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Copyright Statement

PJ28 IAO

INTEGRATED AIPORT OPERATIONS

This Demonstration Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 731787 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document acts as the final summary and results document for the Very Large-Scale Demonstration on Integrated Airport Operations (IAO).

The demonstration project consists of four different demonstrations executed in Germany, France and Hungary, covering solutions to support the tasks of tower and apron controllers as a means of ensuring greater efficiency. In addition to that, the project supported new development for on-board safety nets recording flight data during line operations. Demonstrations at Nice, Budapest and Hamburg have been conducted to demonstrate the readiness of the solutions to be deployed at European airports. Detailed results for each of the demonstration sites have been prepared in the document as well as a consolidated view on the solution addressed.

The successful demonstrations in a close to operational environment provided an important step to the deployment phase. They demonstrated that the solutions can bring benefits, but implementation needs to pay attention to local characteristics and requirements as well as quality and availability of underlying data and information.

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1 Executive summary

Traffic growth is expected to increase in the coming years for most European airports. The SESAR programme will deliver solutions, which aim at fulfilling the challenges that those airports will encounter within the next years. To demonstrate the applicability of these solutions and to encourage their early adoption, the SESAR Joint Undertaking and its partners put these solutions to the test in close to real operational environments in so-called Very-Large scale Demonstrations (VLD). The Integrated Airport Operations (IAO) project is one of these demonstrations, exploring mature solutions for three areas of air traffic management at airports, to support the tasks of tower and apron controllers as a means of ensuring greater efficiency, namely:

- Departure Management Synchronised with Pre-departure sequencing,
- Automated Assistance to Controller for Surface Movement Planning and Routing and
- Airport Safety Nets.

In addition, the PJ28 project supports the development of on-board alerting systems. As ADS-B data performance is a key enabler for these systems, the demonstration provides evidence, that the challenges of ADS-B employment for Safety Net application can be overcome to provide a sound usage of this technology for the intended purpose.

Indra Navia, the Norwegian branch of the global technology company Indra, in collaboration with the Hungarian air traffic control organisation HungaroControl, was responsible for the demonstration at Budapest Airport. The demonstration at Nice Airport (PCP Airport) was carried out by the French Air Navigation Service Provider DSNA (Direction des Services de la navigation aérienne), while the demonstration at Hamburg Airport was coordinated by the German Aerospace Center (DLR) and executed together with the Norwegian research institution SINTEF (Stiftelsen for industriell og teknisk forskning). The three airport demonstrations covered the same SESAR1 solutions but with different coverage of the functionalities. Therefore, a coordinated approach has been taken on the definition of the objectives for the exercises even the airports might have special characteristics.

Besides the on-board demonstration collecting data during real airline operations, the three airport demonstrations have been conducted in passive shadow mode. The PJ28 systems have been connected to operational airport systems and used live data during the trials. In addition, local Controllers from the ANSPs and airports took part in the exercises, bringing expert knowledge into the demonstrations.

At all airport sites the systems have been installed successfully and the demonstration trials have been conducted mainly as planned. Some risks concerning the availability of operational staff have been materialized but with a participation of twenty Tower controllers and thirteen apron controllers, significant results could be obtained. The variety of operational observations in nominal and non-nominal conditions was limited to the duration of each demonstration exercise

Regarding the quality of the results it can be stated, that the results are based on very realistic demonstrations with connected live systems in real airport environments with very experienced participants and hence the results can be considered to be of high quality from an operational point of view. Data from multiple sources (Questionnaires, Metrics, Expert Feedback, ISA, SA) were used for answering each success criterion, as per experimental protocol and the data was collected mostly during the more significant traffic periods of the day. The results for the solutions can be summarized as follows:

Automated Assistance to Controller for Surface Movement Planning and Routing

- The routing and planning function was successfully demonstrated, but limitations have been observed related to special pushback procedures and the operational particularities of each airport for which routes are proposed by the systems.
- The Situational Awareness and the Workload were successfully demonstrated with the new function, with minor exceptions.
- The route modification capabilities have been successfully demonstrated but are highly dependent on HMI implementation and quality of proposed routes (to keep required modifications to a low level).
- Predicted Taxi-time accuracy was partially demonstrated and indicated deviations from the real taxi-time when local constraints such as intermediate runway crossings, airline characteristics and pushback procedures were involved.

Airport Safety Nets.

- Conflicting ATC Clearances and Conformance Monitoring safety nets were rated very positively although routing issues were present during demonstration.
- The Situational Awareness and the Workload are still acceptable with the new function.
- Quality of position data and correct tuning of the functions are essential for acceptability.

Departure Management Synchronised with Pre-departure sequencing

- Good results in Budapest although the Departure Manager was prepared to provide departure, and not pre-departure sequences. Hamburg and Nice could not demonstrate the solution.
- Very dependent on accurate taxi times
- Shadow mode bias might be more significant here – final results related to local implementation

ASD-B Data collection

- The collection of data was successful and data have been evaluated. All results have been delivered to the project PJ03B to support the further development.

In summary, the demonstrations have been successfully carried out as planned in a very close to operational environment. While some results can confirm the expected benefits, some others could not be demonstrated. Most of the objectives have been partially demonstrated, indicating that some issues have been discovered and need to be addressed when implementing the functions at airports. The used shadow mode setup had some bias to the results, but the intermediate step of the VLD was very important to reveal challenges taking the solutions from simulation to real airport operations.

The provision of up-to-date and standardised layout (ASRN) data and related information as a means of enabling the effectiveness of routing solutions and, by extension, safety net and DMAN solutions is essential. Therefore, standardized exchange formats developed should be used. In addition, it needs to be pointed out that benefits can only be achieved when local procedures are fully implemented (not only published ones), the data quality the functions are based on is high enough and the Controllers have enough training and familiarisation time with the new functions and the human machine interface)

As dissemination is also one of the key aspects defined for VLDs, the project also worked on the dissemination of the activities and results. Besides dissemination material like website and flyers, videos have been produced to reach a wider audience. For each test site a video is available to concentrate on the specific challenges and characteristics of the exercise as well one overall video summarizing the efforts of the project and the solutions operating being developed.

2 Introduction[1]

2.1 Purpose of the document

The document acts as the final summary and results document for the Very Large-Scale Demonstration on Integrated Airport Operations (IAO).

The demonstration project finally consists of four different demonstrations executed in Germany, France and Hungary and on board of aircraft recording flight data during line operations. PJ28 is structured in such a way that the individual demonstrations are independent of each other. It is apparent that some demonstrate similar functionalities, but this is the core intention of the VLDs in the de-risking effort to the deployment phase. This is reflected in the Demonstration Report, where a clear distinction is made between the four different demonstration exercise plans, but also a summary section compiling the results from all exercises.

As the three airport demonstrations are covering almost the same SESAR1 solutions, a coordinated approach has been taken on the definition of the objectives for the exercises. Even each of these exercises might have a special focus in the demonstration objectives are similar and are therefore aligned.

As dissemination is one of the key aspects defined for VLDs the document also reports on the dissemination activities.

2.2 Scope

This document provides the Demonstration Report for PJ28 - Integrated Airport Operations.

It includes an overview of the VLD including a summary of the demonstration plan as well as detailed exercise results descriptions for the different demonstration exercises. In addition, it includes conclusions and recommendations for the solutions addressed. It also covers dissemination and communication activities. Human Performance Assessment Report and Safety Assessment Report are also part of the document.

2.3 Intended readership

The intended audience of this Demonstration Report internal to the project is:

- Project Team
  This report gives the Project Team an overview of the results of the four demonstrations
- Project Management Board and Extended Project Management Board members
  This plan gives high-level information about the achievements and a summary of the activities.

[1] The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

- Communication departments

The intended audience of this Demonstration Report external to the project is:

- PJ19 (Content Integration), responsible for managing the content integration process to ensure the needed coherency (in terms of operational concept, architecture) between the different SESAR 2020 projects.
- PJ20 (Master Plan Maintenance), responsible for ATM Master Plan maintenance
- PJ03a (Integrated Surface Management), continuation of SESAR1 OFA 04.02.01 work
- PJ03b (Airport Safety Nets), continuation of SESAR1 OFA 01.02.01 work
- Airspace Users in relation to the airborne demonstration work package
- SJU - The plan gives information on objectives, setup and planning of the demonstrations to be aligned with the overall execution of the SESAR2020 work programme.
- EUROCAE WG41 – A-SMGCS
- Airports
- ANSPs
- Industry – manufacturers and provider of solutions related to the solutions covered
- Standardization bodies

2.4 Background

In the framework of the SESAR 1 Programme, the demonstrations to be conducted in PJ28 are considered as a follow-up on previous operational and technical research executed in different OFAs (Operational Focus Areas):

- OFA04.02.01 – Integrated Surface Management (Solutions #22)
- OFA 01.02.01 – Airport Safety Nets (Solution #02)
- OFA 04.01.01 – Integrated Arrival/Departure Management at Airports (Solution #53)

Extending the background coming from SESAR1 developments, some additional research & development backgrounds have been achieved out of SESAR1 scope, and are used as a baseline for some solutions demonstrated in this project.

Regarding the inputs coming from external activities, it is important to mention the activities conducted in the framework of EUROCAE standardisation groups, such as:

- EUROCAE WG 41 (Surface Movement Guidance and Control System) concerning the development of a single A-SMGCS Minimum Aviation System Performance Standard (MASPS) document
- A-SMGCS Specification Document developed by the EUROCONTROL A-SMGCS task force, in collaboration with EUROCAE WG 41, as result of the revision of the A-SMGCS Implementation Package.

2.5 Structure of the document

The document is organised as follows:

- Section 1 is this Executive Summary;
- Section 2 is this introduction;
- Section 3 defines the scope of this VLD including purpose and solutions addressed and a summary of the Demonstration plan
- Section 4 provides a summary of the overall demonstration results;
- Section 5 provides a summary of the overall conclusions and recommendations;
- Section 6 contains the project's Communication and Dissemination activities;
- Section 7 provides the list of applicable reference documents;
- Annexes
  - Appendix A - Demonstration Exercise #01 (LFMN)
  - Appendix B - Demonstration Exercise #02 (ADS-B)
  - Appendix C - Demonstration Exercise #03 (LHBP)
  - Appendix D - Demonstration Exercise #04 Report
  - Appendix E - Demonstration Exercise #05 (EDDH)
  - Appendix F - Safety Assessment Report (SAR)
  - Appendix G - Security Assessment Report (SecAR)
  - Appendix H - Human Performance Assessment Report (HPAR)
  - Appendix I - VLD progress towards TRL-7
  - Appendix J - Communication Material / Records

2.6 Glossary of terms

Term	Definition	Source of the definition
CTOT – Calculated Take Off Time	1. A time calculated and issued by the Central Flow Management unit, as a result of tactical slot allocation, at which a flight is expected to become airborne. 2. An Air Traffic Flow & Capacity Management (ATFCM) departure slot, forming part of an Air Traffic Control (ATC) clearance, which is issued to a flight affected by Network Management regulations.	Eurocontrol Lexicon [25]
EXOT - Estimated Taxi-Out Time	The estimated time between off-block and take off. This estimate includes any delay buffer time at the holding point or remote de-icing prior to take off.	Eurocontrol Lexicon
Human Factors (HF)	HF is used to denote aspects that influence a human's capability to accomplish tasks and meet job requirements. These can be external to the human (e.g. light & noise conditions at the work place) or internal (e.g. fatigue). In this way, "Human Factors" can be considered as *focussing on the variables that determine Human Performance*.	
Human Performance (HP)	HP is used to denote the human capability to successfully accomplish tasks and meet job requirements. In this way, "Human Performance" can be considered as focussing on the observable result of	

	human activity in a work context. Human Performance is a function of Human Factors (see above). It also depends on aspects related to Recruitment, Training, Competence, and Staffing (RTCS) as well as Social Factors and Change Management.	
HP activity	An HP activity is an evidence-gathering activity carried out as part of Step 3 of the HP assessment process. An HP activity can relate to, among others, task analyses, cognitive walkthroughs, and experimental studies.	
HP assessment	An HP assessment is the documented result of applying the HP assessment process to the SESAR Solution-level. HP assessments provide the input for the HP case.	
HP assessment process	The HP assessment process is the process by which HP aspects related to the proposed changes in SESAR are identified and addressed. The development of this process constitutes the scope of Project 16.04.01. It covers the conduct of HP assessments on the Solution-level as well as the HP case building over larger clusters of Solutions.	
HP Argument	An HP argument is an HP claim that needs to be proven through the HP Assessment Process.	
HP benefit	An HP benefit relates to those aspects of the proposed ATM concept that are likely to have a positive impact on human performance.	
HP case	An HP case is the documented result of combining HP assessments from SESAR Solutions into larger clusters (e.g. SESAR Projects, deployment packages) in SESAR.	
HP issue	An HP issue relates to those aspects in the ATM concept that need to be resolved before the proposed change can deliver the intended positive effects on Human Performance.	
HP impact	An HP impact relates to the effect of the proposed solution on the human operator. Impacts can be positive (i.e. leading to an increase in Human Performance) or negative (leading to a decrease in Human Performance).	
HP recommendations	HP recommendations propose means for mitigating HP issues related to a specific operational or technical change. HF recommendations are proposals that require additional analysis (i.e. refinement and validation). Once this additional analysis is performed, HF recommendations may be transformed into HF requirements.	
HP requirements	HP requirements are statements that specify required characteristics of a solution from an HF point of view. HP requirements should be integrated into the DOD, OSED, SPR, or specifications. HF requirements can be	

	seen as the stable result of the HF contribution to the Solution, leading to a redefinition of the operational concept or the specification of the technical solution.	
TOBT – Target Off-Block Time	The time that an aircraft operator / handling agent estimates that an aircraft will be ready, all doors closed, boarding bridge removed, push back vehicle present, ready to start-up / push back immediately upon reception of clearance from the Tower	Eurocontrol Lexicon
TSAT - Target Start Up Approval Time	The time provided by ATC taking into account TOBT, CTOT and/or the traffic situation that an aircraft can expect to receive start-up / push back approval.	Eurocontrol Lexicon
TTOT - Target Take-Off Time	1. An ATM computed take off time. It is not a constraint but a progressively refined planning time that is used to: -refine the departure airport sequencing and optimization of RWY throughput -plan the take-off in order to achieve targets at the destination and during flight, whilst maintaining optimum flight efficiency. 2. The Target Take Off Time taking into account the TOBT/TSAT plus the EXOT. Each TTOT on one runway is separated from other TTOT or TLDT to represent vortex and / or SID separation between aircraft."	Eurocontrol Lexicon

Table 2-1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
A/C	Aircraft
A/G	Aircraft/Ground
ACA	Airport Operator - Aéroports de la Côte d'Azur
A-CDM	Airport Collaborative Decision Making
ACI Europe	Airports Council International Europe
ACL	ATC Clearance and Information service
A-CWP	Advanced Controller Working Position
ADC	Aerodrome Controller
ADQ	Aeronautical Data Quality
ADS-B	Automatic Dependent Surveillance - Broadcast
AF	ATM Functionality
A-FDPS	Automated Flight Data Processing System
AGL	Above ground level

AID	Aircraft Interface Device
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation And Control
AIRM	ATM Information Reference Model
AIS	Aeronautical Information Services
AIXM	Aeronautical Information Exchange Model
AMC	ATS Messaging Management Centre
AMXM	Aerodrome Mapping Exchange Model
ANS CR	Air Navigation Services of the Czech Republic
ANSP	Air Navigation Service Provider
AO	Airport Operator
AOBT	Actual Off Block Time
AOC	Airline Operational Control
AODB	Airport Operation Data Base
AOR	Areas of Responsibility
APR	Apron
ARIF	Airport Research & Innovation Facility
ASAT	Actual Startup Approval Time
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASRN	Aerodrome Surface Routing Network
ASS	Assumption
ASTERIX	All-purpose structured EUROCONTROL surveillance information exchange
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFCM	An Air Traffic Flow & Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
ATSA-SURF	Airborne Traffic Situational Awareness to support surface operations
AU	Airspace User
AUO	Airspace User Operations
BUD	Airport Budapest Liszt Ferenc (IATA Code)

CAEP	Committee on Aviation Environmental Protection
CANSO	Civil Air Navigation Services Organisation
CATC	Conflicting ATC Clearance Alerts for Controllers
CBA	Cost-Benefit Analysis
CDC	Clearance Delivery Controller
CDM	Collaborative Decision Making
CLD	Clearance Delivery control position
CLR	Clearance
CMAC	Conformance Monitoring Alerts for Controllers
COTS	commercial off-the-shelf
CPDLC	Controller Pilot Data Link Communication
CR	Change Request
CRT	Criteria
CS	Certification Specifications
CTOT	Calculated Take Off Time
CWP	Controller Working Position
DCB	Demand and Capacity Balancing
DCL	Departure Clearance
DEMO	Demonstration
DEMOP	Demonstration Plan
DEV	Deviation
DFS	Deutsche Flugsicherung GmbH
DLR	German Aerospace Center
DLR FL	German Aerospace Center (DLR e.V.), Institute of Flight Guidance
DMAN	Departure Manager
DOD	Detailed Operational Documents
DPA	Deutsche Presse-Agentur
DPO	Data Protection Officer
DS	Data Set
DSNA	Direction des Services de la navigation aérienne
D-TAXI	Datalink Taxi Support
EASA	European Aviation Safety Agency
EATMA	European ATM Architecture
ECAC	European Civil Aviation Conference

EDDH	Hamburg Airport (ICAO Code)
EFB	Electronic Flight Bag
EFS	Electronic Flight Strip
EOBT	Estimated Off Block Time
E-OCVM	European Operational Concept Validation Methodology
EPMB	Extended Project Management Board
EU	European Union
EUROCAE	European Organization for Civil Aviation Equipment
EXE	Exercise
EXOP	Estimated Outbound Taxi
EXOT	Estimated Taxi Out Time
FANS	Future Air Navigation System
FHG	Hamburg Airport
FIS	Flight Information Services
GA	Grant Agreement
GDPR	General Data Protection Regulation
GND	Ground Controller Position
GPS	Global Positioning System
GRC	Ground Controller
GRD	Clearance Delivery
HAM	Hamburg Airport (IATA Code)
HAT	Height above terrain
HF	Human Factors
HMI	Human Machine Interface
HP	Human Performance
HPAR	Human Performance Assessment Report
IA	Innovation Action
IAO	Integrated Airport Operations
ICAO	International Civil Aviation Organization
ID	Identifier
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INTEROP	Interoperability Requirements
IOP	Interoperability

IR	Industrial Research
ISA	International Standard Atmosphere
ISRM	Information Service Reference model
JU	Joint Undertaking
KPA	Key Performance Area
KPI	Key Performance Indicator
LAN	Local Area Network
LFMN	Aéroport Nice Côte d'Azur (ICAO Code)
LHBP	Airport Budapest Liszt Ferenc (ICAO Code)
LND	Landing
LTP	Linked Third Party
LUP	Line Up the Runway (AC operation)
MASPS	Minimum Aviation System Performance Standard
MAWAP	Multi-Annual Work Programme
MAWP	Multi-annual Work Program
MED	medium
MET	Meteorological
MOPS	Minimum Operational Performance Standards
MSSC	Minimum Set of Security Controls
NA	not applicable
NATMIG	North-European ATM Industry Group
NCE	Aéroport Nice Côte d'Azur (IATA Code)
NDR	Norddeutscher Rundfunk
NM	Nautical Mile
NOK	Not OK
NOTAM	Notice(s) to Airmen
NTO	Notice To Operations
OBJ	Objective
OFA	Operational Focus Area
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PB	Pushback
PCMCIA	Personal Computer Memory Card International Association
PCP	Pilot Common Project

PJ	Project
POC	Proof of Concept
POK	Partially OK
POPD	Protection of Personal Data
PTT	Push-To-Talk
PTZ	pan–tilt–zoom
PU	Public
QFU	Aviation Q-code for Magnetic Heading of a Runway
R&D	Research & Development
R/T	Radio Transmission
RECOM	Recommendation
REG	Registration
REZ	runway engagement zone
RF	Radio frequency
RIMCAS	Runway Incursion Monitoring and Collision Avoidance System
RIMS	Runway Incursion Monitoring System
RMCA	Runway Monitoring and Conflict Alerting
RNAV	Area Navigation
RPAS	Remotely Piloted Aircraft Systems
RTCA	Radio Technical Commission for Aeronautics
RTCS	Recruitment, Training, Competence, and Staffing
RTE	Route
RTL	Radio Télévision Luxembourg
RTS	Real Time Simulation
rTWR	Remote Tower
RWY	1. Runway / 2. Runway Controller position
SA	Situational Awareness
SAC	Safety Criterion/Criteria
SAF	Safety
SAP	Safety Assessment Plan
SAR	Safety Assessment Report
SASHA	Situation Awareness for SHAPE
SE-DMF	System Engineering Data Management Framework
SESAR	Single European Sky ATM Research Programme

SHAPE	Solutions for Human Automation Partnerships in European ATM
SID	Standard Instrument Departure
SINTEF	Stiftelsen for industriell og teknisk forskning
SJU	SESAR Joint Undertaking
SO	Safety Objective
SOURCE	Safety Assessment Report
SPR	Safety and Performance Requirements
SR	Safety Requirements
SSR	Secondary Surveillance Radar
STC	Supplemental Type Certificate
STU	Start Up
SURF A	Surface Alert System
SURF IA	Surface Indications and Alert System
SUT	System under Test
SW	Software
SWIM	System Wide Information Model
TBS	Time Based Separation
TCAS	Traffic Alert and Collision Avoidance System
TLDT	Target Landing Time
TMA	Terminal Manoeuvring Area
TOBT	Target Off-Block Time
TOF	Take Off
TPC	TMA Planner Controller
TRL	Technology readiness levels
TS	Technical Specification
TSAT	Target Start Up Approval Time
TTOT	Target Take-Off Time
TV	Television
TWR	Tower
V&V	Verification & Validation
V&VI	Validation & Verification Infrastructure
V&VP	Validation & Verification Platform
VAC	Vacating the Runway (AC operation)
VALP	Validation Plan

VALS	Validation Strategy
VFR	Visual flight rules
VHF	Very High Frequency
VLD	Very Large Scale Demonstration
WAC	World ATM Congress
WG	Working Group
WP	Work Package
WTC	Wake Turbulence Category

Table 2-2: List of acronyms

3 Very Large Demonstration (VLD) Scope

3.1 Very Large Demonstration Purpose

Traffic growth is expected to strengthen for the coming years in most European airports. The SESAR programme will deliver solutions, which aim at fulfilling the challenges that those airports will encounter within the next years.

As a response to this challenge, this project **PJ28** Integrated Airport Operations – **IAO**, which is part of the SESAR 2020 Multi-annual Work Program (S2020 MAWP) for the period 2016-2019, worked on demonstrating the benefits that specific promising SESAR solutions are expected to provide. Hamburg with a crossing runway system (Multiple Dependent Runways, non-complex Surface Layout) and Nice and Budapest (Multiple Dependent Runways, Complex Surface Layout), where traffic congestion daily takes place during the peak season have been the airports for the demonstrations. Therefore PJ28 contributes to de-risking the deployment of future operations of the on-board Safety Net functionalities. Since the on-board Safety Net traffic alerting system uses ADS-B technology to get information about surrounding traffic, the ADS-B data performance is a key enabler for on-board traffic alerting functions. This demonstration will provide evidence that ADS-B employment for on-board traffic alerting is mature enough to provide a sound usage of this technology for the intended purpose.

The PJ28 project addresses the topic "Integrated Airport Operations" with the topic identifier "SESAR.IR-VLD.Wave1-22-2015: Integrated Airport Operations (incl. TBS)" as stated in the S2020 MAWP Cluster D.1 High Performing Airport Operations. The VLD covers SESAR1 Solutions #22, part of the OFA04.02.01 - Integrated Surface Management), Solution #02 (part of the OFA04.02- Airport Safety Nets) and Solution #53 (part of the OFA 04.01.01 - Integrated Arrival/Departure Management at Airports).

3.2 SESAR Solution(s) addressed by VLD

The following solutions are addressed by this VLD.

