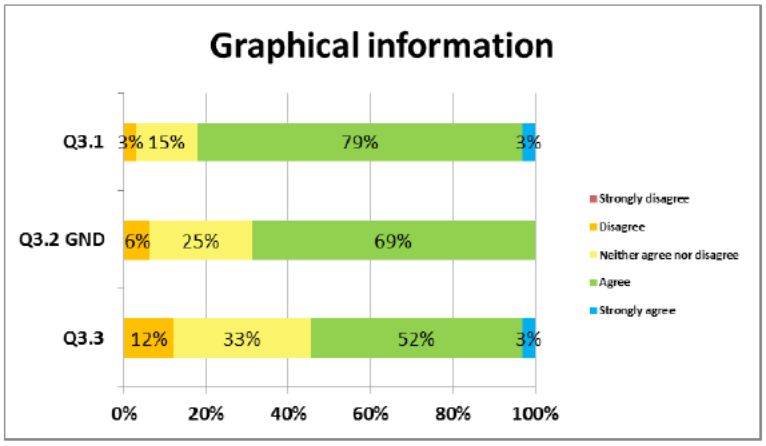


Figure 45: EXE-614 - HMI Questionnaire Results – Graphical Information

For this objective, the perceptions of the controllers are very positive, reaching over the 80 % of positive assessment for the graphical representation of the alerts.

The perception over the graphical representation of the route improves from the second day of the simulation, coinciding with a change in the color of the graphical representation demanding by the controllers, what allow them to distinguish better the taxi route.

Question	Scale	Average score	Status
Q3.1	[1-5]	3.8	●
Q3.2 GND	[1-5]	3.6	●
Q3.3	[1-5]	3.5	●
Average	[1-5]	3.6	●

Table 35: EXE 614 - Global assessment of the questionnaire – Graphical information

The overall numerical assessment was positive (over 3.5 score) mainly driven by the good scores of the first two questions (graphical representations of alerts and taxi routes), the low score of the question Q3.3 is due to the excessive number of highlights, mainly for GND ATCOs.

6.1.3.1.3.4.2 Briefing analysis

Alerts

In general, the graphical representations received a good feedback as their textual counterparts. The colours and highlights used for alerts were clear and helped the controllers to focus their attention to the alerts.

The main negative feedback regarding the alerts on the HMI was that during the simulation there were too many of them. This was caused because of the high number of relevant ATC events simulated and because all alerts where shown in every A-CWP. The only way of not seeing an alert was if the alert was generated in an area of the airport no displayed (due to the zoom, position of the windows...) on neither of the screens of the A-CWP.

Routing

The graphical display of the route received positive feedback. It is worth saying that the colours used were changed during the training due to the comments of the controllers (colours used for available segments and selected segments were too similar). The colour combination used in the graphical display and edition of the route should be carefully chosen or may create a negative impact on the otherwise well received functionality.

6.1.3.1.3.4.3 Validation Objective Status

OK: controllers found it easy to appreciate symbols, objects and type displayed on the A-CWP.

6.1.3.1.3.5 OBJ-06.09.02-VALP-0001.0040

Objective description: to validate consistency and completeness of the information displayed by the A-CWP.

Success criteria: controllers confirm that the displayed information is coherent and complete to manage the traffic in a safe manner.

6.1.3.1.3.5.1 Survey results

The questions addressing this validation objective are:

- *Q4.1The representation of the information regarding alerts is concise and complete, enabling the identification of the type of conflict.*
- *Q4.2 The representation of the routing information is concise and complete.*

The figure below presents the graphical distribution of the answers for all controllers in Q4.1 and only for GND controllers in Q4.2:

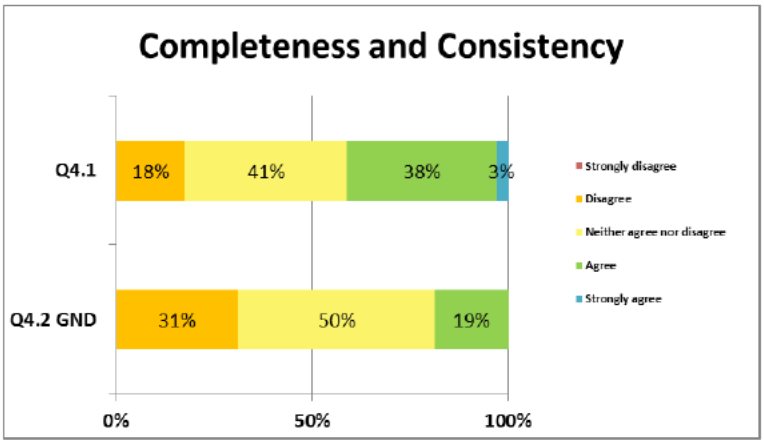


Figure 46: EXE-614 - HMI Questionnaire Results – Completeness and Consistency

In both questions, there are a significant percentage of indecisive answers (over 40%) and a vision more positive of the completeness and consistency of the alerts information than the routing.

Question	Scale	Average score	Status
Q4.1	[1-5]	3.3	●
Q4.2 GND	[1-5]	2.9	●
Average	[1-5]	3.1	●

Table 36: EXE 614 - Global assessment of the questionnaire – Completeness and Consistency

The average score, below 3.5 gives a hint that there are aspects to improve regarding this objective, mainly in terms of making the information more concise, reducing the acronyms for the alerts and the number of segment showed for the routing.

6.1.3.1.3.5.2 Briefing analysis

The information was considered complete and consistent in most of the cases by the controllers. The main comments regarding this topic where:

Alerts

When displaying incursion alerts, controllers feel that it would help if a velocity vector of the aircraft and the restricted are shown and highlighted.

Routing

The textual routing information displayed on the label, as well as on the route edition window, was considered too long to be useful or handled in a safe manner. This information contains the name of every segment of the taxiways used to build the route. This had two undesired effects: the information on the label was useless sometimes because it only displayed consecutive segments of the same taxiway. It would be more desirable (as said by the controllers) to have the intersections, turns or

transfer points shown on the label. The second negative effect was on the route edition mode:, the routes presented (actual routes and alternatives proposed) are too long, thus it took a lot of time to read all the routes; it was also costly to localise the difference between routes using the textual description and sometimes they were forced to used the scroll to see the final segments of the route, as it was longer than the size of the window.

6.1.3.1.3.5.3 Validation Objective Status

NOK: although the information displayed was found coherent and complete, the objective is considered NOK because the displayed information did not help to manage the traffic in a safe manner (mainly due to the high amount of information displayed and the constant highlights).

6.1.3.1.3.6 OBJ-06.09.02-VALP-0001.0050

Objective description: to validate timeliness and prioritization of the information displayed by the A-CWP.

Success criteria: The displayed information is timely and correctly prioritised.

6.1.3.1.3.6.1 Survey results

The questions addressing this validation objective are:

- *Q4.3 The alert information is presented in the appropriate moment,*
- Q4.4 *The alert information presentation prioritizes the information in a proper manner.*
- *Q4.5 The routing information is presented in the adequate moment.*

The figure below presents the graphical distribution of the answers for all controllers:

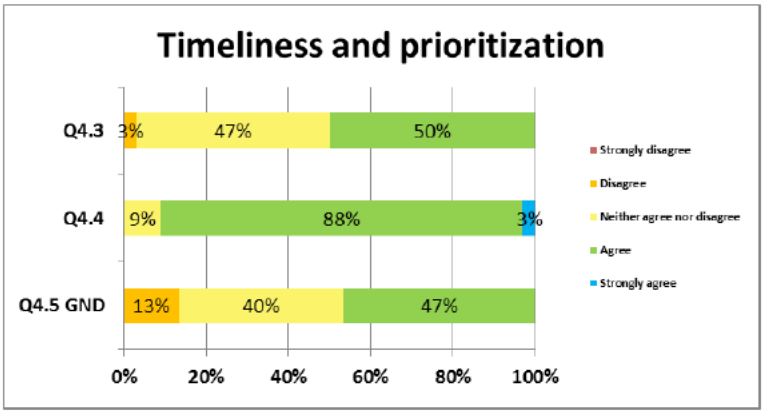


Figure 47: EXE-614 - HMI Questionnaire Results – Timeliness and prioritization

From the figure, it is important to highlight the positive assessment of the alert prioritizations. Prioritization should be understood in this context as the ability of the tool to order the alerts in the label showing the most severe at the left. This way of prioritizing the information was well received by the users. The questions about timeliness of the information offer a great number of indecisive answers and should be considered at a qualitative level.

Question	Scale	Average score	Status

Q4.3	[1-5]	3.5	●
Q4.4	[1-5]	3.9	●
Q4.5 GND	[1-5]	3.3	●
Average	[1-5]	3.6	●

Table 37: EXE 614 - Global assessment of the questionnaire – Timeliness and prioritization

In numerical terms, the global assessment of the objective is positive due to the high score achieved to the prioritization question but remarking that there are things to improve regarding the timeliness of the information.

6.1.3.1.3.6.2 Briefing analysis

There was little number of comments on the prioritization of the information. One of the remarks was that on the Alerts Window all alerts are shown in grey and are organised by the type of alert (no prioritization or differentiation at all). Using this window, it was impossible to distinguish the severity of the alerts or in what part of the airport they were generated.

Regarding the timeliness of the information, there were several complaints regarding the area incursion alerts. The general feeling was that when the system showed the alert it was too late to take action to avoid the incursion. This problem is more likely to be related to the way this conflict is detected rather than to the way it is presented by the HMI.

6.1.3.1.3.6.3 Validation Objective Status

OK: In general, it was considered that the HMI displays the information in time and important information is well prioritised.

6.1.3.1.3.7 OBJ-06.09.02-VALP-0001.0060

Objective Description: Validate the adequacy of information from the Advanced integrated CWP.

Success Criterion: Controllers consider the displayed information to be adequate to perform their tasks.

6.1.3.1.3.7.1 Survey results

The questions addressing this validation objective are:

- *Q4.6 The alerts are presented in the adequate places.*
- *Q4.7 The information presented in the A-CWP is not contradictory with the information presented elsewhere in the same A-CWP.*

The figure below presents the graphical distribution of the answers for all controllers:

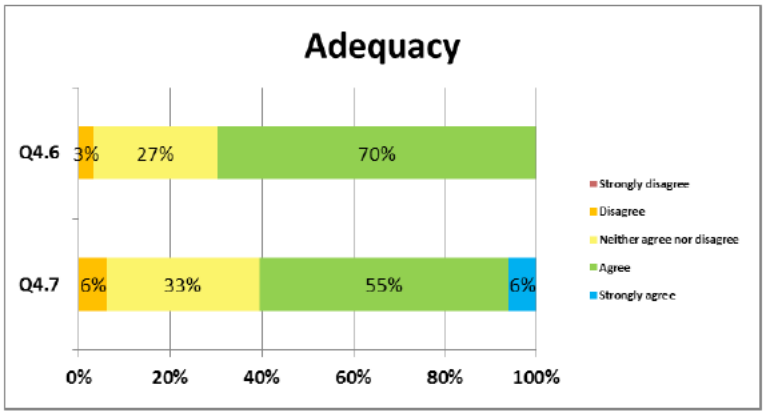


Figure 48: EXE-614 - HMI Questionnaire Results – Adequacy of the information

From the graphic, it could be assessed that the localization of the alerts is adequate (70% of positive answer) and more than 60 % of the answers consider the information presented on the label not contradictory with the information presented in other windows.

For this objective, the representation per role is not significant.

Question	Scale	Average score	Status
Q4.6	[1-5]	3.7	●
Q4.7	[1-5]	3.6	●
Average	[1-5]	3.7	●

Table 38: EXE 614 - Global assessment of the questionnaire – Adequacy of the information

The global assessment of the objective is positive both questions are above 3.5 in the average score.

6.1.3.1.3.7.2 Briefing analysis

To confirm the results of the questionnaire, the feedback of the controllers who take part on the simulation was positive; nevertheless, there are issues to be improved:

Alerts

The information of the alerts in the label was considered as adequate, one repeated request is to have the possibility to filter the alerts per role, and to highlight in some way the alerts which affect or are going to affect the flights assumed by the position. In the simulation, all the alerts were showed in all the positions without filter.

For the alerts related with runway incursions or prohibited taxiways, the option to have not only a information alert on the label but a highlight on the affected runway/taxiway was a requirement of runway controllers mainly.

Regarding the alerts window, it was considered hard to use, at least with the existing design, the use of colours (same as in the label) was recommended.

Also, it was mentioned than the alerts are not shown in the electronic flight strip, there were mixed opinions regarding that, some controllers prefer not to add more information in the electronic flight

strip and consider that is enough to have it in the label.

Routing

The only problem with the information displayed by the routing function is described in the previous sections, the information is considered adequate but, a way of displaying it in a more abbreviated manner should be implemented in order to make it really helpful.

6.1.3.1.3.7.3 Validation Objective Status

OK: the new information presented to the controllers was considered adequate to perform their tasks.

6.1.3.1.3.8 OBJ-06.09.02-VALP-0001.0070

Objective Description: Validate the practicability and intuitiveness of commands on HMI objects.

Success Criterion: Controllers consider information finding and sorting quick, easy, practical and intuitive.

6.1.3.1.3.8.1 Survey results

The questions addressing this validation objective are:

- *Q5.1 The interaction with the routing function is easy and intuitive.*
- *Q5.2 The interaction with the alert function is easy and intuitive.*

The figure below presents the graphical distribution of the answers for all controllers in Q5.2 and for the GND controllers in Q5.1:

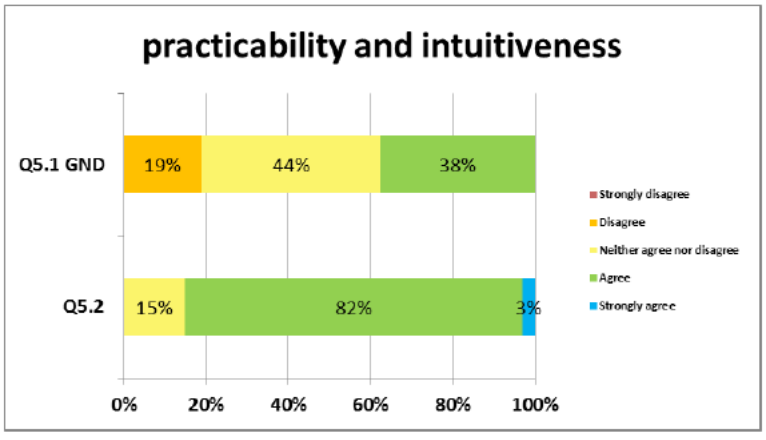


Figure 49: EXE-614 - HMI Questionnaire Results – practicability and intuitiveness

The assessment of the easiness and intuitiveness of the interaction with the alert function has been positive. This is not the case for the routing function, the assessment of the GND controllers, which

are the main users of this feature, is rather negative.

Question	Scale	Average score	Status
Q5.1 GND	[1-5]	3.2	●
Q5.2	[1-5]	3.9	●
Average	[1-5]	3.7	●

Table 39: EXE 614 - Global assessment of the questionnaire – practicability and intuitiveness

Although the global assessment of the objective is positive (due to the high score of Q5.2), there are aspects to improve regarding the easiness and intuitiveness of the interaction with the routing information.

6.1.3.1.3.8.2 Briefing analysis

The interaction with the alerts information was considered easy and intuitive and no negative remarks were made on it. This is not the case with the routing interaction; a lot of remarks and suggestions were made on that:

- In general, the route graphical edition tool was better appreciated than the route modification window.
- If something has changed in a route, the full route blinks making it very difficult for the controller to identify the modification; it would be useful if only the changes blink.
- It is possible to display only one route at a time, this does not allow to use the route tool as a support to prevent potential conflicts.
- Some controllers request the option to clear the full route until the runway entry point for departures, or the stand for arrivals, as it is the procedure in their dependency. It was explained them that according to the SESAR requirements ATCOs can only clear routes inside their AoR.
- The routing modification tool was considered not very flexible and very dependent on the adaptation data. The criteria used to show the system suggestion in case of a route modification was the shortest distance taking into account the AIP direction of the taxiway, this was creating confusion to the controllers familiar with the platform, that sometimes do not identify the suggested route as a preferred one.

It should be remarked that the controllers not familiar with the environment made a better assessment of the routing tools than the controllers from Madrid airport, who do not need a supporting tool to modify a route. This leads to think than this could be a tool more useful in training than in day-to-day operation.

6.1.3.1.3.8.3 Validation Objective Status

NOK: mainly because of the routing functionality. It was considered that it was not easy or practical to find information as the textual routing information was too long and, in the graphical mode, only one route was displayed at a time. The alerts' HMI received better feedback.

6.1.3.1.3.9 OBJ-06.09.02-VALP-0001.0080

Objective Description: Validate the adequacy of feedbacks of commands / actions on HMI objects.

Success Criterion: HMI objects provide adequate feedbacks for each controller input.

6.1.3.1.3.9.1 Survey results

The question addressing this validation objective is:

- *Q5.3 The response of the HMI to each controller action is what is expected.*

The figure below presents the graphical distribution of the answers for all controllers and differentiated per role:

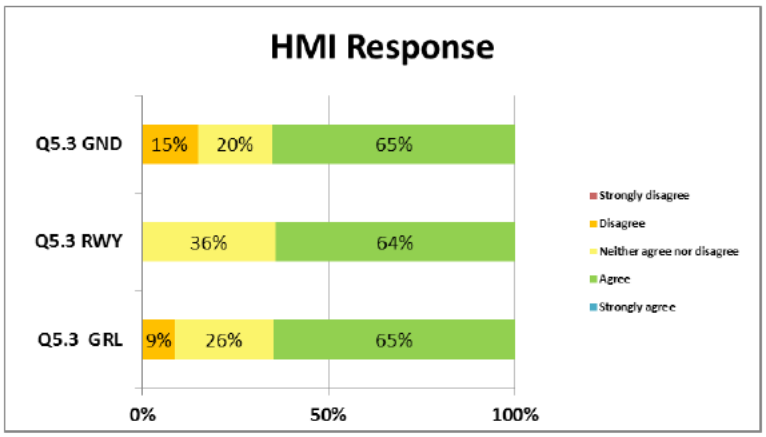


Figure 50: EXE-614 - HMI Questionnaire Results general and per role – HMI response

From the graphical representation, it could be extracted that the perception of the response of the HMI is seen in the same way by both roles and the percentage of positive answers is over 60 %.

The numerical score of this question shows a positive assessment of the objective.

Question	Scale	Average score	Status
Q5.3	[1-5]	3.6	●
Average	[1-5]	3.6	●

Table 40: EXE 614 - Global assessment of the questionnaire – HMI response

6.1.3.1.3.9.2 Briefing analysis

Although in the question 5.3 there was no differentiation between routing and alerts functionality, almost all the controllers' feedback was referred to the routing.

There was some confusion if, during the time a modification is being made on the route, the aircraft is reaching another point of the sequence of the taxiway. In this case, all the modifications made to the route are rejected by the system (*Message Starting point not valid*) and it is necessary to start again

the operation. This occurs both on the graphical and textual routes.

Other issue creating confusion is the obligation to first select the track before displaying the graphical route, instead of using the left button of the mouse over the track symbol as it was used in the air to show the air route.

6.1.3.1.3.9.3 Validation Objective Status

OK: the HMI reacted as expected to controllers' inputs.

6.1.3.1.3.10 OBJ-06.09.02-VALP-0001.0090

Objective Description: Validate the adequacy of number and sequence of actions on graphical objects needed to accomplish control tasks

Success Criterion: Controllers confirm that the number and the sequence of actions required to perform their tasks is acceptable

6.1.3.1.3.10.1 Survey results

The questions addressing this validation objective are:

- *Q5.4 The interaction with the graphical objects (windows, icons, menus) is fast and simple.*
- *Q5.5 The number and sequence of actions required to manage routing information are adequate.*
- *Q5.6 Once the new functionalities have been tested, it is simple to make graphical modifications.*

The figure below presents the graphical distribution of the answers for all controllers in Q5.4 and 5.6 and for the:

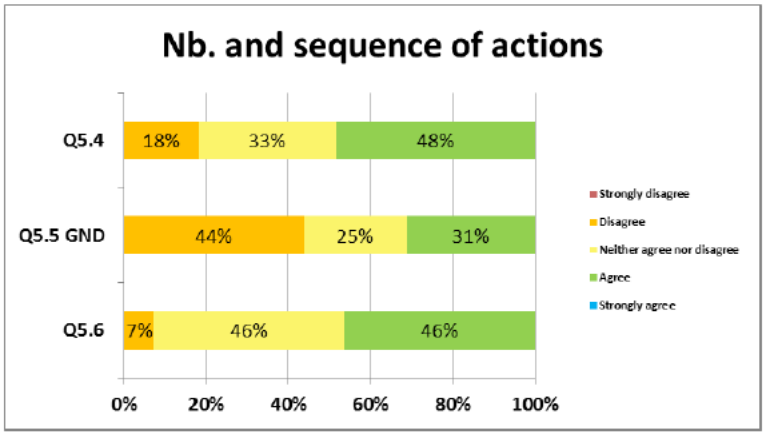


Figure 51: EXE-614 - HMI Questionnaire Results general– Number and sequence of actions

In the three questions, the number of positive answers lies down 50%. It is important to highlight the 44% of negative answers regarding the number of actions required to manage the routing information.

It is important also to highlight the difference between roles in the answer of Q5.6 regarding the simplicity of making graphical modifications.

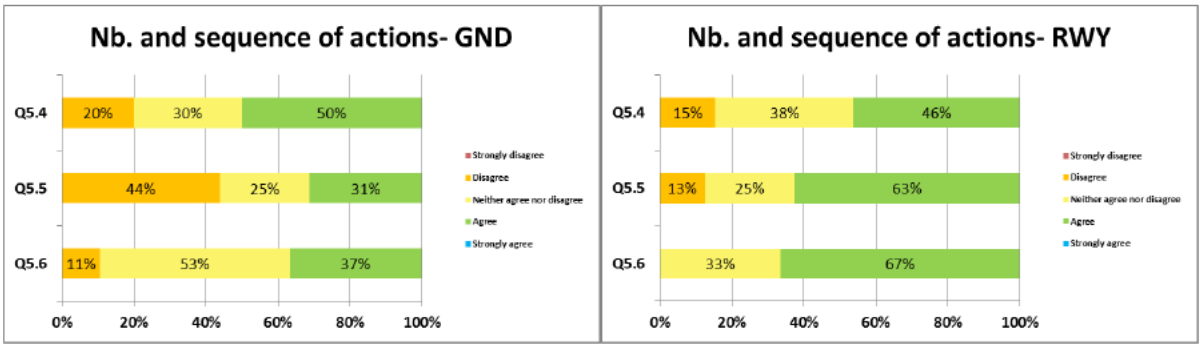


Figure 52: EXE-614 - HMI Questionnaire Results per role– Number and sequence of actions

None of the three questions addressing this objective reaches the minimum score to assess it positively.

Question	Scale	Average score	Status
Q5.4	[1-5]	3.3	●
Q5.5	[1-5]	2.9	●
Q5.6	[1-5]	3.4	●
Average	[1-5]	3.2	●

Table 41: EXE 614 - Global assessment of the questionnaire – Number and sequence of actions

6.1.3.1.3.10.2 Briefing analysis

As could be deducted from the questionnaire analysis, there are a lot of remarks and objections from the controllers:

Alerts

The remarks on the Alerts information come from the necessity of "clicking" the label to stop the blinking alerts; this is even aggravated by the number of alerts displayed in all the positions (not only the correspondent to the AoR of each ATCO).

Routing

In general, the number of interactions (button clicks) needed to perform some of the most common operations in the routing was considered excessive by the users, some examples:

- Too many clicks to display the graphical route, it was suggested to do it just in one click
- The routing clearance requires too many clicks, as the routing information shows all the segments, many times is needed to scroll down to find the last point of the leg until the route could be cleared.

Regarding the question 5.6, as the users test the tools, some of the issues that arise in the first sessions of the simulations were solved but the overall impression is that, even in the last runs of the simulations, the route modification

process although easier was long and not evident. It was evidenced that the current tool is not flexible enough to deal with occurrences that sometimes could lead to a "creative" solutions by the controllers.

6.1.3.1.3.10.3 Validation Objective Status

NOK: the number of actions required to perform most of the actions was considered excessive.

6.1.3.1.3.11 OBJ-06.09.02-VALP-0001.0100

Objective Description: Validate that the A-CWP supports the controller in the decision-making process.

Success Criterion: Controllers confirm that the outputs and triggers provided by the different tools and displayed on the HMI support them during the decision-making process.

6.1.3.1.3.11.1 Survey results

The questions addressing this validation objective are:

- *Q6.1The representation of the alerts in the A-CWP helps the decision-making process.*
- *Q6.2 The representation of the routing information helps the decision-making process.*

The figure below presents the graphical distribution of the answers for all controllers in Q6.1 and for GND controllers for Q6.2:

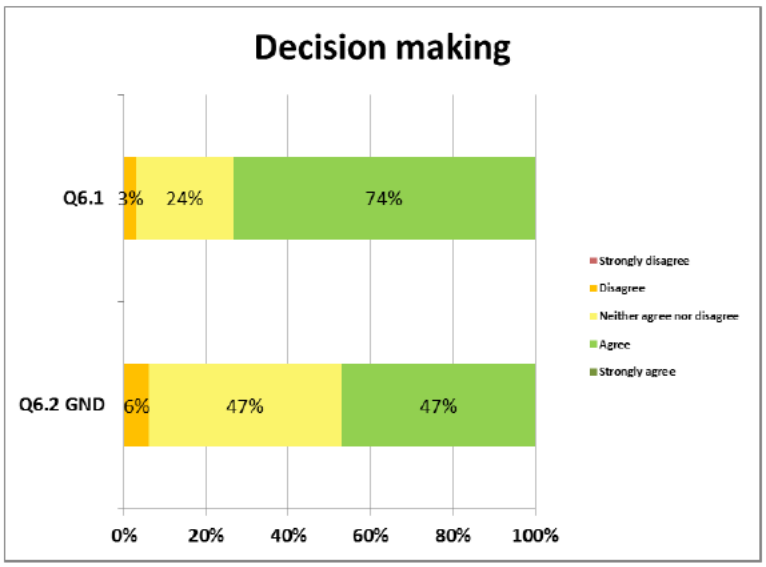


Figure 53: EXE-614 - HMI Questionnaire Results general– Decision-making

Looking at the graph, the alert information helps more the decision-making process than the routing. In this case, it is important to bring up the difference percentages in the answers per role. In the light of the graphs, the alert information helps much more the decision-making process of the RWY controller.

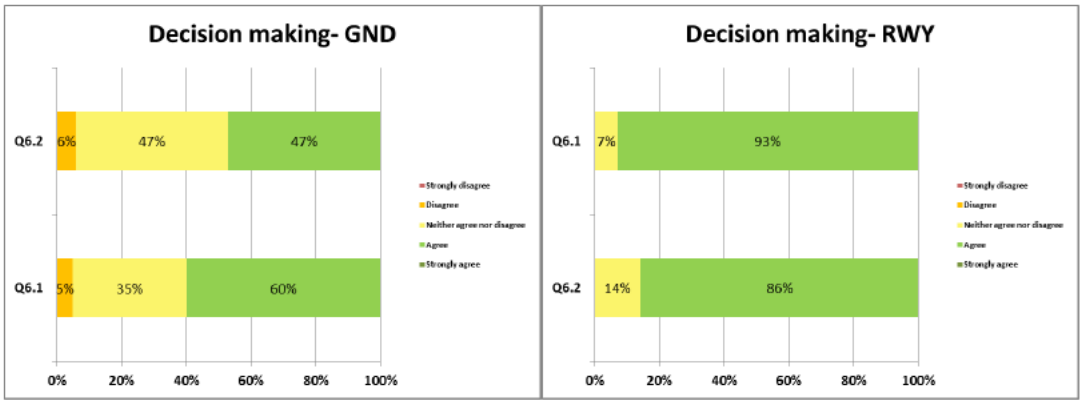


Figure 54: EXE-614 - HMI Questionnaire Results per role– Decision-making

Question	Scale	Average score	Status
Q6.1	[1-5]	3.7	●
Q6.2 GND	[1-5]	3.4	●
Average	[1-5]	3.5	●

Table 42: EXE 614 - Global assessment of the questionnaire – Decision-making

Although the numeric assessment could be positive, the number of comments (see next section) indicates that there are aspects to improve in terms of implementation.

6.1.3.1.3.11.2 Briefing analysis

The majority of the users´ comments indicates the usefulness of having available in the controller position the information related to alerts and routing and their contribution to the decision-making process, but, in the way the Human Machine Interface is implemented right now other aspects like the higher workload hide these benefits.

The runway incursion alerts were unanimously identified as the best support for the decision-making process. In the other side, the display of all the alerts in all the positions and the need to act on them to stop the blinking was identified a as a distraction for the majority of the users.

6.1.3.1.3.11.3 Validation Objective Status

OK: when familiarized with the new functionalities the controllers reported that, in fact, they related on them when making decisions.

6.1.3.1.3.12 OBJ-06.09.02-VALP-0001.0110

Objective Description: To assess that the Advanced integrated CWP keeps controllers workload at an acceptable level.

Success Criterion: Controllers confirm that their workload is kept at an acceptable level.

6.1.3.1.3.12.1 Survey results

The questions addressing this validation objective are:

- *Q6.3 It is possible to work in peak traffic situations with the representation of alerts and routing information.*
- *Q6.4 The representation/HMI of the alerts does not difficult the analysis and resolution of the conflicts.*
- *Q6.5 The routing HMI does not difficult the route generation process.*

The figure below presents the graphical distribution of the answers for all controllers in Q6.3 and 6.4 and for the GND controllers in Q6.5.

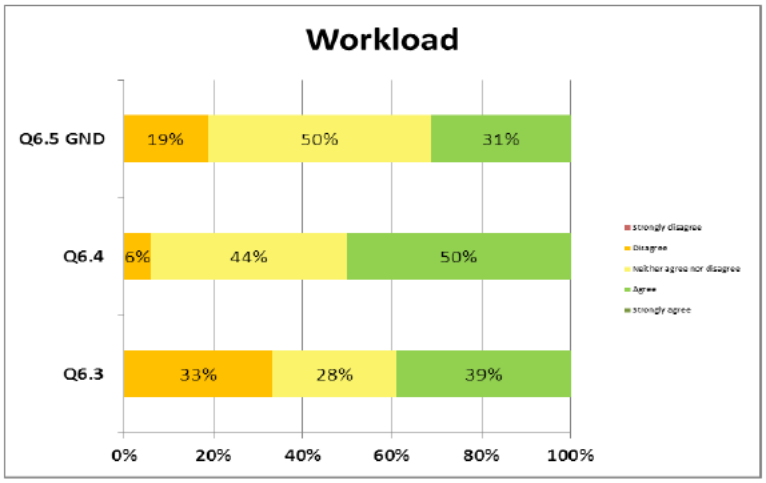


Figure 55: EXE-614 - HMI Questionnaire Results general– Workload

The following should be highlighted:

- The high percentage of indecisive answers for Q6.4 (alerts supporting the resolution of conflicts) and Q6.5 (routing function supporting the route generation)
- One third of the answers consider that the functionality is not suitable for working in peak traffic situations.

Question	Scale	Average score	Status
Q6.3	[1-5]	3.1	●
Q6.4	[1-5]	3.4	●
Q6.5 GND	[1-5]	3.1	●
Average	[1-5]	3.2	●

Table 43: EXE 614 - Global assessment of the questionnaire – Workload

Analyzing the global assessment of the table above it could be stated that neither the Routing functionality nor the alerts contribute to reduce the workload of any of the two roles.

6.1.3.1.3.12.2 Briefing analysis

The assessment on the workload is influenced by two key issues, one for each of the tested functionalities:

- **Alerts:** The display of all the alerts in all the positions and the need to "recognize" the alert, by clicking on the track, to stop the blinking on the severe alerts, increased notably the workload of the controllers and distracted them for their duties.

- **Routing:** Some design solutions, like the obligation of clicking twice on the track to display the graphical route, the display of all the segments of the taxiway and the need of scroll down to find the clearance limit will count against the reduction of the workload. The absence of a data link with the pseudo-pilots force the controllers to input the routing data on the tool and, at the same time to transmit the instructions via voice, duplicating the existing workload.

A new assessment of this objective should be made in a simulation including data link and avoiding the need of transmitting the instructions via voice.

6.1.3.1.3.12.3 Validation Objective Status

NOK: The long interactions (number of clicks) required to interact with the functions via the HMI increased the workload of the controllers. Also, the high level of information displayed required the controllers to dedicate part of their time to understand and acknowledge the inputs.

Also, even it is not and HMI aspect, the lack of some functionalities such as D-TAXI messages or automated guidance systems make that some actions on the HMI only have the purpose of input information on the system, increasing the workload without replacing other actions (such as voice instructions or clearances).

6.1.3.1.4 Results impacting regulation and standardisation initiatives

No impact has been identified on regulation and standardisation initiatives. A member of the regulatory body was presented during the execution of the exercise.

6.1.3.2 Analysis of Exercise Results

This section provides a joint analysis of the results provided previously.

6.1.3.2.1 On Safety Nets - functionality

Alerts were triggered correctly following the aircraft and vehicles incidents provoked. Controllers recognized timely dangerous situations. Workload remained within acceptable limits but safety was not increased as expected.

The display of alerts in all the positions has deeply impacted the Situational Awareness of the controllers.

The tool supported controllers in identifying incidents and mobiles involved, the priority of alerts was considered as adequate as well as their level of severity. Some controllers indicated that all the ground alerts should be INFORMATION alerts, and ALARM alerts should be used only in the runway.

Runway related alerts were more appreciated than ground related alerts.

Runway incursion alerts, baseline during the exercise, were the most appreciated, followed by the non-conformance monitoring, conflicting ATC clearances, and finally area intrusion, also baseline.

The feedback on conflicting ATC clearances alerts has to be considered taking into account that the number of alerts simulated was limited due to the layout of Madrid-Barajas, and to the fact that some controllers issued conditional clearances although instructed otherwise.

Although controllers received training on the paperless environment, have already performed other validation activities and even though one of them works in this environment, they did not systematically introduce the clearances provided via voice in the system which provoked false alerts. During high workload peaks they stopped entering clearance information into the system.

The fact that all the alerts were displayed to all controllers impacted greatly on Situational Awareness and workload of the controllers. This should be avoided in future implementations, so only the alerts of interest for each controller should be displayed to him/her (see section 6.1.3.1.2.1.2 Utility and Usability).

Controllers indicated that they only want to visualize alerts affecting their positions. The description provided was:

- All controllers want to see the alerts of mobiles under their responsibility (in R/T) regardless of whether they are under their area or have moved to another one, e.g. vehicles assumed by ground controllers that perform a runway incursion. This is also linked to the mode of operation where ground controllers temporarily assume part of the AoR of the adjacent controller.

- Runway controllers want to see the alerts of mobiles that are on the runway, on the area of protection of the runway, or that may perform a runway incursion, even if they are not under their responsibility.

- Ground controllers want to see the alerts of aircraft that are in the previous ground/runway position, their route enters in their area of responsibility, and are about to enter their area of responsibility. Examples given by the controllers were related to route deviation as it may have an impact on their area, e.g. they want to see a "route deviation" information alert if an aircraft takes a runway exit different from the expected one, but not a "no contact" alert.

- Some ground controllers with the area of responsibility limiting with a runway want to see the alert of mobiles on the runway. This was not shared by all the controllers,

The presence of the Routing and Planning function made that the controllers could select only routes with all the taxiways open, adequate for the type of aircraft and active runways, if departing, with an active runway. The manual mode should have allowed controllers to define a route contrary to the airport rules (not available in this simulation), but in this case, it would launch a warning from the Routing and Planning function. This warning would duplicate the next alerts:

- Taxi authorised on closed segment of taxiway.

- Closed runway (line-up and take-off).

Other feedback on the alerts functionality are:

- The requirement related to the "no taxi clearance" information alert should be modified to exclude the arrival aircraft on taxiways vacating the runway.

- The requirement related to the alert "no landing" should be amended to include that, if the aircraft is labelled as "missed approach" or "go around", the “no landing” alert should not be triggered.

- The requirement related to the alert of "no take-off clearance" should be amended to exclude

aborted take-offs.

- If a runway has a displaced threshold, the RPA may be defined in the AIP accordingly without covering the whole runway, nevertheless controllers may expect that an alert is triggered always when a vehicle enters a runway. This should be clarified when defining parameters of the alerts.

- The requirement related to the alert of "taxi route deviation" should be amended to have a information alert only when the aircraft deviated from the assigned route, not from the cleared route if this is coherent with the operational procedure if the airport.

- The "no contact" information alert was reduced from 150 seconds to 90 seconds following controllers' feedback.

- The information alert "stationary after clearance" was rejected by controllers when the aircraft was in the line-up and runway positions. The reason provided was that flight crew must follow the procedure to perform a complete check of aircraft functionalities and must be concentrated on doing it. Controllers do not want to disturb the flight crew during this delicate process, even if it takes them a long time. In other positions, the information was differently assessed depending on the controller.

- The requirement related to "aircraft taxiing" with high speed should be amended to exclude the rapid exit taxiway.

6.1.3.2.2 On Safety Nets - HMI

In order to be useful, information regarding safety nets has to be easily understandable. Therefore, the alerts displayed should be relevant for the operation and distinguishable. The conclusions extracted during the simulations regarding this topic are aligned with this statement (i.e. reduction of simultaneous alerts displayed, reduction of the number of different acronyms).

In general, the graphical representation of alerts received a good feedback as their textual counterparts. The colours and highlights used for alerts were clear and helped the controllers to focus their attention to the alerts.

The information of the alerts in the label was considered as adequate. The interaction with the alerts information was considered easy and intuitive.

The main negative feedback regarding the alerts on the HMI was that, during the simulation, there were too many at the same time. This was caused because of the high number of relevant ATC events simulated and because all alerts where shown in every A-CWP. To enable each ATCO to focus on the problems that require an action from them, only the alerts relevant to their operational responsibilities should be displayed to each of them

Controllers weren't able to appreciate the meaning of most of the acronyms used for identifying the different alerts. In the future, the numbers of acronyms should be reduced or even not used at all and their meaning should be easily identifiable (similar acronyms should be avoided).

Controllers reported that, when using the Alert window, it was impossible to distinguish the severity of the alerts or in what part of the airport they were generated. Alert Window showed all alerts in grey, organised by the type of alert (no prioritization). Controllers would prefer to have the same colour code as in the label and some prioritization. If only alerts of the own position are shown in this window, the need of prioritization may be already covered by the colour coding.

Regarding to the fact that Alerts were not shown in the electronic flight strip, there were mixed opinions: some controllers preferred not to add more information in the electronic flight strip and

consider that is enough to have it in the label.

6.1.3.2.3 On Routing and planning function - functionality

The Routing and Planning function was indicated as providing high workload and loss of Situational Awareness that did not compensate the support provided by the tool. This was linked to the use of R/T and no data-link, which duplicates the task controllers have to perform.

It was appreciated the different ways of modifying the route, and each controller preferred a different one. Route selection was simple and intuitive to most controllers regardless of whether they were using graphical or textual inputs.

Routing information was indicated as useful by the controllers not familiarised with the Madrid-Barajas layout.

Routes in general were considered as adequate by controllers but some of them were indicated as not adequate. This happened in two situations:

- When they needed to taxi an aircraft in the opposite direction, since the routing function did not allow this.
- During the initialisation of the taxi from the stand, the taxi route function usually proposed longer routes than the ones that controllers would propose. This feedback was provided by controllers from Madrid-Barajas, and the shortcuts they are used to sometimes contained a short taxiing in the non-standard direction.

The requirements of the operational project indicate that there should be a mode to enter a complete route that allowed total flexibility when designing the route. This was not implemented in the prototype. When controllers were presented with this option during the debriefings, they disregarded it. They indicated that, if a taxiway segment is closed, they already have a lot of work and cannot define all the segments of the routes.

Other feedback to the function:

- If needed by the mode of operation, the routing modification and clearances should be able to be issued for other areas of responsibility.
- Need of higher flexibility at the beginning of the route, related to the pushback direction. The default route may need to include a short taxi in a non-nominal direction.
- The function should allow the modification of the route even if, during its edition, the aircraft has moved to a new taxiway segment and the initial point of the route differs from the original one.

6.1.3.2.4 On Routing and planning function – HMI

For the correct use of the Routing and Planning function, it is critical that the HMI is as simple as possible. During the simulation, the number of actions required to modify routes had a negative impact on the ATCOs' workload.

The possibility of checking the routes of upcoming traffic and the alerts on the labels helped the controllers to have a picture of what was going on and what to expect in the near future. To support this aspect, controllers suggested the possibility of displaying the route of more than one aircraft at the same time.

The textual routing information displayed on the label, as well as on the route edition window, was considered too long to be useful or handled in a safe manner. I took a lot of time to read the routes and their alternatives. It would be more desirable to provide meaningful information such as the intersections, turns or transfer points.

The graphical display of the route received positive feedback. The colour combination used in the graphical display and edition of the route should be carefully chosen avoiding that colours for available segments and selected segments are too similar.

Other conclusions were extracted:

- The different tones for cleared and pending route on the text in the label were also well received.
- Controllers reported that they do not want to acknowledge on route modifications that they or other controllers have performed. A possible solution indicated was that the modified part of the route was presented in the HMI in a different colour for information.
- Some design solutions, like the obligation of clicking twice on the track to display the graphical route, the display of all the segments of the taxiway and the need of scroll down to find the clearance limit will count against the reduction of the workload.

6.1.3.2.5 On other areas - operation

MODE OF OPERATION

Controllers received training on paperless environment, have performed other simulations in this environment and one of them works daily in this environment. Nevertheless, they were not fully comfortable and the mode of operation was not systematic. The input of clearances in the system was performed according to the workload of controllers, and the same tools were used differently.

Controllers reported that they would have wanted to spend more time looking out of the window, but the system demanded their attention. Most of them indicated that, with more training and practice, they would be able to spend more time controlling the traffic out of the window, but some indicated that they were not sure due to the new tasks created by the new functionalities.

OVERLOADED AREAS IDENTIFICATION

Supervisors indicated that they were able to identify the most-used areas of the airport, but that a predictive tool that helps them to foresee the incoming traffic would be more useful, as they already have an off-line tool in their office that provides the analysis of the flights served by the airport.

6.1.3.2.6 On other areas - CWP

The A-CWP concept addresses the integration of systems into an integrated Control Working Position (CWP). The CWP in this exercise consists of two different screens for all positions. Having similar positions in the different roles, the interoperability is ensured and the controllers' operation results improved in terms of the need of training depending on their responsibilities. The concept globally improves the operation of the controllers but the increase of the size of the screens is crucial for them just to avoid the dispersion of the common information management, reducing at the same time the amount of data they have to scan and process. The controllers' fear is that the development of new devices and functionalities will increase the amount of time dedicated to be head-down on the system, worsening their Situational Awareness and increasing their workload impending them the visual scanning essential for a tower controller. Another aspect to improve is the coherency of the information and the data input (mainly when they have to use the keyboard, or when create flight

plans or vehicle electronic strips).

6.1.3.2.7 Analysis of Exercises Results summary

See Table 19 for a summary of exercise results per objective.

Objective and subjective data collected during the exercise are the main source of information, which give the initial start to the whole results analysis.

To analyse data collected during the simulation by questionnaires, debriefings, over the shoulder observations and systems logs, the following steps have been followed:

- Information integration of quantitative and qualitative data
- Final conclusion in relation to specific exercise objectives.