SESAR Solution ID and Title	SESAR Solution Description	OI Steps ref. (coming from EATMA)	Enablers ref. (coming from EATMA)
Solution #02 Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances	Operational requirements and technical specification for a system that detects conflicting ATC clearances during runway operations, and non-conformance to procedures or clearances for traffic on runways, taxiways and in the apron/stand/gate area	AO-0104-A Airport Safety Nets for Controllers in Step 1	AERODROME-ATC-06 A-SMGCS incorporating the function that detects Conflicting ATC Clearances (CATC) for runway operations
			AERODROME-ATC-07 SMGCS incorporating the function that provides Conformance Monitoring Alerts for Controllers (CMAC) on the movement area
			AERODROME-ATC-12 Provision of automatically generated taxi routes for aircraft and vehicles
			AERODROME-ATC-50 Advanced Airport Tower Controller Working Position (A-CWP)
Solution #22 Automated Assistance to Controller for Surface Movement Planning and Routing	Route Planning function of A-SMGCS that relies on an automatic taxi route generator which uses: - Airport layout description - Flight plan information (e.g. aircraft type, destination stand), - Known operational constraints (e.g. closed taxiways) and CDM data (e.g. TSAT) These routes are stored in the A-FDPS and can be displayed on the controller working position. ATCO can graphically edit the routes, to match taxi clearances given to mobile. For each taxi route, the Route Planning function computes an estimated taxi time (stored by A-FDPS)	AO-0205 Automated Assistance to Controller for Surface Movement Planning and Routing	AERODROME-ATC-12 Provision of automatically generated taxi routes for aircraft and vehicles
			AERODROME-ATC-13 Surface movement information processing system enhanced with storage and dissemination of surface routes
			AERODROME-ATC-50 Advanced Airport Tower Controller Working Position (A-CWP)
			REG-0201 Means of Compliance for A-SMGCS Routing and Planning
			REG-0513 CS/AMC on Airport CDM (PCP)

Solution #53 Pre-Departure Sequencing supported by Route Planning	Pre-Departure management has the objective of delivering an optimal traffic flow to the runway. Accurate taxi time forecasts provided by route planning are taken into account for TSAT-Calculation before off-block. Pre-Departure sequence (TSAT sequence) is set up by Tower Clearance Delivery Controllers who will follow TSAT-window when issuing startup approval	TS-0202 Pre-Departure Sequencing supported by Route Planning	AERODROME-ATC-18 Interfacing between DMAN and Routing module
			AERODROME-ATC-50 Advanced Airport Tower Controller Working Position (A-CWP)
			AIRPORT-36 Provision by the Airport Operator of the relevant constraint to Aerodrome ATC
			REG-0513 CS/AMC on Airport CDM (PCP)
			STD-059 Update of EUROCONTROL A-CDM Manual (PCP)

Table 3-1: SESAR Solution(s) under Demonstration

In addition, PJ28 contributed to the Development of the S2020 solution PJ.03b-05 (Table 3-2).

SESAR Solution ID and Title	SESAR Solution Description	OI Steps ref. (coming from EATMA)	Enablers ref. (coming from EATMA)
PJ.03b-05 Traffic Alerts for Pilots for Airport Operations	Traffic Alerts for pilots for airports operations refer to enhancing on-board systems in order to detect risks of collision with other traffic during runway and taxiway operations. In all cases the flight crew are provided with appropriate alerts.	AUO-0605 Traffic Alerts for Pilots during Runway Operations	A/C-43a1 Traffic Alerts for Pilots during Runway Operations
			A/C-48a Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260B
			A/C-67 ADS-B IN
		AUO-0615 Traffic Alerts for Pilots during Taxiway Operations	A/C-24 Airport moving map and own aircraft position display in cockpit.
			A/C-25 Airborne Traffic Situational Awareness to support surface operations (ATSA-SURF), including reception (ADS-B in), processing and display
			A/C-43a2 Traffic Alerts for Pilots during Taxiway Operations
			A/C-48a Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260B

Table 3-2: Contribution to SESAR2020 Solution(s)

The following documents represent the material available for the VLD that describes the SESAR Solution(s) under the scope of the project.

SESAR Solution [02]

[1] Project 06.07.01, D32, “Final OSED for Conflicting ATC Clearances and Conformance Monitoring Alerts for Controllers”, 00.01.01, 10/11/2016

[2] Project 06.07.01, D05, “Operational concept for the integration of the safety support tools: updated OCD (third year)”, 00.01.03, 01/11/2016

[3] Project 06.07.01, D29, “06.07.01 SPR for "Conflicting ATC Clearances" and " Conformance Monitoring for Controllers", 00.01.01, 21/11/2014

[4] Project 06.07.01, D29b, “Safety Assessment Report (SAR) for Conflicting ATC Clearances", 00.01.01, 21/11/2014

[5] Project 06.07.01, D29C, “Safety Assessment Report for Conformance Monitoring for Controllers", 00.01.01, 21/11/2014

[6] 01_CN_Solution_02_Airport_Safety_Nets_for_ATC

[7] Project 12.03.02, D64, “Phase 3 - Technical Specifications - Final Report", 00.02.00, 12/09/2016

[8] Project 12.05.04, D93, “Final System Requirements", 00.03.00, 27/09/2016

SESAR Solution [22]

[9] Project 06.07.02, D46, “OFA04.02.01 (Integrated Surface Management) Final OSED”, 00.01.02, 10/11/2016

[10] Project 06.07.02, D45, “OFA04.02.01 (Integrated Surface Management) Final SPR”, 00.01.01, 24/10/2016

[11] Project 06.07.03, D28, “OFA04.02.01 (Integrated Surface Management) Final INTEROP", 00.01.00, 16/09/2016

[12] 01_CN_Solution_22_ASMGCS_Routing_and_Planning_Function

[13] Project 12.03.03, D36, “Final Technical Specifications", 00.03.00, 19/05/2016

[14] Project 12.04.03, D38, “Final Technical Specifications", 00.03.00, 25/05/2016

[15] Project 12.05.04, D93, “Final System Requirements", 00.03.00, 27/09/2016

SESAR Solution [53]

[16] Project 06.08.04, D17, “6.8.4-S01V3 Final OSED”, 00.01.01, 22/07/2015

[17] Project 06.08.04, D18, “S01V3 Final SPR”, 00.01.11, 28/09/2015

[18] Project 06.08.04, D82, “S01V3 Final INTEROP", 00.01.01, 22/07/2015

[19] 1_Pre-departure_sequencing_supported_by_route_planning_contextual_note

[20] Project 12.04.04, D01, “Technical Specification", 00.02.00, 12/09/2011

SESAR Solution [PJ03b-05]

[21] Project 9.14, D36, “Final OSED for "Traffic Alerts for pilots" following V3 trials”, 13/11/2015

[22] [Project 9.14, D37, “Consolidated Final SPR for "Traffic Alerts for pilots" following V3 trials”, 00.02.00, 21/01/2016

[23] Project 9.14, D38, “Consolidated Final INTEROP for "Traffic Alerts for pilots" following V3 trials", 00.02.00, 19/02/2016

[24] Project 9.14, D46, “WA1 High Level Functional Requirements Definition (FRD) - issue 4”, 00.02.00, 24/04/2016

3.2.1 Deviations with respect to the SESAR Solution(s) definition

On-board Traffic alerting

WP3 demonstration exercise addresses ADS-B data collection as a support to develop on-board traffic alerting system functions which is part of SESAR2020 PJ03b-05. The alerting algorithms of the system of the own aircraft receives ADS-B information and uses it to display traffic on airport moving map and to determine whether a flight crew alert should be triggered.

ADS-B data performance is a key enabler for proper function of the system. The WP3 exercise in Wave 1 aims on providing evidence that ADS-B data performance is sufficient to support proper functioning of the system rather than on demonstrating the solution PJ03b-05 itself. This approach deviates from the original idea of the VLD however it is considered necessary to provide evidence around the technical and operational readiness in early stage, therefore the inclusion in a Very Large Scale Demonstration is important. As the successor, the full demonstration of the on-board traffic alerting system, including the display of the alerts in the cockpit for the flight crews during regular passenger operations is expected to take place in Wave 2 of the VLD.

3.3 Contribution to PCP

PJ28 addresses Air Traffic Management (ATM) sub-functionalities requested by the Pilot Common Project (PCP Commission Implementation Regulation IR N° 716/2014), all part of ATM Functionality #2 – Airport Integration and Throughput (AF#2).

PCP Requirement	Description
Departure Management Synchronised with Pre-departure sequencing	Departure management synchronised with pre-departure sequencing is a means to improve departure flows at one or more airports by calculating the Target Take Off Time (TTOT) and Target Start Approval Time (TSAT) for each flight, taking multiple constraints and preferences into account. Pre-departure management consists of metering the departure flow to a runway by managing Off-block-Times (via Start-up-Times) which take account of the available runway capacity. In combination with Airport — Collaborative Decision Making (A-CDM), Pre- departure management reduces taxi times, increases Air Traffic Flow Management-Slot (ATFM-Slot) adherence and predictability of departure times. Departure management aims at maximising traffic flow on the runway by setting up a sequence with minimum optimised separations.
Automated Assistance to Controller for Surface Movement Planning and Routing	The routing and planning functions of A-SMGCS shall provide the automatic generation of taxi routes, with the corresponding estimated taxi time and management of potential conflicts. Taxi routes may be manually modified by the air traffic controller before being assigned to aircraft and vehicles. These routes shall be available in the flight data processing system.
Airport Safety Nets	Airport safety nets consist of the detection and alerting of conflicting ATC clearances to aircraft and deviation of vehicles and aircraft from their instructions, procedures or routing which may potentially put the vehicles and aircraft at risk of a collision. The scope of this sub-functionality includes the Runway and Airfield Surface Movement area.

	ATC support tools at the aerodrome shall provide the detection of Conflicting ATC Clearances and shall be performed by the ATC system based on the knowledge of data including the clearances given to aircraft and vehicles by the air traffic controller, the assigned runway and holding point. The air traffic controller shall input all clearances given to aircraft or vehicles into the ATC system using a digital system, such as the EFS. Different types of conflicting clearances shall be identified (for example Line-Up vs. Take-Off). Some may only be based on the air traffic controller input; others may in addition use other data such as A-SMGCS surveillance data. Airport Safety Nets tools shall alert air traffic controllers when aircraft and vehicles deviate from ATC instructions, procedures or route. The air traffic controller instructions available electronically (through a digital system, such as EFS) shall be integrated with other data such as flight plan, surveillance, routing, published rules and procedures. The integration of this data shall allow the system to monitor the information and when inconsistencies are detected, an alert shall be provided to the air traffic controller (for example no push-back approval).

Table 3-3: PCP requirements addressed by PJ28

PJ28 addressed these requirements by exercises at three different airports implementing pre-operational systems in a close to real live environment.

3.4 Summary of the Demonstration Plan

3.4.1 Demonstration Plan Purpose

Overview

The Demonstration Plan acted as the base for the coordination and management of the Very Large Scale Demonstration on Integrated Airport Operations (IAO).

The plan was delivered in three versions starting with the initial version covering the basic approach and the project management structures. In the course of the project more details on the exercises, the objectives and technical systems became available and have been described in a second version. Shortly before the execution of the first (airport) exercise the document was produced in its final version with all final updates and adjustments.

While the first version covered all five planned exercises (including the Manual Taxi Routing planned by Thales) the later versions where adapted by not addressing the exercise any further.

Finally, the demonstration project consists of four different demonstrations executed in Germany, France and Hungary as well as On-board of commercial airline aircraft. PJ28 is structured in such a way that the individual demonstrations are independent of each other. It is apparent that some demonstrate similar functionalities, but this is the core intention of the VLDs in the de-risking effort to the deployment phase. This is reflected in the Demonstration Plan, where a clear distinction is made between the four different demonstration exercise plans.

As the three airport demonstrations are covering almost the same SESAR1 solutions, a coordinated approach has been taken on the definition of the objectives for the exercises. Even each of these exercises might have a special focus in the demonstration objectives are similar and are therefore aligned.

As dissemination is one of the key aspects defined for VLDs, the Demonstration Plan defined objectives and strategy for dissemination actions. Applicable communication and dissemination channels are identified and activities, the targeted audience and the planned schedule are described.

The Demonstration Plan also provides information on management procedures and defines roles and responsibilities for the project.

3.4.1.1 Operational and technological Environment – Nice

The demonstration platform can be operated in 2 modes:

- In a training mode, to train controllers to their new CWP tools and safety nets using prepared RTS scenarios
- In shadow mode, for the VLD

The architecture of the DSNA Innovation airport platform TANGO platform and its RTS mode is reused for training purpose.

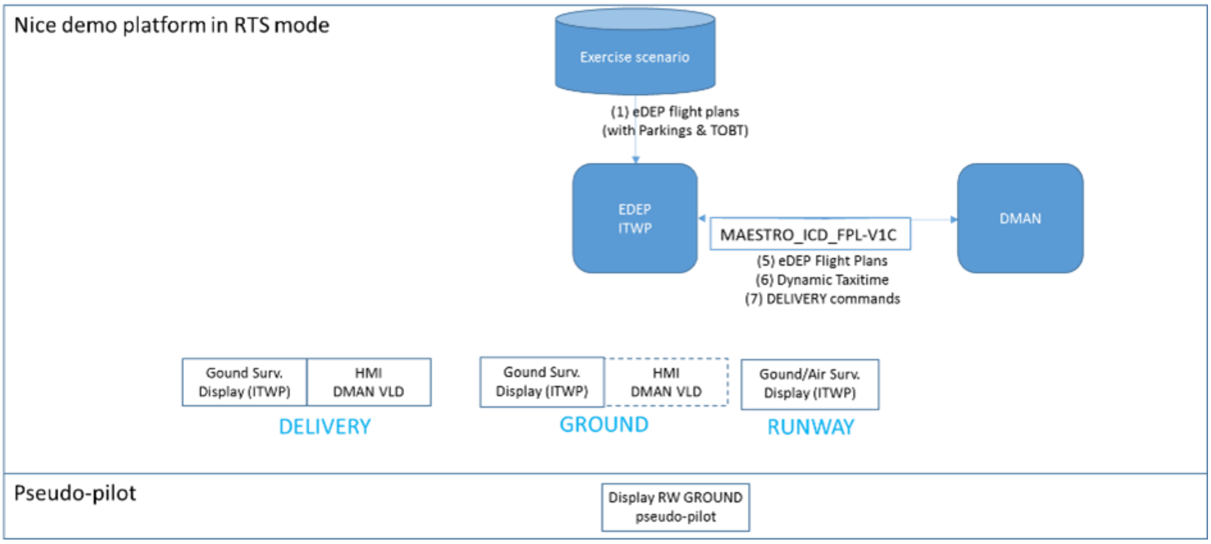


Figure 3-1: Demonstration platform in RTS mode (for training purposes)

The architecture slightly changes to accept operational flight plans inputs and live updates in shadow mode for the VLD.

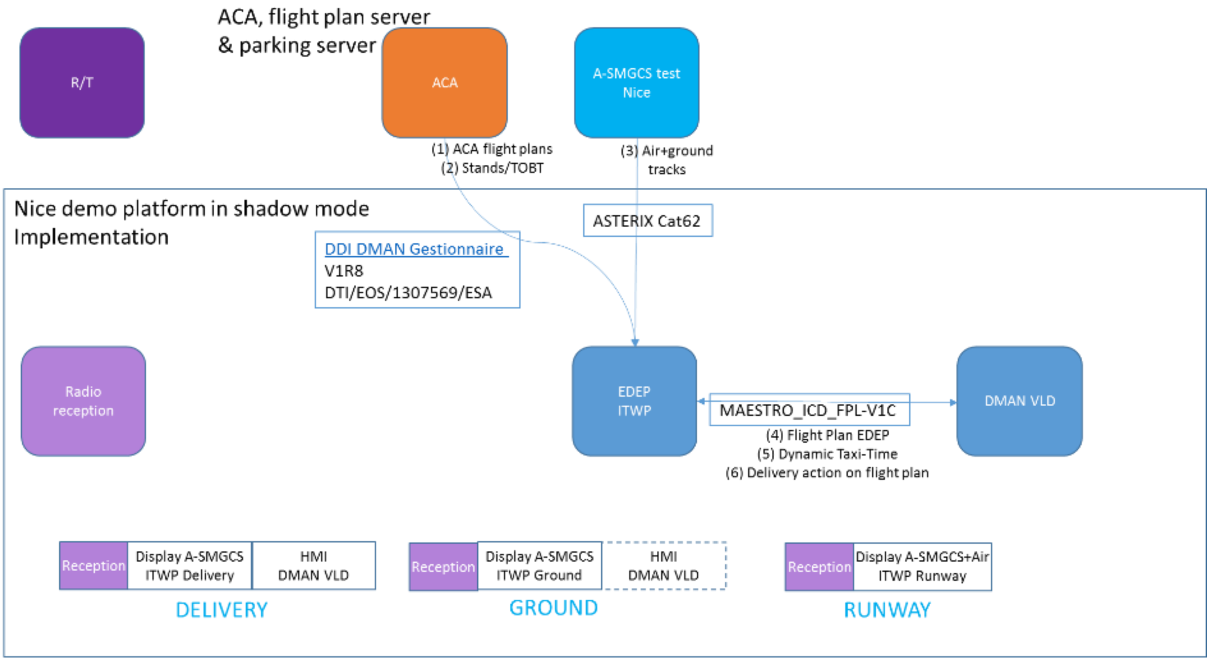


Figure 3-2: Demonstration platform in shadow mode

The platform is connected to:

- the Airport Operator (ACA) to input flight plans and stands data in eDEP (mainly used to create flight plan for departures)
- Operational ASTERIX Cat62 tracks data (mainly used to create flight plans for arrivals and flight updates in the airport area)

3.4.1.2 Operational and technological Environment – Onboard Traffic Alerts

For demonstration exercise #2 (WP3), methods and tools for ADS-B data collection in accordance with the technical specification as stated in exercise #2 section of PJ28 DEMOP [1] have been developed.

The demonstration exercise has made available hereby:

- Participation of AUs Swiss and Germania and Turkish in the project was secured. All necessary documents were prepared and signed and are now in place.
- Material required for ADS-B data collection was acquired and distributed to AUs.
- Data collection procedure documents we created and distributed to AUs.
- AUs obtained operational approvals.
- SW tools have been created and distributed to AUs.
- Honeywell cloud storage was used for data collection.
- All elements of data collection chain were tested in interaction with AUs

Based on above stated the airspace users collected data on their aircraft (4 aircraft in total) uploading data to Honeywell cloud storage every week for the duration of 40 weeks.

3.4.1.3 Operational and technological Environment - Budapest

The demonstration platform builds upon the InNOVA platform used in different validation exercises in SESAR1 and it is adapted to the Budapest airport layout and procedures. It is the evolution of the NOVA A-SMGCS product, which is currently in use in Budapest both in the Tower and in the contingency room.

The following functional blocks of the platform are provided to support the demonstration (mapping to EATMA):

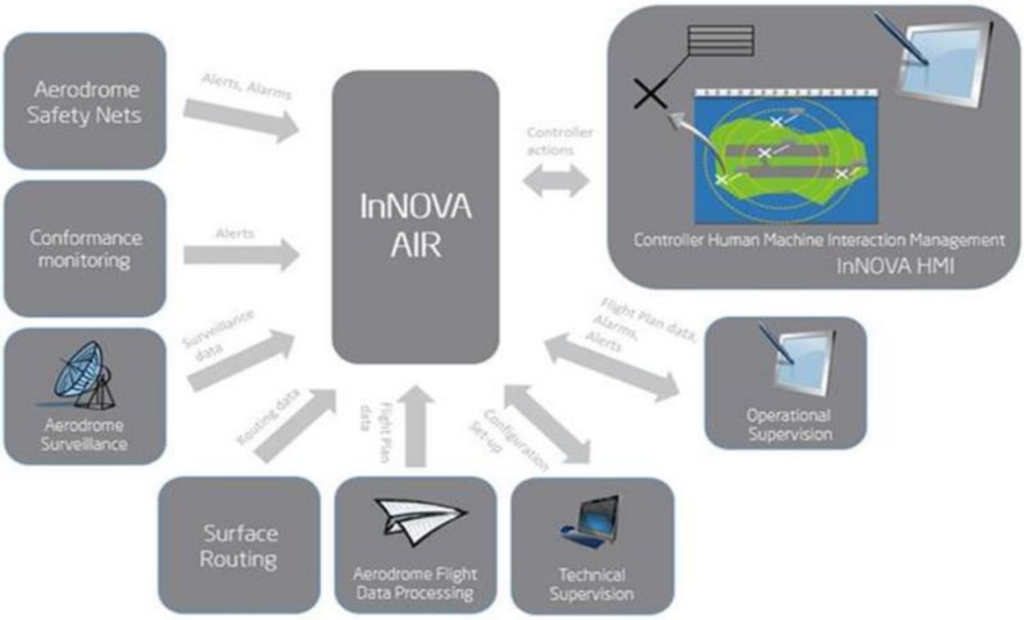


Figure 3-3: Budapest demonstration platform: functional blocks

The demonstration platform builds on SESAR1 solutions installed in the facilities presently used for contingency, but have been modified to meet the requirement of the demonstration.

3.4.1.4 Operational and technological Environment - Hamburg

The demonstration at Hamburg Airport will be in shadow mode, not interfering with the live operation. The following figure illustrates the Hamburg Exercise setup.

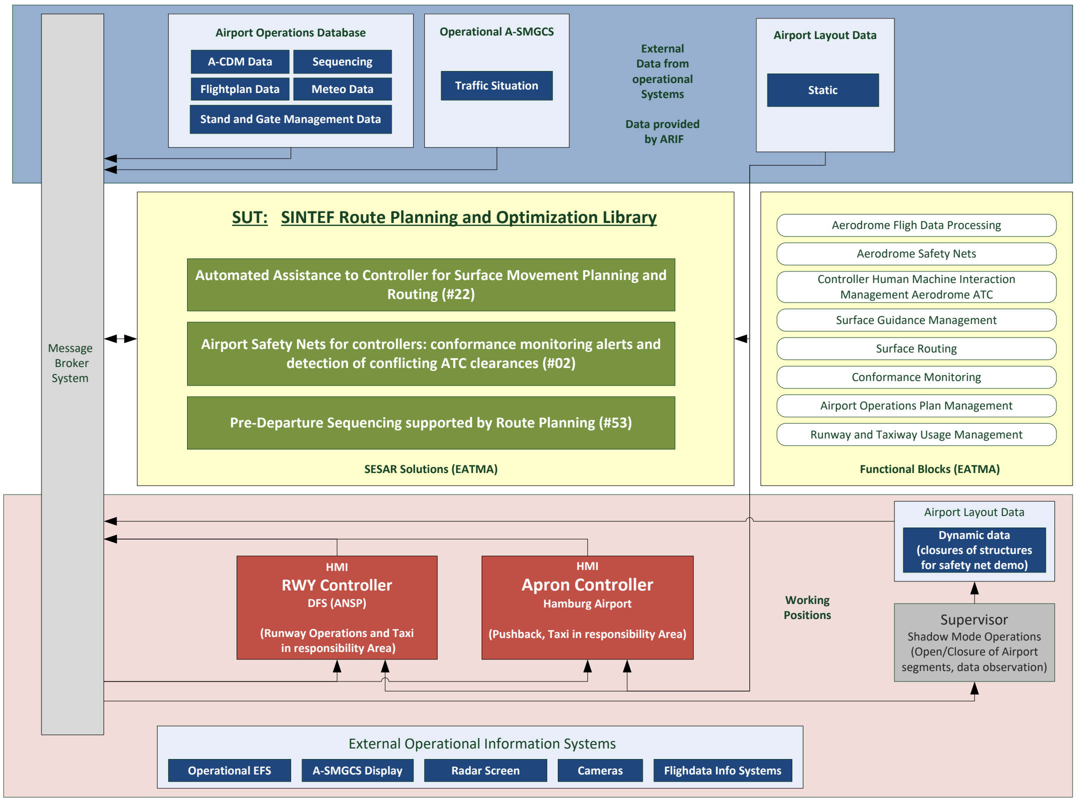


Figure 3-4: Exercise Hamburg Setup

The external data are provided by the ARIF Framework, which is connected to the operational data systems and provides real time data of the airport operations. While the traffic situation is provided by the operational A-SMGCS system, all flight plan related data as well as A-CDM and Meteo data are provided by the central data management system of the airport.

3.4.2 Operating method description

Airport Exercises (Nice, Budapest, Hamburg)

For the airport exercises in PJ28 (WP2, WP4, WP6), functionalities are tested in passive shadow mode. Real data from the operational environment is used to feed into the system under test. Data is processed and the results are shown on graphical user interfaces of the industrial solutions or, in case the industrial solution does not provide a graphical user interface, results are fed into a specific demonstration human machine interface.

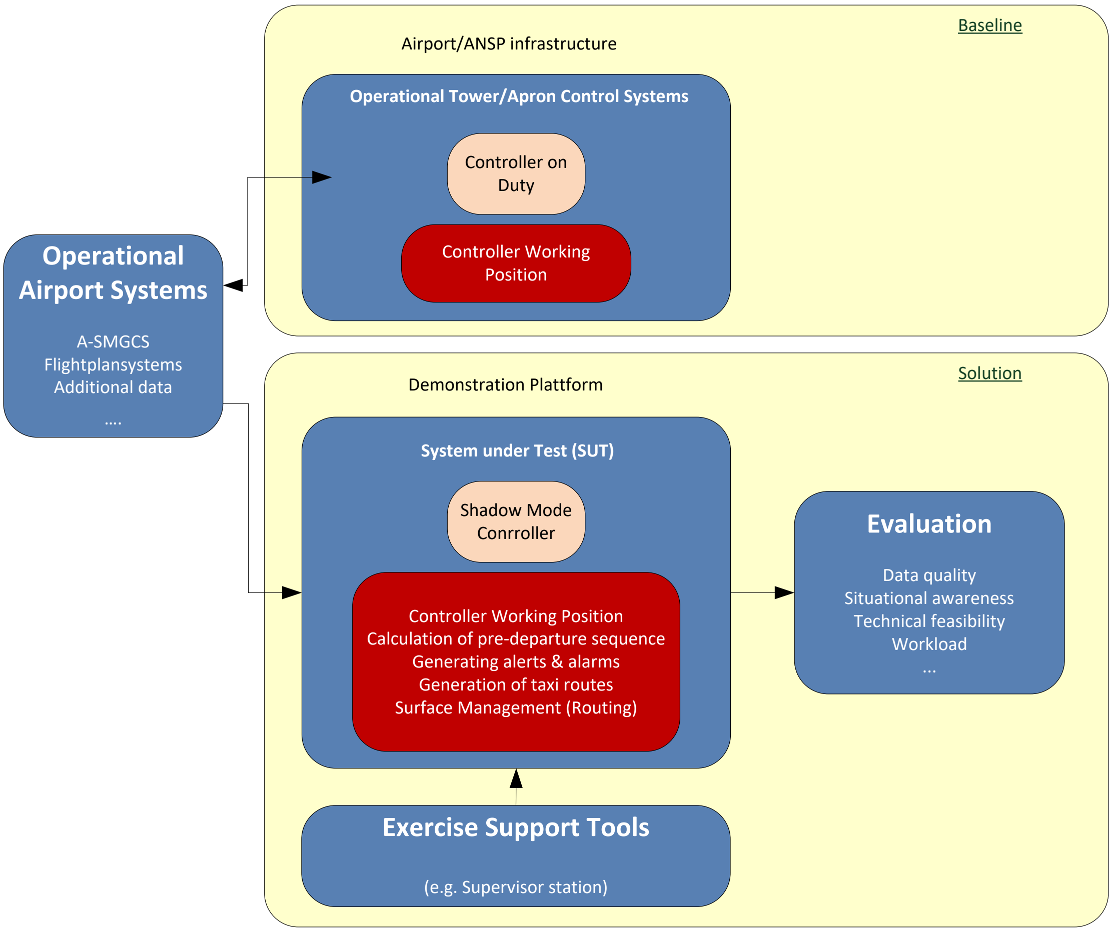


Figure 3-5: Operating method description for ground-based demonstration

Technical and operational experts base their evaluation on the output presented on the HMI, in conjunctions with additional information available at the demonstration platform. Those additional information sources can be:

- meteorological information
- data on airport configuration
- radio communication between air traffic control and pilots
- A-SMGCS system and clearances input on its observation of traffic situation

There is no feedback from the demonstration platform into the operational systems. So, safety and efficiency of real airport operation is not affected by the passive shadow mode test whilst the platform is fed with realistic data. Passive shadow mode test does not allow to actively influence operations on basis of the information provided by the demonstration platform.

3.4.3 Summary of Demonstration Objectives and success criteria

Objectives Summary

The following Table 3-4 summarizes the Objectives and the coverage by the exercises:

Identifier	Solution	Title	Nice LFMN		On-board TA		Budapest LHBP		Man. Taxi Routing	Hamburg EDDH	
			Plan	EXE	Plan	EXE	Plan	EXE		Plan	EXE
OBJ-VLD-28-001	22	Demonstrate utility of routing and planning functions.	x	x			x	x		x	x
OBJ-VLD-28-002	22	Demonstrate the utility and usability of route modification capabilities.	x	x			x	x			x
OBJ-VLD-28-003	22	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	x	x			x	x		x	x
OBJ-VLD-28-004	22	Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable.	x	x			x	x			
OBJ-VLD-28-005	22	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	x	x			x	x		x	x
OBJ-VLD-28-006	02	Demonstrate the utility of CATC alerts functions.	x	x			x	x			
OBJ-VLD-28-007	02	Demonstrate the utility of CATC functions in predictive mode.	x	x			x	x			
OBJ-VLD-28-008	02	Demonstrate the usability of CATC function.	x	x			x	x			
OBJ-VLD-28-009	02	Demonstrate the utility of CMAC functions.	x	x			x	x		x	x
OBJ-VLD-28-010	02	Demonstrate the usability of CMAC functions.	x	x			x	x			
OBJ-VLD-28-011	02	Demonstrate that safety with regards to Airport operations is improved with the successful integration of CMAC		x							
OBJ-VLD-28-012	02	Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC		x							
OBJ-VLD-28-013	02	Demonstrate that the controller workload incurred due to integration of CMAC is acceptable.	x	x			x	x			
OBJ-VLD-28-014	02	Demonstrate that the controller workload incurred due to integration of CATC is acceptable.	x	x			x	x			
OBJ-VLD-28-015	02	Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC	x	x			x	x			x
OBJ-VLD-28-016	02	Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC.	x	x			x	x			
OBJ-VLD-28-017	02	Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions	x	x			x	-			
OBJ-VLD-28-018	53	Demonstrate the utility of DMAN functions supported by route planning.	x	x			x	x		x	x
OBJ-VLD-28-019	53	Demonstrate the usability of DMAN functions supported by route planning.	x	x			x	x			
OBJ-VLD-28-020	53	Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable.	x	x			x	x			
OBJ-VLD-28-021	53	Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved.	x	x			x	x		x	x
OBJ-VLD-28-022	02,22,53	Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	x	x			x	x		x	x
OBJ-VLD-28-023	PJ03b-05	ADS-B data analysis delivered to PJ03b-05			x	x					
OBJ-VLD-28-024	22	Demonstrate utility of routing and planning functions in non-nominal conditions.	x	x						x	x

Table 3-4: Objectives coverage overview – planned and actual

Safety Net - Alerts coverage

The following Table 3-5 gives an overview of the Safety Nets envisaged by each demo and the final coverage during the exercises.

Identifier	Title	Nice LFMN		Budapest LHBP		Hamburg EDDH	
		Parallel Dependent		Parallel Dependent		Crossing Dependent	
		Plan	Exe	Plan	Exe	Plan	Exe
3.2.2	Conflicting ATC Clearances (CATC)	PREDICTIVE + ALERT					
3.2.2.1	Line Up vs Line Up	No	No	Yes	Yes	No	No
3.2.2.2	Line Up vs Cross or Enter	No	No	Yes	Yes	No	No
3.2.2.3	Line Up vs Take Off	Yes	Yes	Yes	Yes	No	No
3.2.2.4	Line Up vs Land	No	No	Yes	Yes	No	No
3.2.2.5	Cross or Enter vs Line Up	No	No	Yes	Yes	No	No
3.2.2.6	Cross or Enter vs Cross or Enter	No	No	Yes	Yes	No	No
3.2.2.7	Cross or Enter vs Take Off	No	No	Yes	Yes	No	No
3.2.2.8	Cross or Enter vs Land	Yes	Yes	Yes	Yes	No	No
3.2.2.9	Take Off vs Line Up	Yes	Yes	Yes	Yes	No	No
3.2.2.10	Take Off vs Cross or Enter	No	No	Yes	Yes	No	No
3.2.2.11	Take Off vs Take Off	Yes	Yes	Yes	Yes	No	No
3.2.2.12	Take Off vs Land	No	No	Yes	Yes	No	No
3.2.2.13	Land vs Line Up	No	No	Yes	Yes	No	No
3.2.2.14	Land vs Cross or Enter	Yes	Yes	Yes	Yes	No	No
3.2.2.15	Land vs Take Off	No	No	Yes	Yes	No	No
3.2.2.16	Land vs Land	Yes	Yes	Yes	Yes	No	No
3.2.3	Conformance Monitoring Alerts for Controllers (CMAC)						
3.2.3.1	Route Deviation Alert (Instruction)	Yes	Yes	Yes	Yes	Yes	Yes
3.2.3.2	No Push Back approval (Instruction)	Yes	Yes	Yes	Yes	No	Yes
3.2.3.3	No Taxi approval (Instruction)	Yes	Yes	Yes	Yes	Yes	Yes
3.2.3.4	Stationary (Instruction)	Yes	Yes	Yes	Yes	No	No
3.2.3.5	No Contact (Instruction)	No	No	Yes	Yes	No	No
3.2.3.6	No Transfer (Instruction)	Yes	Yes	Yes	Yes	No	No
3.2.3.7	No Take Off Clearance (Instruction)	Yes	Yes	Yes	Yes	Yes	Yes
3.2.3.8	No Landing Clearance (Instruction)	Yes	Yes	Yes	Yes	No	No
3.2.3.9	Landing on wrong runway (Instruction)	No	No	Yes	Yes	No	No
3.2.3.10	Red Stop Bar Crossed (Instruction)	No	No	No	No	Yes	Yes
3.2.3.11	Lining Up on the wrong runway (Instruction)	Yes	Yes	Yes	Yes	Yes	Yes
3.2.3.12	Runway Incursion (Procedure or Instruction)	Yes	Yes	Yes	Yes	No	No
3.2.3.13	Runway or Taxi Type (Procedure)	Yes	Yes	Yes	Yes	No	No
3.2.3.14	Runway Closed (Procedure)	No	No	Yes	Yes	Yes	Yes
3.2.3.15	Taxiway Closed (Procedure)	Yes	Yes	Yes	Yes	Yes	Yes
3.2.3.16	High Speed (Procedure)	Yes	Yes	Yes	Yes	No	No

Table 3-5: Safety Net - Alerts coverage Plan/Exercise implemented

3.4.4 Demonstration Assumptions

The following Table 3-6 lists general assumptions for PJ28.

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-VLD-28-001	Solutions reached required maturity.	Aircraft Equipage/ Technology. Ground tools/ Technology	VLD expects demonstration of V3 mature solutions or support V2 mature solutions.	Objective of this VLD is to de-risk future deployment of mature solutions.	Airport, Terminal Area	N/A	Expert opinion	N/A	Primary Projects	High
ASS-VLD-28-002	AU users participation	N/A	AU users participate in the project	AU users play key role in the project	Airport, Terminal Area	N/A	Expert opinion	N/A	Primary Projects	High
ASS-VLD-28-003	Shadow mode demo support VLD objectives	N/A	Shadow mode demo support VLD objectives		Airport, Terminal Area	N/A	Expert opinion	N/A	Primary Projects	High
ASS-VLD-28-004	Real ADS-B data and its analysis represents real environment.	N/A	Real ADS-B data and its analysis represent reality, thus can provide relevant arguments.	ADS-B data analysis provides tangible and valid results corresponding to reality. Only representative results can provide arguments supporting certification and system deployment.	Airport, Terminal Area	N/A	Expert opinion	N/A	Primary Projects	High

Table 3-6 Demonstration Assumptions overview

3.4.5 Demonstration Exercises List

The following tables give an overview of the Exercises that are part of the VLD:

Nice

[EXE]

Identifier	EXE-VLD-28-001
Title	Demonstration Nice
Description	The exercise at Nice airport (PCP airport) aims at demonstrating the following SESAR1 PCP solutions: #02: Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances #22: Automated Assistance to Controller for Surface Movement Planning and Routing #53: Pre-Departure Sequencing supported by Route Planning
Demonstration Technique	Passive shadow-mode
KPA/TA Addressed	Situational awareness, Safety, Human Performance
Number of flights	Live traffic
Start Date	15/04/2019
End Date	30/04/2019
Demonstration Coordinator	Christelle Pianetti
Demonstration Platform	DSNA platform
Demonstration Location	Nice Airport
Status	Finished
Dependencies	N/A

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	#02
<SESAR Solution>	#22
<SESAR Solution>	#53
<Demo Objective>	

[EXE]

On-board Traffic Alerting

Identifier	EXE-VLD-28-002
Title	Demonstration of on board Traffic Alerting

Description	ADS-B data collection using logging capability installed on several airline aircraft flying their regular flights mainly within Europe. Collected data will be consequently used in the laboratory simulator to demonstrate that ADS-B data performance is acceptable to trigger a correct on board traffic alerts while minimising the number of spurious alerts.
Demonstration Technique	Real ADS-B data collection & laboratory simulations
KPA/TA Addressed	Safety, Human Performance
Number of flights	1500 ownship flights
Start Date	01/03/2018
End Date	31/08/2019
Demonstration Coordinator	Honeywell
Demonstration Platform	Honeywell TCAS with logging capability & laboratory SW tools.
Demonstration Location	Primarily Europe
Status	Finished
Dependencies	N/A

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	PJ03b-05
<Demo Objective>	

[EXE]

Budapest

Identifier	EXE-VLD-28-003
Title	Demonstration Budapest
Description	The exercise at Budapest airport aims to demonstrate the following SESAR1 PCP solutions: #02: Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances #22: Automated Assistance to Controller for Surface Movement Planning and Routing #53: Pre-Departure Sequencing supported by Route Planning
Demonstration Technique	Passive shadow mode
KPA/TA Addressed	Situational awareness, Safety, Human Performance
Number of flights	Live traffic
Start Date	08/04/2019
End Date	12/04/2019
Demonstration Coordinator	INDRA
Demonstration Platform	INNOVA Tower Platform

Demonstration Location	HungaroControl premises at Budapest Airport
Status	Finished
Dependencies	None

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	#02
<SESAR Solution>	#22
<SESAR Solution>	#53
<Demo Objective>	

[EXE]

Manual Taxi Routing

Identifier	EXE-VLD-28-004
Title	Demonstration Manual Taxi Routing
Description	WP terminated and originally planned EXE cancelled
Demonstration Technique	
KPA/TA Addressed	
Number of flights	
Start Date	
End Date	
Demonstration Coordinator	
Demonstration Platform	
Demonstration Location	
Status	
Dependencies	

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	
<Demo Objective>	

Hamburg

[EXE]

Identifier	EXE-VLD-28-005
Title	Demonstration Hamburg
Description	The exercise at Hamburg airport will demonstrate parts of the following SESAR1 PCP solutions: #02: Airport Safety Nets for controllers: conformance monitoring alerts #22: Automated Assistance to Controller for Surface Movement Planning and Routing #53: Pre-Departure Sequencing supported by Route Planning
Demonstration Technique	Shadow Mode
KPA/TA Addressed	Safety, Human Performance,
Number of flights	Live Traffic (450 per day)
Start Date	25/03/2019
End Date	29/03/2019
Demonstration Coordinator	DLR (AT-One)
Demonstration Platform	Airport research and Innovation Facility (ARIF) with integrated NATMIG Optimization Library
Demonstration Location	Hamburg, Germany
Status	Finished
Dependencies	None

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	#02 (partial)
<SESAR Solution>	#22 (partial)
<SESAR Solution>	#53 (partial)
<Demo Objective>	

Table 3-7: Demonstration Exercises Overview

3.5 Deviations

3.5.1 Deviations with respect to the SJU Project Handbook

There is no deviation from the SJU Project Handbook.

3.5.2 Deviations with respect to the Demonstration Plan

There are no general deviations from the demonstration plan. There have been some deviations within the exercises that are described in the respective sections of the Exercises (A2, B2, C2 and E2).

4 Demonstration Results

4.1 Summary of Demonstration Results

Results summaries:

- All safety nets planned (32) were demonstrated by at least one exercise. 5 safety nets were demonstrated by all 3 exercises,
- Out of the 22 objectives planned, 14 resulted in a POK status and 8 resulted in an OK status, as follows:
  - Solution #22: Routing and Planning – All resulting statuses (7) were POK,
  - Solution #02: Safety Nets – 6 out of 11 resulting statuses were OK and 5 out of 11 resulting statuses were POK,
  - Solution #53: DMAN – 1 out of 5 resulting statuses was OK, and 4 out of 5 were POK.
  - Solution #23: ADS-B – 1 out of 1 resulting status was OK.

The following nomenclature has been used:

OK	Demonstration objective achieves the expectations
NOK	Demonstration objective does not achieve the expectations
Partially OK	Demonstration objectives does not fully achieve the expectation
N/A	Demonstration objectives out of scope of the demonstration, as identified by deviations from objectives

For the assessment some general principles have been set:

- All exercise results NOK, OK, POK, N/A -> the result is accordingly
- N/A has not been taken into account -> other values define the overall value
- If there is one POK the result is POK

In some cases, the general scheme has been overruled. This reflects for instance minor issues leading to a POK at one site but a strong OK on another site. Explanations are given at the Objective assessment.

Further, the following nomenclature was used to identify the sites from which the arguments were taken:

Nice	NCE	LFMN
Budapest	BUD	LHBP
Hamburg	HAM	EDDH

The following Table 4-1 summarizes the results for the airport exercise Nice, Budapest and Hamburg.

Plan						Results			
Identifier	Solution	Title	Nice LFMN	Budapest LHBP	Hamburg EDDH	LFMN	LHBP	EDDH	Overall
OBJ-VLD-28-001	22	Demonstrate utility of routing and planning functions.	x	x	x	POK	OK	POK	**POK**
	CRT-VLD-28-001-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.	x	x	x	POK	Ok	POK	POK
	CRT-VLD-28-001-002	Positive evaluation of the calculated routes' relevance.	x	x	x	POK	Ok	POK	POK
OBJ-VLD-28-002	22	Demonstrate the utility and usability of route modification capabilities.	x	x		POK	OK	POK	**POK**
	CRT-VLD-28-002-001	Positive evaluation of route modification capabilities when real surveillance data is used	x	x		POK	OK	POK	POK
	CRT-VLD-28-002-002	Positive evaluation route modifications outside of controllers' Areas Of Responsibility (AOR) when real surveillance data is used	x			N/A	-	-	N/A
	CRT-VLD-28-002-003	Positive evaluation of the routes representation (e.g. different status)	x	x		POK	OK	-	OK
OBJ-VLD-28-003	22	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	x	x	x	NOK	POK	NOK	**POK**

	CRT-VLD-28-003-001	Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.	x	x	x	NOK	POK	NOK	POK
OBJ-VLD-28-004	22	Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable.	x	x		POK	OK	-	**POK**
	CRT-VLD-28-004-001	Positive evaluation of the workload of Ground Controllers due to planning and routing functions.	x	x		POK	OK	-	POK
	CRT-VLD-28-004-002	Positive evaluation of the workload of Runway Controllers due to planning and routing functions.	x	x		OK	OK	-	OK
	CRT-VLD-28-004-003	Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.	x	x		POK	OK	-	OK
OBJ-VLD-28-005	22	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	x	x	x	POK	OK	POK	**POK**
	CRT-VLD-28-005-001	Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.	x	x	x	POK	OK	POK	POK
	CRT-VLD-28-005-002	Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.	x	x	x	OK	OK	N/A	OK
	CRT-VLD-28-005-003	Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.	x	x		POK	OK	-	OK
OBJ-VLD-28-006	02	Demonstrate the utility of CATC alerts functions.	x	x		OK	OK	-	**OK**
	CRT-VLD-28-006-001	Positive evaluation of the utility of the CATC alerts functions when real surveillance data is used.	x	x		Ok	OK	-	OK

OBJ-VLD-28-007	02	Demonstrate the utility of CATC functions in predictive mode.	x	x		OK	OK	-	**OK**
	CRT-VLD-28-007-001	Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.	x	x		Ok	Ok	-	OK
OBJ-VLD-28-008	02	Demonstrate the usability of CATC function.	x	x		POK	OK	-	**OK**
	CRT-VLD-28-008-001	Positive evaluation of the usability of CATC alerts functions.	x	x		Ok	OK	-	OK
	CRT-VLD-28-008-002	Positive evaluation of the usability of CATC functions in predictive mode.	x	x		POK	OK	-	OK
OBJ-VLD-28-009	02	Demonstrate the utility of CMAC functions.	x	x	x	POK	OK	POK	**POK**
	CRT-VLD-28-009-001	Positive evaluation of the utility of CMAC functions when real surveillance data is used.	x	x	x	POK	OK	POK	POK
OBJ-VLD-28-010	02	Demonstrate the usability of CMAC functions.	x	x		POK	POK	-	**OK**
	CRT-VLD-28-010-001	Positive evaluation of the audio alarm.	x	x		OK	N/A	-	OK
	CRT-VLD-28-010-002	Positive evaluation of the level of alerts generated (information or alarm).	x	x		POK	POK	-	POK
	CRT-VLD-28-010-003	Positive evaluation of the usability of CMAC alerts functions.	x	x		POK	OK	-	OK

OBJ-VLD-28-011	02	Demonstrate that safety with regards to Airport operations is improved with the successful integration of CMAC.	x		POK	-	-	**POK**
	CRT-VLD-28-011-001	Positive evaluation that the safety is improved with the successful integration of CMAC for the GROUND controller	x		POK	-	-	POK
	CRT-VLD-28-011-002	Positive evaluation that the safety is improved with the successful integration of CMAC for the RUNWAY controller	x		POK	-	-	POK
OBJ-VLD-28-012	02	Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC.	x		OK	-	-	OK
	CRT-VLD-28-012-001	Positive evaluation that the safety is improved with the successful integration of CATC for the RUNWAY controller.	x		OK	-	-	OK
OBJ-VLD-28-013	02	Demonstrate that the controller workload incurred due to integration of CMAC is acceptable.	x	x	POK	POK	-	**POK**
	CRT-VLD-28-013-001	Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable.	x	x	NOK	POK	-	POK
	CRT-VLD-28-013-002	Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable.	x		OK	OK	-	OK
OBJ-VLD-28-014	02	Demonstrate that the controller workload incurred due to integration of CATC is acceptable.	x	x	OK	OK	-	**OK**
	CRT-VLD-28-014-001	Positive evaluation that the workload of RUNWAY controller due to the integration of CATC is acceptable.	x	x	OK	OK	-	OK
OBJ-VLD-28-015	02	Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC	x	x	POK	OK	POK	**POK**
	CRT-VLD-28-015-001	Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved.	x	x	NOK	Ok	POK	POK

	CRT-VLD-28-015-002	Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved.	x	x		OK	OK	NA	OK
OBJ-VLD-28-016	02	Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC.	x	x		OK	OK		**OK**
	CRT-VLD-28-016-001	Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved.	x	x		OK	OK		OK
OBJ-VLD-28-017	02	Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions	x	x		POK	N/A		**POK**
	CRT-VLD-28-017-001	Positive evaluation of the utility of the CATC and CMAC integrated with RMCA.	x	x		POK	N/A		POK
	CRT-VLD-28-017-002	Positive evaluation of the usability of the CATC and CMAC integrated with RMCA.	x	x		POK	N/A		POK
	CRT-VLD-28-017-003	Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts.	x	x		POK	N/A		POK
OBJ-VLD-28-018	53	Demonstrate the utility of DMAN functions supported by route planning.	x	x	x	N/A	POK	N/A	**POK**
	CRT-VLD-28-018-001	Positive evaluation of the utility of the DMAN function supported by route planning.	x	x	x	N/A	POK	NA	POK
OBJ-VLD-28-019	53	Demonstrate the usability of DMAN functions supported by route planning.	x	x		N/A	OK	-	POK
	CRT-VLD-28-019-001	Positive evaluation of the usability of the DMAN function supported by route planning.	x	x		N/A	Ok	-	POK[2]
OBJ-VLD-28-020	53	Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable.	x	x		N/A	POK	-	**POK**

	CRT-VLD-28-020-001	Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable.	x	x		N/A	N/A	-	NA
	CRT-VLD-28-020-002	Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable.	x	x		N/A	Ok	-	POK[2]
	CRT-VLD-28-020-003	Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable.	x	x		N/A	OK	-	POK[2]
OBJ-VLD-28-021	53	Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved.	x	x	x	N/A	POK	NOK	POK
	CRT-VLD-28-021-001	Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved.	x	x		N/A	N/A	-	N/A
	CRT-VLD-28-021-002	Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved	x	x	x	N/A	POK	NOK	POK
	CRT-VLD-28-021-003	Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved.	x	x	x	N/A	POK	NA	POK
OBJ-VLD-28-022	02,22,53	Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	x	x	x	N/A	OK	POK	POK
	CRT-VLD-28-022-001	Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	x	x	x	N/A	OK	POK	POK

[2] Rating on purpose, check detailed assessment for explanation

OBJ-VLD-28-024	22	Demonstrate utility of routing and planning functions in non-nominal conditions.	x	x	POK		POK	**POK**
	CRT-VLD-28-024-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operation in case of specific events (e.g. taxiway closure).	x	x	POK	-	POK	POK
	CRT-VLD-28-024-002	Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure).	x	x	POK	-	POK	POK

Table 4-1: Summary of Demonstration Exercises Results – WP2, 4, 6

The following Table 4-2 summarizes the results for the on-board ADS-B exercise.