Objective ID	Scenario ID	PI ID	Measure Value
OBJ-06.03.01-VALP-00614-0001	SCN-06.03.01-VALP-0614.0002	Subject assessment of Situational Awareness for runway controllers	The major part of ATCO feedback highlights the fact that the new tools do not increase Situational Awareness even if the general feedback was positive. (Refer to 6.1.3.1.2.2.2)
OBJ-06.03.01-VALP-00614-0002	SCN-06.03.01-VALP-0614.0002	Subject assessment of Situational Awareness for ground controllers	The major part of ATCO feedback highlights the fact that the new tools do not increase Situational Awareness even if the general feedback was positive. (Refer to 6.1.3.1.2.2.2)
OBJ-06.03.01-VALP-00614-0001	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-0614.0002	Subject assessment of information provision and alert coexistence for runway controllers	ATCOs feedback indicated that the tool supported them in identifying incidents and mobiles involved but the different type of alerts have sometimes misled them. (Refer to 6.1.3.1.2.2.1)
OBJ-06.03.01-VALP-00614-0002	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-0614.0002	Subject assessment of information provision and alert coexistence for ground controllers	ATCOs feedback indicated that the tool supported them in identifying incidents and mobiles involved but the different type of alerts have sometimes misled them. (Refer to 6.1.3.1.2.2.1)
OBJ-06.03.01-VALP-00614-0001 OBJ-06.03.01-VALP-00614-0002	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-0614.0002	Type and priority of alerts, involved aircraft, and alert time correctly displayed according to ATCOs and observers assessment.	ATCOs considered the type and priority of alert, involved aircraft, and alert time as adequate. Nevertheless, some alert parameters should be improved to include exceptions. Observers supported this feedback. (Refer to 6.1.3.1.2.2.1)
OBJ-06.03.01-VALP-00614-0001 OBJ-06.03.01-VALP-	SCN-06.03.01-VALP-0614.0002	ATCOs' subject assessment of Surface Safety nets alerts utility and usability	Discordant feedback was collected in relation to Surface Safety Nets alerts usability. During the debriefings it was concluded that controllers appreciated Surface Safety Nets operational concepts but there is room for improvement

Objective ID	Scenario ID	PI ID	Measure Value
00614-0003			specially in the display of alerts to all controllers. (Refer to 6.1.3.1.2.1.2).
OBJ-06.03.01-VALP-00614-0003	SCN-06.03.01-VALP-0614.0002	ATCOs' subject assessment of routing utility and usability	ATCOs assessed the new tools irregularly. The support provided was scored 2.60 out of 4 while the easiness of usage was scored 2.84 out of 4. (Refer to 6.1.3.1.2.1.2)
OBJ-06.03.01-VALP-00614-0003	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-0614.0002	Subject assessment of workload for runway controllers	The Runway Controller's feedback shows that the workload remained within acceptable limits during the exercise, although higher than during the reference. ATCOs indicated that the new tools increase their workload. (Refer to 6.1.3.1.2.1.1)
OBJ-06.03.01-VALP-00614-0003	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-0614.0002	Subject assessment of workload for ground controllers	The Ground Controller's feedback shows that the workload remained within acceptable limits during the exercise, although higher than during the reference. ATCOs indicated that the new tools increase their workload. (Refer to 6.1.3.1.2.1.1)
OBJ-06.03.01-VALP-00614-0003	SCN-06.03.01-VALP-0614.0002	ATCOs' subject assessment of their confidence on new tools' outputs	64% of ATCOs have assessed the information provided by the SSN as correct. Routing information has been assessed as correct by 45% of them. (Refer to 6.1.3.1.2.2.2)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0002	ATCOs' subject assessment of adequacy of routes proposed	Routes proposed as first option were positively assessed. Score of 2.8 out of 4.

Objective ID	Scenario ID	PI ID	Measure Value
		as first option	(Refer to 6.1.3.1.2.3.1)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0002	Percentage of routes accepted as first option recorded by the system	System recordings indicate that over a 70% of the time the initial route was accepted. (Refer to 6.1.3.1.2.3.2)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0002	ATCOs' subject assessment of adequacy of automatic alternative routes proposed.	Routes proposed as alternative options were intermedialy assessed. Score of 2.7 out of 4. Main problem detected was the inability to route an aircraft against the AIP direction. (Refer to 6.1.3.1.2.3.1)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0002	ATCOs' subject assessment of adequacy of edited alternative routes.	Edited routes have been positively evaluated. Score over 2.8 out of 4. Main problem detected was the inability to route an aircraft against the AIP direction. (Refer to 6.1.3.1.2.3.1)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0002	Percentage of flights modified in manual mode.	Manual mode, route modified entering the whole path, was rarely used. This is attributed to the inability to route against the AIP direction and the effort required from the ATCO. (Refer to 6.1.3.1.2.3.1)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0002	Percentage of feasible routes provided by the system	The system provided a feasible route over 74% of the time after Analysis or Execution request. (Refer to 6.1.3.1.2.3.1)
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-	Average taxiing times recorded by the system	Average taxi-out time worsens by 5% and average taxi-in time improves by 17% with the functionality enabled. (Refer to 6.1.3.1.2.4.2)

Objective ID	Scenario ID	PI ID	Measure Value
	0614.0002		
OBJ-06.03.01-VALP-00614-0004	SCN-06.03.01-VALP-0614.0001 SCN-06.03.01-VALP-0614.0002	Standard deviation of taxiing times recorded by the system	Standard deviation of taxi-out time improves by 2% and Standard deviation of taxi-in time worsens by 5% with the functionality enabled. (Refer to 6.1.3.1.2.4.2)
OBJ-06.03.01-VALP-00614-0005	SCN-06.03.01-VALP-0614.0002	Supervisors' subjective assessment on airport map of overloaded areas	The airport metric and map of overloaded areas was assessed as easy to understand but not useful during the execution phase. (Refer to 6.1.3.1.2.4.1)

Table 44: EXE 614 - Validation matrix

Previously P06.09.02 validation results were presented in relation to the validation objectives defined for Release 3 in the project. In this section, the conclusions extracted during EXE-06.0302-VP-614 exercise will be presented organised per KPA, following the Benefit Mechanisms defined for controllers by P06.09.02. As remarked by the SJU in the review of the 06.09.02 VALP [50], looking at the Benefit Mechanisms described there it is hard to distinguish between the impacts due to the new functionalities or the new HMI. Making this differentiation also proved to be difficult when evaluating the exercise results. The main impact of any HMI is on Human Performance, it can be argued that HP is related with almost any other KPA. In order to maintain consistency with the validation plan, we'll try to follow the links described in the mentioned BM.

KPA	OBJ	Outcome	Comments
Safety	OBJ-06.09.02-VALP-0001.0020, OBJ-06.09.02-VALP-0001.0030, OBJ-06.09.02-VALP-0001.0040, OBJ-06.09.02-VALP-0001.0050,	3 OK 2NOK	No contingency situations were simulated during VP-614, therefore only the impact on "quality of information / data" remains to assess the effect on Safety according to the BM. Based on the feedback and observations in-situ, the conclusion is that, even though additional information does improve the safety levels, there is still work to do in order to find the exact level of information that is useful without overloading the controllers with excessive information. Therefore, from the HMI perspective, it

KPA	OBJ	Outcome	Comments
	OBJ-06.09.02-VALP-0001.0060		is fair to say that there is no improvement in this area at this stage.
Efficiency	N/A		The impact on efficiency is determined by an expected reduction of the "waiting times / delay" (extracted from the number of A/C in time). This was not measured by P06.09.02 in this simulation. The Efficiency KPA is related to the actual 4D-trajectories of the aircraft, making it difficult to draw conclusions regarding this KPA from the HMI point of view.
Capacity	N/A		Capacity is expected be impacted in a positive manner by the implementation of the new HMI, thanks to the expected improvements on the ATCOs' efficiency and waiting times / delay. ATCOs' efficiency will be addressed in the next section (Human Performance) and, as it is stated before, no record of "number of A/C in time" was performed by 06.09.02. Having all of this in mind, the only way to assess an impact on capacity would be to extract conclusions based on the workload and overall performance of the controllers while using the new HMI; but, even with an improvement in Human Performance, there may not be an improvement in Capacity due to other factors not related to the HMI.
Human Performance	OBJ-06.09.02-VALP-0001.0001, OBJ-06.09.02-VALP-0001.0060, OBJ-06.09.02-VALP-0001.0070, OBJ-06.09.02-VALP-0001.0090, OBJ-06.09.02-VALP-0001.0100, OBJ-06.09.02-VALP-0001.0110	4 OK 2 NOK	The main goal of the new HMI is to improve the Human Performance while enabling the use of the new functionalities. Impact on other performance areas can be considered side-effects of the changes on the Human Performance (of the ATCOs, in this case). Considering what is said in the previous paragraph, and the feedback received during and after each simulation run, the main conclusion regarding the Human Performance is that the new HMI functionalities have, in general, a good impact on the Human Performance. Even with the small amount of training, the problems with the local implementation of some procedures, and the high number of actions required by some functionalities, the workload stayed at an acceptable level.

Table 45: EXE 614 - P06.09.02 feedback per KPA

6.1.3.2.8 Unexpected Behaviours/Results

No unexpected behaviour/results to report.

6.1.3.3 Confidence in Results of Validation Exercise

6.1.3.3.1 Quality of Validation Exercise Results

Different validations means were used to collect the exercise results:

- Questionnaires after each run to collect controllers' subjective opinion followed by a debriefing were the main results were discussed between the different participants.
- Feedback provided by controllers through personal interviews.
- Observations collected during the runs.
- Objective data from system recording.

The combination of all these techniques ensures the correctness and reliability of the results obtained.

The first day, with the all the functionalities enabled, controllers indicated that some alerts should be turned off as they created more confusion than support, which was implemented the next day, see 6.1.2.3.

6.1.3.3.2 Significance of Validation Exercise Results

Five active controllers from four Spanish towers performed seven runs of one hour each. The controllers rotated between all the positions to collect their feedback on the functionalities tested from the different roles point of view. However, the number of runs and participants were considered not large enough to perform statistical tests. The results must be interpreted as tendencies.

Significant effort was spent to ensure that the simulations would seem realistic to the participants, combined with all the relevant ATC situations needed to test the different types of alerts. The used traffic samples were prepared to achieve the usual amount of traffic in Madrid-Barajas airport on a day with medium-high workload (28 departure and 28 arrivals per hour). Relevant ATC situations were prepared thoroughly and internal and external design of the Ops Room was as accurate as possible. Finally, participants in the validations received a specific training in the subject, and support staff, including the ones in charge of the training, attended also to the validations to offer in-situ assistance to the controllers.

Regarding the operational significance of the environment, the questionnaire included four questions relative to the realism of the simulation and the general environment.

The questions related to the significance of results were the following, obtaining the following results (all roles consolidated):

- *Q0.1 The simulation exercise has been (traffic characteristics, difficulty level...)*

  This question, based on a 4-degree scale obtained a 96% of positive answers (very realistic and adapted to reality) against a 4% of negative results. Although there were no answers associated to “not realistic at all”.

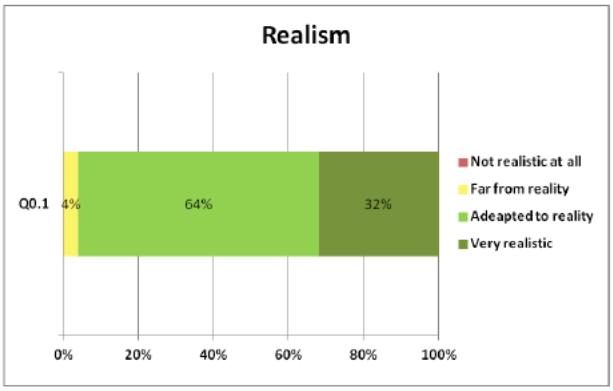


Figure 56: EXE 614 - Consolidated results for question Q0.1 (realism)

- *Q0.2 The formation, training and information received to perform this exercise have been*

  Most of the answers related to this question were positive (72%). However, 28% of the controllers declared the information was inadequate or very inadequate which means that controllers needed help during the simulation activities. Some comments showed the need of providing more training before developing the exercises. This need of training was specially requested regarding the new HMI, alerts and routing functional system, in order to improve their performance during the validation activities.

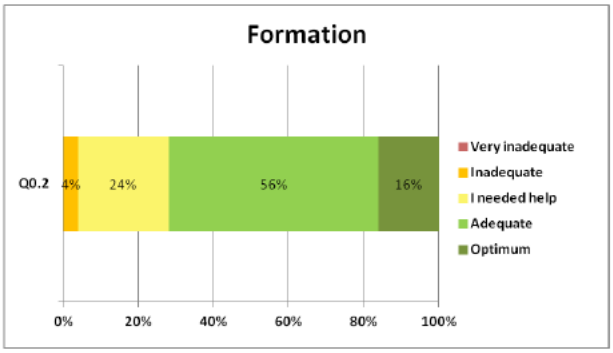


Figure 57: EXE 614 - Consolidated results for question Q0.2 (formation)

- *Q0.3 I have found the activity of pilots in this exercise*

  96% of the answers were positive (excellent and adequate) against a 4% of answers showing a behaviour not very adequate of the pseudo-pilots. None of the answers showed a very inadequate performance of the pilots. Controllers reported some technical difficulties from the pseudo-pilots part when they asked them to perform strange or forbidden manoeuvres to test the routing and alert functions.

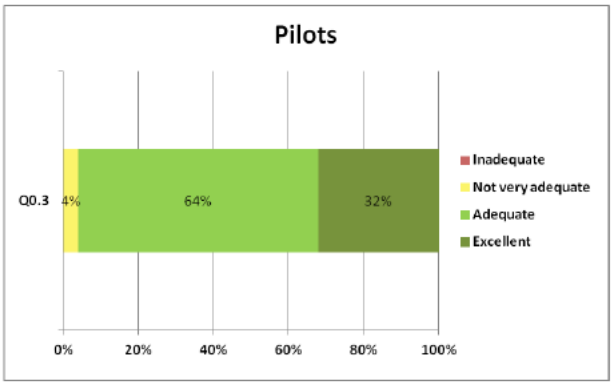


Figure 58: EXE 614 - Consolidated results for question Q0.3 (pilots)

- *Q0.4 I think I have experienced a situation in which*

  80% of the answers from the controllers found that situation and the general environment perceived during the runs was similar to that in the Ops. Room. 20% of answers showed that the controllers had the feeling of not controlling the situation.

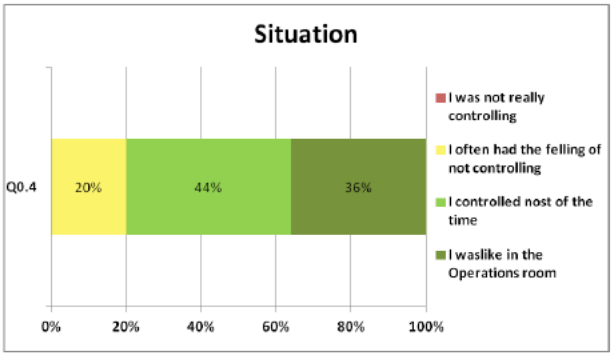


Figure 59: EXE 614 - Consolidated results for question Q0.4 (situation)

All of the above conclusions allow the validation team to be very confident in the robustness of any conclusions contained in this document.

6.1.4 Conclusions and recommendations

6.1.4.1 Conclusions

This section provides a summary of the main results of the real-time simulation performed in January 2014 by Aena in Madrid, using the Madrid-Barajas airport simulated environment with operational tower controllers, in AENA HQ Pre-operational IBP, TWR segment. The aim of the simulation is to report on the joint impact of the enhanced Routing and Planning function with the Surface Safety Nets - conflicting ATC clearances, non-conformance monitoring - and already existing alerts - runway incursions and restricted area intrusions alerts (A-SMGCS Level 2 function).

Quantitative and qualitative data collection methods allowed assessing very important results. In order to better elicit them, for each operational concept and related investigated OIs, Table 46 reports the main results and aspects to be further investigated.

Operational concept	Main results	Aspects to be better investigated
Surface Safety Nets AO-0104A: Airport Safety Nets for Controllers in Step 1	• Concept suitable for TWR environment. • Controllers appreciated the operational concept. • Controllers indicated that the high number of alerts have impacted in the workload and the Situational Awareness. • Controllers indicated that the priority of alert was quite correct.	• Surface Safety Nets HMI to be improved in order to have a sectorisation of alerts per controller working position. • The need of a new option in the CWP to indicated conditional clearances. • Impact of alerts if controllers stop entering clearance information into the system due to high workload peaks. • Investigate the acceptance of the alert related to stationary after clearance. • Although priority of alerts is quite correct it needs further investigation.
Routing AO-0205 Automated Assistance to Controller for Surface Movement Planning and Routing	• Controllers indicated that the Routing and Planning function without data link increased workload and loss of Situational Awareness without improvements in other areas. • Controllers appreciated the different options for modifying a route.	• Controllers able to clear the whole route. • Increase of flexibility when modifying a route. Include a way to modify the route against any constraint without having to introduce the whole path.
A-CWP AO-0208-A: Advanced Information Management and System	• The new HMI functionalities are considered beneficial for the TWR environment. • Alerts displayed to a controller should be relevant to their operational	• Confirm the alerts that each controllers position want to see. • Colour coding and prioritization in the Alert Window

Operational concept	Main results	Aspects to be better investigated
Integration in the ATC Tower for Step1	responsibilities and easily differentiable. • For the correct use of the Routing and Planning function, it is critical that the HMI is as simple as possible.	• Investigate if alerts are needed both in labels and electronic flight strips. • Investigate what is the meaningful route information that should be displayed. • Investigate the display of a route change through a different colour to avoid the need to acknowledge the changes.
Other areas	• Supervisors were able to identify most used areas. • They indicated the tools as useful for reports but not during the execution.	• Modify the tool into a predictive tool for incoming traffic.

Table 46: EXE 614 - Main Conclusions

6.1.4.2 Recommendations

Recommendations coming from Exercise 614 are those expressed in the following Table 47:

TYPE	RECOMENDATION
Surface Safety Nets	The triggering condition related to the "no taxi clearance" information alert should be modified to exclude the arrival aircraft on taxiways vacating the runway.
	The cancellation condition related to the "no landing" alert should be amended to include that, if the aircraft is labelled as "missed approach" or "go around"; the "no landing" alert should not be triggered or cancelled in case the alert is triggered first.
	The cancellation condition related to the "no take-off clearance" alert should be amended to exclude aborted take-offs.
	The severity condition related to the "taxi route deviation" alert should be amended to have a information alert only when the aircraft deviated from the assigned route, not from the cleared route, if this is coherent with the operational procedure if the airport.
	If a runway has a displaced threshold, the RPA may be defined in the AIP accordingly without covering the whole runway. Nevertheless, controllers may expect that an alert is always triggered when a vehicle enters a runway. This should be clarified when defining parameters of the alerts.

TYPE	RECOMENDATION
	The triggering condition related to the "aircraft taxiing with high speed" alert should be amended to exclude the rapid exit taxiway.
Routing and planning function	If needed by the mode of operation, the routing modification and clearances should be able to be issued outside the area of responsibility.
	The function should allow the modification of the route even if, during its edition, the aircraft has moved to a new taxiway segment and the initial point of the route differs from the original one.
	Need of higher flexibility at the beginning of the route, related to the pushback direction. The default route may need to include a short taxi in a non-nominal direction.
Advanced integrated Controller Working Position	The alerts displayed in each CWP should only be the ones relevant to that position.
	Minimize (or even avoid) the use of acronyms, when possible.
	After a route modification, only the modified part should be highlighted (instead of the whole route); and this highlight should be only shown on the position of the controllers affected by the change.
	Remaining taxi time shall not be displayed in the label. The same applies to any information reported as unnecessary by the controllers. The A-CWP HMI shall be configurable to the point of allowing different information configurations for each airport and position implementation.
	Textual routing information should be kept to a minimum, with only meaningful parts.
	The Routing and Planning Function should allow the controllers to see the routes of more than one mobile at the same time

Table 47: EXE 614 - recommendations

6.2 Exercise 652 Validation Report

This section provides detailed information about the exercise in terms of execution and related results.

6.2.1 Exercise Scope

The exercise took place in Milano Malpensa airport from the 25th to 29th November 2013. The exercise applied two different validation techniques: real time simulation and shadow mode in order to validate all proposed validation objectives.

In detail, the focus of the simulation was to validate Surface Safety Nets, enhanced ADS-B ground station and A-CWP, comparing reference and solution scenarios, in order to cover validation objectives proposed in the corresponding Validation Plan [52].

6.2.2 Conduct of Validation Exercise

6.2.2.1 Exercise Preparation

Preparation steps for the Exercise 652 validation exercise were:

- High-level definition of exercise, including selection of functionalities available in the prototype, traffic samples, validation scenarios, special events, etc.
- Updating of the V&V platform
- Prototype testing/acceptance
- Writing of the Availability Note document
- Preparation of the exercise. This activity includes, amongst others:
  - Definition of physical scenario
  - Adaptation of the traffic
- Definition of the data gathering methods that were used, including questionnaires, structured interviews, data log, etc.
- Preparation of the training material, including presentations and user manual
- Selection/invitation of ATCOs and pseudo-pilots to be involved in the simulation
- Preparation of the site and room hosting the exercise.

The preparation of the Exercise 652 required the involvement and the cooperation of different actors with specific skills, roles, responsibilities and tasks. The key actors of the team form the Validation Exercise Management Group (VEMG).

The following table summarises the activities carried out by the VEMG members during the preparation phase and their role in preparation activities.