Demonstration Objective ID	Demonstration Objective Title	Success Criterion ID	Success Criterion	Demonstration Results	Demonstration Objective Status
OBJ-VLD-28-023	ADS-B data analysis delivered to PJ03b-05.	CRT-VLD-28-023-001	Real ADS-B data successfully collected.	OK	**OK**
		CRT-VLD-28-023-002	ADS-B data analysis performed and report created.	OK	

Table 4-2: Summary of Demonstration Exercises Results – WP3

4.2 Detailed analysis of Demonstration Results per Demonstration objective

The nomenclature described in 4.1 has been used:

4.2.1 OBJ-VLD-28-001 Routing and Planning Function

For the routing and planning function the results are as follows:

CRT-VLD-28-001-001
Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations

Nice	Budapest	Hamburg	Overall
POK	OK	POK	POK

The criterion is rated to be POK because:

- Calculated routes generally conformed to operational needs/rules for managing certain surface operations but points of improvement concerning both departure and arrival routing have been observed
- Improvements in terms of adapting routes to operational particularities of each airport are possible. To integrate the operational needs by the controllers (not published as standard procedures) into algorithms needs to be covered.

CRT-VLD-28-001-002
Positive evaluation of the calculated routes' relevance

Nice	Budapest	Hamburg	Overall
POK	OK	POK	POK

The criterion is rated to be POK because:

- Certain systematic routing issues impacted the relevance of calculated routes, due to sub-optimal routing solutions which were not commonly practiced (NCE).
- Pushback procedures could/have not been adequately considered (HAM).

Overall result:

OBJ-VLD-28-001	**Demonstrate the utility of routing and planning functions.**	**POK**

4.2.2 OBJ-VLD-28-002 Route Modification Capabilities

For the Route Modification Capabilities the results are as follows:

CRT-VLD-28-002-001
Positive evaluation of route modification capabilities when real surveillance data is used

Nice	Budapest	Hamburg	Overall
POK	OK	POK	POK

The criterion is rated to be POK because:

- The Nice HMI encountered issues concerning certain routes proposed by the system which were erroneous (e.g. loops, stand crossings, inverted) and sub-optimal (longer than that proposed by the tower controller).

- The Hamburg HMI was a prototype HMI, that needs more improvement and familiarization time was too short. The POK is therefore more related to the implementation then to the function itself.

CRT-VLD-28-002-002
Positive evaluation route modifications outside of controllers' Areas Of Responsibility (AOR) when real surveillance data is used

Nice	Budapest	Hamburg	Overall
N/A	-	-	N/A

The criterion is rated to be N/A because:

- Manual route modifications outside of controllers' respective Areas of Responsibilities were not applicable to working methods practiced at Nice.

CRT-VLD-28-002-003
Positive evaluation of the routes representation (e.g. different status)

Nice	Budapest	Hamburg	Overall
POK	OK	-	OK

The criterion is rated to be OK because:

- At Nice, routes' representation was generally positive. However, a visual feedback (flickering route) upon modifying successfully a route was not always present, due to performance lags.

Overall result:

OBJ-VLD-28-002	**Demonstrate the utility and usability of route modification capabilities.**	**POK**

4.2.3 OBJ-VLD-28-003 Taxi Time Accuracy

For the Taxi Time Accuracy the results are as follows:

CRT-VLD-28-003-001
Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point

Nice	Budapest	Hamburg	Overall
NOK	POK	NOK	POK

The criterion is rated to be POK because:

- At Nice, the delay incurred by aircraft due to crossing the inner, arrival runway was not taken into consideration for predicting the taxi-time (Note: There is no integration of DMAN and arrival management functionalities in the system under demonstration),
- HAM real taxi times differ from planned ones, related to pushback procedures, runway crossings and high variability between airlines
- BUD, improved taxi time calculation will be needed to support operational use.

- The overall rating is POK. The criterion depends on airport layout and procedures. While good results have been demonstrated in BUD, runway crossing operations seem to be lead to higher deviations and uncertainties.

Overall result:

OBJ-VLD-28-003	**Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.**	**POK**

4.2.4 OBJ-VLD-28-004 Controller Workload for routing and planning functions

For the Controller Workload for routing and planning functions the results are as follows:

CRT-VLD-28-004-001
Positive evaluation of the workload of Ground Controllers due to planning and routing functions

Nice	Budapest	Hamburg	Overall
POK	OK	-	POK

The criterion is rated to be POK because:

- At Nice, workload performance was generally OK but a few cases exist where the workload was negatively impacted by the routing issues encountered.

CRT-VLD-28-004-002 Positive evaluation of the workload of Runway Controllers due to planning and routing functions

Nice	Budapest	Hamburg	Overall
OK	OK	-	OK

The criterion is rated to be OK:

CRT-VLD-28-004-003 Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers

Nice	Budapest	Hamburg	Overall
POK	OK	-	OK

The criterion is rated to be OK because:

- At Nice, materialisation of VHF clearances was effective although minor exceptions were noted which arose mostly from system bugs and lack of HMI proficiency rather than functional limitations.

Overall result:

OBJ-VLD-28-004	**Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable.**	**POK**

The overall result is POK as some issues have been observed.

4.2.5 OBJ-VLD-28-005 Situational Awareness for routing and planning functions

For the Controller Workload for routing and planning functions the results are as follows:

CRT-VLD-28-005-001 Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	OK	POK	**POK**
The criterion is rated to be <u>POK</u> because: • At Nice, Situational Awareness was generally OK but a few cases exist where it was negatively impacted by the routing issues encountered. • There is a risk, that controller spent more time interacting with the HMI (was biased by shadow mode, as controllers tried to follow the decisions of real controllers)			

CRT-VLD-28-005-002 Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	N/A	**OK**
The criterion is rated to be <u>OK</u> because: • N/A HAM - Could not be addressed as only one RWY controller was available in Hamburg			

CRT-VLD-28-005-003 Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	OK	-	**OK**
The criterion is rated to be <u>OK</u> because: • At Nice, materialisation of VHF clearances was effective although minor exceptions were noted which arose mostly from system bugs and lack of HMI proficiency rather than functional limitations.			

<u>Overall result:</u>

OBJ-VLD-28-005	**Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.**	**POK**

The overall result is POK as some issues have been observed.

4.2.6 OBJ-VLD-28-006 CATC utility alerts

For the CATC utility alerts the results are as follows:

CRT-VLD-28-006-001 Positive evaluation of the utility of the CATC alerts functions when real surveillance data is used			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	-	**OK**
The criterion is rated to be OK:			

Overall result:

OBJ-VLD-28-006	Demonstrate the utility of CATC alerts functions.	OK

4.2.7 OBJ-VLD-28-007 CATC utility predictive mode

For the CATC utility predictive mode the results are as follows:

CRT-VLD-28-007-001 Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	-	**OK**
The criterion is rated to be OK:			

Overall result:

OBJ-VLD-28-007	Demonstrate the utility of CATC functions in predictive mode.	OK

4.2.8 OBJ-VLD-28-008 CATC usability

For the CATC usability the results are as follows:

CRT-VLD-28-008-001 Positive evaluation of the usability of CATC alerts functions			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	-	**OK**
The criterion is rated to be OK:			

CRT-VLD-28-008-002 Positive evaluation of the usability of CATC functions in predictive mode			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	OK	-	**OK**
The criterion is rated to be OK because: • At Nice, the usability of the predictive indicator was effective, although the data concerns a subset of controllers since they did not all observe the predictive indicator			

for all alerts due mainly to a lack of conflicting situations during their runs.

Overall result:

OBJ-VLD-28-008	**Demonstrate the usability of CATC function.**	**OK**

4.2.9 OBJ-VLD-28-009 CMAC utility

For the CMAC utility the results are as follows:

CRT-VLD-28-009-001 Positive evaluation of the utility of CMAC functions when real surveillance data is used			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	OK	POK	**POK**
The criterion is rated to be POK because: • At Nice, CMAC was generally OK, although exceptions were noted due mainly to parameterization and routing issues. • In Hamburg the function was rated positive by the controllers. However some special situations (special pushback procedures) caused some false alerts. Needs to be configured correctly with detailed procedures information available.			

Overall result:

OBJ-VLD-28-0009	**Demonstrate the utility of CMAC functions.**	**POK**

4.2.10 OBJ-VLD-28-010 CMAC usability

For the CMAC usability the results are as follows:

CRT-VLD-28-010-001 Positive evaluation of the audio alarm			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	N/A	-	**OK**
The criterion is rated to be OK because:			
• The audio alarm was not evaluated due to system limitations. This function is not used in Budapest.			
CRT-VLD-28-010-002 Positive evaluation of the level of alerts generated (information or alarm)			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	POK	-	**POK**
The criterion is rated to be POK because: • At Nice, the alert levels were generally satisfactory although an exception was noted in terms of the NO LND CLR alert which switches too rapidly from “information” to “alarm” level. • At Budapest, Information and Alarm level configuration was not in all cases followed			

the recommendation (Eurocontrol A-SMGCS Guideline document (Edition 01 March 2018)) and issues were reported due to alert prioritization.

CRT-VLD-28-010-003 Positive evaluation of the usability of CMAC alerts functions			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	OK	-	**OK**
The criterion is rated to be OK because: • At Nice, the usability was generally effective although minor cases where controllers misread the alert labels, interactions with the label could slow-down and overlapping labels hindered interactions, were encountered.			

Overall result:

OBJ-VLD-28-010	**Demonstrate the usability of CMAC functions.**	**OK**

The overall rating is set to OK, as only minor issues pertaining to the implementation and training with the system were encountered.

4.2.11OBJ-VLD-28-011 Safety with regards to integration of CMAC

For Safety with regards to integration of CMAC the results are as follows:

CRT-VLD-28-011-001 Positive evaluation that the safety is improved with the successful integration of CMAC for the GROUND controller			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	-	-	**POK**
The criterion is rated to be POK because: • Some issues reported with the routing function and certain design bugs (e.g. parking bugs or missing ID/labels for certain aircraft).			

CRT-VLD-28-011-002 Positive evaluation that the safety is improved with the successful integration of CMAC for the RUNWAY controller			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	-	-	**POK**
The criterion is rated to be POK: • The overall CMAC alert nuisance rate was low (2.8 per day) for the RWY controller. Nuisance RTE DEV alerts accounted for 65% of the occurrences.			

Overall result:

OBJ-VLD-28-011	**Demonstrate that safety with regards to Airport operations is improved with the successful integration of CMAC.**	**POK**

4.2.12 OBJ-VLD-28-012 Safety with regards to integration of CATC

For the Safety with regards to integration of CATC the results are as follows:

CRT-VLD-28-012-001 Positive evaluation that the safety is improved with the successful integration of CATC for the RUNWAY controller.			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	-	-	**OK**
The criterion is rated to be OK:			

Overall result:

OBJ-VLD-28-012	**Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC.**	**OK**

4.2.13 OBJ-VLD-28-013 CMAC controller workload

For CMAC controller workload the results are as follows:

CRT-VLD-28-013-001 Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable			
Nice	**Budapest**	**Hamburg**	**Overall**
NOK	POK	-	**POK**
The criterion is rated to be POK because: • At Nice, the workload was negatively impacted by un-justified CMAC alerts arising from routing issues, although controllers estimated the traffic as unexceptional.			

CRT-VLD-28-013-002 Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	-	**OK**
The criterion is rated to be OK:			

Overall result:

OBJ-VLD-28-013	**Demonstrate that the controller workload incurred due to integration of CMAC is acceptable.**	**POK**

4.2.14 OBJ-VLD-28-014 CATC controller workload

For the CATC controller workload the results are as follows:

CRT-VLD-28-014-001 Positive evaluation that the workload of RUNWAY controller due to the integration of CATC is acceptable			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	-	**OK**
The criterion is rated to be OK:			

Overall result:

OBJ-VLD-28-014	Demonstrate that the controller workload incurred due to integration of CATC is acceptable.	OK

4.2.15 OBJ-VLD-28-015 CMAC controller situational awareness

For the CMAC controller situational awareness the results are as follows:

CRT-VLD-28-015-001 Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved			
Nice	**Budapest**	**Hamburg**	**Overall**
NOK	Ok	POK	**POK**
The criterion is rated to be POK because: • At Nice, the situational awareness was negatively impacted by un-justified CMAC alerts arising from routing issues for the Ground Controller, • In Hamburg the handling of alerts on the HMI was considered time consuming. It is biased by the shadow mode and expected to have better results when the controller is in charge and the number of alerts are lower.			

CRT-VLD-28-015-002 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	N/A	**OK**
The criterion is rated to be OK: • Only one Runway controller in HAM – not applicable			

Overall result:

OBJ-VLD-28-015	Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC	POK

4.2.16 OBJ-VLD-28-016 CATC controller situational awareness

For the CATC controller situational awareness the results are as follows:

CRT-VLD-28-016-001 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved			
Nice	**Budapest**	**Hamburg**	**Overall**
OK	OK	-	**OK**
The criterion is rated to be OK:			

Overall result:

OBJ-VLD-28-016	Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC.	OK

4.2.17 OBJ-VLD-28-017 Integration of RMCA, CATC and CMAC

For the Integration of RMCA, CATC and CMAC the results are as follows:

CRT-VLD-28-017-001 Positive evaluation of the utility of the CATC and CMAC integrated with RMCA			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	N/A	-	**POK**
The criterion is rated to be POK because: • At Nice, RMCA occurrences observed in the demonstration were unjustified and as such can be considered to have only been partially integrated with other alerts.			
• This function was not demonstrated because RMCA alerts are not in operational use in Budapest			

CRT-VLD-28-017-002 Positive evaluation of the usability of the CATC and CMAC integrated with RMCA			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	N/A	-	**POK**
The criterion is rated to be POK because: • At Nice, RMCA occurrences observed in the demonstration were unjustified and as such can be considered to have only been partially integrated with other alerts. • This function was not demonstrated because RMCA alerts are not in operational use in Budapest			

CRT-VLD-28-017-003 Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts			
Nice	**Budapest**	**Hamburg**	**Overall**
POK	N/A	-	**POK**
The criterion is rated to be POK because: • At Nice, RMCA occurrences observed in the demonstration were unjustified and as such can be considered to have only been partially integrated with other alerts. • This function was not demonstrated because RMCA alerts are not in operational use in Budapest			

Overall result:

OBJ-VLD-28-017	**Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions.**	**POK**

4.2.18 OBJ-VLD-28-018 Utility of DMAN functions

For the Utility of DMAN functions the results are as follows:

CRT-VLD-28-018-001 Positive evaluation of the utility of the DMAN function supported by route planning			
Nice	**Budapest**	**Hamburg**	**Overall**
N/A	POK	N/A	**POK**

The criterion is rated to be POK because:

- At Nice, a DMAN baseline for comparison was not operational at the time of the demonstration.
- Generally, the function was positively evaluated in Budapest by the controllers but assumptions and limitations had impact on the result
- The function was tested, but it was not a main task for the participating Apron Controllers. Therefore, the results were set to N/A for Hamburg and not taken into account

Overall result:

OBJ-VLD-28-018	**Demonstrate the utility of DMAN functions supported by route planning.**	**POK**

4.2.19 OBJ-VLD-28-019 Usability of DMAN functions

For the Usability of DMAN functions the results are as follows:

CRT-VLD-28-019-001 Positive evaluation of the usability of the DMAN function supported by route planning			
Nice	**Budapest**	**Hamburg**	**Overall**
N/A	OK	-	**POK**

The criterion is rated to be OK because:

- At Nice, a DMAN baseline for comparison was not operational at the time of the demonstration.

Overall result:

OBJ-VLD-28-019	**Demonstrate the usability of DMAN functions supported by route planning.**	**POK**

Given that only 1 out of 3 exercises managed to appropriately demonstrate DMAN functionalities, the overall usability is POK as more data would be required to substantiate a global OK claim.

4.2.20 OBJ-VLD-28-020 Controller workload DMAN (supported by route planning)

For the Controller workload DMAN (supported by route planning) the results are as follows:

CRT-VLD-28-020-001
Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable

Nice	Budapest	Hamburg	Overall
N/A	N/A	-	N/A

The criterion is rated to be N/A because:

- At Nice, given the lack of a baseline DMAN for comparison, the workload incurred by the CLEARANCE DELIVERY controller due to its functions was not demonstrated,
- In Budapest the workload of the Clearance Delivery Controller was demonstrated together with the Ground Controller due to the use of combined jurisdiction

CRT-VLD-28-020-002
Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable

Nice	Budapest	Hamburg	Overall
N/A	OK	-	POK

The criterion is rated to be OK because:

- At Nice, given the lack of a baseline DMAN for comparison, the workload incurred by the GROUND controller due to its functions was not demonstrated,
- Although the results for Budapest indicate an OK, the overall result is rated as POK. Due to the general limitations with DMAN functions the POK indicates, that attention has to be paid for the implementation

CRT-VLD-28-020-003
Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable

Nice	Budapest	Hamburg	Overall
N/A	OK	-	POK

The criterion is rated to be POK because:

- At Nice, given the lack of a baseline DMAN for comparison, the workload incurred by the RUNWAY controller due to its functions was not demonstrated,
- Although the results for Budapest indicate an OK, the overall result is rated as POK. Due to the general limitations with DMAN functions the POK indicates, that attention has to be paid for the implementation

Overall result:

OBJ-VLD-28-020	**Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable.**	**POK**

4.2.21 OBJ-VLD-28-021 Situational awareness DMAN (supported by route planning)

For the Situational awareness DMAN (supported by route planning) the results are as follows:

CRT-VLD-28-021-001
Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved

Nice	Budapest	Hamburg	Overall
N/A	N/A	-	**N/A**

The criterion is rated to be POK because:

- At Nice, given the lack of a baseline DMAN for comparison, the SA incurred by the CLEARANCE DELIVERY controller due to its functions was not demonstrated
- The situational awareness of the Clearance Delivery Controller was demonstrated together with the Ground Controller due to the use of combined jurisdiction

CRT-VLD-28-021-002
Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved

Nice	Budapest	Hamburg	Overall
N/A	POK	NOK	**POK**

The criterion is rated to be POK because:

- At Nice, given the lack of a baseline DMAN for comparison, the SA incurred by the GROUND controller due to its functions was not demonstrated
- Improvement of the situational awareness was not proved; however, the level of situational awareness was acceptable for the participants in Budapest.
- It could not be demonstrated, that the situational awareness is improved. There is already pre-departure sequencing information available in the operational system in Hamburg.

CRT-VLD-28-021-003
Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved

Nice	Budapest	Hamburg	Overall
N/A	POK	N/A	**POK**

The criterion is rated to be POK because:

- At Nice, given the lack of a baseline DMAN for comparison, the SA incurred by the RUNWAY controller due to its functions was not demonstrated
- At Budapest degradation of situational awareness can mostly be attributed to the challenge of handling simultaneous actions on the limited size HMI
- In Hamburg only one TWR controller was available

Overall result:

OBJ-VLD-28-021	**Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved.**	**POK**

4.2.22 OBJ-VLD-28-022 Integration of routing and planning functions, airport Safety Nets and DMAN functions

For the Integration of routing and planning functions, airport Safety Nets and DMAN functions the results are as follows:

CRT-VLD-28-022-001 Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning			
Nice	**Budapest**	**Hamburg**	**Overall**
N/A	OK	POK	**POK**
The criterion is rated to be POK because: • At Nice, only a partial demonstration was achieved using the routing and safety nets solutions. A baseline DMAN for comparison was lacking. • For HAM the HMI plays an important factor on the acceptance. To give a full feedback, the system needs to be demonstrated in much more different situations (high traffic situation – different weather condition) over a longer period			

Overall result:

OBJ-VLD-28-022	**Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.**	**POK**

4.2.23 OBJ-VLD-28-023 ADS-B data analysis delivered to PJ03b-05

For the ADS-B data analysis the results are as follows:

CRT-VLD-28-023-001 Real ADS-B data successfully collected			
			Overall
			OK

CRT-VLD-28-023-002 ADS-B data analysis performed and report created			
			Overall
			OK

Overall result:

OBJ-VLD-28-023	**ADS-B data analysis delivered to PJ03b-05**	**OK**

4.2.24 OBJ-VLD-28-024 Routing and Planning Function non-nominal

For the Routing and Planning Function non-nominal the results are as follows:

CRT-VLD-28-024-001
Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operation in case of specific events (e.g. taxiway closure)

Nice	Budapest	Hamburg	Overall
POK	-	POK	POK

The criterion is rated to be POK because:

- At Nice, the calculated routes generally abided by operational needs but cases where a lack of conformance in non-nominal conditions were encountered.
- The system reacted quickly and correct in the given situation but more non nominal situations need to be demonstrated and other traffic demands might be relevant.

CRT-VLD-28-024-002
Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure)

Nice	Budapest	Hamburg	Overall
POK	-	POK	POK

The criterion is rated to be POK because:

- At Nice, the calculated routes were relevant except in cases where taxi direction was inverted by the system and non-nominal conditions lead to erroneous routing solutions, since those were not parameterised in the system.
- At Hamburg, routes in non-nominal situations where relevant, but the same issues as in nominal situations have been observed

Overall result:

OBJ-VLD-28-0024	**Demonstrate utility of routing and planning functions in non-nominal conditions.**	**POK**

4.3 Confidence in Results of Demonstration Exercises

4.3.1 Limitations and impact on the level of Significance

In summary all demonstration objectives and success criteria were addressed by the exercises and have a high level of significance ensured by expert review of controllers reported outcomes. However not all have been addressed at all airports and for some reliable results could only be obtained by one of the demonstrations sites.

Significance can be assured by the following:

- All exercises managed to integrate the SESAR solutions in an operational environment working with real live data
- It could be demonstrated, that the solutions are able to process traffic situation and flight plan information in real time and generate the expected output
- All exercises have been performed with local controllers and operational staff
- A significant number of controllers took part in the exercises. While in Nice and Budapest air traffic controllers where available, Hamburg had some limitations on the runway controller position. In contrast a high number of apron controllers evaluated the solutions from their perspective.
- For most cases the controller working positions were counterbalanced within each controller group (ground and runway positions),
- There was enough qualitative (Situation Awareness questionnaires) and quantitative (metrics, workload) data gathered during the demonstration, including multiple, unique data sources for corroborating information,
- Safety net experts and human factors specialists participated actively in the conduct of the demonstrations, in the analysis of the data and the consolidation of results and recommendations.
- All results have been obtained during typical days of operation, with all kind of aircraft types

Limitations

- In some cases participating ATCOs were not familiar with the environments at the beginning of the training sessions, and the limited time available for bringing controllers up to speed with electronic environment concepts as well as demonstration objectives adversely impacted the usage of more advanced function on the HMI
- While in some cases the traffic situation was very high and controllers had limited time to work with all functionalities (e.g. NCE) in other situations traffic was sometimes too low to evaluate the full impact of the solution with each of the controllers
- A number of operations haven't been included. Especially towing movement influence the routing and planning and need to be considered additionally.
- VFR operations haven't been considered in the planning as they were not associated to an IFR Flight Plan.
- Pushback where implemented based on standard procedures. Often controllers used specialised procedures causing deviations from the proposed plan
- Some solutions rely on extensive tuning and adaption. Especially the situation in HAM with the constantly changing layout, the period for tuning the algorithms was very short.

- Especially for the Hamburg Exercise a prototype HMI was used, providing only basic functions to demonstrate the solutions.
- The shadow-mode influenced results by adding a delay in the reaction-time of controllers (listen to clearances heard over radio) and some limitations on evaluating impact for the departure management.

4.3.2 Quality of Demonstration Exercises Results

As is the case with all demonstration exercises, only a very limited set of exercises could be performed, due to the limited duration of demonstration trial days and the availability of the supporting demonstration platform. This results in a limited set of observable traffic situations.

Regarding the quality of the results it can therefore be stated that the results are based on realistic demonstrations on a (passive-shadow mode) live systems in real airport environments with very experienced participants and hence the results can be considered to be of high quality from an operational point of view.

Data from multiple sources (Questionnaires, Metrics, Expert Feedback, ISA, SA) was used for answering each success criterion, as per experimental protocol and the data was collected mostly during relevant traffic periods of the day.

However, only a limited set of non-nominal conditions and a limited set of traffic situations could be observed by each participant and therefore the results cannot easily be generalized.