ACTOR	ROLE
Exercise Manager	• Managed the preparation process in order to ensure the execution of the exercise in line with objectives and timeline.
Validation	• Coordinated the validation activity acting as the interface among the ENAV SESAR unit, the operational

ACTOR	ROLE
Coordinator	project and the Malpensa Operational site.
WP3 Support Coordinator	• Managed the evolution of the MXP IBP according to the WP3 engineering process.
Exercise Technical Coordinator	• Coordinated with SELEX ES the provision of software for IBP platform and its integration according to project requirements and schedule. • Mediated between the industry and the other members of the VEMG. • Organised regular Technical and Operational Tests, according to the project schedule.
Exercise Operational Leader	• Supported the definition of the operational scenario applied. • Contributed to the definition of ATCOs' working methods and operational procedures. • Supported the definition and evaluation of the traffic samples. • Coordinated the ATCOs' availability during tests and exercise. • Managed the training preparation.
Scenario Creator	• Prepared the operational scenarios for the exercise. • Prepared the traffic samples for tests, training and exercise. • Implemented non-nominal events in the traffic samples if needed.
Human Factors Expert	• Contributed to define the exercise organisation. • Contributed to select the data collection methods applied. • Prepared data collection tools (observation grids, scripts for debriefings, questionnaires). • Contributed to define the recording specifications. • Defined eventual non-nominal events to be introduced in the traffic samples, if needed. • Defined experimental design and agenda of the exercise. • Defined the ATCOs seating plan according to the experimental design.
Safety Expert	• Contributed to select the data collection methods applied. • Prepared data collection materials (observation grids, scripts for debriefings, questionnaires). • Contributed to define the recording specifications. • Contributed to define experimental design and agenda of the exercise. • Defined non-nominal events to be introduced in the

ACTOR	ROLE
	traffic samples, if needed.
Subject Matter Expert	• Having a controller background supported HF Analysts in assessing usage, acceptability and suitability of new procedures and tools.

Table 48: Preparatory activities

6.2.2.1.1 IBP acceptance

The ENAV Malpensa IBP is composed of the following systems:

- ground system capabilities (e.g. route planning and surface collision alert)
- ground surveillance and a simulated environment for navigation and piloting of mobiles (aircraft). For the shadow-mode validation technique, the real data could be used for surveillance purpose.

The real-time validation platform is built of the following three macro-modules:

1. PP/Navigation module is an ATC real-time simulation facility for human-in-the-loop simulation enabling the reproduction of aircraft activities on the airport surface, as well as on the final approach and initial climb segment, following ATCOs clearances/instructions. The pseudo-pilots/drivers, sitting in a dedicated room, can communicate with the ATCOs via a simulated radio transmission line. Each pseudo-pilot/driver can communicate with one CWP on one dedicated frequency and can manage the flights under the control of the corresponding controller. The number of pseudo-pilots/drivers is configurable according to the objectives of the validation exercise. An appropriate pseudo-pilot HMI was developed; it is really close to pseudo-pilot HMIs used on other RTS platforms (e.g. Escape) but it was customised on the basis of Malpensa TWR activities. Using this interface a pseudo-pilot/driver can pilot/drive an aircraft/vehicle following the clearances given by the ATCO.
2. TWR (A-SMGCS) module is an ATC real-time simulation facility for human-in-the-loop simulation reproducing the Malpensa TWR equipment/facilities. This module can reproduce all the Tower CWPs available in the Malpensa TWR: CDD (Clearance-Delivery Dispatcher), GEC (Ground Executive Controller) and TEC (Tower Executive Controller). It is possible to set different CWP configurations as requested by the simulation objective. The CWP was enhanced with new services/functions:
   - To guarantee air/ground surveillance of departing/arriving aircraft.
   - To offer new flight management instruments using Tower Electronic Flight Strips (EFS)
   - To offer the new route planning functionality.
3. A tool, called GTG, will guarantee the transfer of the flight track managed by the pseudo-pilot to the TWR (A-SMGCS) module.

In addition to the macro-modules listed before, the platform is provided also with the following module:

- AudioSet module is an ATC real-time simulation facility for simulating the radio communication between ATCOs and Pseudo-pilots. It can simulate a point-to-point communication, between ATCOs, and a frequency communication between ATCOs and pilots. It can record the voice communication that occurred.

In particular, the following prototypes were integrated into the ENAV IBP Malpensa platform:

- **12.03.02** - Enhanced Surface Safety Nets;
- **12.05.02** - Airport Safety Nets and wind-shear;
- **15.04.05b** - ADS-B ground station enhancements (Prototype).

The integration test activities performed by ENAV and SELEX ES to confirm that IBP was ready to begin the validation exercise were:

- Supporting A-CWP Services
- Traffic Situation Management Service
- Airport Layout Set up Service
- Traffic Data Update Service
- A-CWP Flight Plan Update
- System Supported Data Exchange and Co-ordination Service
- Monitoring and Safety Support Service
- Mobile Routing Management Service
- SSN Integrated Service
- Enhanced ADS-B Ground station

The IBP validation was declared as successful when all scenarios and simulation exercises had been tested with technical and operational assessment. The Availability Note document was produced.

6.2.2.1.2 Architecture and system specifications

This section aims to briefly describe the prototypes evaluated.

Prototypes	Technical WP
ADS-B Ground Station Prototype	WP15.04.05b
Second prototype of Surface Safety Nets Server	P12.03.02
Second prototype of Surface Alert HMI	P12.05.02

Table 49: Exercise 652 Prototypes

6.2.2.1.2.1 ADS-B Ground Station Prototype

ADS-B is an ATC surveillance technology, which enables cost-efficient Gate-to-Gate Ground-based Surveillance and Airborne Surveillance. The future SESAR ATM Services include ADS-B applications

(such as "ADS-B out" and ASAS) which have an impact on both the ground and airborne Surveillance system in terms of safety, performance, interoperability, security. Enhancements will thus be required to the ground Surveillance system to make it compliant and capable to support the SESAR development and validation activities, as well as the timely and efficient transition to industrialization and operational deployment. P15.04.05b received ADS-B ground system enhancements requirements specifications and test specifications from Project 15.04.05a as base input to develop and verify ADS-B 1090 Extended Squitter ground station and Surveillance Data Processing and Distribution (SDPD) prototypes to support SESAR ATM Services.

ADS-B application - SELEX ES Prototype 15.04.05b - was used with the following new functionalities implemented:

- Enhancement of the ADS-B GS with new functionalities (TDOA validation and Enhanced ADS-B target report validation exploiting WAM data) to check the validity of the ADS-B derived data and to discard possible spoofing messages as well as messages transmitted by erratic ADS-B transponders, guaranteeing an improvement of the surveillance in terms of security and safety.
- Rationalization of Surveillance infrastructure through a prolific integration of the ADS-B system and WAM system. This integration offers the advantage of an infrastructure-sharing between the two surveillance systems, providing a more flexible and cost-effective solution, and also the potential for substantial improvement of the 1090ES detection capability (and hence performance robustness of ADS-B reception) by taking into account multilateration-derived data during the squitter decoding process.

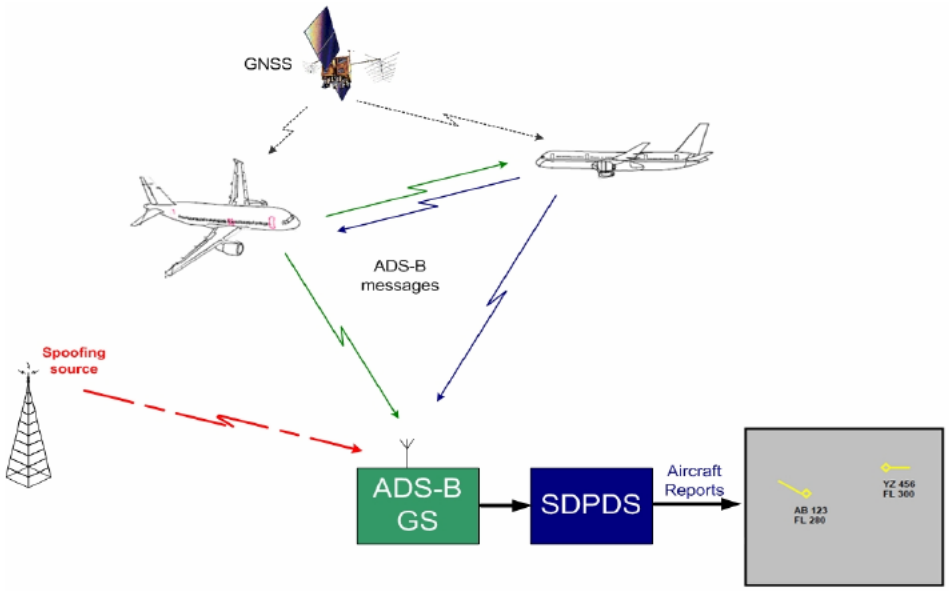


Figure 60: ADS-B Scenario

6.2.2.1.2.2 Prototype of Surface Safety Nets Server

P12.03.02 is a project that aims to develop a Surface Safety Nets (SSN) server able to alert controllers when an aircraft using the aerodrome movement area makes an unauthorised or hazardous manoeuvre.

The objective of the SSN function is to monitor movements on the aerodrome surface and in the adjacent airspace in order to detect and to foresee conflict situations having impact on runway and taxiway phases of flight, and to alert controllers and other interested parties.

Four sets of conflict situations were addressed:

- **Runway incursions**: Alert generation by monitoring data from the surveillance system to detect, according to ICAO definition, "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft".
- **Non-conformance to ATC procedures and instructions**: detects non-conformance to aerodrome procedures and instructions using data coming from the instructions given by the ATCO through EFS and 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 or 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. [44]
- **Conflicting ATC Clearances:** Alert generation by combining surveillance data with data about clearances coming from EFS given to detect error caused by ATCO when providing clearances to aircraft. 'Conflicting' in the title refers to the fact that certain clearances input on the EFS at the same time by an ATCO do not comply with the local ATC rules/procedures, it does not mean that the aircraft/vehicles have ended up in conflict with each other.[45]

The performances of the Safety Nets are dependent upon the input data received from the surveillance system, but also associated clearances and taxi route information derived from the Surface Routing Server and Controller Working Position. The SSN provides information alerts and/or alarm alerts in order to prevent a potential conflict.

Please note that, even though A-SMGCS Level 2 (RIMS) is considered baseline for SESAR, it was considered active only in the solution scenario.

As specified into P06.07.01 OSED [43] "*The new CATC and CMAC alerts are not meant to replace RIMS but to complement RIMS by predicting incidents before the RIMS Alarm triggers. Therefore, the RIMS alerts have a higher priority than other alerts*" and as said into P6.7.1 OCD [42], some Non-conformance to ATC instructions can be identified as precursors of runway incursions; safety nets that in this case are: Take off without clearance, Landing without clearance, Landing in wrong runway, Line-up without clearance and Line-up in wrong runway (shown in Table 50), are non-conformance to ATC instructions that, of course, can lead to a runway incursion.

Table 50 provides the list of the available customized INFORMATION/ALARM alerts per Surface Safety Nets type with relative thresholds used for this exercise.

SSN EXE 652		INFORMATION	ALARM	LABEL
Runway Incursion	There is an approaching aircraft and another aircraft that is taking off in the opposite direction on the same runway	19 NM from runway threshold (at the IAF point)	10 NM from runway threshold (at descent path)	OPPDI
	There is an approaching aircraft and another aircraft that is taking off in the opposite direction on the parallel runway	19 NM from runway threshold (at the IAF point)	10 NM from runway threshold (at descent path)	OPPDI

	There is an approaching aircraft and another aircraft is entering in the OFZ	Approaching aircraft is at 3 NM from runway threshold	Approaching aircraft is at 2 NM from the runway threshold (at descent path)	RUINC
	There is a taking off aircraft and another aircraft is entering in the OFZ and ahead of the taking off one	N/A	The aircraft intercepts the OFZ	RUINC
	There is an approaching aircraft to a closed runway (in both directions)	The aircraft is at 10 NM from runway threshold	The aircraft is at 5 NM from the runway threshold	CLOR
	There is a lining-up aircraft on a closed runway (in both directions)	N/A	The aircraft lines-up on the runway	CLOR
	There is an approaching aircraft to a closed runway (in direction of landing only)	The aircraft is at 10 NM from runway threshold	The aircraft is at 5 NM from the runway threshold	CLOR
	There is a lining-up aircraft on a closed runway (in the direction of proceeding)	N/A	The aircraft lines-up on the runway	CLOR
Non-conformance to ATC procedures	Speed limit on the taxiway	N/A	The aircraft's speed exceeds 40 knots	SPEL
Non-conformance to ATC instructions[3]	Take off without clearance	N/A	The aircraft is taking off without clearance	NOTOF
	Landing without clearance	N/A	The aircraft is at 1NM from the runway threshold and it has not received landing clearance	NOLND
	Landing on a wrong runway	N/A	The aircraft is inside the descending path of a runway that is different from the one on the flight plan	LAWRR
	Taxi route deviation	The aircraft is taxiing and its position differs by more than 70m with respect to the cleared route	N/A	TXDEV
	Taxi on a closed segment of a taxiway	N/A	The aircraft enters into a closed segment	CLTWY
	Approaching without any TWR contact	The aircraft is at 6 NM from the runway threshold and the related flight plan is owned by the "approach" position	N/A	NOCON
	Pushback without clearance	The aircraft is pushing back without clearance	N/A	NOPB
	Taxi without clearance	The aircraft is taxiing without clearance	N/A	NOTX
	Line-up without clearance	N/A	The aircraft is lining up without clearance	NOLUP

[3] Some Non-conformance to ATC instructions (such as take off without clearance, landing without clearance, landing on a wrong runway, Line-up without clearance and Line-up in wrong runway) can be identified as precursors of runway incursions [42].

	Line-up on a wrong runway	The aircraft is lining up on a wrong runway	N/A	LUWRR
	Stationary after pushback clearance	The aircraft is stationary after 120s of pushback clearance	N/A	STAPB
	Stationary after line-up clearance	The aircraft is stationary after 120s of taxi clearance	N/A	STALU
	Stationary after taxi clearance	The aircraft is stationary after 120s of line-up clearance	N/A	STATX
	Stationary after take-off clearance	The aircraft is stationary after 120s of take-off clearance	N/A	STATO
Conflicting ATC clearances	Line-up vs. line-up on opposite runway	N/A	Two line-up on opposite runway	LU/LU
	Line-up vs. line-up on the same runway at opposite holding points	N/A	Two line-up on the same runway at opposite positions	LU/LU
	Line-up vs. line-up on the same runway at the same entry point	N/A	Two line-up on the same runway at the same positions	LU/LU
	Landing vs. line-up on same runway	N/A	Landing clearance and line up clearance	LU/LA
	Landing vs. line-up on opposite runway	N/A	Landing clearance and line up clearance	LU/LA
	Line-up vs. take off on the same runway	N/A	Take-off vs. line-up in front	LU/TO
	Line-up vs. take off on opposite runway	N/A	Take-off vs. line-up opposite runway	LU/TO

Table 50: Exercise 652 Safety Nets conflict types

6.2.2.1.2.3 Prototype of Surface Alert HMI

The purpose of this system (at least for this phase of the project) is to manage on the Controller Working Position the different alarm alerts and information alerts related to foresee and detect conflicts on the Airport (both ground and final approach) by the Surface Safety Nets engine component (developed by P12.03.02).

The nature of this system is a Human Machine Interface, and the functional requirements can be grouped into:

- Acquisition of SSN alerts: The capability of receiving and processing the alert reports coming from the SSN server (developed in P12.03.02);
- Alert Notification: The capability of notifying the alerts on the A-CWP, managing the way of presentation and the priorities of the alerts;
- ASN HMI alert amendment: The capability of managing the acknowledgements of the alerts (locally to the A-CWP);

6.2.2.1.2.4 Tower CWP

The Selex ES Tower CWP is customizable in order to meet different operative expectations and speed up the specific operations performed by each controller.

It foresees different roles to be associated with the different positions. The powers associated with each role are customizable by a potential customer in order to satisfy different operative needs for different airport layouts and procedures. This behaviour permits a correct work split in the airport environment.

The CWP deployed in Milan Malpensa for Release 3 includes one Clearance Delivery Dispatcher position (CDD), one Ground position (GEC) and one Tower position (TEC).

The Selex ES Tower CWP is enriched by a touch screen and it is organized in strip bays using Electronic Strip Bay (ESB).

Each ESB can be organised in sub-bays according to the position role (i.e. CLD, GND, TWR), the flight status and the performed operations.

The Electronic Flight Strips in the ESB can be managed through a mouse or a touch screen device (with a touch screen pen). As soon as created, through the insertion of a flight plan, the Strips are displayed in a dedicated Bay.

The Electronic Flight Strips can be moved through the different bays in different ways:

- Drag and drop,
- Automatic movement as a consequence of a performed event (e.g. after a clearance input by the controller).

Figure 61: Exercise 652 Electronic Strip Bay display

Figure 62 shows in detail the strip workflow from each controller working position to the other ones.

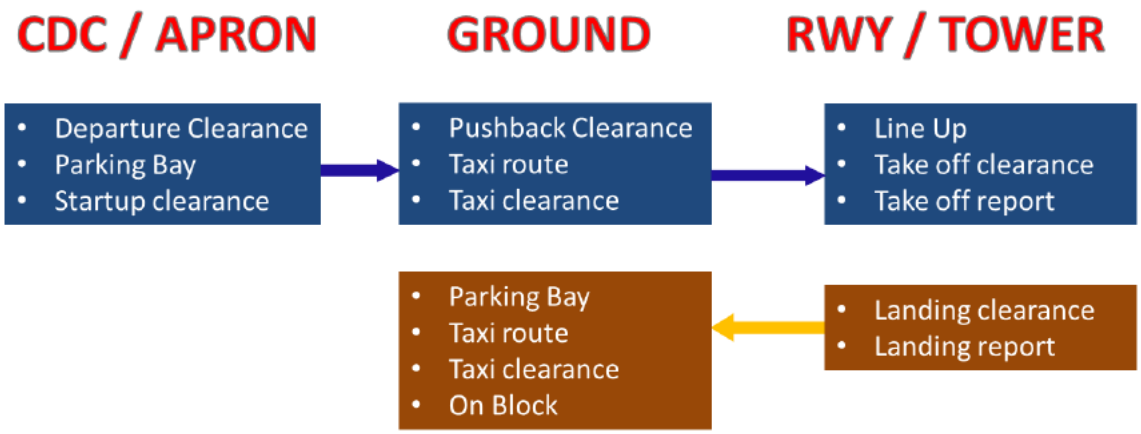


Figure 62: Exercise 652 Strip workflow

6.2.2.1.3 Training

In order to provide all needed information to the participants and familiarise them with the system under evaluation, the training session was divided into the following activities:

- training in a classroom with "Validation activities Overview" provided by the Human Factors Expert;
- training in a classroom with "HMI presentation and ADS-B" provided by SELEX ES HMI experts;
- training in the simulation room with the demonstration of the Reference scenario;
- training in the simulation room with the demonstration of Safety Nets Service scenario;
- Reference Scenario training runs;
- Safety Nets Scenario training runs.

6.2.2.2 Exercise execution

The execution of the exercise was performed from 25th to 29th November 2013.

In order to satisfy the scope of the exercise, the following simulation scenarios were tested:

Scenario 1 – Reference. The *Reference scenario* for live traffic run executed in order to compare it against the Enhanced ADS-B functionalities in scenario 4. This scenario was simulated by means of a shadow mode simulation with real traffic and relevant data were opportunely recorded.

Scenario 2 – Reference + unusual events. The *Reference + unusual events scenario* proposed the current Italian ATC aerodrome working environment enriched with the operational improvements foreseen for the next years (up to 2017) related to Electronic Flight Strips. Simulation runs related to this scenario were characterised by faults injections. This scenario was simulated by means of a real time simulation.

Scenario 3 – Surface Safety Nets + unusual events. *The Surface Safety Nets + unusual events scenario* was based on the Scenario 2 in which were injected some unusual events detected by Surface Safety Nets in order to evaluate their added value respect to Scenario 2. This scenario was simulated by means of a real time simulation. Simulation runs related to Scenario 3 were characterised by faults injections reproducing specific unusual events that triggered alarm alerts and/or information alerts provided by Safety Nets under evaluation.

Scenario 4 – ADS-B. In order to validate ADS-B Ground Station Prototype, one additional scenario was experimented through shadow mode. The Enhanced ADS-B Ground Station was fed with real traffic data, and the CWPs were provided with both ADS-B and MSF tracks. The Enhanced ADS-B Ground Station improvement was tested comparing the MSF tracks (including MLAT and WAM sensors and exploiting the enhanced ADS-B validation algorithm) against the ADS-B stand-alone tracks.

Please note that in scenarios 2 and 3 Surface Routing and Planning functions (Surface Manager) and Electronic Flight Strips[4] were available while RIMS was considered active only in the solution scenario (even though A-SMGCS Level 2 (RIMS) is considered baseline for SESAR) .

The above scenarios were executed during the validation sessions as reported below in Figure 63.

[4] The scenarios proposed the current Italian ATC aerodrome working environment enriched with the operational improvement foreseen for the next years (up to 2017) related to Electronic Flight Strips.

Figure 63: Exercise 652 agenda

Figure 64 expresses the legend of colours used for the scheduling table in Figure 63.

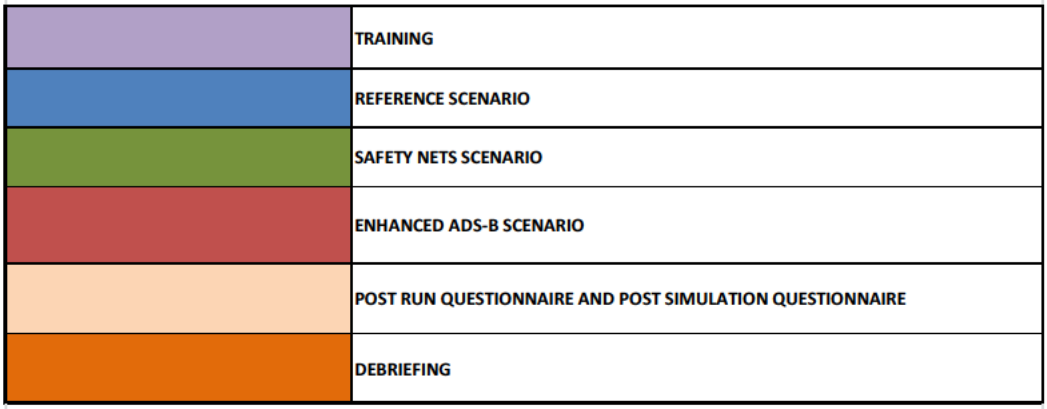


Figure 64: Exercise 652 run ID coding

Five ATCOs were available for the simulation and indicated with letters from A to E in Figure 63. Actually, four controllers work in Milano Malpensa TWR and the other one works in Roma Fiumicino TWR. For each run, they changed their working position in order to make the simulation as real as possible and receive more complete feedback.

The main positions of the simulation were three:

- Clearance Delivery Controller who is responsible for the provision of:
  - departure clearance for IFR flights
  - start-up clearance
  - coordination with GND controller.
- Ground Controller who is responsible for:
  - traffic movements on the manoeuvring area with the exception of the runways
  - aircraft movements on the Apron
  - management of push-back
  - management of taxiing
  - coordination with CDC controller
  - coordination with TWR controller
  - coordination of GND movements on the landing area with the RWY controller
  - sequencing of the departure flights in order to define an optimal departure sequence to minimise delay
  - provision of taxi instructions and advice.
- Runway Controller who is responsible for:

- operations on the active runways and aircraft flying within the area of responsibility of the TWR
- management of the runway occupancy
- provision of take-off/landing clearances to departing/arriving aircraft
- sequencing of aircraft on the runway for take-off.

Three controllers occupied these positions while, the other two had an observer role for Ground and Runway stations that were considered the main impacted working stations.

As shown in Figure 63, two main kinds of runs were executed: training and measured runs.

Training runs, characterised by a traffic density of 50 a/c per hour (high-medium traffic density), lasted about 50 minutes in order to allow controllers to become familiar with the specific controllers' positions they were managing during the measured runs.

Measured run, characterised by a traffic density of 50 a/c per hour (high medium traffic density – refer to [52]), lasted about 60 minutes to collect consistent data in order to address both qualitative and quantitative measurements.

Please note that, the measured run n°9 (scenarios 1 and 4), dedicated to the ADS-B, was obviously based on real traffic that there was in Milano Malpensa airport at the time of the simulation.

Measured runs were repeated in order to:

- collect feedback from all involved controllers about the operational concepts under evaluation and for the different simulated controller working positions;
- increase the significance of quantitative data by iterating the same runs, varying exclusively human performances (such as rotating controllers on working positions) and then mediating data in order to obtain results.

Several data collection methodologies were applied in order to address all validation objectives defined in the corresponding Validation Plan [52]. During each measured run, Human Factors and Safety Experts observed ATCOs behaviour in relation to record:

- Unusual events occurrences,
- Interaction with the Human Machine Interfaces,
- Utilization of new tools.

After each measured run, the controllers were interviewed by the Human Factors and the Safety Experts and filled in a dedicated questionnaire in order to collect feedback related to workload, Situational Awareness and safety inherent to the specific run and to each controller position.

The questionnaire answers (see Table 511) were based on how much they agreed or disagreed with each question. As indicated in the table below, there was the possibility to choose from **1** (strongly negative feedback) to **6** (strongly positive feedback) and/or give comments to explain their point of view.

strongly negative	negative	slightly negative	slightly positive	positive	strongly positive
1	2	3	4	5	6
☹	☹	☹	☺	☺	☺

Table 51: Answers options in the questionnaire

Debriefing sessions involving controllers and validation experts were performed at the end of each simulation day in order to clarify and point out particular events which occurred during the simulation runs, unexpected behaviour of the system, to share and discuss about specific feedback on safety nets.

During each measured run, system data were recorded in order to address quantitative analysis especially in relation to Safety and Human Performance Key Performance Area. Hereafter different collected data are reported:

- Surface Safety Nets data:
  - Alert type
  - Involved aircraft
  - Alert time
  - ATCO impacted
- ADS-B data:
  - Valid
  - Not valid
  - Not executed

Moreover, for each measured run, screen captures at fixed time intervals of the three controller positions were recorded in order to support qualitative analysis and debriefing sessions.

At the end of the whole validation session, the controllers had to fill in a final post simulation questionnaire in order to provide their overall feedback related to the acceptability and the usability of the new tools used during the validation session in order to cover the defined validation objectives [52].

6.2.2.3 Deviation from the planned activities

The deviations from the planned activities concern the kind of runs executed during the simulations. For the SSN evaluations, in order to compare the reference and the solution scenarios 14 runs were used (7 with SSN and 7 without), one run was dedicated entirely to conflicting ATC clearances, one to compare the reference and the solution scenarios related to Enhanced ADS-B algorithm and one dedicated entirely to SSN solution scenario in order to collect additional impressions.

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

To obtain the status of the exercise results both qualitative and quantitative data were taken into account. Table 52 shows the data collection methods utilized and their link to the type of data gathered.

Data Collection Methods	Qualitative	Quantitative	Objective	Subjective
Over the shoulder Observations	√		√	
Questionnaires	√	√		√
Debriefings	√			√
System data Collection		√	√	

Table 52: Data collection method

Taking into account every kind of outcome of the exercise, Table 53 summarizes the exercise results per validation objectives and per success criteria as identified within the Validation Plan ([52]).

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
Exercise 652	**OBJ-06.03.01-VALP-0652.0001**	Surface Safety Nets	CRT-06.03.01-VALP-0652.0101	Correct type of alert is triggered. Confirmed by the ATCOs in questionnaires, debriefing and observation simulation runs.	**Success criterion achieved** Correct type of alert was triggered even though new types of SSN could be implemented and some of them could be enhanced.	**OK**
			CRT-06.03.01-VALP-0652.0102	False alerts are kept to an acceptable level. There should be no false alerts during the exercise. However, should there be an occurrence; it should not prevent the ATCO from continuing the exercise. Confirmed by the ATCOs during debriefing and by observation during the simulation runs.	**Success criterion achieved** False alerts occurred but they did not prevent the ATCO from continuing the exercise as they were kept to an acceptable level	
			CRT-06.03.01-VALP-0652.0103	Answers to questionnaires and debriefings confirmed that the Surface Safety Nets alerts are beneficial.	**Success criterion achieved**	
			CRT-06.03.01-VALP-0652.0104	Surface Safety Nets alerts allow the prevention of unusual events in respect to the reference scenario.	**Success criterion partially achieved** Globally, compared to the reference scenario where no SSN were used, in the solution scenario ATCOs	

					confirmed that SSN helped them (especially under adverse weather conditions where they were not supported by the out-of-window view). Nonetheless, for particular SSN types, it was suggested to have a "preventing" advice that warns ATCOs not to give a wrong clearance.	
			CRT-06.03.01-VALP-0652.0105	The System allowed the controllers to improve their Situational Awareness. Confirmed by the ATCOs during debriefings and by observation during the simulation runs.	**Success criterion partially achieved** In general, the use of SSN allowed controllers to improve SA even though they needed some further improvements to enhance this aspect.	
	OBJ-06.03.01-VALP-0652.0002	ADS-B	CRT-06.03.01-VALP-0652.0201	Data quality increased with regard to the current surveillance system by means of ADS-B application.	**Success criterion achieved** Since scenario reference 1 and solution 4 were compared, ATCOs effectively noticed a data quality increase by means of the enhanced ADS-B application with regard to the current surveillance system. Confronting the type of data of the state of validation (i.e. valid, not valid, validation not executed), it was possible to demonstrate that no valid data were excluded from the system improving data quality.	**OK**

			CRT-06.03.01-VALP-0652.0202	Controller Situational Awareness was improved.	**Success criterion achieved** ATCOs asserted that ADS-B is useful to improve their Situational Awareness especially in case of low visibility conditions.	
	OBJ-06.03.01-VALP-0652.0003	Advanced Controller Working Position (A-CWP)	CRT-06.03.01-VALP-0652.0301	Controller Situational Awareness was improved in comparison with reference scenario.	**Success criterion achieved** Globally the Situational Awareness in solution scenario was higher than in reference one.	**OK**
			CRT-06.03.01-VALP-0652.0302	Controller workload was reduced or unaltered in comparison with reference scenario.	**Success criterion achieved** Globally the workload in solution scenario was lower than in reference one.	
			CRT-06.03.01-VALP-0652.0303	Controllers were fully confident in the new tools outputs.	**Success criterion partially achieved** Controllers were confident in the new tools' outputs although they proposed to implement other functions and to provide additional tuning adjustments.	
			CRT-06.03.01-VALP-0652.0304	Controllers considered the proposed Advanced Controller Working Position as intuitive and usable.	**Success criterion partially achieved** Controllers considered the proposed Advanced Controller Working Position quite intuitive and usable; moreover, they suggested to	

					improve it by reducing schematic and complex activities.	
			CRT-06.03.01-VALP-0652.0305	Controllers appreciated timeliness and prioritization of data displayed by Surface Safety Nets.	**Success criterion partially achieved** In general, controllers appreciated timeliness and prioritization of data displayed by Surface Safety Nets; nevertheless, they gave some suggestions to improve these aspects: ATCOs asserted that the alert thresholds need to be better fine-tuned in order to avoid false and nuisance alerts. Moreover, especially for conflicting clearances safety net, they would prefer a more preventing function that warns ATCOs with a due notice.	

Table 53: Summary of Validation Exercises Results

6.2.3.1.1 Results on concept clarification

The analysis addressed especially the validation of particular Surface Safety Nets and Enhanced ADS-B functionalities impacting different Key Performance Areas; in the next section 6.2.3.1.2, the results will be presented per key performance and transversal areas pointing out also aspects about concept clarification and implementation.

6.2.3.1.2 Results per KPA

The results for each KPAs/TA per validation objective, obtained by means of the integration and analysis of data collected during the exercise, are reported hereafter.

As anticipated in the validation plan [52], Exercise 652 focused mainly on the following KPAs/TA:

- Safety,
- Human Performance.

Moreover, to better elicit the main results, it has been chosen to present them according to the specific area of investigation on which the analysis focused.

Results presented in this report are opportunely supported by graphical presentations of data, which were collected by means of post simulation questionnaires, post run questionnaires and system data recordings.

6.2.3.1.2.1 Human Performance

Human Performance Transversal Area was investigated in terms of new features usability according to controllers' opinion. Usability refers to the effectiveness, efficiency and self-satisfaction with which controllers can achieve their tasks in the validation environment. It covers practical aspects, such as comprehensibility, readability, visibility, perceptibility, and comfort of use.

The Human Performance Transversal Area is related to the validation objective: **OBJ-06.03.01-VALP-00652-0003** *"The integration and exploitation of surface safety nets functions with current elements such as surveillance and Electronic Flight strips into an Advanced Controller Working Position (A-CWP) will result in enhanced usability and Situational Awareness for ATCOs."*

To assess the global ATCOs feedback with respect to A-CWP, integrated with Surface Safety Nets functions and current elements such as Surveillance and Electronic Flight strips, a lot of data like questionnaires, debriefing and over the shoulder observations were gathered.

Most controllers' feedbacks related to Advanced Controller Working Position usability were that they appreciated the innovative HMI concepts but, on the other hand, they provided also several suggestions to improve its usability. They worried especially about the risk that the excessive use of technical innovations could distract them from the external view of the aerodrome even though, in case of bad weather conditions or ATCO distraction, they agreed on SSN operational support.

In general, the A-CWP with use of SSN enabled the automation of a lot of processes but this aspect should be improved by further reducing the number of manual inputs. For example, regarding EFS management, controllers asserted that EFS were time-consuming and increasing their workload,

especially in case of unusual events, so they would prefer a more automatic use instead of manual and schematic one that reminded them of the actual use of paper strips[5]. Moreover, since the database of taxiways of Milano Malpensa airport was not completely updated, by using keyboard, controllers spent time to insert taxiway routes that consequently decreased a bit their level of attention to the traffic. Of course, for real applications, the airport taxiways database will be improved with pre-existent taxiways names in order to avoid inputting single alphanumeric data.

Some ATCOs' feedback was related also to the position of strips especially in case of a potential conflict arising. In particular, they suggested improving the position of strips of arrival and departure traffic bays in order to allow a more useful management of traffic in case of critical situations.

About Surface Safety Nets operational concept, controllers appreciated the tool as it supported them in highlighting potential critical situations. Nevertheless, some issues or suggestions for further implementations were raised and reported hereafter.

Another important outcome was that they would prefer to filter the alert list per controller working position because having all alerts listed on their screen got them confused, increasing their workload and reducing their attention to the traffic under their control. An ideal solution they suggested could be to use a label with as much possible information instead of using an alert list.

False alerts, defined as "Alert which does not correspond to a situation requiring particular attention or action" [ATM Lexicon], arose during the simulation runs and were related especially to TAXI ROUTE DEVIATION and LINE UP IN WRONG RUNWAY. Those alerts created an increase of workload and a decrease of Situational Awareness and surely, to avoid them, the system needs to be refined with a better threshold tuning (anticipating or postponing) which should also consider typical ATCO reaction time for alert acknowledgment.

Moreover, nuisance alerts, defined as "an alert which is correctly generated according to the rule set but is considered operationally inappropriate" [ATM Lexicon], happened and were related especially to SPEED LIMIT ON TAXI, RUINC and STATIONARY TRAFFIC. In particular, the first two alerts were linked to the lack of the system that did not consider the altitude variable moreover, the second and the third ones were not appropriately set for the operational use. As an example, the Figure 65 shows what happened during the exercise: the ADH121 aircraft, 3.5 NM far from the runway, was approaching on RWY 35L of Malpensa airport and the GWI3821 was cleared to take-off. A RUINC alert appeared on the ATCO screen but it was a nuisance alert because the threshold used did not conform to the Milano Malpensa regulation.

[5] Of course, it is foreseen to give to controllers as less impact as possible to the change and switch to the automatic use in a gradual manner.

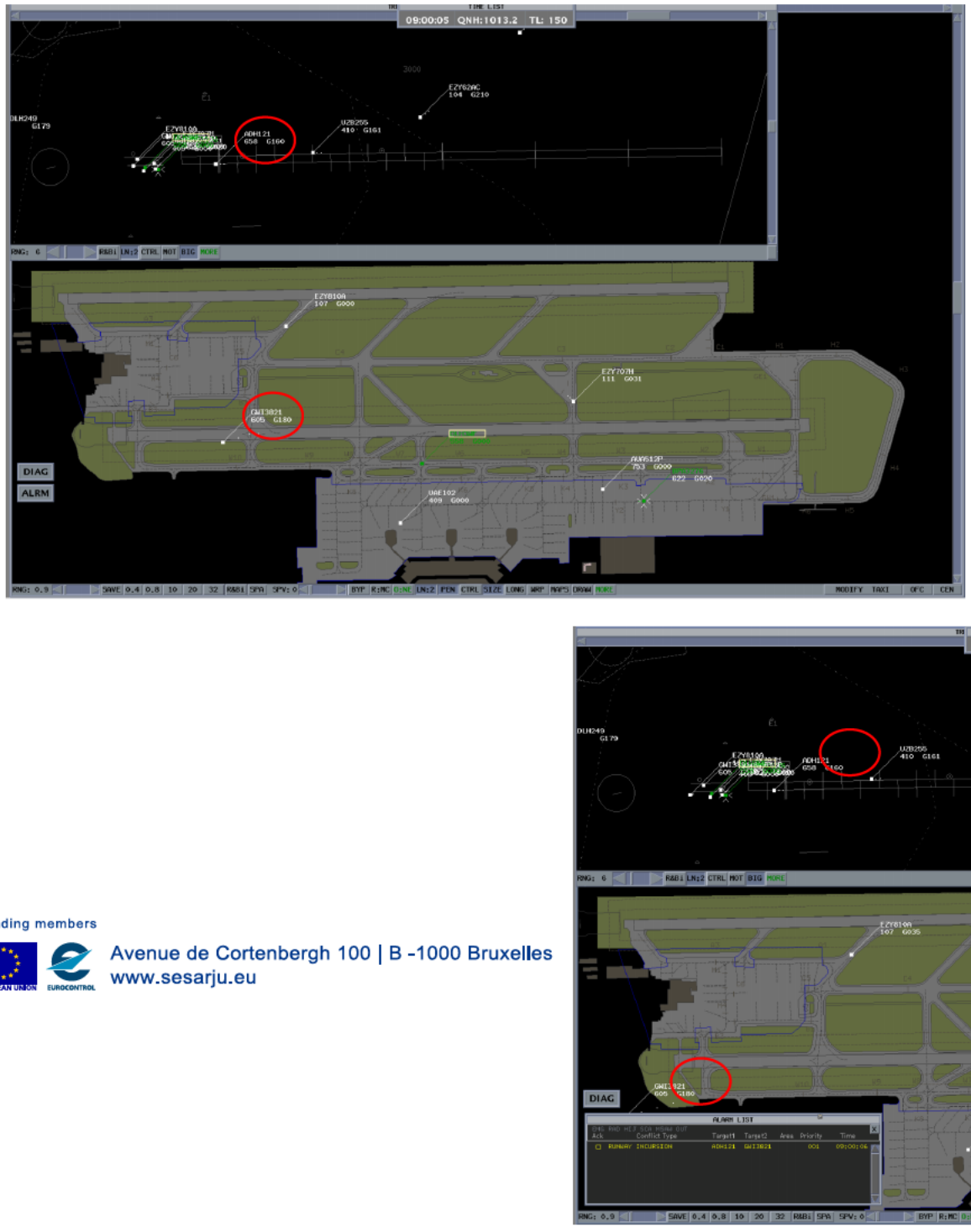


Figure 65: Exercise 652 False Alert Example: Runway Incursion

It is important to note that, considering the total number of runs performed with SSN, the median value of the ratio of the number of false alerts respect to the total number of alerts was less than 0.15 and so, the reliability of the system resulted to be higher than 85%.

With the aim to present alerts with the right notice and give controllers enough time to take decision and react, it is recommended to fine tune the alert thresholds according to controllers expectations and airport regulations.

Controllers also raised suggestions regarding colours to be used. For example:

- in case of CLOSED RUNWAY, it could be useful to adopt different showing up colours for:
  - aircraft that are entering the concerned runway,
  - the concerned closed runway, and
  - the strip involved;
- in case of CLOSED TAXIWAY, it is suggested to adopt a more intense colour for the concerned closed taxiway.

Other feedbacks regarded acronyms to be adopted to indicate alerts and controllers would prefer acronyms similar to the ones used in the aeronautical field. For example, in case of CLOSED RUNWAY instead of using "CLOR" acronym, ATCOs would prefer the term "RWCLS". Of course, they agreed that training could be very useful to better familiarize them with tools and related acronyms.

Considering that 5 controllers participated in the simulation giving, for each question proposed in the PSQ, a possible answer from 1 to 6 (see Table 51), the results presented above can be also confirmed by the following quantitative and qualitative data collected.