4.3.3 Significance of Demonstration Exercises Results

Statistical significance

- The solutions have been fully or partially demonstrated at the three airports of Nice, Budapest and Hamburg with different airport characteristics.
- With a total of 20 tower controllers and 13 apron controllers participating in the exercises (and additional controllers during training exercises) a significant number of participants has been realised. In addition all participants have been active controllers for the respective airports.
- Different scenarios and sessions have been used to cover the demonstration objectives over a period of at least one week or more during typical days of operation.
- Objectives and criteria have been streamlined between the exercises to allow consolidation of results for the evaluation of the solutions

Operational significance

- All exercises have been conducted in shadow mode. Instructions of the operational controller where available, to operate the demo systems according to the real traffic situation
- All systems have been connected to operational airport systems and worked with real live data
- Exercises have used the actual airport layout with published procedures

5 Conclusions and recommendations

5.1 Conclusions

General

- The exercises demonstrated, that Airport layout and characteristics are an important factor for the applicability of the solution
- In general, the shadow-mode protocol used for demonstrating solutions influenced results by adding a delay in the reaction-time of controllers when materialising clearances heard over radio. The impact concerned primarily routing performance and by extension, safety net performances,
- The exercises confirmed that implementation approach and SUT maturity have a strong influence on the results.
- The VLD covered different types of system implementations (Industry product, Advanced Demonstration platform, Prototype implementation)

Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing.

Routing and planning utility

- Currently, routing by controllers is performed based on common-practice rather than standard routes. As such, all possible routing solutions are not known and therefore certain routes are not proposed by the system.
- Shortest route approach is not the most relevant for route proposals. Optimisation criteria are not general and need to be adapted to each airport. Flexibility is sometimes more important than Efficiency (related to minimizing taxi times).
- Runway entry and exit points are a significant part of the route proposal. These points were sometimes miscalculated as live operations differed. Actual used points are sometimes available at a very late stage, which is not helpful for pre-planning.
- Route planning dependent on the correct pushback procedure (heading of aircraft after PB) -> route proposals need to be changed based on late information on operational situation.
- Towing operations need to be taken into account for the overall planning.
- Some complex procedure rules based on airport layouts need to be covered (e.g. stand procedures dependent on aircraft size or complex pushback procedures depended on nearby stand usage).
- Route planning faces additional challenges, when different institutions are responsible for the ground operations with different criteria (e.g. HAM – runway crossing can deviate from defined standard procedures when better due to planned parking position; needs to be directly coordinated between the two responsible controllers).
- There is a wide variety of non-nominal conditions which need to be parametrized in the system to allow the proposition of appropriate routing solutions. However, such conditions occur irregularly and as such, require extensive observations to be captured.

Route modification

Routes undergoing modifications were represented satisfactorily to controllers. However, the performance of route modifications was sometimes impacted negatively by several factors:

- The shadow-mode protocol led to a much higher number of route modifications than would normally be practiced during live operations,
- Controllers had individual routing preferences which were not always proposed by the system, thereby leading to erroneous or non-optimal routing propositions,
- The familiarisation of controllers with manual route modifications was a longer process than expected, and
- Controllers did not have a use for modifying routes outside their AOR, as per their current working methods.
- Shadow mode had a significant impact on evaluation as number of modifications are expected to be lower in live operation
- Sufficient training and familiarisation is an important factor and was limited in some exercises.

Accuracy of A-SMGC Taxi times

The taxi-time estimations were NOK in 2 out of 3 exercises due to local complexity variables which were not integrated in the estimates:

- Delays due to runway crossings in the case of parallel dependent runway configurations or with the crossing runway system,
- Pushback procedures as part of the taxi process are an important factor and are highly dependent on aircraft type and airline procedures. A much more detailed model of this process (including a high number of specifics) would be needed to get more accurate results.
- Taxi times are highly variable.
- As controllers very often have personal preferences a general implementation is challenging.
- Shadow mode had a impact on evaluation as number of route modifications are expected to be reduced when controller work live.

Controller Workload and Situational Awareness

- Workload and SA was satisfactorily demonstrated
- Some concerns are related to the number of route modifications necessary – this is highly dependent on the proposed routing proposals
- Results have been influenced by the shadow mode setup. This can be relaxed, as it is expected, that this is not relevant in full operation

Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.

CATC and CMAC utility:

- In general the utility of CATC has been demonstrated positively
- The utility of CMAC has been partially demonstrated due to a number of nuisance alerts triggered by parametrization and routing issues

- The predictive mode was positively demonstrated
- Not all alerts have been demonstrated during the sessions

CATC and CMAC usability:

- In general, the usability of CATC and CMAC has been demonstrated positively Usability highly dependent on HMI implementation.
- The audio alarm was rated positively when implemented
- Alert prioritisation needs to be handled in case of multiple alerts at the same time

Controller Workload

- Workload was satisfactorily demonstrated
- Some concerns are related to the number of route modifications necessary – this is highly dependent on the maturity of the system to propose commonly practiced routing solutions,

Controller Situational Awareness

- Situational Awareness was satisfactorily demonstrated for Runway Controllers
- Integration of the CMAC for the Ground Controller has been rated differently between exercises. Some issues have been experienced with un-justified alerts resulting from the routing function.
- In specific exercises, alerts have been generated by the system based on special pushback procedures (not implemented in the system) causing distractions
- Shadow mode setup has an influence, as controller worked based on the real controller decision.

Effectiveness of integrating RMCA with CATC and CMAC

- RMCA were only observed in the NCE demonstration and have been qualified as unjustified occurrences. As such, their integration with CATC and CMAC can be considered to have only been partially demonstrated.

Solution #53 — Pre-Departure Sequencing supported by Route Planning

The NCE baseline DMAN was not operational at the time of the demonstration and DMAN results have been excluded from the conclusions.

Exercise experienced very different experiences and results for the integration. There are some general experiences from the exercises, but no overall conclusion is possible.

- Exercises managed to integrate the DMAN functions with the usage of real live data
- While Budapest has good results with improvements over the actual system, Hamburg could not demonstrate the expected benefits
- The improvement of the pre-departure sequence based on improved taxi times could not been demonstrated for Hamburg. This also relates to the results from the accurate taxi time calculation, which are also not demonstrated in Hamburg (crossing runway operations)
- Due to the shadow mode trials controllers stick to the real sequence, instead of operating based on the calculated Start-Up sequence; no demonstration of the improvements due to the DMAN function possible.

- It was observed, that the used static taxi time matrices are already very good for the pre-departure sequencing task.
- A couple of HMI related issues to the DMAN functions have been observed
- Conceptual issues have been observed, by not updating TTOT after Off-Block. Due to uncertainties in the Pushback procedures. Much better results are observed by updating TTOT after taxi-clearance

PJ.03b-05 – Traffic Alerts for Pilots for Airport Operations

WP3 analysis of causes of long update intervals (gaps) showed the overwhelming majority was caused by RF shielding by airport buildings and hills, and a small minority was caused by RF shielding by traffic or could have been caused by multipath issues. Airports in Zurich, Istanbul (LTBA), and London Heathrow accounted for 83.9% of all detected long gaps, and each of these airports accounted for a higher portion of long gaps than its portion of ownship operations and than its portion of traffic operations. The large majority of the long gaps found in Zurich was caused by RF shielding by airport buildings and hills; the long gaps relevant for runway alerting were for the most part for ownship in one runway and traffic in a non-intersecting and non-parallel runway, to a lesser extent, in an intersecting runway and, even less so, in the same runway. The large majority of the long gaps in Istanbul was caused by RF shielding by an airport building; the long gaps relevant for runway alerting were for the most part for ownship in one runway and traffic in a non-intersecting non-parallel runway and, to a lesser extent, in the same runway; the long gaps in the same runway were often caused by another shielding traffic between the ownship and the traffic while the runway was used as a taxiway. All except two long gaps in London Heathrow were caused by RF shielding by an airport building; the long gaps relevant for runway alerting were for ownship in one runway and traffic in a parallel runway.

In general, the shielding of RF signals on or near the airport surface may result in reduced benefit for some ADS-B In applications used on the airport surface, such as SURF IA: the RF shielding may lead to missed alerts, including delayed alerts. The RF shielding seems unlikely to result in nuisance alerts.

Analysis of impact on potential missed alerts of update intervals over 25 s, and of those over 6 s for traffics with ground speed over 40 kt disclosed only one occurrence with an impact, for 2575 ownship operations.

5.2 Recommendations

5.2.1 Recommendations for industrialization and deployment

General to all solutions

(RECOM-VLD-28-001) A couple of situations have been observed, that should be included and covered in the deployment process
- Avoid the usage of same call signs for departures and arrivals or for multiple flights at the day
- Make sure that all operations are with transponder operating. Operations without or with transponder switched on too late cause incorrect results for the solutions
- Cover special situation of Return to stand manoeuvres or aircraft aborting

Take-off and lining up again without returning to a stand
- Make sure that towing operations are defined the same way as normal flights (starting position, end position, timings, aircraft information …)
- Cover Low approaches without detailed information (DMAN)

(RECOM-VLD-28-002) Implement a master data management strategy for airport related data like airport layout, stands, operational constraints, performance data

Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing

From the Contextual note the following recommendations have been confirmed:

- The efficiency of the CWP with integrated functionalities can be considered as critical for the acceptability of Solution #22 by controllers,
- The working methods of controllers need to be adapted if needed
- Controller training on the new working methods is an essential part and should be planned accordingly,
- Local operations and procedures need to be considered in order to adapt the route generation algorithm to local needs and thus to improve the efficiency and the support to controllers.

(RECOM-VLD-28-003) Push-Back procedures have been critical for the solutions and should be implemented into the algorithms according to the operational needs and best practices used by the controllers.

(RECOM-VLD-28-004) Improve the robustness and completeness of routing functionalities by integrating:
- Airport static information, such as Airport layout, Stands, Standard routes, Restrictions)
- Local operations and procedures such as Push back procedures, Towing manoeuvres, De-icing procedures
- Controllers' working procedures

(RECOM-VLD-28-005) Integrate dynamic information on temporary restrictions on usable parts of the airport like construction areas or closed structures (NOTAMS)

(RECOM-VLD-28-006) The criteria for the route proposal algorithm need to be carefully defined to reduce manual modifications

(RECOM-VLD-28-007) Integrate a functionality for selecting runway entries

(RECOM-VLD-28-008) In case of different institutions integrate operational agreements and procedures into the algorithms

Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances

From the Contextual note the following recommendations have been confirmed:

- Only the relevant alerts for the airport should be implemented as some of the alerts might not be used. When the full set is needed, a progressive approach should be taken, implementing a set of the most important ones and extend step by step

- The benefit in human performance strongly relies on the Human Machine Interface usability (HMI).

(RECOM-VLD-28-009) The airport surveillance system is the key for some the Safety Net functions as most of them rely on accurate data. Consider data accuracy of positional data and integrate data from different sources with varying availability and accuracy. Combination and cross-verification from multiple sources can increase the confidence level.

(RECOM-VLD-28-010) Identify areas with possible reduced accuracy and impact to safety net function (Proximity of buildings (e.g. for Pushback procedure), Complex taxi hotspots (e.g. for route deviations)

(RECOM-VLD-28-011) Consider the tuning and parameterization of relevant alert parameters as very important and challenging and specific to each implementation (Triggers, Length, Activation and end time, prioritisation

(RECOM-VLD-28-012) Ensure that the handling of the alerts is acceptable in terms of workload, situational awareness and safety

(RECOM-VLD-28-013) Some of the Safety Net functions are based on the accuracy of the surveillance system. Currently there are different values defined for specific areas on the airport for A-SMGCS systems. The reported position accuracy requirements (RPA) for runways (12m), for taxiways and stand taxi lanes (20m) and for stands (25 m) should be checked if suitable for the Safety Net solutions. Route deviation functions or alerts regarding clearances (PB, Taxi) should take into account these values for tuning and triggering alerts.

Solution #53 — Pre-Departure Sequencing supported by Route Planning

(RECOM-VLD-28-014) The effectiveness of dynamic taxi times (compared to statistical times) should be established for each airport individually.

(RECOM-VLD-28-015) There are a high number of uncertainties in daily operations that are hardly to be completely reflected by algorithms and can negative impact on the taxi time calculations (some based on airport layout constraints). Consider if there are possibilities to reduce the uncertainties (additional solutions)

(RECOM-VLD-28-016) An adapted experimental protocol should be elicited as a means of enabling the demonstration of pre-departure sequencing function (DMAN).

PJ.03b-05 – Traffic Alerts for Pilots for Airport Operations

(RECOM-VLD-28-017) From industrialization and deployment and regulation and standardisation perspectives it is recommended to collect data also form non-Europe environment. Collecting of such data and its analysis is of significant benefit to upcoming demonstration and deployment of the SURF A system. This complementary collection campaign is to mitigate the risk that the PJ03B-05 solution does not work under some specific operational conditions in other regions of the world. In parallel with preparing a large demonstration in the European environment, it is recommended to monitor the global interoperability risk which was not addressed in PJ03B and should not be addressed in the VLD either due to the focus on European airlines short range carriers.

(RECOM-VLD-28-018) If issues were detected early enough, the implementation could embark mitigation strategies in the certified solution so as to ensure that future long range carriers implementing the SESAR solution can operate internationally.

(RECOM-VLD-28-019) If this additional collection campaign was not performed, or delayed, the PJ03B-05 solution would still be validated for use in the European environment. It is not on the critical path of VLD or deployment, however, it is considered that addressing the global interoperability risk too late could result in a significant industrial cost, probably preventing corrections at a late stage, and thus limiting adoption of the SESAR solution in other regions of the world.

5.2.2 Recommendations on regulation and standardisation initiatives

(RECOM-VLD-28-020) The provision of up-to-date and standardised layout (ASRN) data and related information as a means of enabling the effectiveness of routing solutions and, by extension, safety net and DMAN solutions is essential. Therefore standardized exchange formats developed should be used.

(RECOM-VLD-28-021) For long term changes, such as the opening of a new runway or taxiway or the definitive closure thereof, the AIRAC cycle could provide an effective means of triggering the dissemination of up to date airport layout information.

(RECOM-VLD-28-022) As for middle /short term changes, such as planned runway or taxiway closures or restrictions, the integration of NOTAM information could be useful. Defined formats like AIXM [48] or AMXM [49] can handle actual information about the airport situation, including digital NOTAMS.

(RECOM-VLD-28-023) The HMI should provide a means to dynamically modify the available layout (real-time closures, including runways, taxiways and apron stands) to adapt to the live airport environment.

(RECOM-VLD-28-024) Required accuracy values for A-SMGCS need to be defined in the standardisation documents related to the safety net functions.

5.2.3 Recommendations for updating ATM Master Plan Level 2

N/A

6 Summary of Communications and Dissemination activities

6.1 Summary of communications and dissemination activities

The success of the project's communication and dissemination activities is summarised in Table 6-1. As qualitative criteria, an overview of the generated dissemination material is listed together with quantitative measures as defined in the DEMO plan in the following table. A detailed list of dissemination material is given in Appendix J.

The intensity of the dissemination and communications activities was linked to the phases of the project and increased over the project duration with every trial and demonstration that took place. The publication of project results is still an on-going task. Especially scientific results are under evaluation and will be published after official end of the project.

To be conform to the new European GDPR, recorded web site statistics for the IAO website have been limited as far as possible and anonymised. Instead of where the audience comes from, only the audience's language settings have been recorded. There are no statistics available for the project site on the SESAR website.

In addition to the table below, all partners published information about project activities and project events in their social media channels like twitter, Facebook or LinkedIn throughout the project.

Communication channel	Qualitative achievements	Quantitative achievements
Project website	• IAO Website prepared with news blog and updates on project activities on a regular basis	• About 7300 page views and 5200 page visits (i.e. session of at most 30min) on the IAO project website since 01/2018 • Language settings: 56% German, 21% English, 5% Spanish, 5% French, 2% Norwegian
Videos	• Summary / overall video • Videos about Hamburg, Nice, and Budapest trials • Sat1 regional TV channel report about Open Days at Hamburg Airport	• Four videos including one overall video have been produced within the IAO project. All have been presented at the IAO Open Day. The Overall video is available at the SESAR Youtube channel. With Sat1 a German regional TV channel produced an additional video as report about the Open Day.
Demonstration events	• IAO Open Day at Hamburg Airport • Budapest HungaroControl Remote Tower Facility	• About 90 participants • About 30 participants
Publications	• Scientific Articles • Project Flyers	• 1 (+ X under preparation) • 2

	• Article in SESAR Newsletter • Partners Magazines / Newsletter • External general press publications	• 1 • 13 • 14
Presentations at relevant ATM stakeholder forums, SESAR demonstration events or seminars	• WAC 2018, SESAR Walking Tour, Madrid • XIV. ANNUAL MEETINGS OF AIR CARRIERS AND AVIATION COMMUNITY, Prague, Czech Republic • ACI EUROPE's Technical, Operations and Safety Committee presented by SJU (based on partner presentations from DemoDay) • IAO Open Day at Budapest • IAO Demo Day at Hamburg	10 presentations

Table 6-1: Communication and Dissemination Success Criteria

6.2 Target Audience Identification

Successful communication requires the adaption of information to the respective audience. Amongst others, this concerns aspects like complexity, amount of detail, assumed pre-recognition, focus point, etc. Figure 6-1 depicts important audience groups for PJ28 IAO arranged according to their significance as well as the targeted amount of necessary information and level of detail:

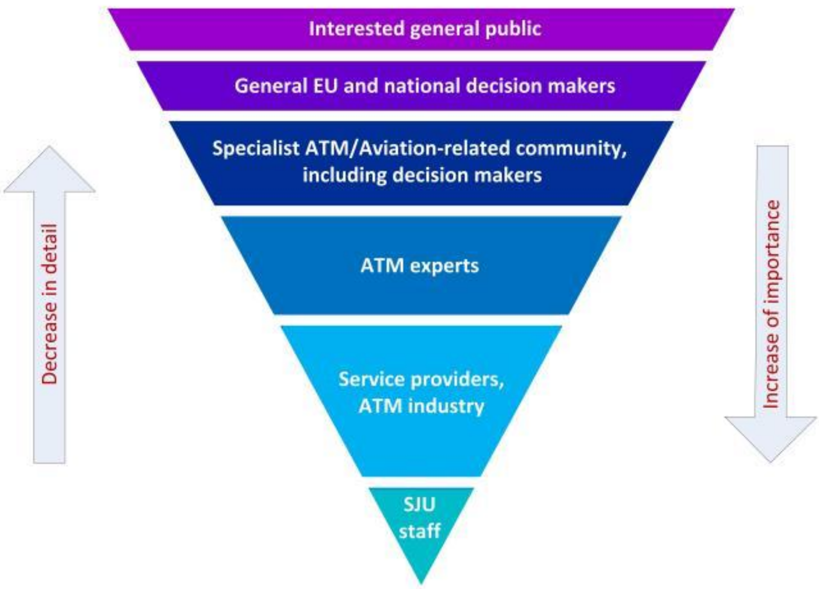


Figure 6-1: Audience targeted by IAO

For the IAO project targeted audiences have been in detail:

- Staff of the SESAR Joint Undertaking
- Airport operators (especially those targeted by the PCP, but also all interested others)
- Airspace users
- Air navigation service providers
- ATM industry partners
- ATM industry associations and their members
- Aircraft industry
- ATM experts from research and industry
- Broader European R&D community
- Aviation-related community, including decision makers
- Institutional decision-makers (EU, national, international)
- General interested public

The three High-level messages identified in section 6.3 are conveyed to all of the above listed audiences. Detailed information on the cross correlation between the audience and the dissemination activities please see Table 6-2.

The following table connects the dissemination activities, the targeted audience and the solutions under the scope of the demonstration project:

Dissemination Activity	Targeted Audience	Approach	Connected solution
Videos	All audiences identified in Figure 6-1	Presented at Open Day and publicly available through Youtube channels to boost the project's achievements and highlight the readiness for deployment of the functionalities developed in SESAR 1.	Sol. #22 Sol. #53 Sol. #02
Airport Demonstration events	ATM stake-holders/ industry, decision makers at local, national and European levels	Participation at demo events did provide confidence in the presented solutions and in their readiness for real life operations	Sol. #22 Sol. #53 Sol. #02
IAO Project website and SESAR project specific website	All audiences identified in Figure 6-1	Websites provided basic information on IAO together with current project news, event announcements and videos	Sol. #22 Sol. #53 Sol. #02
Factsheets, flyers and other communications material	ATM stake-holders/ industry, Aviation-related community, general interested public	Provided basic information on IAO and thus rose awareness of the project	Sol. #22 Sol. #53 Sol. #02

Press release	All audiences identified in Figure 6-1	Informed about the project and its events	Sol. #22 Sol. #53 Sol. #02
Social media	All audiences identified in Figure 6-1	Rose awareness of IAO and informed about project events	Sol. #22 Sol. #53 Sol. #02
Articles in written media	ATM stake-holders/ industry, ATM experts, Aviation-related community, SJU staff	Raise awareness and inform about IAO as well as promote its demonstrated solutions	Sol. #22 Sol. #53 Sol. #02
Presentations and paper at relevant ATM forums	ATM stake-holders/ industry, ATM experts, Aviation-related community, SJU staff	Inform about IAO and promote its demonstrated solutions	Sol. #22 Sol. #53 Sol. #02

Table 6-2: Cross correlation between the audience and the solutions

6.3 Project High Level Messages

The key massages for IAO are based on the specific messages about SESAR 2020 and underpin their statements. The additional tagline aims at the goal of VLDs to prove operational readiness and to ease deployment.

IAO Tagline ***"Seeing is believing"***

Message 1: *As very large-scale demonstration with three airport demonstrations across Europe, the project IAO advances the deployment of SESAR solutions by proving their readiness for day-to-day operations.*

Message 2: *The solutions for integrated airport operations, demonstrated in IAO enable more efficient and safe airport operations*

Message 3: *With its three demonstrations of new developments in the area of taxi guidance and planning as well as safety nets, IAO is showing the way forward regarding integrated Airport Operations.*

7 References

Content Integration

[25] Eurocontrol ATM Lexicon - SESAR Integrated Dictionary (https://ext.eurocontrol.int/lexicon/index.php/SESAR)

Communication and dissemination

[26] SESAR 2020 Communication Guidelines 07.00.00, 14/01/2019

System and Service Development

[27] MOPS Version Two is RTCA DO-260B

Safety

[28] SESAR, Safety Reference Material, Edition 4.0, April 2016

[29] SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016

[30] SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015

[31] SESAR, Resilience Engineering Guidance, May 2016

Human Performance

[32] HP Assessment Process from V1 to V3 (16.06.05 D27 - 00 01 00 -HP Assessment Process for V1 to V3.xlsx)

[33] PJ28 HP Assessment Plan (PJ28_HP-Assessment_Plan_00_01_00 (1_0).docx)

[34] PJ28 Demonstration Plan (PJ28_D1_1_Demo_Plan_03_00_00), Annex C

Programme management

For what concerns the general collaboration between all the members of the programme:

[35] SESAR 2020 Membership Agreement, 06/07/2016

[36] SESAR 2020 Programme Management Plan, edition 01.00.00, TBD

For what concerns the specific scope of work covered by this project and the general way of working expected from all projects in the SESAR 2020 programme:

[37] 731787 PJ28 IAO Grant Agreement, [19/02/2019]

[38] SESAR 2020 Project Handbook, edition 01.00.00, [27/04/2017]

[39] SESAR 2020 Integrated Planning Guidelines, edition01.00.00, 16/12/2016

[40] SESAR 2020 Programme RIO Guidance, edition01.00.00, 13/12/2017

Ethics

[41] D8.1 H - Requirement No. 1, edition 01.00.00, 30/04/2017

[42] D8.2 POPD - Requirement No. 2, edition 01.00.00, 30/04/2017

[43] D8.3 EPQ - Requirement No. 3, edition 01.00.00, 30/04/2017

[44] D8.4 M - Requirement No. 4, edition 01.00.00, 30/04/2017

Maturity Assessment

[45] Maturity Gate Guidance

7.1 Reference Documents

[46] ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[3]

[47] Transition Plan at Budapest Airport: "HUNGAROCONTROL MAGYAR LÉGIFORGALMI SZOLGÁLAT ZÁRTKÖRŰEN MŰKÖDŐ RÉSZVÉNYTÁRSASÁG SZABÁLYZATA A LÉGIFORGALMI SZOLGÁLTATÁS cTWR MUNKATEREMBŐL TÖRTÉNŐ ELLÁTÁSÁRA VALÓ ÁTÁLLÁSRÓL"

[48] Aeronautical Information Exchange Model - AIXM, http://www.aixm.aero/

[49] Aerodrome Mapping Exchange Model - AMXM, http://www.amxm.aero/

[3] The EUROCAE ED-78A has been used as an initial guidance material. ED-78A is useful, but is not an applicable document, because it mostly addresses the V4-V5 phases, whilst the SESAR R&D programme is focussed on development (V1-V2-V3, and because of its partial compliance with safety regulatory requirements).