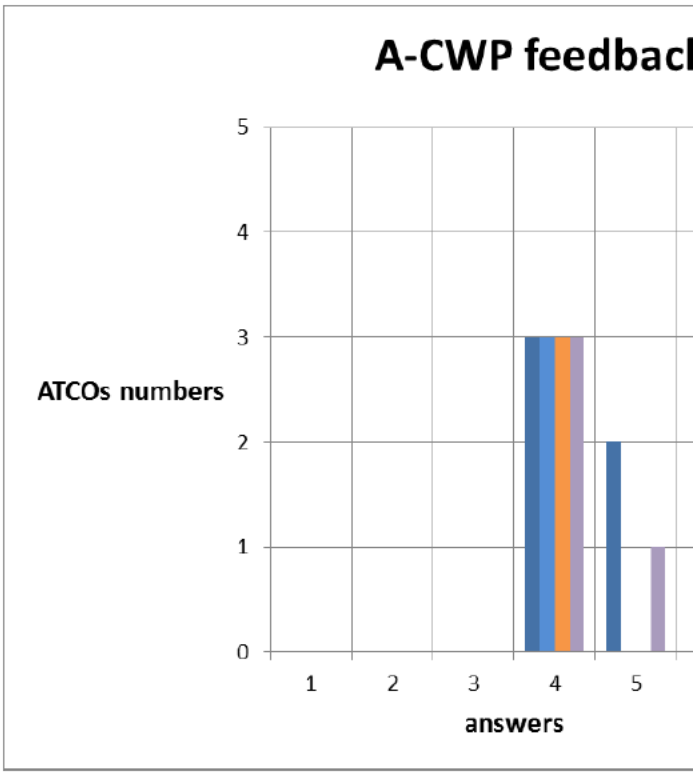


Figure 66: Controllers' feedback about A-CWP ALARM alert usability

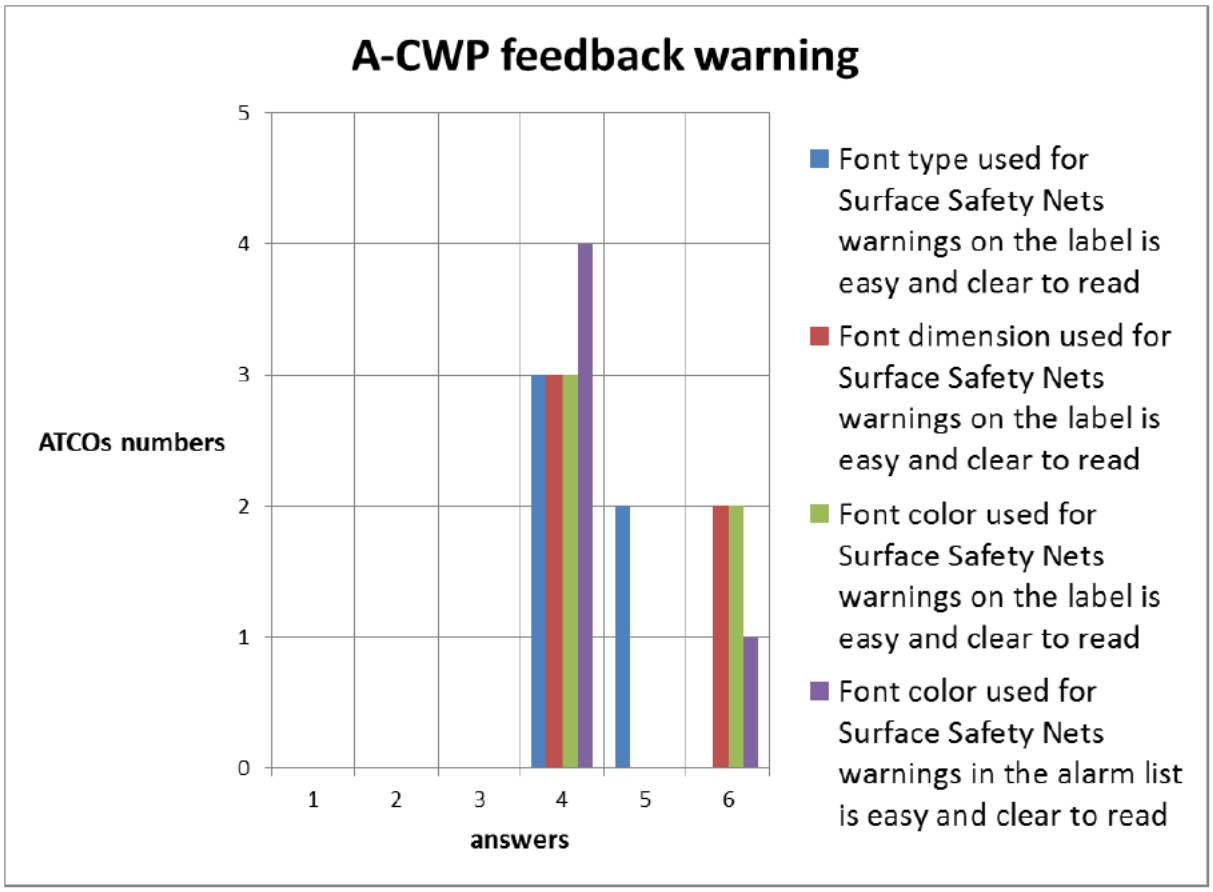


Figure 67: Controllers' feedback about A-CWP INFORMATION alert usability

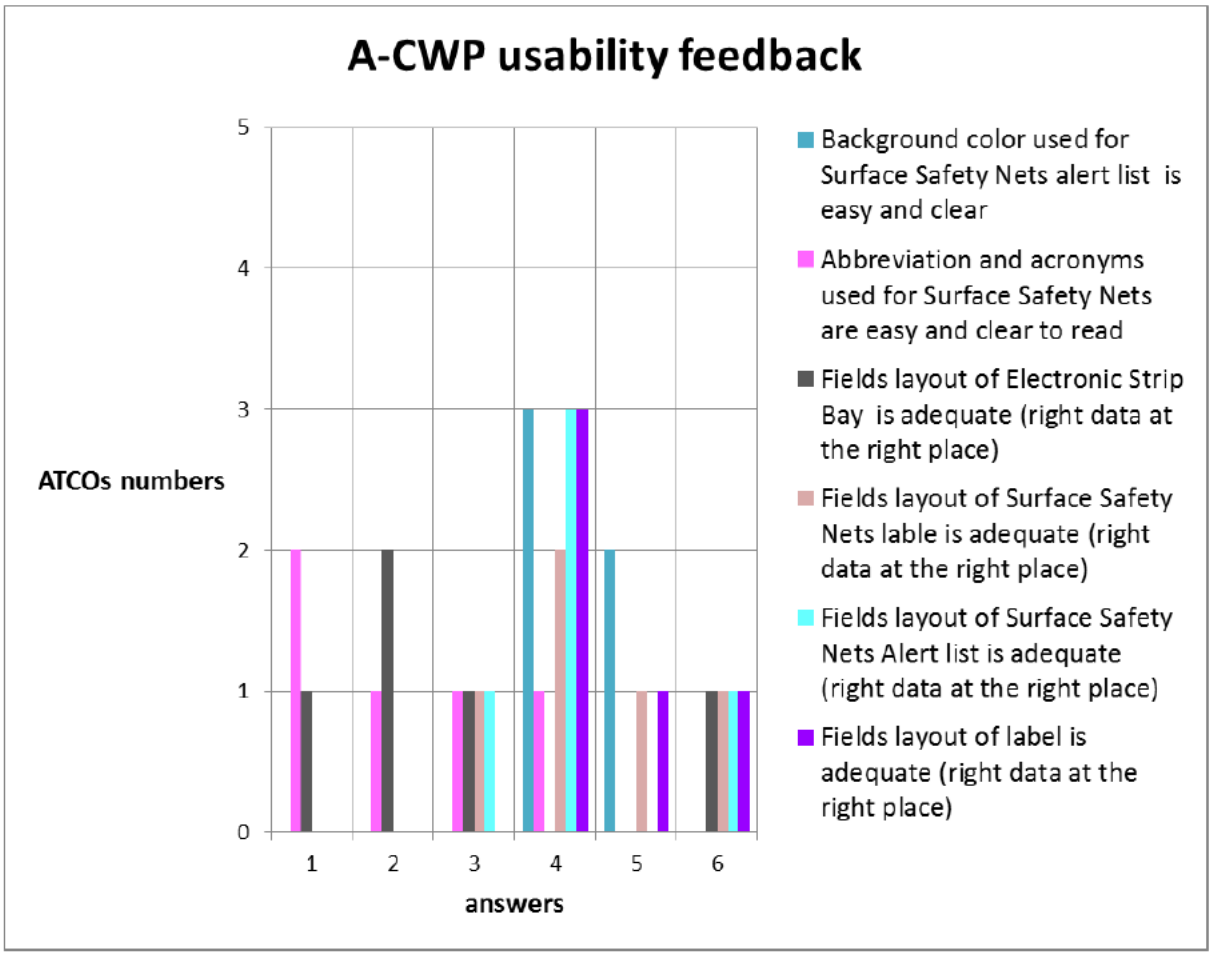


Figure 68: Controllers' feedback about A-CWP usability (other feedbacks)

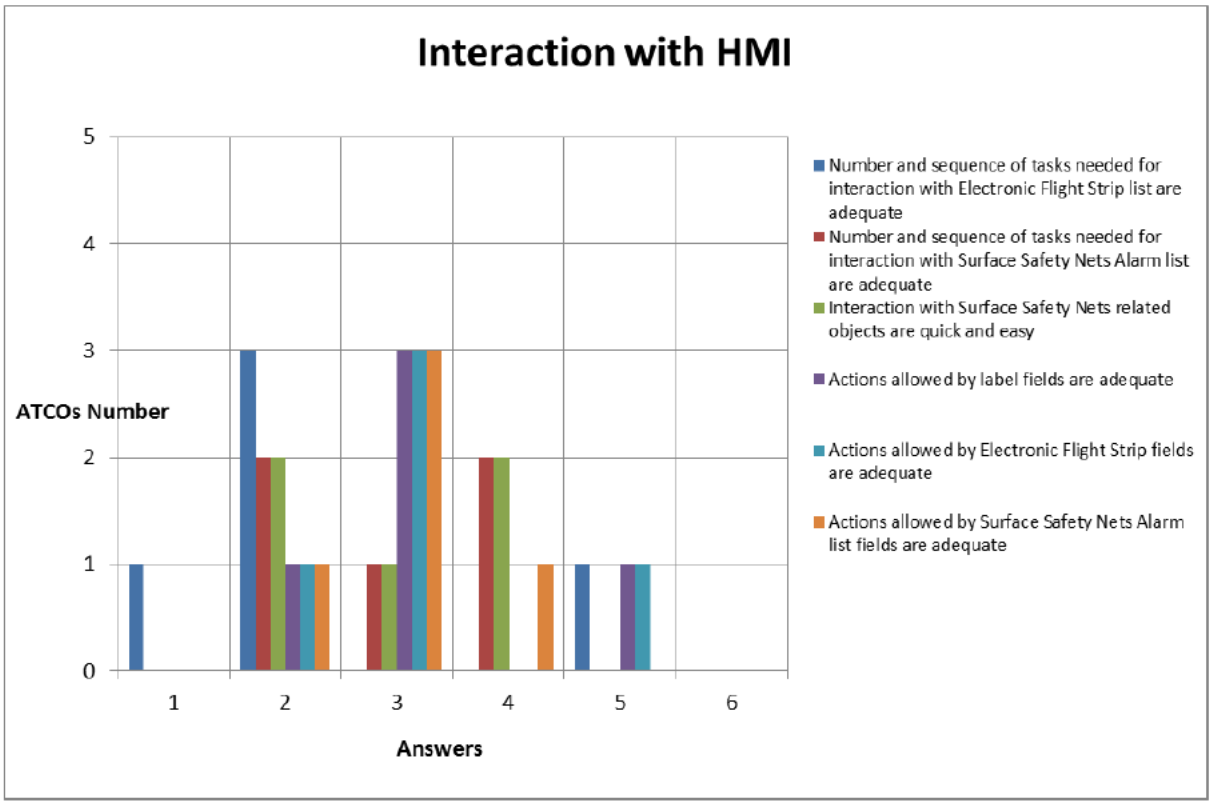


Figure 69: Controllers' feedback about HMI

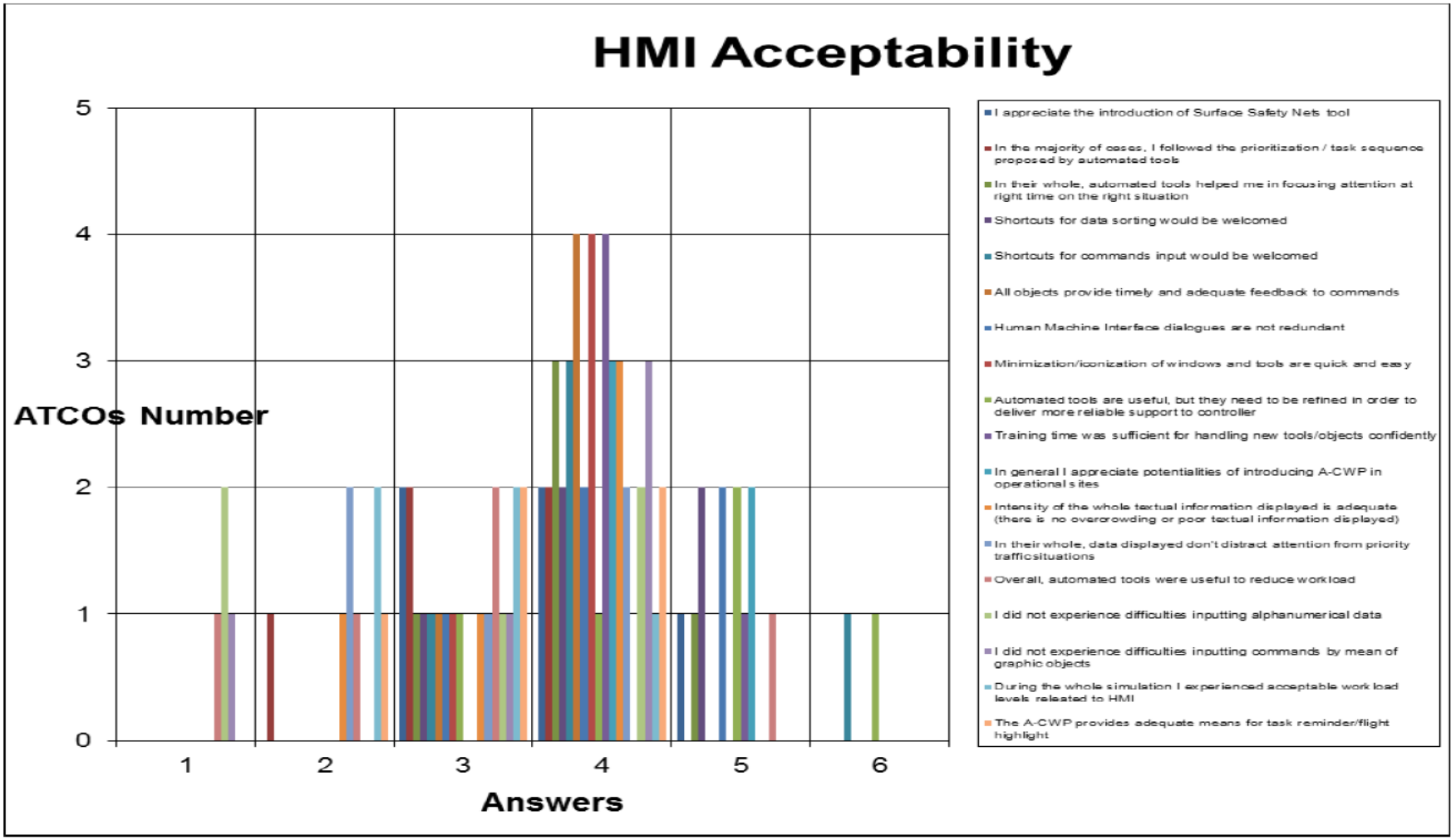


Figure 70: Controllers' HMI acceptability

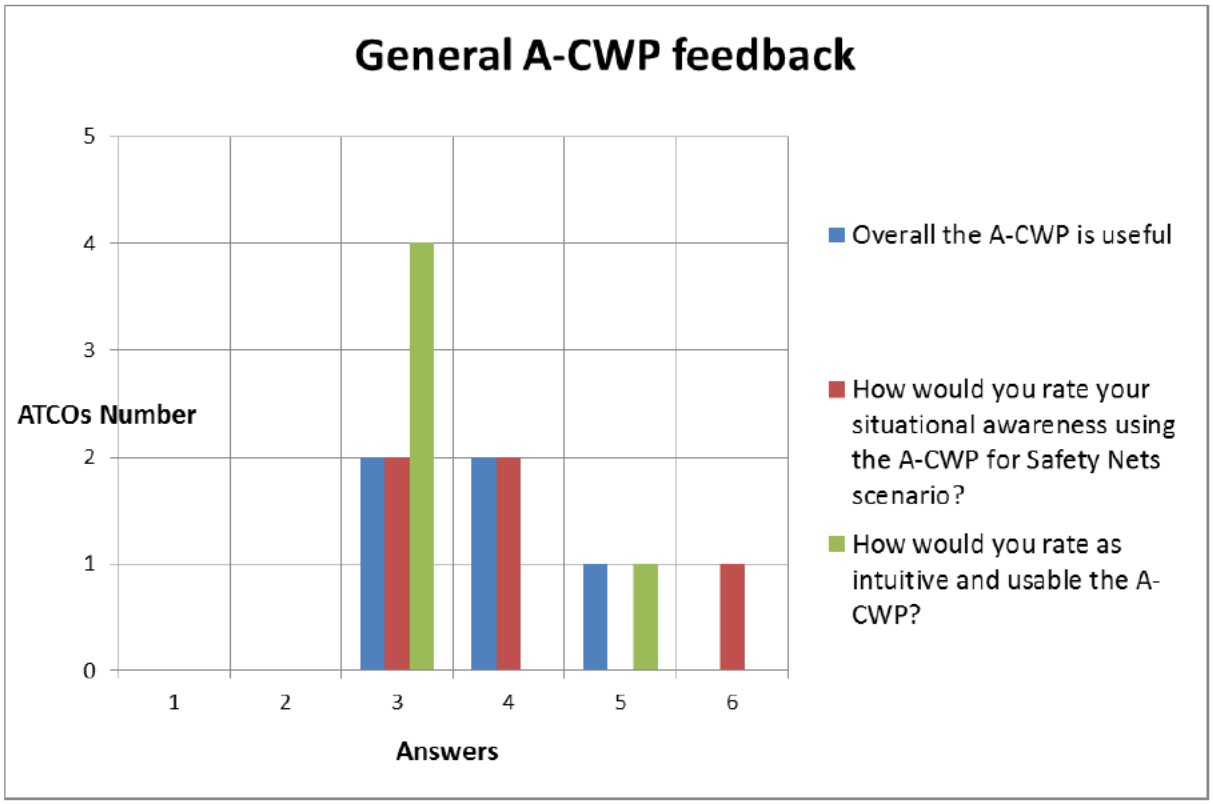


Figure 71: General A-CWP ATCOs feedback

Considering figures from 66 to 71, controllers gave both positive and negative answers expressing the idea to improve the A-CWP usability in order to better address their needs and increase their Situational Awareness.

Here below, the ATCOs feedback on alarm alerts and information alerts collected through the Post Simulation Questionnaires (PSQ) are reported.

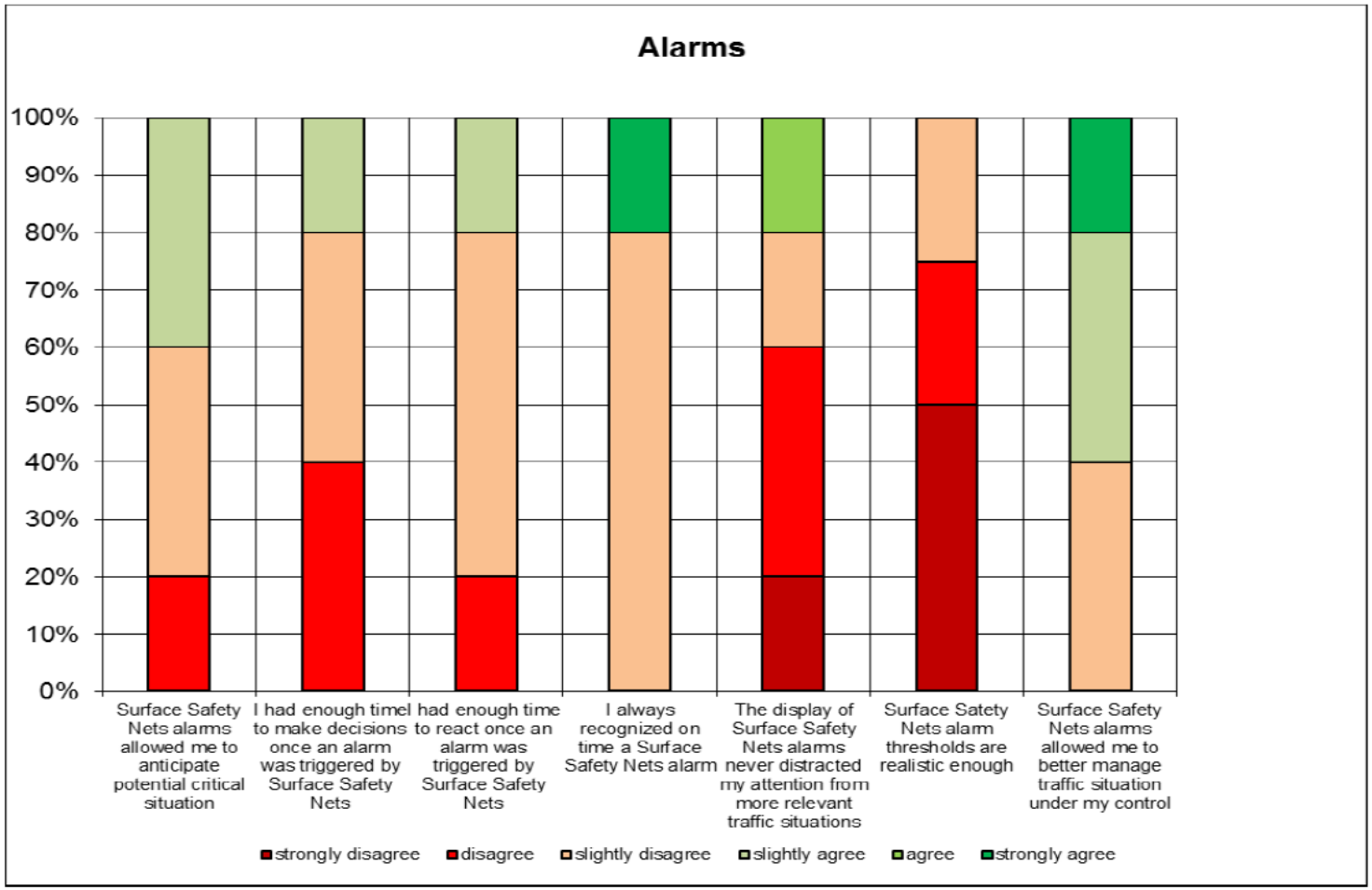


Figure 72: Exercise 652 assessment of SSN: feedbacks on Alarm alerts

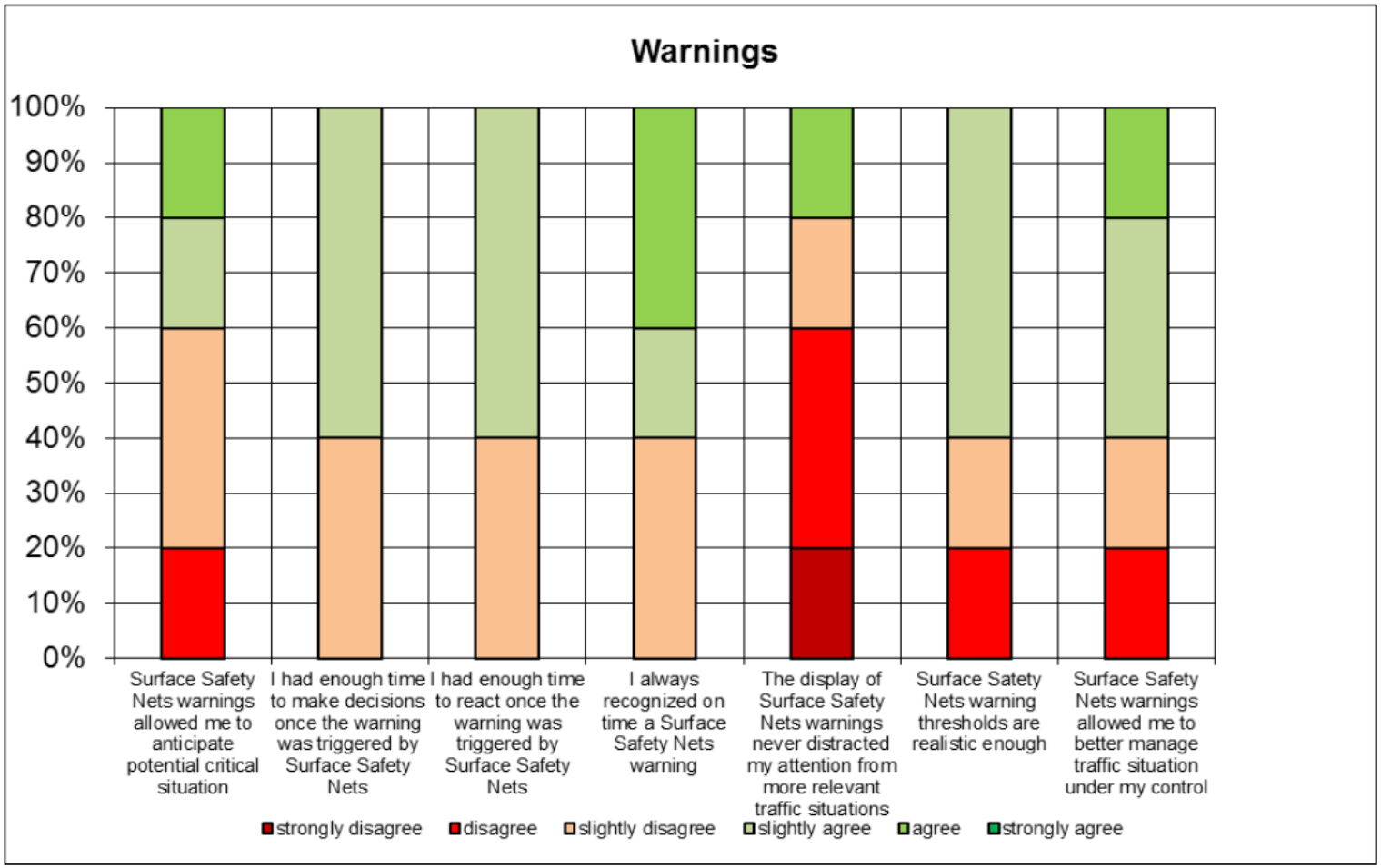


Figure 73: Exercise 652 assessment of SSN: feedbacks on Information alerts

6.2.3.1.2.2 Safety

Safety KPA was expected to be enhanced due to an improvement of both Situational Awareness and surveillance information impacting respectively the following validation objectives:

OBJ-06.03.01-VALP-00652-0001 - Validate improvement of controllers' Situational Awareness and safety on airport surface by means of system detection of:

- Surface conflict
- Runway incursion
- Area intrusion
- Non-conformance to ATC procedures
- Non-conformance to ATC instructions
- Conflicting ATC clearances.