Appendix A Demonstration Exercise #01 (LFMN)

A1 Summary of the Demonstration Exercise #01 Plan

As in PJ28_D1_1_Demo_Plan_03_00_00.

A1.1 Exercise description and scope

A1.1.1 Operational Scope

The demonstration exercise at Nice Airport was planned for April 2019. This Very Large Demonstration addresses solutions relative to airport safety nets, routing and planning functions. These concepts were demonstrated in a passive shadow mode exercise on the eDEP platform.

The main actors impacted are the Tower Controllers: Clearance delivery, Ground and Runway. Clearance delivery and Ground position were regrouped.

A1.1.2 Key Demonstration Objectives and Scenarios

The Nice VLD Exercise demonstrates the following solutions:

- Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.

  Two support services were addressed during the VLD, i.e. Conflicting ATC Clearances (CATC) and Conformance Monitoring Alerts for Controllers (CMAC).

  Conformance Monitoring Alerts consist of the detection of non-conformances to ATC instructions and/or procedures by aircraft and following alerts, as for instance aircraft following unauthorised routes or landing on the wrong runway. The function uses surveillance data and data filled by the controllers regarding clearances and/or routes given to aircraft.

  Conflicting ATC Clearances alerts are another part of the Airport Safety Nets for controllers. It consists of detecting and alerting about inconsistencies or contradictory clearances given to different aircraft by the controller on the CWP, as for instance Take-Off vs. Landing clearances given on crossing runways. The necessity for the runway controller to fill the system is essential for the correct functioning of the CATC system.

  In line with SESAR1 Solution#02 recommendations, only the most relevant alerts to the local operational context were selected as the full set of alerts described in this solution was not required. Furthermore, SESAR1 recommends a progressive approach, starting with a limited set of alerts.

- Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing.

  A-SMGCS Routing and Planning service function focuses on the route generation integrated with planning information.

The generation of the route considers the rules of circulation, the parking of the aircraft and some specific events as for example a taxiway closed; in this case the planned route bypasses the taxiway.

Once the planned route is made available by the system, controllers update the system with all clearances given over radio to aircraft. The updating of the system is crucial as it allows the Safety Nets functionalities to work as expected.

- Solution #53 — Pre-Departure Sequencing supported by Route Planning

  The main demonstration objective is Integrated Surface Management using A-SMGCS planning function integrated with DMAN.

A1.1.3 Demonstration Technique and Platform

It was approached as a passive shadow-mode experiment.

Although controllers have received data and heard the radio frequencies from the real operational room, their own actions were not transmitted back, and therefore had no incidence on the normal work operations. The main objective of the VLD was to demonstrate the feasibility of the PCP operational deployment at Nice.

This demonstration platform builds on experience in SESAR1. However, this platform was significantly modified to consider the needs for the demonstration (e.g. implementation of Nice layout and connection of DMAN).

A1.2 Summary of Demonstration Exercise #01 Demonstration Objectives and success criteria

Demonstration Objective	Demonstration Success criteria	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise 1 Objectives	Demonstration Exercise 1 Success criteria
OBJ-VLD-28-001	CRT-VLD-28-001-001	Fully covered	EX1-OBJ-VLD-28-001 Demonstrate the utility of routing and planning functions	EX1-CRT-VLD-28-001-001 Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.
	CRT-VLD-28-001-002	Fully covered		EX1-CRT-VLD-28-001-002 Positive evaluation of the calculated routes' relevance

OBJ-VLD-28-002	CRT-VLD-28-002-001	Fully covered	EX1-OBJ-VLD-28-002 Demonstrate the utility and usability of route modification capabilities.	EX1-CRT-VLD-28-002-001 Positive evaluation of route modification capabilities when real surveillance data is used.
	CRT-VLD-28-002-002	Fully covered		EX1-CRT-VLD-28-002-002 Positive evaluation route modifications outside of controllers' Areas Of Responsibility (AOR)
	CRT-VLD-28-002-003	Fully covered		EX1-CRT-VLD-28-002-003 Positive evaluation of the routes' representation (e.g. different status)
OBJ-VLD-28-003	CRT-VLD-28-003-001	Fully covered	EX1-OBJ-VLD-28-003 Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	EX1-CRT-VLD-28-003-001 Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.
OBJ-VLD-28-004	CRT-VLD-28-004-001	Fully covered	EX1-OBJ-VLD-28-004 Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable	EX1-CRT-VLD-28-004-001 Positive evaluation of the workload of Ground Controllers due to planning and routing functions.
	CRT-VLD-28-004-002	Fully covered		EX1-CRT-VLD-28-004-002 Positive evaluation of the workload of Runway Controllers due to planning and routing functions.
	CRT-VLD-28-004-003	Fully covered		EX1-CRT-VLD-28-004-003

				Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.
OBJ-VLD-28-005	CRT-VLD-28-005-001	Fully covered	EX1-OBJ-VLD-28-005 Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	EX1-CRT-VLD-28-005-001 Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.
	CRT-VLD-28-005-002	Fully covered		EX1-CRT-VLD-28-005-002 Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.
	CRT-VLD-28-005-003	Fully covered		EX1-CRT-VLD-28-005-003 Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.
OBJ-VLD-28-006	CRT-VLD-28-006-001	Fully covered	EX1-OBJ-VLD-28-006 Demonstrate the utility of CATC alerts functions	EX1-CRT-VLD-28-006-001 Positive evaluation of the utility of the CATC alerts functions when real surveillance data is used.
OBJ-VLD-28-007	CRT-VLD-28-007-001	Fully covered	EX1-OBJ-VLD-28-007 Demonstrate the utility of CATC functions in	EX1-CRT-VLD-28-007-001 Positive evaluation of the utility of CATC

			predictive mode	functions in predictive mode when real surveillance data is used.
OBJ-VLD-28-008	CRT-VLD-28-008-001	Fully covered	EX1-OBJ-VLD-28-008 Demonstrate the usability of CATC functions	EX1-CRT-VLD-28-008-001 Positive evaluation of the usability of CATC alerts functions
	CRT-VLD-28-008-002	Fully covered		EX1-CRT-VLD-28-008-002 Positive evaluation of the usability of CATC functions in predictive mode
OBJ-VLD-28-009	CRT-VLD-28-009-001	Fully covered	EX1-OBJ-VLD-28-009 Demonstrate the utility of CMAC functions	EX1-CRT-VLD-28-009-001 Positive evaluation of the utility of CMAC functions when real surveillance data is used.
OBJ-VLD-28-010	CRT-VLD-28-010-001	Fully covered	EX1-OBJ-VLD-28-010 Demonstrate the usability of CMAC functions	EX1-CRT-VLD-28-010-001 Positive evaluation of the audio alarm
	CRT-VLD-28-010-002	Fully covered		EX1-CRT-VLD-28-010-002 Positive evaluation of the level of alerts generated (information or alarm)
	CRT-VLD-28-010-003	Fully covered		EX1-CRT-VLD-28-010-003 Positive evaluation of the usability of CMAC alerts functions
OBJ-VLD-28-011	CRT-VLD-28-011-001	Fully covered	EX1-OBJ-VLD-28-011 Demonstrate that safety with regards to Airport operations is improved with the successful	EX1-CRT-VLD-28-011-001 Positive evaluation that the safety is improved with the successful integration of CMAC

			integration of CMAC e	for the GROUND controller
	CRT-VLD-28-011-002	Fully covered		EX1-CRT-VLD-28-011-002 Positive evaluation that the safety is improved with the successful integration of CMAC for the RUNWAY controller
OBJ-VLD-28-012	CRT-VLD-28-012-001	Fully covered	EX1-OBJ-VLD-28-012 Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC	EX1-CRT-VLD-28-012-001 Positive evaluation that the safety is improved with the successful integration of CATC for the RUNWAY controller
OBJ-VLD-28-013	CRT-VLD-28-013-001	Fully covered	EX1-OBJ-VLD-28-013 Demonstrate that the controller workload incurred due to integration of CMAC is acceptable	EX1-CRT-VLD-28-013-001 Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable
	CRT-VLD-28-013-002	Fully covered		EX1-CRT-VLD-28-013-002 Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable
OBJ-VLD-28-014	CRT-VLD-28-014-001	Fully covered	EX1-OBJ-VLD-28-014 Demonstrate that the controller workload incurred due to integration of CATC is acceptable	EX1-CRT-VLD-28-014-001 Positive evaluation that the workload of RUNWAY controller due to the integration of CATC is acceptable
OBJ-VLD-28-015	CRT-VLD-28-015-001	Fully covered	EX1-OBJ-VLD-28-015 Demonstrate that the Situational Awareness of controllers is	EX1-CRT-VLD-28-015-001 Positive evaluation that the situational awareness of

			improved with the integration of CMAC	Ground controllers due to the integration of CMAC is improved
	CRT-VLD-28-015-002	Fully covered		EX1-CRT-VLD-28-015-002 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved
OBJ-VLD-28-016	CRT-VLD-28-016-001	Fully covered	EX1-OBJ-VLD-28-016 Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC	EX1-CRT-VLD-28-016-001 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved
OBJ-VLD-28-017	CRT-VLD-28-017-001	Fully covered	EX1-OBJ-VLD-28-017 Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions	EX1-CRT-VLD-28-017-001 Positive evaluation of the utility of the CATC and CMAC integrated with RMCA
	CRT-VLD-28-017-002	Fully covered		EX1-CRT-VLD-28-017-002 Positive evaluation of the usability of the CATC and CMAC integrated with RMCA
	CRT-VLD-28-017-003	Fully covered		EX1-CRT-VLD-28-017-003 Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts
OBJ-VLD-28-018	CRT-VLD-28-018-001	Fully covered	EX1-OBJ-VLD-28-018 Demonstrate the utility of DMAN functions supported by route planning	EX1-CRT-VLD-28-018-001 Positive evaluation of the utility of the DMAN function supported by route

				planning
OBJ-VLD-28-019	CRT-VLD-28-019-001	Fully covered	EX1-OBJ-VLD-28-019 Demonstrate the usability of DMAN functions supported by route planning	EX1-CRT-VLD-28-019-001 Positive evaluation of the usability of the DMAN function supported by route planning
OBJ-VLD-28-020	CRT-VLD-28-020-001	Fully covered	EX1-OBJ-VLD-28-020 Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable	EX1-CRT-VLD-28-020-001 Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable
	CRT-VLD-28-020-002	Fully covered		EX1-CRT-VLD-28-020-002 Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable
	CRT-VLD-28-020-003	Fully covered		EX1-CRT-VLD-28-020-003 Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable
OBJ-VLD-28-021	CRT-VLD-28-021-001	Fully covered	EX1-OBJ-VLD-28-021 Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved	EX1-CRT-VLD-28-021-001 Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved
	CRT-VLD-28-021-002	Fully covered		EX1-CRT-VLD-28-021-002

				Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved
	CRT-VLD-28-021-003	Fully covered		EX1-CRT-VLD-28-021-003 Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved
OBJ-VLD-28-022	CRT-VLD-28-022-001	Fully covered	EX1-OBJ-VLD-28-022 Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning	EX1-CRT-VLD-28-022-001 Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning
OBJ-VLD-28-024	CRT-VLD-28-024-001	Fully covered	EX1-OBJ-VLD-28-024 Demonstrate utility of routing and planning functions in non-nominal conditions.	EXE1-CRT-VLD-28-024-001 Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operation in case of specific events (e.g. taxiway closure).
	CRT-VLD-28-024-002	Fully covered		Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure).

Table Appendix A-1: Summary Demonstration Objectives and Criteria Exercise #01

A1.3 Summary of Validation Exercise #01 Demonstration scenarios

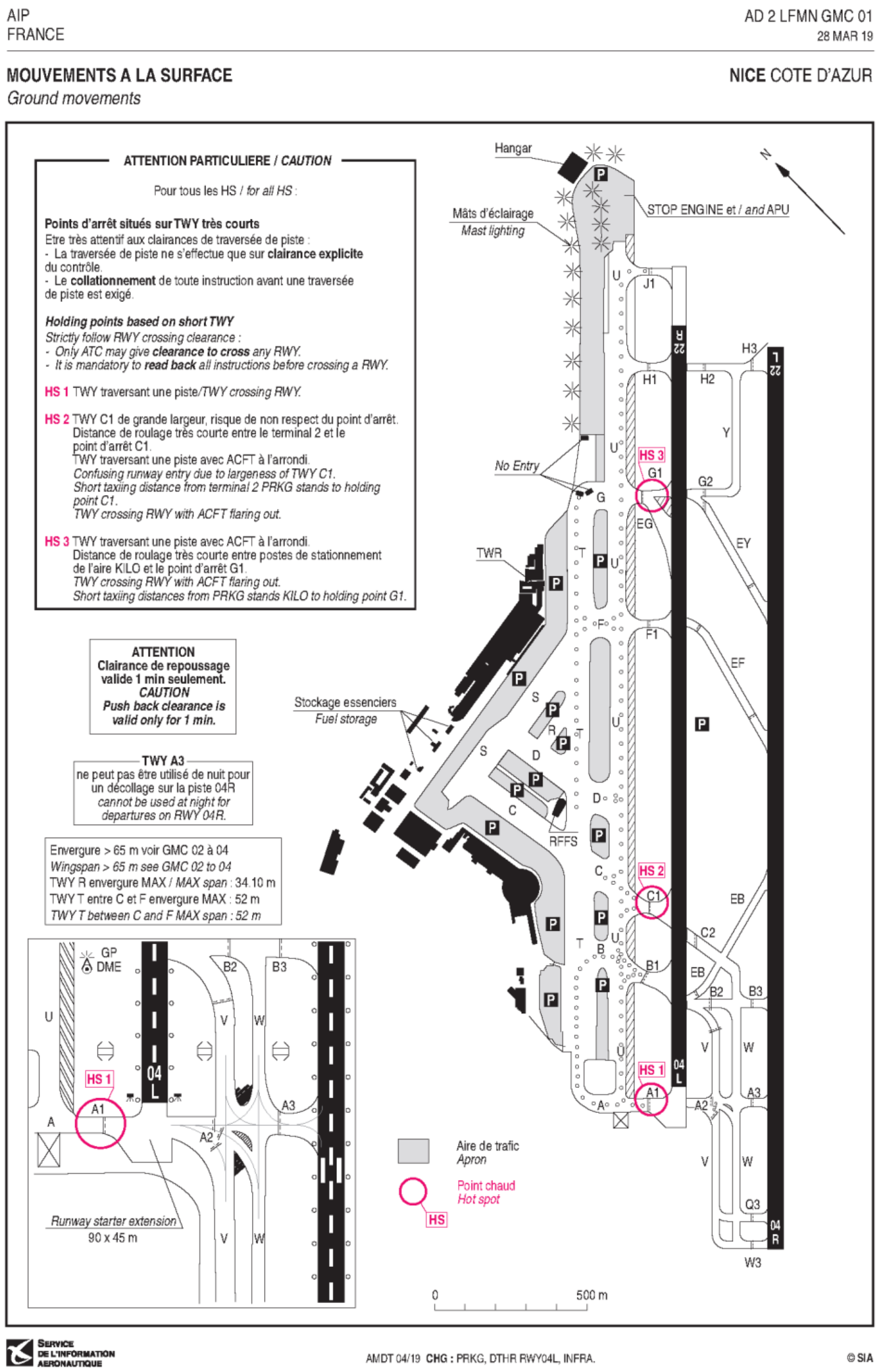


Figure Appendix A-1: LFMN Ground Movements

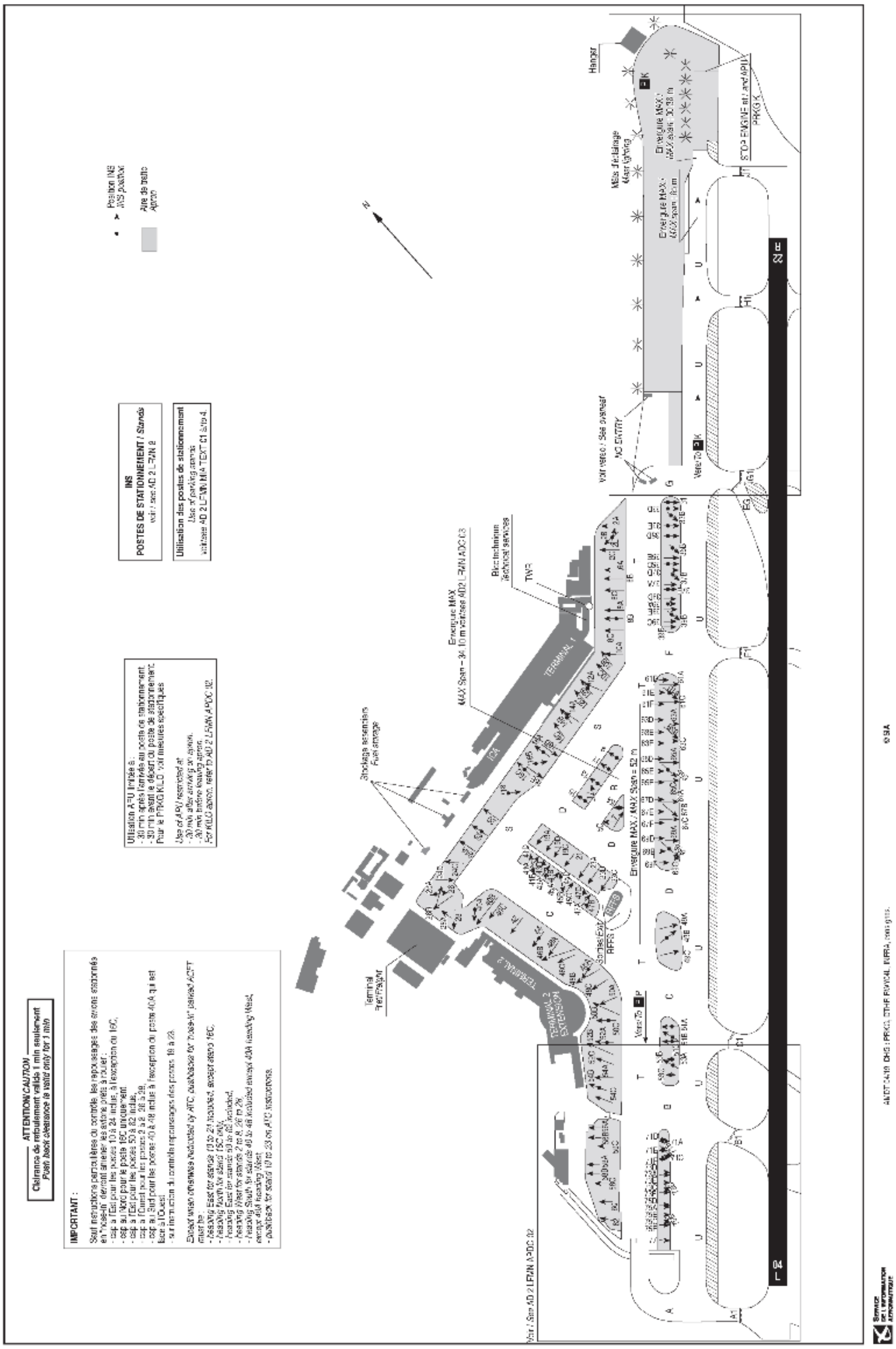


Figure Appendix A-2: LFMN Parking Areas

A1.3.1.a Reference Scenario(s)

The reference baseline scenario was the current day operations at Nice LFMN airport which is A-SMGCS equipped with RMCA (Runway Monitoring and Conflict Alerting) using R/T to communicate with mobiles and paper strips as main aircraft management support. This also included the current DMAN system.

The runway configuration made use of specialised runways for departures and landing as well as single-runway configuration.

More details on the current operations are provided next.

Controller Roles and Tools

The current system used is paper based. Ground and Runway controllers use paper strips in their activities. Each paper strip embodies the flight information of a single flight. Controllers organise these strips on a stripboard and according to a system of incoming and departing aircraft, to materialise a representation of the current traffic situation. These paper strips are updated manually (pen and paper) each time a flight clearance has been acted or an updated piece of information received.

Three positions were addressed during the Very Large Demonstration:

- The Clearance Delivery control position referred as “CLEARANCE DELIVERY”
- The Ground Controller position referred as “GROUND”
- The Runway Controller position referred as “RUNWAY”

The scope of the current demo report includes the roles of stakeholders and the tool functionalities related to IFR (Instrument Flight Rules) flights only.

The controller roles concerned are described below along with the tools related to each role as a means of understanding the tower environment.

The Clearance Delivery Controller

The CLEARANCE DELIVERY controller gives departure clearances such as SSR code, QFU, Standard Departure, Ground R/T frequency, following pilots’ requests via R/T or datalink. A Departure Manager (DMAN) as a means of automating and facilitating tasks related to departures was not yet in place at Nice at the time of the VLD.

Currently, CLEARANCE DELIVERY controllers at Nice use mainly the following two devices type:

1. Clearance delivery manager system. It allows the CLEARANCE DELIVERY controller to give departure clearances as well as the start-up authorisation to pilots via voice or through datalink. The system is used for visualising and editing departure information such as:
    - The visualisation of departure flights awakened and activated,
    - The visualisation of the flight plans information,
    - The activation and cancellation of an awakened flight.

2. Airport Information Network. It is a system managing the parking stands for departures and arrivals.

The Ground Controller

The Ground controller ensures that aircraft are safety cleared from the manoeuvring area and out of restricted runway areas.

The controller manages the ground taxiing of the incoming aircraft from the runway exit to the gate, and of the departing aircraft from the gate to the runway holding points.

For a departing aircraft, controllers provide a push-back clearance or a taxi clearance to guide aircraft to the runway holding points following the pilots' requests via R/T.

These authorisations are given depending on the available timeslots and according to ground movements in the vicinity of the aircraft's gate. This is done to optimise traffic flow in the area.

The Ground controller organises the departure sequence by performing ground-overtaking whenever judicious and suggesting intermediate access taxiways.

To carry out this task, the Ground controller considers the slots, the performances and wake vortex category of the aircraft.

Currently at Nice airport, Ground controllers mainly operate using the same systems as the CLEARANCE DELIVERY as well as:

- A-SMGCS (Advanced Surface Movement Guidance and Control Systems)

Advanced-Surface Movement Guidance and Control Systems (A-SMGCS) comprise a combination of surveillance systems providing services and aids to ATCOs.

A-SMGCS allows controllers to access a representation of the actual airport traffic on a display, regardless of a clear line-of-sight between the controller and objects around the airport. This helps in anticipating potential conflicts such as hazardous situations between aircraft or between aircraft and vehicles.

- Clearance delivery manager system

The Runway Controller

Concerning ground responsibilities, the Runway controller manages the runways and their restricted areas, including the taxiways between the runways.

S/he also controls the spacing of incoming aircraft in final approach using speed constraints, provides information to pilots, clears landing authorisations, and initiates go-around procedures as required.

The Runway controller also provides line-up and take-off clearances to departing aircraft. The sequence of departures is calculated according to the availability of account-slots, aircraft performances, wake vortex categories and aircraft position on the access taxiways.

As required, departing aircraft are held before the landing runway if there is an incoming flight and Runway controllers manage the landing runway crossing by the departing aircraft (see Figure Appendix A-1, Figure Appendix A-2).

Currently at Nice airport, Runway controllers use mainly, the following devices:

- A-SMGCS Display

A-SMGCS is used by RUNWAY controllers to access an enriched representation of the actual airport traffic on the HMI.

- Approach Radar Display (or Air situation display)

Air Radar screen data is also available to Runway controllers as a means of anticipating arrival flights and subsequently, manage incoming and departing aircraft.

A1.3.1.b Solution Scenario(s)

The SESAR Solutions addressed are:

- Solution #02 "Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances" includes the automatic detection of non-conformances to clearances and instruction (CMAC alerts) and pairs of conflicting clearances (CATC alerts),
- Solution #22 "Automated Assistance to Controller for Surface Movement Planning and Routing" includes the automatic proposal of surface routes by the system and the ability to modify them and provide clearances/instructions via the HMI. As compared to the paper-based reference scenario, clearances are input in the system via the aircraft labels or any of their alternate representations on the HMI (flight DYPs, Lists),
- Solution #53 "-Departure Sequencing supported by Route Planning" includes a runway sequence window in the system with pre-departure sequencing functionalities, based on the information managed through the routing and planning system,

The solution scenario used focused on demonstrating Solution #02, Solution #22 and Solution #53.

A1.4 Summary of Demonstration Exercise #01 Demonstration Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-PJ28-VLD-DEMOP-001.0001.	Specialised runways	Platform constraint	(Tower) Runway configuration should be specialised	The platform does not handle landing on runway 04R and take-off from 04L	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	High
ASS-PJ28-VLD-DEMOP-001.0002.	Mobiles	Platform constraint	(SUT) There is no control over non-aircraft mobiles	The platform is equipped to handle aircraft only, and vehicles are not controlled at Nice (except for runway operations).	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-PJ28-VLD-DEMOP-001.0003.	Operational DMAN	Nominal Operations	(SUT) DMAN is in operation	Core part of Solution #53 in the SUT	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	High
ASS-PJ28-VLD-DEMOP-001.0004.	Functional Alerts	Nominal Operations	(SUT) SESAR 1 Alerts are functional	Core part of Solution #02 in the SUT	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Medium

ASS-PJ28-VLD-DEMOP-001.0005.	Sector Grouping CLEARANCE DELIVERY/ GROUND	Nominal Operations	(SUT) CLEARANCE DELIVERY/GROUND sector grouping can be in effect	The platform is equipped to handle CLEARANCE DELIVERY/GROUND grouping.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-PJ28-VLD-DEMOP-001.0006.	Sector Grouping GROUND/RUNWAY	Platform constraint	(SUT) GROUND/RUNWAY sector grouping shall not be in effect	The platform is not equipped to handle GROUND/RUNWAY grouping.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-PJ28-VLD-DEMOP-001.0007.	Runway Closures	Platform constraint	There should be no runway closures	The platform is not equipped to handle single runway operations.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Medium
ASS-PJ28-VLD-DEMOP-001.0008.	Taxiway Closures	Platform constraint	There can be taxiway closures with a sufficient amount of planning time	The platform is not equipped to handle dynamically random taxiway closures	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-PJ28-VLD-DEMOP-001.0009.	Helicopter Traffic	Platform constraint	Isolated cases of Helicopter traffic are allowed	Little interference at Nice from helicopter traffic.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low

ASS-PJ28-VLD-DEMOP-001.00010.	RPAS Traffic	Nominal Operations	There should not be interfering RPAS traffic. No VHF transmission delay is considered.	RPAS are considered as any IFR aircraft during shadow mode demonstration.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-PJ28-VLD-DEMOP-001.00011.	VFR Traffic	Platform constraint	VFR traffic shall not be considered	The platform relies on the transmission of an IFR Flight Plan to handle aircraft.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-PJ28-VLD-DEMOP-001.00012.	Wingspan	Nominal Operations	The TAXIWAY TYPE alert under demonstration only depended on wingspan.	Among the criteria for TAXIWAY TYPE alert, wingspan is the most important regarding safety issues.	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Medium

Table Appendix A-2: Demonstration Assumptions overview

A2 Deviation from the planned activities

The following events were considered deviations from the planned activities:

- The additional following objectives were covered by the DSNA exercise for Solution #02 given that they apply to the overall safety demonstrated through CMAC and CATC integration:
  - EX1-OBJ-VLD-28-011 Results - Demonstrate that safety with regards to Airport operations is improved with the successful integration of CMAC
  - EX1-OBJ-VLD-28-012 Results - Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC
- System metrics from Runs occurring on the 24th were not collected due to a technical issue,
- Solution #53 was limitedly demonstrated due to:
  - technical difficulties affecting controllers' interaction with the DMAN pre-sequencing functionalities,
  - the list of aircraft represented in the tool was also not always exhaustive,
  - the start-up sequence observed by real tower controllers at Nice deviated a lot from the VLD DMAN sequence such that the tool was only used to mirror real start-ups, even then the TSAT values were expired, and

Nice Initial DMAN[4] was not yet operational at the time of the VLD although controllers had been through a previous training.

A3 Demonstration Exercise #01 Results

A3.1 Summary of Demonstration Exercise #01 Demonstration Results

The following table summarises the results of the Demonstration Exercise compared to the success criteria identified within the Demonstration Plan per demonstration objective.

The following nomenclature has been used:

- OK
  - Demonstration objective achieves the expectations
- NOK
  - Demonstration objective does not achieve the expectations
- Partially OK
  - Demonstration objectives does not fully achieve the expectation
- N/A

Demonstration objectives out of scope of the demonstration, as identified by deviations from objectives in A.2

[4] Baseline DMAN

Demonstration Objective ID	Demonstration Objective Title	Success Criterion ID	Success Criterion	Sub-operating environment	Exercise Results	Demonstration Objective Status
OBJ-VLD-28-001	Demonstrate the utility of routing and planning functions	CRT-VLD-28-001-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.	High Utilisation Complex layout	It was demonstrated that the calculated routes generally conformed to operational needs/rules for managing certain surface operations but points of improvement concerning both departure and arrival routing were noted.	POK
		CRT-VLD-28-001-002	Positive evaluation of the calculated routes' relevance	High Utilisation Complex layout	Certain systematic routing issues impacted the relevance of calculated routes, due to sub-optimal routing solutions which were not commonly practiced at Nice.	POK
OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.	CRT-VLD-28-002-001	Positive evaluation of route modification capabilities when real surveillance data is used.	High Utilisation Complex layout	The issues encountered (erroneous routes, time required for route modification process) negatively impacted the effectiveness of manual route modification capabilities with real surveillance.	POK
		CRT-VLD-28-002-002	Positive evaluation route modifications outside of controllers' Areas of	High Utilisation Complex layout	Controller working methods did not include modifications outside of AOR. Thus, the use of manual route modifications outside of controllers' respective areas of responsibility	N/A

			Responsibility (AOR)		was not applicable to work at Nice.	
		CRT-VLD-28-002-003	Positive evaluation of the routes' representation (e.g. different status)	High Utilisation Complex layout	The effectiveness of routes' representation was partially demonstrated given the issues reported (performance lags, erratic feedback of route modification).	POK
OBJ-VLD-28-003	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	CRT-VLD-28-003-001	Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.	High Utilisation Complex layout	The planned taxi times that were used were unimpeded taxi times (e.g. no delay at the holding points, no delay after a push or taxi clearance, no hold-short, pilot delays, individual company policies), while in actual operations, these variables account for added delays which are included as part of the taxi calculations. Thus, the average planned taxi-time was lower than the average actual taxi-time.	NOK
OBJ-VLD-28-004	Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable	CRT-VLD-28-004-001	Positive evaluation of the workload of Ground Controllers due to planning and routing functions.	High Utilisation Complex layout	The workload experienced by GROUND controllers due to demonstrated routing and planning functions was partially achieved due to passive shadow-mode bias, failed route modifications and delayed routing proposals.	POK
		CRT-VLD-	Positive evaluation	High Utilisation	The workload experienced by runway	OK

		28-004-002	of the workload of Runway Controllers due to planning and routing functions.	Complex layout	controllers due to routing and planning functions was satisfactory.	
		CRT-VLD-28-004-003	Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.	High Utilisation Complex layout	Given, i) flight representations, ii) click performance, iii) multiple-clearance, iv) clearance interaction, and v) controller experience issues for updating the HMI with clearances heard over the VHF radio, a partial demonstration of the features has been achieved.	POK
OBJ-VLD-28-005	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	CRT-VLD-28-005-001	Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.	High Utilisation Complex layout	Controllers' attention was absorbed by the screen instead of the outside and the awareness of the traffic was heavily impacted by several factors (shadow-mode performance bias, numerous route modifications, unjustified alarms due to routing issues).	POK
		CRT-VLD-28-005-002	Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.	High Utilisation Complex layout	The Situational Awareness experienced by RUNWAY controllers due to routing and planning functions was satisfactory	OK

		CRT-VLD-28-005-003	Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers	High Utilisation Complex layout	Given the multiple issues for updating the HMI with clearances heard over the VHF radio, a partial demonstration of the features has been achieved.	POK
OBJ-VLD-28-024	Demonstrate utility of routing and planning functions in non-nominal conditions	CRT-VLD-28-024-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operation in case of specific events (e.g. taxiway closure)	High Utilisation Complex layout	Given the calculated routes' lack of conformance to operational needs in non-nominal conditions, the utility of routing and planning functions in non-nominal conditions has been partially demonstrated.	POK
		CRT-VLD-28-024-002	Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure).	High Utilisation Complex layout	Given the calculated routes' lacking relevance in certain non-nominal conditions, the utility of routing and planning functions in non-nominal conditions has been partially demonstrated.	POK
OBJ-VLD-28-006	Demonstrate the utility of CATC alerts functions	CRT-VLD-28-006-001	Positive evaluation of the utility of the CATC alerts functions when real surveillance data is	High Utilisation Complex layout	The utility of CATC functions was considered as having been positively demonstrated due to the low level of nuisance alerts and a lack of false alerts.	OK

			used.			
OBJ-VLD-28-007	Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.	CRT-VLD-28-007-001	Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.	High Utilisation Complex layout	The utility of CATC functions was assessed as having been positively demonstrated due to the low level of nuisance alerts and a lack of false alerts.	OK
OBJ-VLD-28-008	Demonstrate the usability of CATC functions	CRT-VLD-28-008-001	Positive evaluation of the usability of CATC alerts functions	High Utilisation Complex layout	The usability of the CATC alert functions was positively demonstrated although certain minor exceptions were noted based mostly on the parameterisation of the system with regards to work practices at Nice.	OK
		CRT-VLD-28-008-002	Positive evaluation of the usability of CATC functions in predictive mode	High Utilisation Complex layout	The predictive indicator was visible, understandable to some controllers who also indicated that the colour coding of the design solution was appropriate. However, all controllers did not observe the predictive indicator for all alerts due mainly to a lack of conflicting situations during their runs, such that it is considered as being partially demonstrated.	POK
OBJ-VLD-28-009	Demonstrate the utility of CMAC functions	CRT-VLD-28-009-001	Positive evaluation of the utility of CMAC functions when real	High Utilisation Complex layout	The utility of CMAC functions was partially demonstrated due to the parameterization and system limitations encountered during the runs (Late detection with NO TOF CLR, Unjustified	POK

			surveillance data is used.		STATIONARY, Unjustified HIGH SPEED, Unjustified RTE DEV).	
OBJ-VLD-28-010	Demonstrate the usability of CMAC functions	CRT-VLD-28-010-001	Positive evaluation of the audio alarm	High Utilisation Complex layout	The usability of the audio alarm associated with the CMAC function was positively demonstrated as being effective.	OK
		CRT-VLD-28-010-002	Positive evaluation of the level of alerts generated (information or alarm)	High Utilisation Complex layout	The effectiveness of the CMAC alert levels was partially demonstrated to the controllers given that the alert threshold of the NO LND CLR remains to be adjusted.	POK
		CRT-VLD-28-010-003	Positive evaluation of the usability of CMAC alerts functions	High Utilisation Complex layout	The overall usability of the CMAC functions was partially demonstrated to the controllers due to issues with alert comprehension and interaction.	POK
OBJ-VLD-28-011	Demonstrate that safety with regards to Airport operations is improved with the successful integration of CMAC	CRT-VLD-28-011-001	Positive evaluation that the safety is improved with the successful integration of CMAC for the GROUND controller	High Utilisation Complex layout	Due to issues reported with the routing function and certain design bugs (e.g. parking bugs or missing ID/labels for certain aircraft) the successful integration of CMAC and its associated safety improvement has been partially demonstrated	POK
		CRT-VLD-28-011-002	Positive evaluation that the safety is improved with the successful	High Utilisation Complex layout	There was no observable negative impact on safety concerning the integration of CMAC for the runway controller. The CMAC for runway controllers were more justified and better	POK

			integration of CMAC for the RUNWAY controller		integrated (much less nuisances and no false alerts) than ground CMAC because the runway perceived little impact from routing issues which might have arisen.	
OBJ-VLD-28-012	Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC	CRT-VLD-28-012-001	Positive evaluation that the safety is improved with the successful integration of CATC for the RUNWAY controller	High Utilisation Complex layout	CATC alerts were triggered as expected and there was no observable negative impact on safety concerning the integration of CATC. Safety experts agree that alerts were successfully triggered and were mostly justified.	OK
OBJ-VLD-28-013	Demonstrate that the controller workload incurred due to integration of CMAC is acceptable	CRT-VLD-28-013-001	Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable	High Utilisation Complex layout	The workload of GROUND controllers due to the integration of CMAC was negatively impacted by the amount of routing issues arising during the runs (un-justified alerts from routing issues)	NOK
		CRT-VLD-28-013-002	Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable	High Utilisation Complex layout	The workload of the RUNWAY controller due to the integration of CMAC was positively demonstrated.	OK
OBJ-VLD-28-014	Demonstrate that the controller workload incurred due to integration of CATC is	CRT-VLD-28-014-001	Positive evaluation that the workload of RUNWAY controller due to the	High Utilisation Complex layout	The workload of the RUNWAY controller due to the integration of CATC was positively demonstrated.	OK

	acceptable		integration of CATC is acceptable			
OBJ-VLD-28-015	Demonstrate whether the Situational Awareness of controllers is improved with the integration of CMAC	CRT-VLD-28-015-001	Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved	High Utilisation Complex layout	The SA of GROUND controllers with integration of CMAC was negatively impacted by the same routing issues as reported in EX1-CRT-VLD-28-013-001.	NOK
		CRT-VLD-28-015-002	Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved	High Utilisation Complex layout	The SA of RUNWAY controllers due to the integration of CMAC was positively demonstrated	OK
OBJ-VLD-28-016	Demonstrate whether the Situational Awareness of controllers is improved with the integration of CATC	CRT-VLD-28-016-001	Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved	High Utilisation Complex layout	The SA of RUNWAY controller due to the integration of CATC was positively demonstrated	OK
OBJ-VLD-28-017	Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions	CRT-VLD-28-017-001	Positive evaluation of the utility of the CATC and CMAC integrated with RMCA	High Utilisation Complex layout	Although controllers find a utility for integrating RMCA to CATC and CMAC, safety experts agree that the RMCA occurrences observed in the demonstration were unjustified and as such can be considered to have only been partially	POK

					integrated with other alerts.	
		CRT-VLD-28-017-002	Positive evaluation of the usability of the CATC and CMAC integrated with RMCA	High Utilisation Complex layout	Controllers and safety experts agree that the usability of the RMCA alert integrated with CMAC and CATC alerts was only partially achieved given that the observations concerned unjustified occurrences.	POK
		CRT-VLD-28-017-003	Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts	High Utilisation Complex layout	Overall, controllers and safety experts agree that the prioritisation of the RMCA alert and CMAC and CATC alerts was partially achieved given that the observations concerned unjustified occurrences.	POK
OBJ-VLD-28-018	Demonstrate the utility of DMAN functions supported by route planning	CRT-VLD-28-018-001	Positive evaluation of the utility of the DMAN function supported by route planning	High Utilisation Complex layout	Given the lack of proper usage of the DMAN, the utility of its functions has not been appropriately demonstrated.	N/A
OBJ-VLD-28-019	Demonstrate the usability of DMAN functions supported by route planning	CRT-VLD-28-019-001	Positive evaluation of the usability of the DMAN function supported by route planning	High Utilisation Complex layout	Given the lack of proper usage of the DMAN, the utility of its functions has not been appropriately demonstrated.	N/A
OBJ-VLD-28-020	Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable	CRT-VLD-28-020-001	Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN	High Utilisation Complex layout	Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, and the regrouped positions, the workload incurred by the CLEARANCE DELIVERY controller due to its functions have not been	N/A

			function supported by route planning is acceptable		appropriately demonstrated.	
		CRT-VLD-28-020-002	Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable	High Utilisation Complex layout	Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the workload incurred by the GROUND controller due to its functions have not been appropriately demonstrated.	N/A
		CRT-VLD-28-020-003	Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable	High Utilisation Complex layout	Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the workload incurred by the RUNWAY controller due to its functions have not been appropriately demonstrated.	N/A
OBJ-VLD-28-021	Demonstrate that the controllers 'situational awareness due to DMAN supported by route planning is improved	CRT-VLD-28-021-001	Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved	High Utilisation Complex layout	Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the SA incurred by the CLEARANCE DELIVERY controller due to its functions have not been appropriately demonstrated.	N/A
		CRT-VLD-	Positive evaluation	High Utilisation	Given the lack of a baseline DMAN and the	N/A

		28-021-002	that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved	Complex layout	arguments listed in EX1-CRT-VLD-28-018-001, the SA incurred by the GROUND controller due to its functions have not been appropriately demonstrated.	
		CRT-VLD-28-021-003	Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved	High Utilisation Complex layout	Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the SA incurred by the RUNWAY controller due to its functions have not been appropriately demonstrated.	N/A
EX1-OBJ-VLD-28-022	Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning	EX1-CRT-VLD-28-022-001	Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning	High Utilisation Complex layout	Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the integration of routing and planning function, safety nets and DMAN has not been appropriately demonstrated.	N/A

Table Appendix A-3: Exercise 1 Demonstration Results

A3.2 Results per KPA

The results per KPA were as follows:

- Situational awareness
  Generally, the Situation awareness of controllers was Ok. Concerning the routing function, the SA of GROUND controllers was impacted by the resources required by route modification. Frequent manual route modifications were not required by the RUNWAY controller and a higher Situational Awareness was reported than GROUND controllers. Concerning alerts integration, un-justified CMAC alerts arising from routing issues was seen to be a critical factor in controllers' perceived SA and acceptance of the system,
- Safety
  The alerts integration had different impact on safety: CATC alerts were triggered as expected and there was no negative impact on safety. Safety experts agree that alerts were successfully triggered and were mostly justified. The triggering of CMAC alerts has been correlated with the rate of nuisance alerts occurring over the runs. Expert feedback was considered to determine whether the operational safety over the course of the exercise could have been affected, if controllers were interacting directly with the aircraft,
- Human Performance
  The shadow-mode protocol has the largest impact on controller performances due to the delayed materialisation of operational actions. The impact was notably present for Ground controllers in busy traffic situation since delays in materialising clearances in the system had a negative effect on routing update, and by extension nuisance alerts with safety net.
- Predictability
  Improvement in predictability of the operations including routing and pre-departure sequencing should be achieved through a reduced variability between planned and actual taxi times. Results from the exercises show that only for BUD the variability has been within acceptable limits while Nice and Hamburg had significant variations (layout with runway crossing operations). High variability in procedures and operation even for same aircraft types has been observed.

A3.3 Results impacting regulation and standardisation initiatives

It is important to note the following evaluation approaches:

- Alerts were considered justified even though they were triggered due to controllers' delays in inputting clearances on the HMI due to the shadow-mode approach used for the demonstration. This is to be contrasted with real-time trials, where controllers usually input clearances on the HMI as soon as they start to verbalise that clearance over VHF radio, and
- Controllers' answers to questionnaires do not directly determine the outcome of a success criterion as they are subjective measures of success. System metrics are used where available as a means of providing an objective basis for demonstration. Further, expert knowledge of the system limitations and experimental biases which might have

been present are used to argument controller feedback as a means of reaching a more objective outcome.

A3.4 Analysis of Exercises Results per Demonstration objective

A3.4.1 EX1-OBJ-VLD-28-001 Results - Demonstrate the utility of routing and planning functions

A3.4.1.a EX1-CRT-VLD-28-001-001 - Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.

The first objective aimed to demonstrate the utility of routing and planning function. Generally, there was as rather positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations (Figure Appendix A-3).

There were some notable exceptions:

- Departure routing - the hold point used for crossing the internal runway was not dependent on the ILS or RNAV configuration in effect, which did not allow the system to correctly route aircraft to A1 or C1 for accessing runway 04R, (see Figure Appendix A-1).
- Arrival routing - the practiced exit route used for G/EG was not through taxiways U -> F, as the system calculated, but through taxiway T.

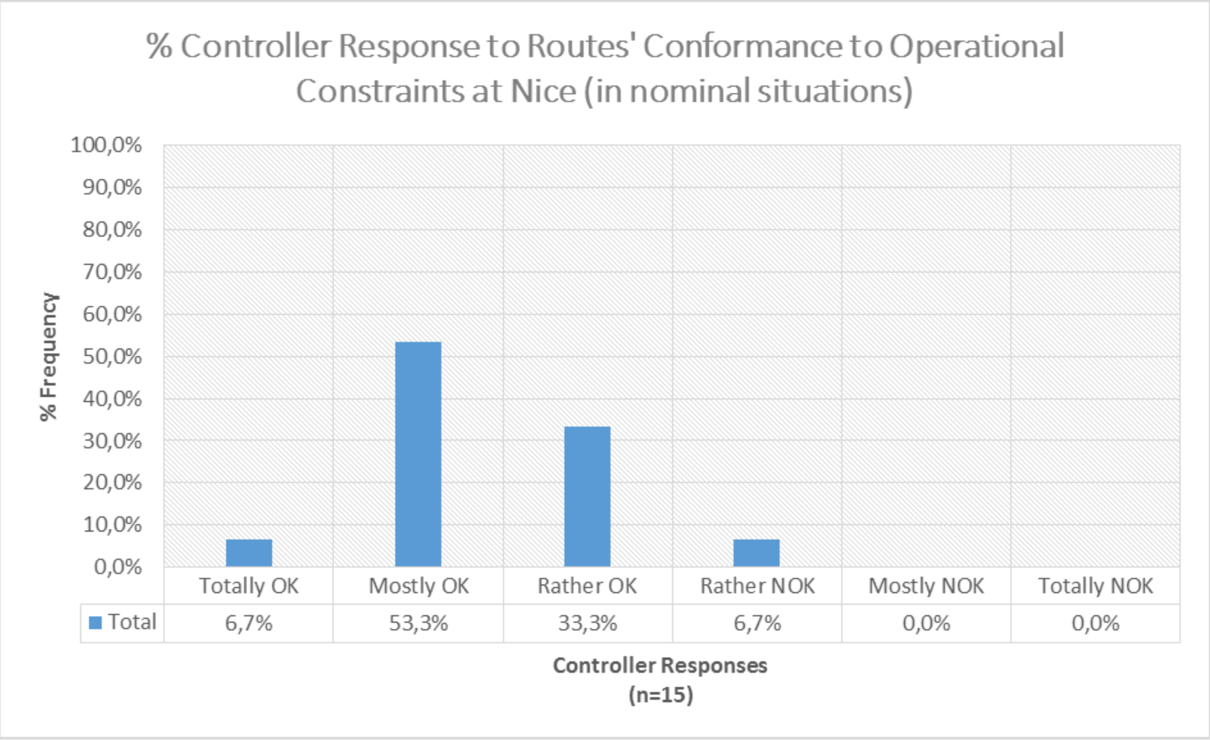


Figure Appendix A-3: Questionnaire - % Controller Response to Routes' Conformance to Operational Constraints at Nice (in nominal situations)

Although standard routes are not prescribed at Nice, certain commonly practiced routes are known and should be integrated in the system to reduce the amount of route modifications.

Thus, it was demonstrated that the calculated routes generally conformed to operational needs/rules for managing certain surface operations but points of improvement concerning both departure and arrival routing were noted.

A3.4.1.b EX1-CRT-VLD-28-001-002 - Positive evaluation of the calculated routes' relevance

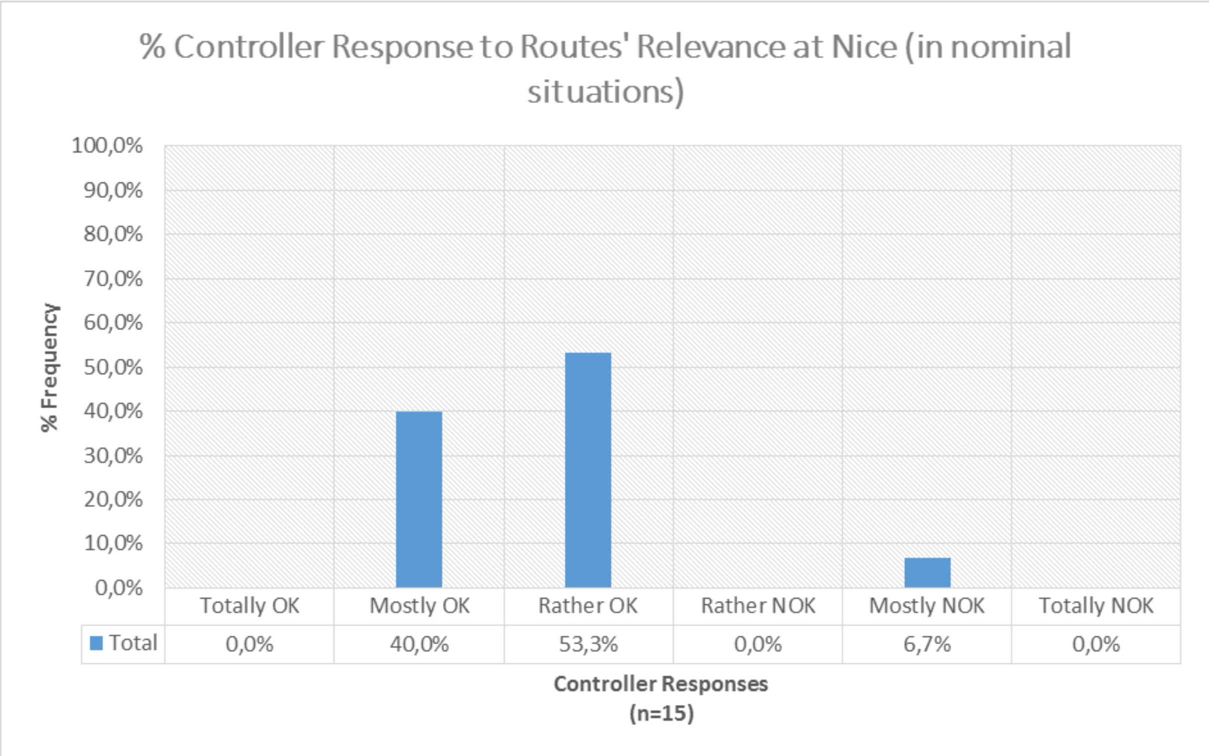


Figure Appendix A-4: Questionnaire - % Controller Response to Routes' Relevance at Nice (in nominal situations)

In general, the relevance of the calculated routes was appropriate (Figure Appendix A-4) and demonstrated positively to controllers. Certain systematic routing issues were encountered and were of several types:

- Miss-calculated initial routes due to the late detection by the system of the routing direction of an aircraft,
- Systematic proposal of routing through taxiway B for departures from parking 54 although, controllers' optimal solution was through C, and
- Routing solutions for pushing aircraft did not take as a condition other push clearance of aircraft in the vicinity and thus, was sub-optimal.