OBJ-06.03.01-VALP-00652-0002 – Validate that ADS-B surveillance data quality is enhanced by means of Enhanced ADS-B algorithms.

Safety assessment regarded both qualitative and quantitative assessment of data collected with questionnaires, debriefing, over the shoulder observations and systems logs.

Here below assessments of safety for SSN and ADS-B will be presented in two separate sections.

6.2.3.1.2.2.1 Safety for Surface Safety Nets

From **SSN** operational concept perspective, safety aspects were analysed especially in terms of Situational Awareness, defined as the continuous extraction of environmental information, the integration of this information with previous knowledge to form a coherent mental picture and the use of that picture in directing further perception and anticipating future events.

In particular, Exercise 652 allowed investigating the Enhanced Surface Safety Nets and the related potential benefits they might provide to controllers. The main objective was to assess whether the Surface Safety Nets really helped ATCOs to timely detect any potential hazardous situation on the airport manoeuvring area. The resulting ATCOs' Situational Awareness was expected to be improved.

That assessment was performed by observing the behaviour of the ATCOs during the RTS runs with the following scenarios:

- SCENARIO 2-*Reference + unusual events scenario:* reproducing a reference scenario including ad hoc injected unusual events. The pseudo-pilots were properly trained to reproduce the hazardous situation which needed to be examined.
- SCENARIO 3-*Surface Safety Nets + unusual events scenario:* where ATCOs were supported in detecting the injected hazardous situations by specific alerts sent by Surface Safety Nets and displayed on the HMI.

Moreover, post-run questionnaires to collect qualitative and quantitative outputs and debriefing sessions (held at the end of each simulation day) enabled us to collect additional information to support the over shoulder observations.

Bearing in mind the full list of Surface Safety Net functions available for the simulation, here below Table 54 reports surface conflict injected alerts simulated during the exercise.

SSN TYPE		SIMULATED
Runway Incursion	There is an approaching aircraft and another aircraft that is taking off in the opposite direction on the same runway	YES
	There is an approaching aircraft and another aircraft that is taking off in the opposite direction on the parallel runway	YES
	There is an approaching aircraft and another aircraft is entering in the OFZ	YES
	There is a taking off aircraft and another aircraft is entering in the OFZ and ahead the taking off one	YES
	There is an approaching aircraft on a closed runway (in both directions)	YES
	There is a lining-up aircraft on a closed runway (in both directions)	NO
	There is an approaching aircraft on a closed runway (in the landing direction only)	NO
	There is a lining-up aircraft on a closed runway (in the direction of proceeding)	NO
Non-conformance to ATC procedures	Speed limit on taxiway	YES
Non-conformance to ATC instructions[6]	Take off without clearance	YES
	Landing without clearance	YES
	Landing on a wrong runway	NO
	Taxi route deviation	YES
	Taxi on closed segment of taxiway	YES

[6] Some Non-conformance to ATC instructions (such as take off without clearance, landing without clearance, landing on a wrong runway, line-up without clearance and line-up on a wrong runway) can be identified as precursors of runway incursions [42].

	Approaching without TWR contact	YES
	Pushback without clearance	YES
	Taxi without clearance	YES
	Line-up without clearance	YES
	Line-up in wrong runway	NO
	Stationary after pushback clearance	YES
	Stationary after line-up clearance	YES
	Stationary after taxi clearance	YES
	Stationary after take-off clearance	YES
Conflicting clearances ATC	Line-up vs. line-up on an opposite runway	YES
	Line-up vs. line-up on the same runway at opposite holding points	YES
	Line-up vs. line-up on the same runway at same entry point	YES
	Landing vs. line-up on the same runway	YES

	Landing vs. line-up on an opposite runway	YES
	Line-up vs. take off on the same Runway	YES
	Line-up vs. take off on an opposite runway	YES

Table 54: SSN simulated during EXE 652

As shown in Table 54 three main types of Surface Safety Nets were simulated:

- **Runway incursions**: Alert generation by monitoring data from the surveillance system to detect according to ICAO definition "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft".
- **Non-conformance to ATC procedures and instructions:** detects non-conformance to aerodrome procedures and instructions using data coming from the instructions given by

the ATCO through EFS and 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 or 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. [44]

- **Conflicting ATC Clearances:** Alert generation by combining surveillance data with data about clearances coming from EFS given to detect error caused by ATCO when providing clearances to aircraft. 'Conflicting' in the title refers to the fact that certain clearances input on the EFS at the same time by an ATCO do not comply with the local ATC rules/procedures, it does not mean that the aircraft/vehicles have ended up in conflict with each other. [52]

Please note that, even though A-SMGCS Level 2 (RIMS) is considered baseline for SESAR, it was considered active only in the solution scenario.

As specified into P06.07.01 OSED [45] "The new CATC and CMAC alerts are not meant to replace RIMS but to complement RIMS by predicting incidents before the RIMS alert triggers. Therefore, the RIMS alerts have an higher priority than other alerts" and as said into P6.7.1 OCD [50], some Non-conformance to ATC instructions can be identified as precursors of runway incursions; safety nets that in this case are: Take off without clearance, Landing without clearance, Landing on a wrong runway, Line-up without clearance and Line-up in a wrong runway. They are non-conformances to ATC instructions that, of course, can lead to a runway incursion.

An important point to highlight is that conformance monitoring and runway incursion services cover mainly potentially hazardous situations caused by pilots' error (e.g. due to misunderstandings or deviations from standard operating procedures or instructions). The added-value with respect to the preceding validation exercise VP-065 [54], conducted in Milano Malpensa in 2012, was the validation of conflicting ATC clearances which, taking into account controllers' error, provided a real added-value from a safety perspective. In order to validate this kind of Surface Safety Net, since they are dependent on controllers' error, instead of injecting unusual events voluntarily caused by pseudo-pilots, the simulation in the thirteenth run was organized inducing ATCOs to make mistakes. In that way, it was possible to collect precise feedback about conflicting ATC clearances.

Generally speaking, the operational concept related to Surface Safety Nets was really appreciated by the controllers, especially in case of ATCOs' distraction or in case of bad weather conditions. Nevertheless, during the simulation, ATCOs highlighted that the tool needed to be further investigated and improved to better address their expectations. Here below are reported the main important feedbacks collected:

- Further refinements of thresholds have to be implemented but, since they are customizable values by the users, a proper requirement should be implemented about providing in advance an alert to allow controllers to have enough time to understand the situation and react.

- Improve the "predictive" feature of SSN especially for conflicting ATC clearance SSN: controllers prefer to have a preventing advice that warns them to not give wrong clearances. For example, before issuing a landing clearance to an aircraft, it should be better to de-activate the function "Line-up and wait" in order to avoid clearing another aircraft to line-up.

- Filtering surface conflict alerts per different working positions. As an example, displaying taxi deviations information alerts on the tower position is not so relevant for the tower controller. Displaying alerts that are not of interest could increase ATCOs workload and

distract them. The reduced attention could cause non-timely detection of potential hazardous situation.

- Need of clearly displaying the type of alert directly in the label in order to avoid that controllers waste time in identifying the detected conflict.
- A more detailed prioritization of alerts with respect to their seriousness should be improved.
- To implement a new type of Surface Safety Nets especially for Conflicting ATC Clearances.

Of course, since safety has to be considered as a very sensitive KPA dependent on several factors, the level of safety could be enhanced by considering also the improvement suggested in the previous sections concerning A-CWP usability.

6.2.3.1.2.2.1.1 Global SSN feedback

Considering that 7 solution scenarios runs with the use of Surface Safety Nets were simulated, the following histograms show the total ATCOs' answers about Surface Safety Nets collected in post-run questionnaires (PRQ) per controller working position.

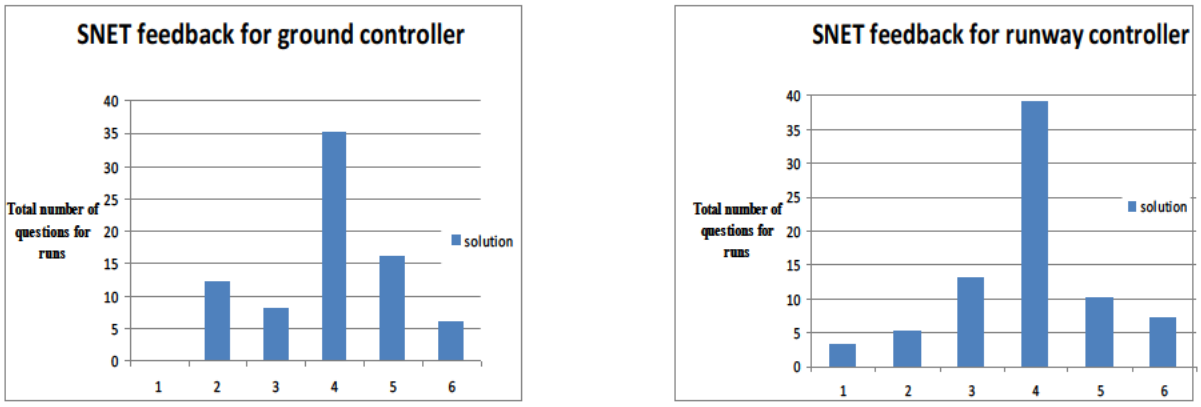


Figure 74: Global PRQ feedback about Surface Safety Nets per CWP

Taking into account that the "4" value of the answer represents a positive opinion (see Table 51) and looking at the shape in Figure 74, it is possible to say that the global feedback about Surface Safety Nets in the case of the solution scenario (i.e. with the use of SSN) for both controller positions was quite appreciable. Although controllers appreciated the global concept, they also suggested improving some aspects in order to achieve the desired level of performance expectations.

6.2.3.1.2.2.1.2 Results per SSN type

In order to collect ATCOs' feedback per kind of Surface Safety Net, Post Simulation Questionnaires (PSQs) were organized ad hoc and the following histograms show the trend of collected data.

Runway Incursion

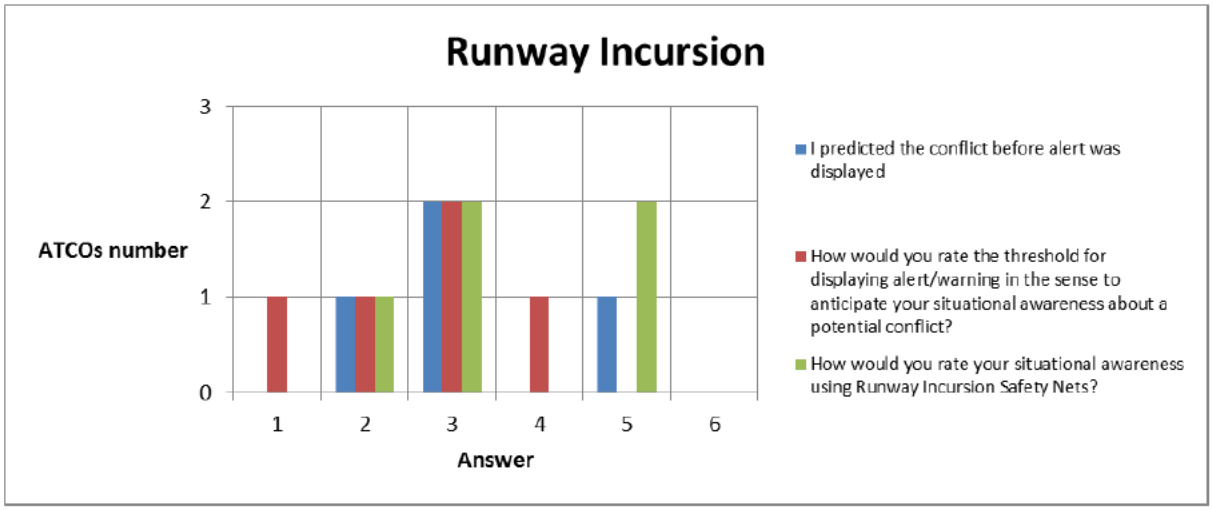


Figure 75: ATCOs' feedback about SA for Runway Incursions Safety Nets

40% of the controllers gave a positive feedback on the fact that the runway incursion SSN anticipated their acknowledgement about conflicts. 60% of the controllers involved gave quite negative answers in respect to SA expecially because they needed more well tuned thresholds: they suggested expecially a better control on the altitude variable that already results as a lack of the system.

Non conformance to ATC procedures and instructions

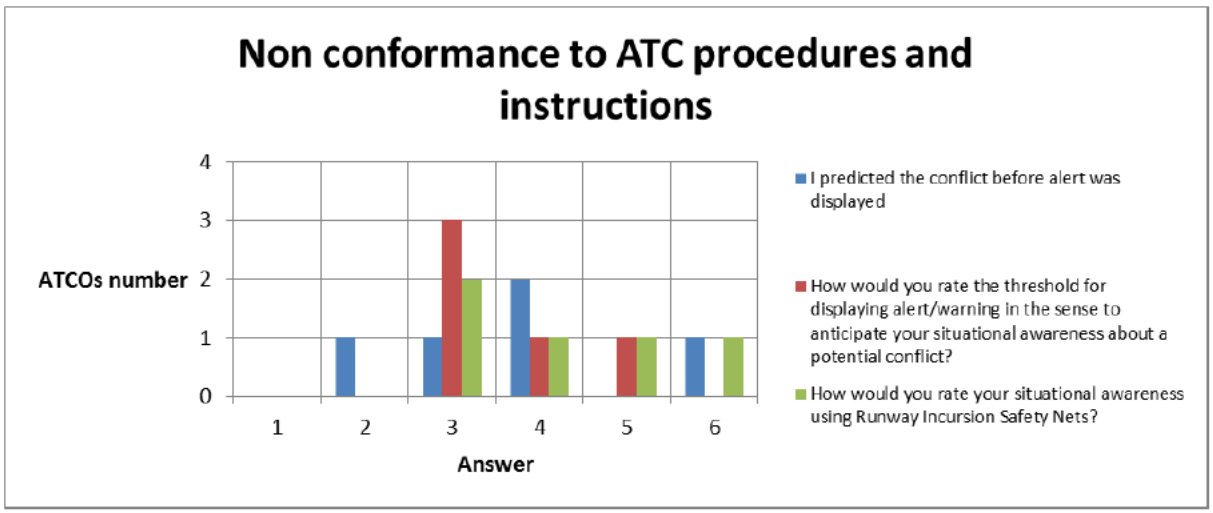


Figure 76: ATCOs' feedback about SA for Non Conformance to ATC procedures and instructions Safety Net

For this kind of Surface Safety Net it is noted that the thresholds satisfied the controllers' needs and that their Situational Awareness was maintained at a quite reasonable level, since 60% of the controllers' answers were positive. Moreover, it is possible to note that, also for this kind of SSN, other additional threshold tunings are needed.

Conflicting Clearances

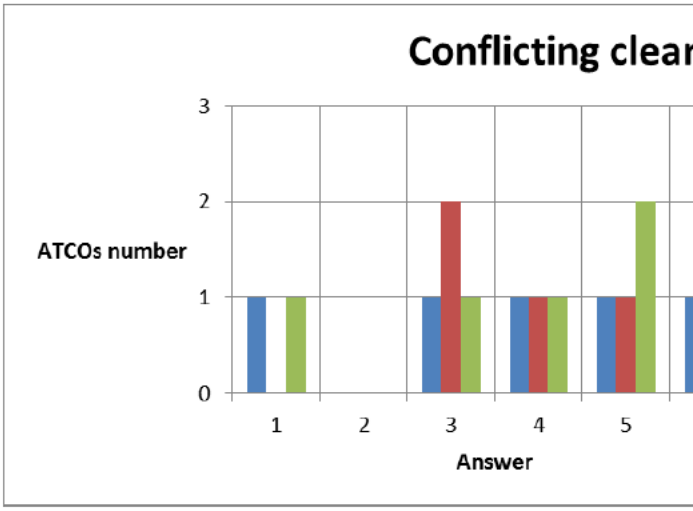


Figure 77: ATCOs feedback about SA Conflicting ATC Clearances Safety Net

For conflicting ATC clearances, the first question expresses the need to implement a more predictive feature because controllers preferred to be alerted before giving a wrong clearance and not after the clearance has already been given. It must be noted that the threshold set up was fine since this does not impact this type of SSN.

6.2.3.1.2.2.1.3 Comparison between reference and solution scenarios per controller working position

Considering that 14 runs were simulated, to make a comparision between the reference and the solution scenarios (7 for reference and 7 for solution), the following data, collected through Post-Run Questionnaires, show the global ATCOs' feedback about Situational Awareness and workload per CWP. Hereafter, only the main positions impacted are reported (i.e. ground and runway controllers opinions) and reference and solution scenarios correspond respectively to the scenarios without and with the use of SSN.

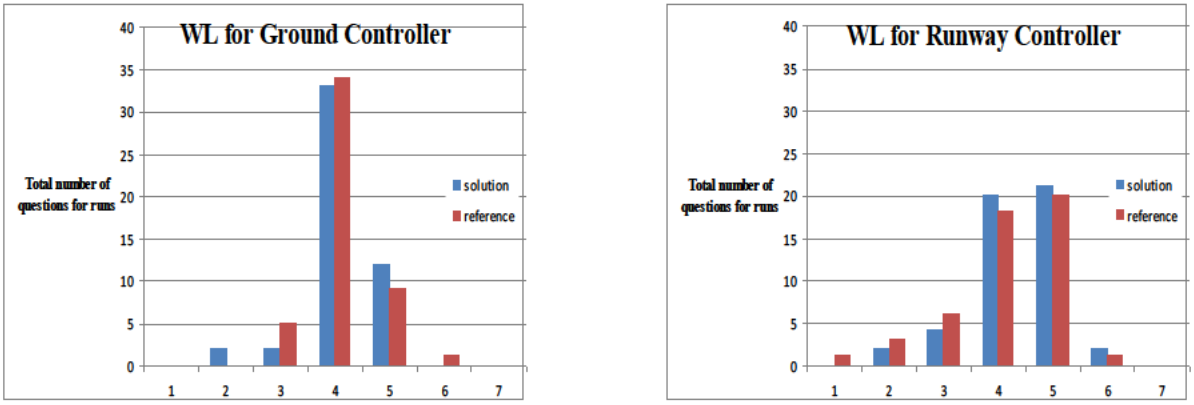
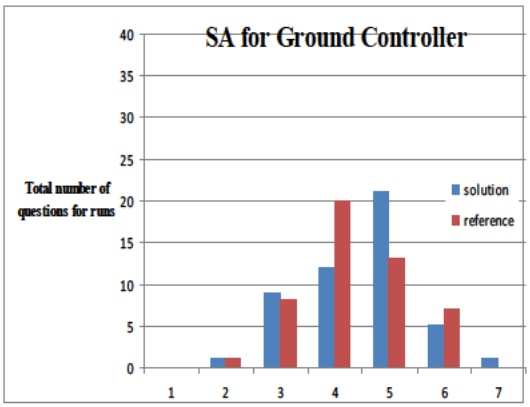


Figure 78: PRQ feedback about Workload per CWP

Comparing the two shapes in Figure 78, it is possible to say that for the ground controller the overall workload decreased (more positive answers) in the reference scenario while, for the runway controller it decreased in solution one.



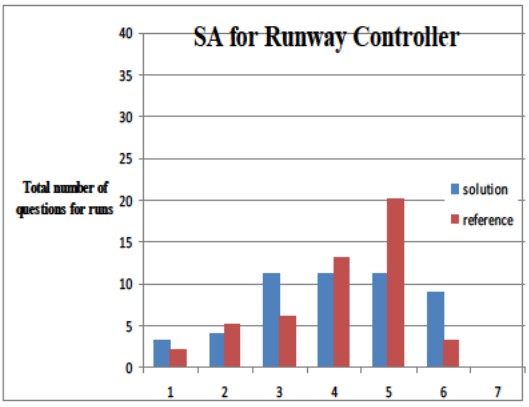


Figure 79: PRQ feedback about Situational Awareness per CWP

For the study of the Situational Awareness, see Figure 79, it is possible to note that for the ground controller SA was high in the solution scenario while, for the runway controller, it was high in the reference one due to the presence of more nuisance alerts for this position in the solution scenario. However, in general, it should be noted that for the RWY ATCO the general trend was quite positive.

Taking into account the previous trends, from a Surface Safety Nets perspective, it is possible to say that the runway controller position was the most impacted since the workload increased and the Situational Awareness decreased.

6.2.3.1.2.2.2 Safety for ADS-B

The positive impact on safety was also experimented by means of the enhanced level of surveillance data quality provided by the use of **Enhanced ADS-B** algorithm. In order to validate ADS-B Ground Station Prototype, one additional scenario was simulated through a shadow mode using real traffic (instead of simulated traffic used to validate SSN) without the use of SSN. In order to point out the data quality enhancement, two CWPs, fed with real traffic data, were compared: the first one with the Enhanced ADS-B Ground Station and the second one with both ADS-B and MSF tracks. In particular, three different colour tracks were displayed:

- green for validated data (displayed on both monitors),
- red for discarded data,
- yellow for data under evaluation.

Since red data were discarded from the Enhanced ADS-B algorithm and thus not presented on the CWP, controllers had the opportunity to notice that the data quality was really improved. It was however noted (highlighted by one controller) that data security should be further investigated.

The figure below expresses controllers' feedback regarding the use of Enhanced ADS-B.

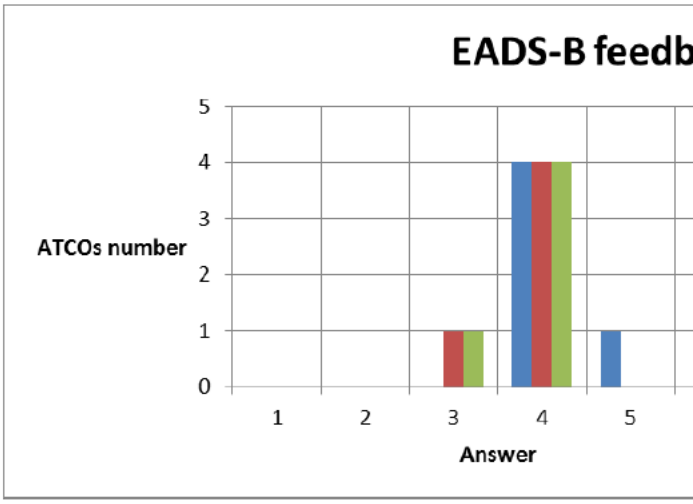


Figure 80: ATCO feedback on the use of EADS-B

Considering that 5 controllers participated in the shadow mode simulation and gave a possible answer from 1 to 6, according to Table 51, for each question proposed in PRQ and PSQ questionnaires, it was noted that they had had the chance to appreciate the reachable benefits of this function, since 4 ATCOs gave a positive answer with a value of 4. Of course, considering the enhancement of data quality and Situational Awareness, the level of safety evidently increases.

Moreover, their qualitative judgement was also supported by a quantitative assessment of ADS-B data recorded during a prefixed time. Table 55 shows a particular set of samples recorded in Milano Malpensa airport. Confronting the type of data, it is possible to demonstrate that each target, captured by radar stamp for a certain number of times, was considered "valid", "not valid" and "not executed" by the system.

ICAO_ADDRESS	#VALID	#NOT VALID	#VALIDATION NOT EXECUTED
5023677	0	0	55
4198619	619	0	1
3958607	1725	82	83
3416456	825	0	2
4220518	2869	7	31
5023632	97	0	32
9003790	40	0	54
655398	3035	41	88
3953736	29	0	0
4220526	1682	10	48
5024238	1109	0	107
4197091	1662	0	18
5276104	262	1521	685
5023985	1691	44	6
4695996	1888	6	14
5023983	307	0	2
4220225	1321	0	8

5023237	414	0	0
9003785	2861	55	17
4763040	545	0	5
5024355	40	0	15
4197442	1560	0	15
5023952	1270	0	6
5024316	368	0	0
3813921	48	0	0
4198140	1129	0	111

3958386	740	0	80
4197772	2263	29	17

Table 55: Enhanced ADS-B recorded data

For example, the target "5276104" (underlined in the table) was considered 262 times valid, 1521 not valid and 685 times not executed. When the target was not valid, it was excluded from the visualization making the system more accurate. The Figure 81 below, linked to data in Table 55, expresses the frequency of type of data for each target (legend on the right of figure).

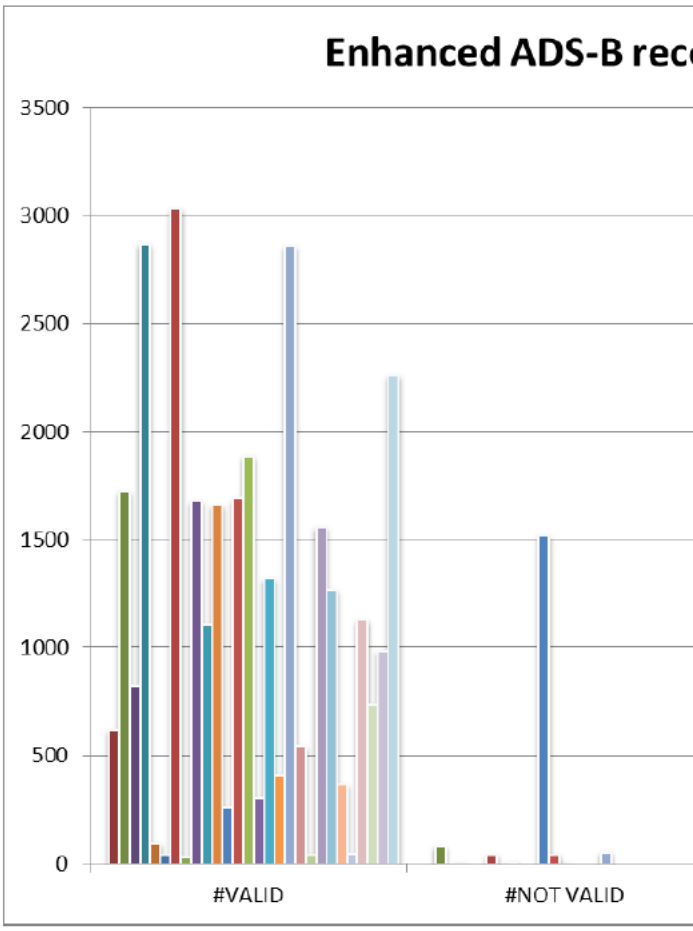


Figure 81: Histogram of enhanced ADS-B recorded data

6.2.3.1.3 Results impacting regulation and standardisation initiatives

Here below considerations for SSN and ADS-B are presented.

6.2.3.1.3.1 Results impacting regulation and standardisation initiatives for SSN

The Surface Safety Nets tool, strictly related to safety aspects and notifying about short-term critical situations, should be appropriately standardized. Moreover, as controllers will always be ultimately responsible for the conflict resolution, they should be adequately trained about the behaviour to follow in case of an alert.

6.2.3.1.3.2 Results impacting regulation and standardisation initiatives for ADS-B

Considering ATCOs' feedbacks on ADS-B, an evident improvement of data quality is accompanied by the need of improving regulations and standardization initiatives regarding security issues.

6.2.3.2 Analysis of Exercise Results

This section provides a general analysis of the exercise results, including the rationale of the results.

Table 56 shows the relation among KPAs, Areas of Interest, Hypothesis, Metrics/Indicators and Data collection methods for each validation objective.

OBJ	KPA	Area	Hypothesis	Metrics/Indicators	Data collection methods
OBJ-06.03.01-VALP-00652.0001	Safety	Situational Awareness	Surface Safety Nets alerts allow ATCOs to prevent unusual situations.	• Controllers' perceived Situational Awareness. • Surface Safety Nets reliability according to controllers' opinion. • Number and type of detected alerts.	Questionnaires Debriefings Over the shoulder observations System logs
OBJ-06.03.01-VALP-00652.0002	Safety	Surveillance data quality	Safety increases due to better surveillance information.	• Controllers' perceived surveillance data quality. • Controllers' perceived Situational Awareness. • % of validation not executed/valid/not valid tracks with respect to the total number of tracks. • Number and type of notifications.	Questionnaires Debriefings Over the shoulder observations System logs
OBJ-06.03.01-VALP-00652.0003	Human Performance	Usability	Surface Safety Nets provide controllers with useful information in an intuitive manner.	• Controllers' perceived efficiency, effectiveness and satisfaction in accomplishing their work.	Questionnaires Debriefings Over the shoulder observations

Table 56: Exercise 652 Validation matrix

Objective and subjective data collected during the exercise are the main source of information, which triggers the whole results analysis.

To analyse data collected during the simulation by questionnaires, debriefings, over the shoulder observations and systems logs, the following steps were followed:

- raw data (objective and subjective) grouping
- raw data synopsis in order to underline the significant aspects concerning both objective and subjective collected data
- Information and integration of quantitative and qualitative data
- Final conclusions in relation to specific exercise objectives.

The performances indicators measured during the runs are collected in Table 57:

Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	ATCOs' subjective assessment of SNET Situational Awareness for each safety net.	**Runway incursion**: 40% of the controllers gave quite a positive feedback with respect to the fact that the runway incursion SSN anticipated their acknowledgement about conflicts. 60% of the controllers involved gave rather negative answers with respect to SA expecially because they suggested some further threshold adjustement to achieve the desired level of detail. (Refer to **Figure 75**) **Non-conformance to ATC procedures and instructions**: 60% of the controllers' answers about SA was positive.(Refer to **Figure 76**) **Conflicting clearances:** 60% of the controllers' answers about SA were positive. (Refer to **Figure 77)**

Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0002 SCN-06.03.01-VALP-00652.0003	Reference + unusual events Surface Safety Nets + unusual events	Global subject assessment of Situational Awareness for runway controllers comparing reference and solution scenarios.	The Runway CWP feedback highlights the fact that the Situational Awareness decreased in the solution scenario even though, considering the general trend of positive answers, this feedback could be seen as quite positive. (Refer to **Figure 79**)
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0002 SCN-06.03.01-VALP-00652.0003	Reference + unusual events Surface Safety Nets + unusual events	Global subject assessment of Situational Awareness for ground controllers comparing reference and solution scenarios.	The Ground CWP feedback shows that the Situational Awareness was high for the solution scenarios. (Refer to **Figure 79**)
• OBJ-06.03.01-VALP-00652-0001 • OBJ-06.03.01-VALP-00652-0003	SCN-06.03.01-VALP-00652.0002 SCN-06.03.01-VALP-00652.0003	Reference + unusual events Surface Safety Nets + unusual events	Global subject assessment of workload for the runway controllers comparing Reference and Solution scenarios.	The Runway CWP feedback shows that the workload was a little higher in the reference scenario. (Refer to **Figure 78**)

Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
• OBJ-06.03.01-VALP-00652-0001 • OBJ-06.03.01-VALP-00652-0003	SCN-06.03.01-VALP-00652.0002 SCN-06.03.01-VALP-00652.0003	Reference + unusual events Surface Safety Nets + unusual events	Global subject assessment of workload for ground controllers comparing Reference and Solution scenarios.	For Ground CWP the overall workload increased in the solution scenario. (Refer to **Figure 78**)
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	Number, type of alerts, involved aircraft, alert time and controllers involved in comparison with screen captures, reordered during the simulation, confirm that correct types of alerts are triggered.	Quantitative data reordered in comparison with screen captures confirm that correct types of alerts were triggered. Nevertheless, some variables (e.g. altitude) and some thresholds need to be adjusted in order to reduce false and nuisance alerts.
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	Type of alerts simulated by injecting unusual events.	Quantitative data of simulation gave the possibility to record the kind of Safety Nets injecting unusual events. Please refer to **Table 54.**

Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	Number of false alerts with respect to the total number of alerts per run is kept to an acceptable level.	For each run, the ratio of the number of false alerts against the total number of alerts is less than 0.15.
• OBJ-06.03.01-VALP-00652-0001	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	Assessment of SNET reliability.	Considering the total number of false alerts with respect to the correct ones for each run, the reliability of the system under investigation results to be higher than 85%.
• OBJ-06.03.01-VALP-00652-0001 • OBJ-06.03.01-VALP-00652-0003	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	ATCOs' subject assessment of Surface Safety Nets alerts usability.	Discordant feedback was collected in relation to the Surface Safety Nets alerts usability. By means of results analysis it was concluded that 100% of the controllers involved appreciated the Surface Safety Nets operational concepts but, on the other hand, they questioned the set-up of the alert thresholds and were not very confident with the HMI solution adopted, resulting in a distraction for them from the aerodrome view. (refer to **Figure 72**)
• OBJ-06.03.01-VALP-00652-0001 • OBJ-06.03.01-VALP-00652-0003	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	ATCOs' subjective assessment of Surface Safety Nets alert usability.	Discordant feedback was collected in relation to the Surface Safety Nets alerts usability. According to the results analysis, it was concluded that 100% of the controllers involved appreciated Surface Safety Nets operational concepts but, on the other hand, they were not very confident with the HMI solution adopted

Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
				resulting in a distraction for them from the aerodrome view. (refer to **Figure 73**)
• OBJ-06.03.01-VALP-00652-0003	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	ATCOs' subjective assessment of A-CWP usability.	100% of the controllers involved suggested further improvements on A-CWP usability with the aim to make the use of CWP closer to their working methods and needs. (see **Figure 66, Figure 67, Figure 68 Figure 69, Figure 70, Figure 71**)
• OBJ-06.03.01-VALP-00652-0003	SCN-06.03.01-VALP-00652.0003	Surface Safety Nets + unusual events	ATCOs' subjective assessment of SSN for ground and runway controllers.	General feedback on SSN concept was positive for both runway and ground controllers since the answer value "4" - *slightly positive* - was associated to the highest number of PRQ questions. (see **Figure 74)**
• OBJ-06.03.01-VALP-00652-0002	SCN-06.03.01-VALP-00652.0001	Reference	ATCOs' subjective assessment of decreased surveillance data quality with respect to ADS-B scenario.	80% of the controllers had the chance to appreciate the reachable benefits of Enhanced ADS-B function. (refer to **Figure 80**)
• OBJ-06.03.01-VALP-00652-0002	SCN-06.03.01-VALP-00652.0004	ADS-B	ATCOs' subjective assessment of increased surveillance data quality with respect to reference scenario.	80% of the controllers had the chance to appreciate the reachable benefits of the Enhanced ADS-B function. (refer to **Figure 80)**
• OBJ-06.03.01-VALP-00652-0002	SCN-06.03.01-VALP-00652.0001	Reference	ATCOs' subjective assessment of decreased Situational Awareness with respect to ADS-B scenario.	80% of the controllers had the chance to appreciate the reachable benefits of Enhanced ADS-B function. (refer to **Figure 80**)
• OBJ-06.03.01-VALP-00652-0002	SCN-06.03.01-VALP-00652.0004	ADS-B	ATCOs' subjective assessment of increased Situational Awareness with respect to	80% of the controllers had the chance to appreciate the reachable benefits of Enhanced ADS-B function.

Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
			reference scenario.	(refer to **Figure 80**)
• OBJ-06.03.01-VALP-00652-0002	SCN-06.03.01-VALP-00652.0004	ADS-B	% number of validation not executed / valid / not valid tracks with respect to the total number of tracks.	Recorded ADS-B data of opportunity traffic (present at time of registration) collected "executed", "valid" and "not valid" tracks. Analysing those data, it is possible to note that "valid" data are filtered with enhanced ADS-B algorithm. (refer **Figure 81 Table 55:** Enhanced ADS-B recorded data)

Table 57: Exercise 652 Performance Indicators

6.2.3.2.1 Unexpected Behaviours/Results

No unexpected behaviours/results to report.

6.2.3.3 Confidence in Results of Validation Exercise

6.2.3.3.1 Quality of Validation Exercise Results

The exercise results are based on:

- controllers' subjective opinions on the concept collected by means of questionnaires, observations and debriefings;
- objective data collected by means of system data recording.

During the exercise, five controllers with different experience were involved. Moreover, the exercise schedule was designed in order to collect as much feedback as possible from all involved controllers. Finally, the application of several interconnected data collection techniques enabled to verify data gathered and to better address further data collection during the exercise. For example, on the one hand, data collected through the observations were then verified and discussed during the debriefings, and, on the other hand, insights emerged during the debriefings were then used to guide the following observations. This combination of techniques was applied to ensure the correctness and the reliability of the results obtained.

The above considerations allow asserting that output results are therefore considered of good quality.

6.2.3.3.2 Significance of Validation Exercise Results

Despite the fact that the simulation environment seems to be unavoidably predictable and unaffected by several realistic external factors and that A-CWP has to be improved to better satisfy user needs, the operational significance of the validation exercise results can be considered as high, since the simulated operational environment has correctly reflected the Milano Malpensa tower environment and usual airport conditions.

Moreover, to ensure the highest reliability and completeness of the analysis, a proper exercise schedule was designed that ensured an appropriate rotation of controllers over the three CWPs and an adequate number of runs. Finally, statistical significance is not applicable.

6.2.4 Conclusions and recommendations

6.2.4.1 Conclusions

Exercise 652 allowed verifying the technical feasibility and the operational suitability of Surface Safety Nets and enhanced ADS-B in an air traffic control tower environment. Final conclusions, based on both quantitative and qualitative data collection methods, are presented separately in Table 58 per operational concept investigated.

Operational concept	Main results	Aspects to be better investigated
Surface Safety Nets AO-0104A: Airport Safety Nets for Controllers in Step 1	• Concept suitable for TWR environment. • Controllers appreciated the operational concept. • Controllers admitted that Conflicting ATC Clearances, taking into account controllers' possible errors, enhanced the global level of safety. • Controllers asserted that the tool has generated mainly real alerts and provided benefits in terms of safety, especially increasing Situational Awareness in low visibility conditions. • Controllers indicated that the priority of alert was quite correct.	• Surface Safety Nets HMI to be improved in order to have a filtering of alerts per controller working position concerned. • Controllers asserted that other kinds of alerts (especially for Conflicting ATC Clearance SSN) should be defined and implemented in order to cover all possible situations and so to assure a good level of safety. • Controllers asserted that some SSNs, especially Conflicting ATC Clearances, should improve their "preventing" function in order to further enhance safety level. • Surface Safety Nets need further tuning actions to better satisfy controllers' expectations and needs. • Although priority of alerts is quite correct it needs further investigation.

Operational concept	Main results	Aspects to be better investigated
ADS-B AO-0201-A: Enhanced Ground Controller Situational Awareness in all Weather Conditions for Step 1	Controllers effectively experienced an enhancement of their Situational Awareness thanks to an evident surveillance data quality improvement by means of enhanced ADS-B algorithm.	• Good data quality presented but data security should be further investigated. • New regulations and standardization initiatives to be considered
A-CWP AO-0208-A: Advanced Information Management and System Integration in the ATC Tower for Step1	• Controllers quite appreciated the innovative HMI solutions although they suggested some additional refinement (e.g. reducing the number of actions to enter information in the system). • Alerts displayed to a controller should be relevant to their operational responsibilities.	• Each CWP has to display only alerts related to flights under control/responsibility of that CWP. • Other command options should be implemented like a preventing feature for alerts before they are triggered and other options for local implementation. • Need to reduce schematic and complex operations on HMI. • Investigate the trade-off between acronyms and full names for alerts to be displayed to the controllers.

Table 58: Exercise 652 Conclusions

Even though involved actors suggested several improvements and complained about some aspects related especially to HMI usability, they widely appreciated the new features of the concept under evaluation.

Recommendations, coming from the previous exercise EXE-06.03.01-VP-065 [54] and concerning Surface Safety Nets, A-CWP and ADS-B functionalities, were implemented for this simulation session. The controllers appreciated these refinements even though they suggested other adjustments. Furthermore, this exercise studied the conflicting ATC clearances resulting in a huge interest from the controllers, which confirmed the added value on safety provided by this SSN. Moreover, to improve the Conflicting ATC Clearances SSN, controllers suggested implementing some kind of preventive information alerts in order to reduce the risk of issuing conflicting clearances.

6.2.4.2 Recommendations

This section contains recommendations for the next phases.

Recommendations resulting from Exercise 652 useful for both WP6 and WP12 are reported in the following Table 59:

TYPE	RECOMMENDATION
Surface Safety Nets	Improve preventing feature of conflicting ATC clearances Surface Safety Net, for example using a pop-up window that notifies the controller prior to issue of the conflicting clearance.
	Adjust the tool by making a control on altitude variable in order to improve some Surface Safety Nets (e.g. RUINC, Speed limit on Taxiways).
	Consider other adjustments for a better tuning of the thresholds for some alerts.
	Enrich the conflicting ATC clearances Surface Safety Net by integrating all possible controllers' source of error (e.g. LINE-UP AND WAIT BEHIND, TAKE OFF AFTER, LANDING AFTER, CROSS/LINE-UP, CROSS/TAKE-OFF, CROSS/LANDING, and TAKE-OFF/LANDING).
Advanced Controller Working Position	Surface Safety Nets HMI to be improved in order to have a filtering of alerts per CWP.
	In case of closed taxiway and runway, consider contrasting colours for taxiways, runways and aircraft.
	Review some acronyms in order to make them more similar to the ones used in the aeronautical field.

	Reduce the number of manual inputs required to perform a specific task in order to avoid a schematic utilization of HMI and to decrease the controller workload.

Table 59: Exe 652 recommendations

7 References

7.1 Applicable Documents

[1] Ops 6.2 DOD - 6.3.1 D75 6.3.2 Release 3 Validation Report – Update 2013 –D100- Edition 00.01.00

[2] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

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

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

[5] European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

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

7.2 Reference Documents

The following documents provide input/guidance/further information/other:

[7] WP C.03, C.03-D03-Regulatory Roadmap Development and Maintenance Process
https://extranet.sesarju.eu/Programme%20Library/Forms/General.aspx

[8] WP C.03, C.03-D02-Standardisation Roadmap Development and Maintenance Process
https://extranet.sesarju.eu/Programme%20Library/Forms/General.aspx

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

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

[11]SESAR Security Reference Material
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