Consequently, certain systematic routing issues impacted the relevance of calculated routes, due to sub-optimal routing solutions which were not commonly practiced at Nice.

A3.4.2 EX1-OBJ-VLD-28-002 Results - Demonstrate the utility and usability of route modification capabilities.

A3.4.2.a EX1-CRT-VLD-28-002-001 - Positive evaluation of route modification capabilities when real surveillance data is used.

Route modification by the Shortcut function was effectively used by ATCOs to perform quick changes to holding points and runway entry and exit points.

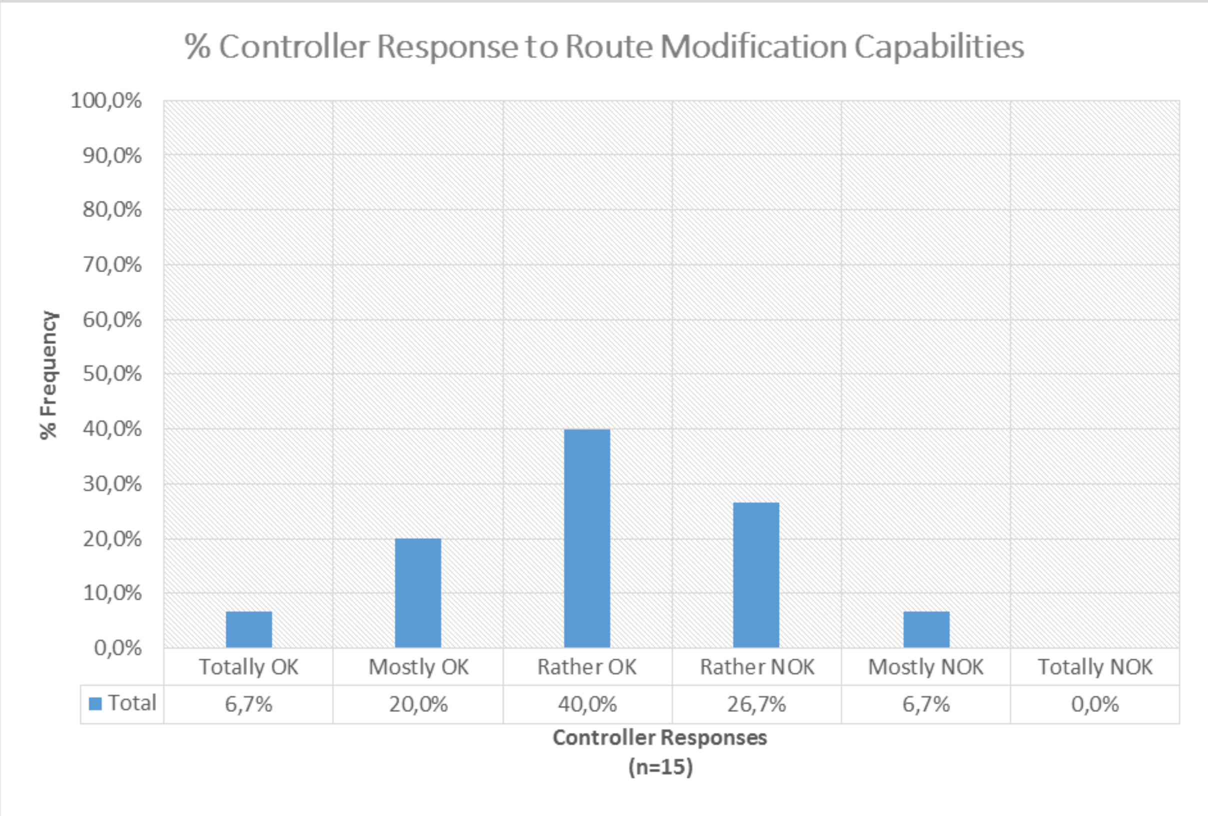


Figure Appendix A-5: Questionnaire - % Controller Response to Route Modification Capabilities

Route modification effectiveness was generally impacted by the routes' relevance issues presented in CRT-VLD-28-001-001 and CRT-VLD-28-001-002, which implied that many modifications were performed [CRT-VLD-28-002-001]. Further, there were issues, typically in order of criticality:

- Certain proposed routes were erroneous, since they consisted of loops, crossed into stands and some ran inverse to the direction of motion of the aircraft,
- Certain proposed routes were sub-optimal since they prolonged the routing of an aircraft along a taxiway while a simpler, more efficient solution which was cleared by the tower controller, existed,
- Other routing solutions were proposed with a performance lag, which impacted the real-time nature of the operation namely in heavy-traffic situations. This was also a nuisance given the nature of the shadow-mode: aircraft had already started to taxi before route modifications were attempted by the controllers, sometimes triggering unjustified alerts,

In most cases, the lack of proficiency of controllers with the route modification functions was a critical factor at the beginning of runs. Sub-optimal routing propositions were abandoned by the VLD controller and re-tried as the aircraft moved along the route already cleared by the tower controller, thus prolonging the route modification process significantly (Figure Appendix A-5).

The issues encountered negatively impacted the effectiveness of manual route modification capabilities with real surveillance.

A3.4.2.b EX1-CRT-VLD-28-002-002 - Positive evaluation route modifications outside of controllers' Areas of Responsibility (AOR)

The option relative to the route modifications outside of controllers' Areas of Responsibility (AOR) was not used by controllers [CRT-VLD-28-002-002]. They mostly only used routing in their own AOR as per current working methods and practices. The proportion of controllers who found that the functionality could be useful at Nice and those who did not foresee any utility, was balanced (Figure Figure Appendix A-7).

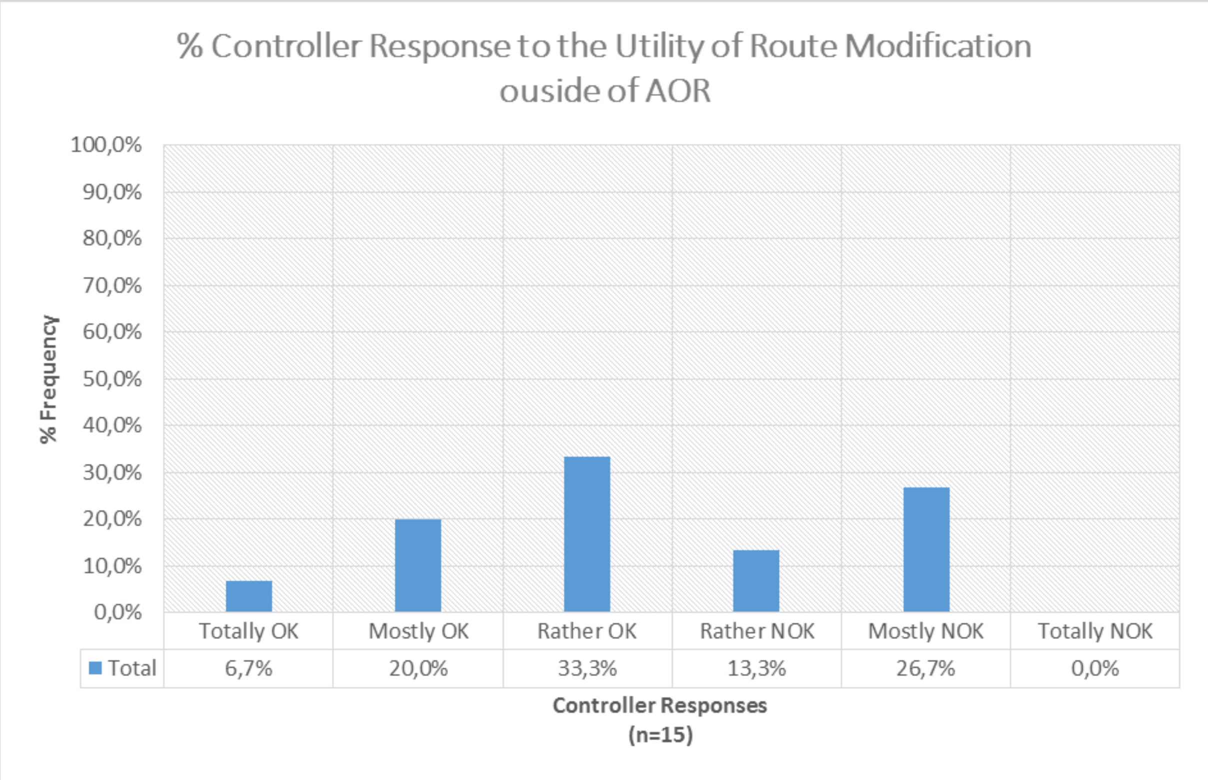


Figure Appendix A-6: Questionnaire - % Controller Response to the Utility of Route Modification outside of AOR

Thus, the use of manual route modifications outside of controllers' respective areas of responsibility was not applicable to work at Nice.

A3.4.2.c EX1-CRT-VLD-28-002-003 - Positive evaluation of the routes' representation (e.g. different status)

In general, the representation of the routes was positively assessed by the controllers, including initial, cleared and pending-modification route representations (Figure Appendix A-7).

A notable exception concerned the visual feedback (flickering route) upon modifying successfully a route, which was not always present. This issue arose from a known technical bug and its criticality was compounded to performance lags which negatively impacted controller's ability to fully trust the route modification function.

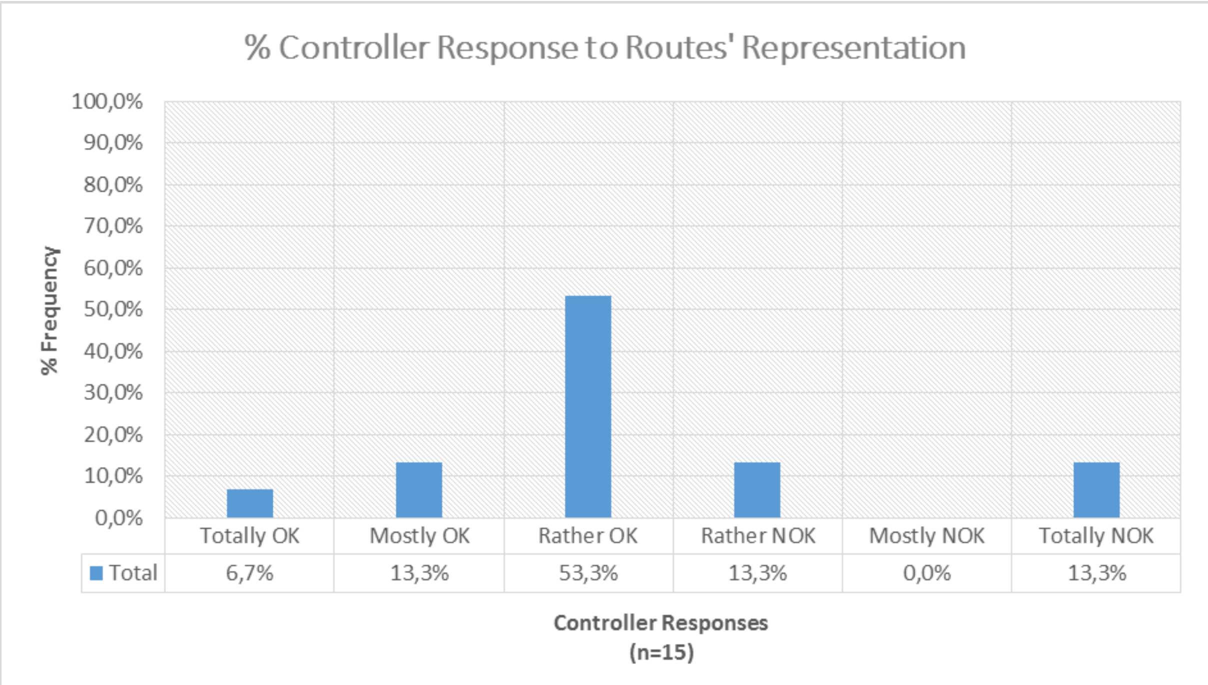


Figure Appendix A-7: Questionnaire - % Controller Response to Routes' Representation

Thus, the effectiveness of routes' representation was partially demonstrated given the issues reported.

A3.4.3 EX1-OBJ-VLD-28-003 Results - Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.

A3.4.3.a EX1-CRT-VLD-28-003-001 - Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.

The actual average taxi-time considering all parking positions used during the VLD is 7 mins 46s. The average planned taxi-time is 4 min 19s (Figure Appendix A-8). The calculation lacks a representation of pushback delays or runway crossing delays. Indeed, at Nice airport, departing flights departure must cross the inner runway. However, this delay is not considered by DMAN in calculating the planned taxi-time.

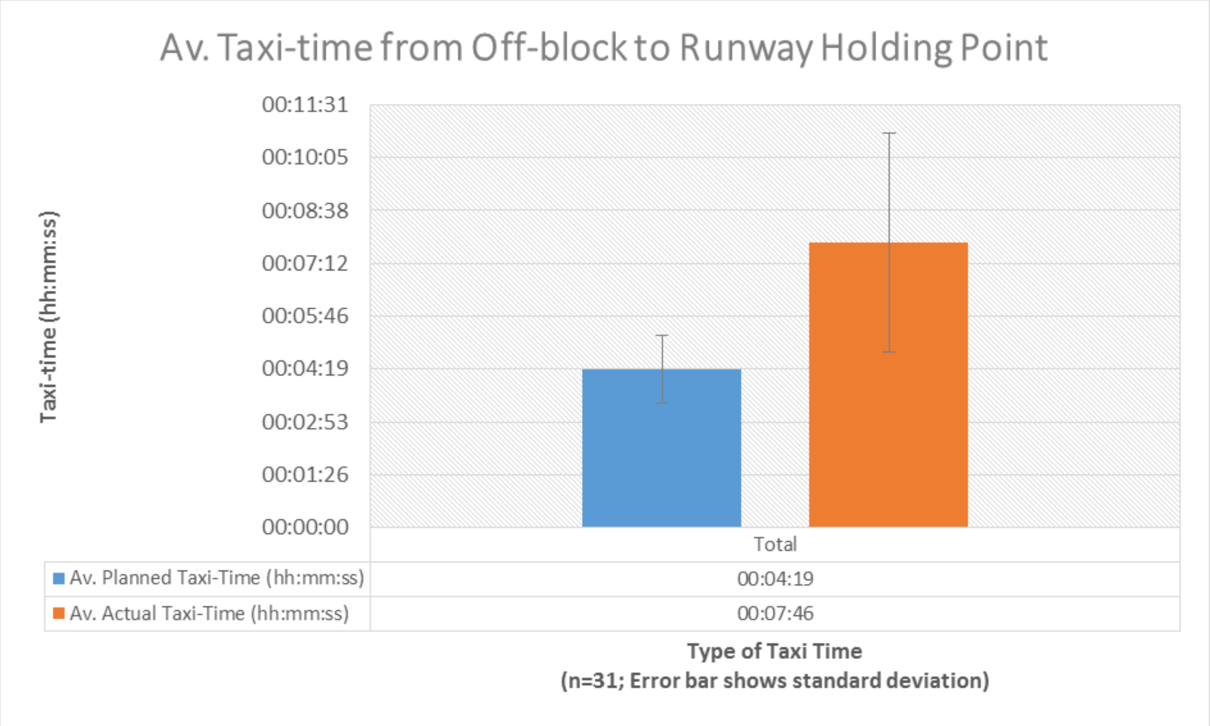


Figure Appendix A-8: Metrics – Average Taxi-time from Off-block to Runway Holding Point

Two factors were identified which impacted the taxi-time estimations:

- Departing aircraft must systematically cross the arrival runway and delays may be incurred due to the cross if arrival runway occupancy is high. With high traffic scenarios, this is even more likely to happen. However, these delays were not integrated in the predicted taxi time computation (Note: There is no integration of DMAN and arrival management functionalities in the system under demonstration),
- Certain parking spots at LFMN demand a PUSH procedure while others do not require the same procedure. It was found (Figure Appendix A-10) that aircraft having a PUSH procedure had on average about 4 minutes longer taxi-time than those without a PUSH due to parking characteristics. However, this particularity was not integrated in the predicted taxi time computation.

The planned taxi times that were used were unimpeded (n=31) taxi times (e.g. no delay at the holding points, no delay after a push or taxi clearance, no hold-short, pilot delays, individual company policies. Thus, the average planned taxi-time was lower (4 mins 19s), and with a lesser standard deviation (55s) the average actual taxi-time (7mins 45s) with a standard deviation of 2 mins 59s.

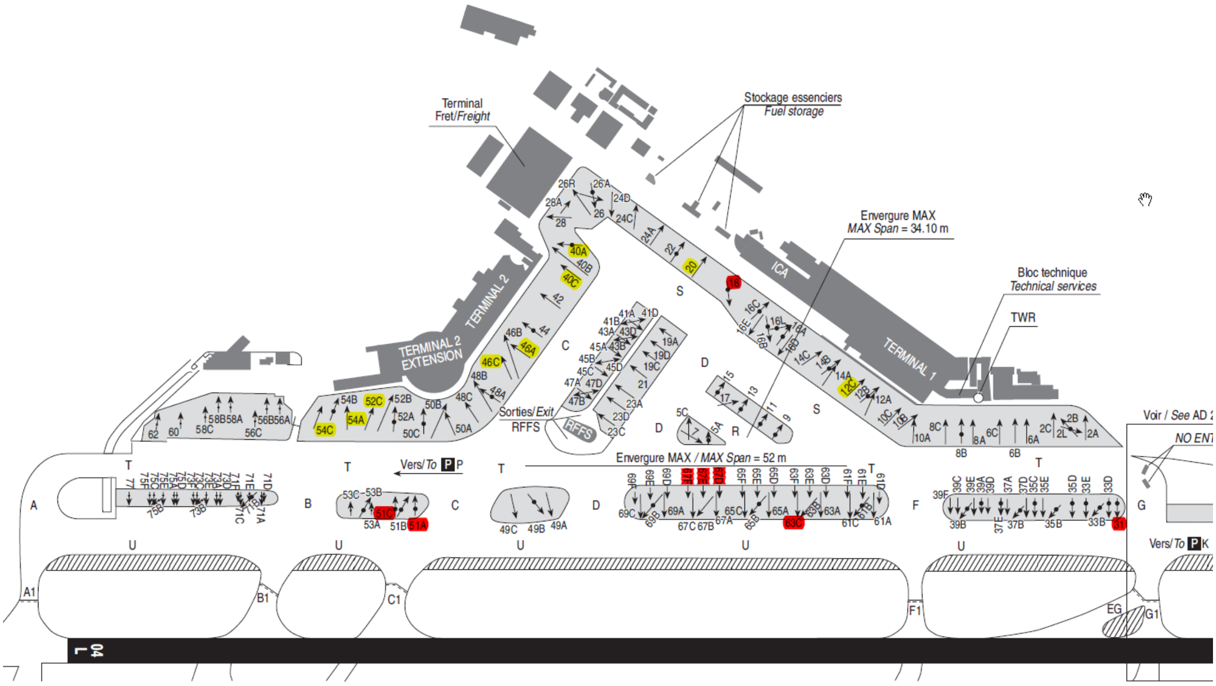


Figure Appendix A-9: Map of LFMN identifying the parkings from which aircraft performed a PUSH (Yellow) and those performing an autonomous departure (Red)

One of the hypotheses concerning the under-estimation of the actual taxi-time was the delays incurred by aircraft as to whether they performed a pushback or not. Figure Appendix A-10shows the average taxi-time by departure type. Autonomous departures are those aircraft not having any pushback operation before TAXI due to the characteristic of the parkings, while PUSHBACK departures involve a push operation (Figure Appendix A-9). The average PUSHBACK clearance delay involving a PUSH instruction and a TAXI instruction was 2 mins 49s (n=21, standard deviation=1 min 48s). The "departure type" variable shows a difference between overall taxi-times but is not a factor explaining the underestimation of actual taxi-times.

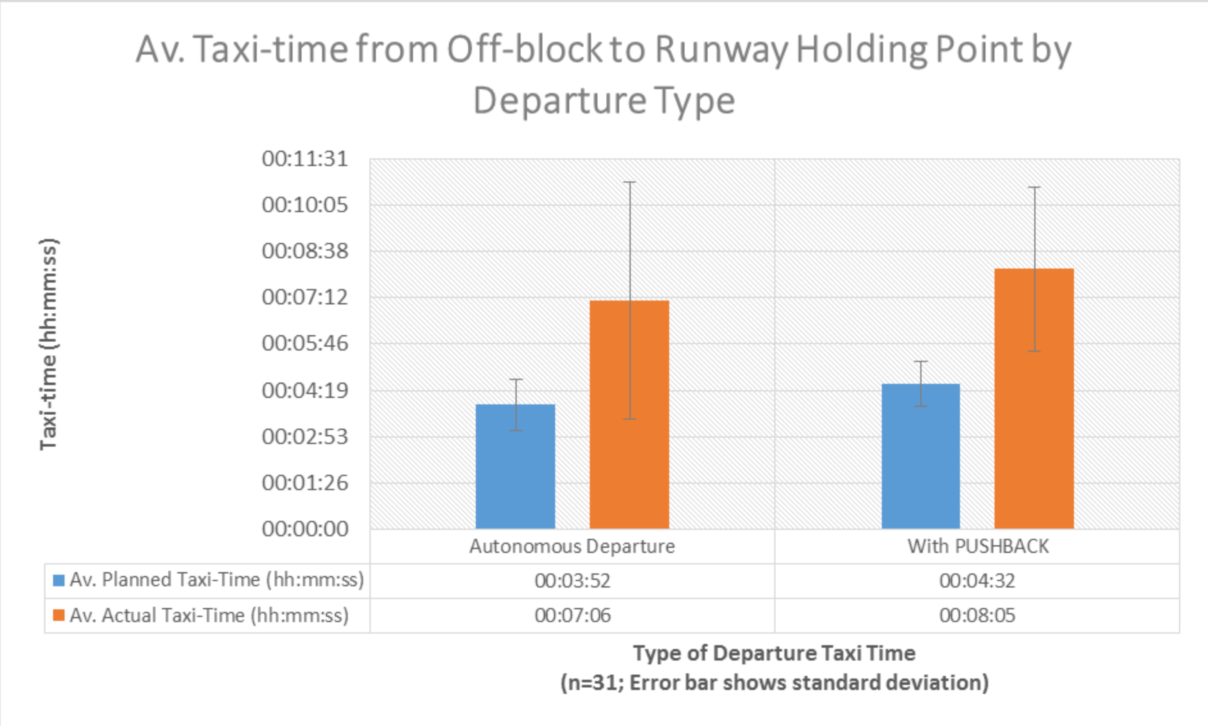


Figure Appendix A-10: Metrics – Average Taxi-time from Off-block to Runway Holding Point by Departure Type

A3.4.4 EX1-OBJ-VLD-28-004 Results - Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable

A3.4.4.a EX1-CRT-VLD-28-004-001 - Positive evaluation of the workload of Ground Controllers due to planning and routing functions.

The workload assessed was limited by the passive shadow mode environment. ATCOs had to reproduce clearance patterns and decisions which were not taken by themselves - in most cases, this led to them having to catch-up on operational actions, despite normal traffic densities.

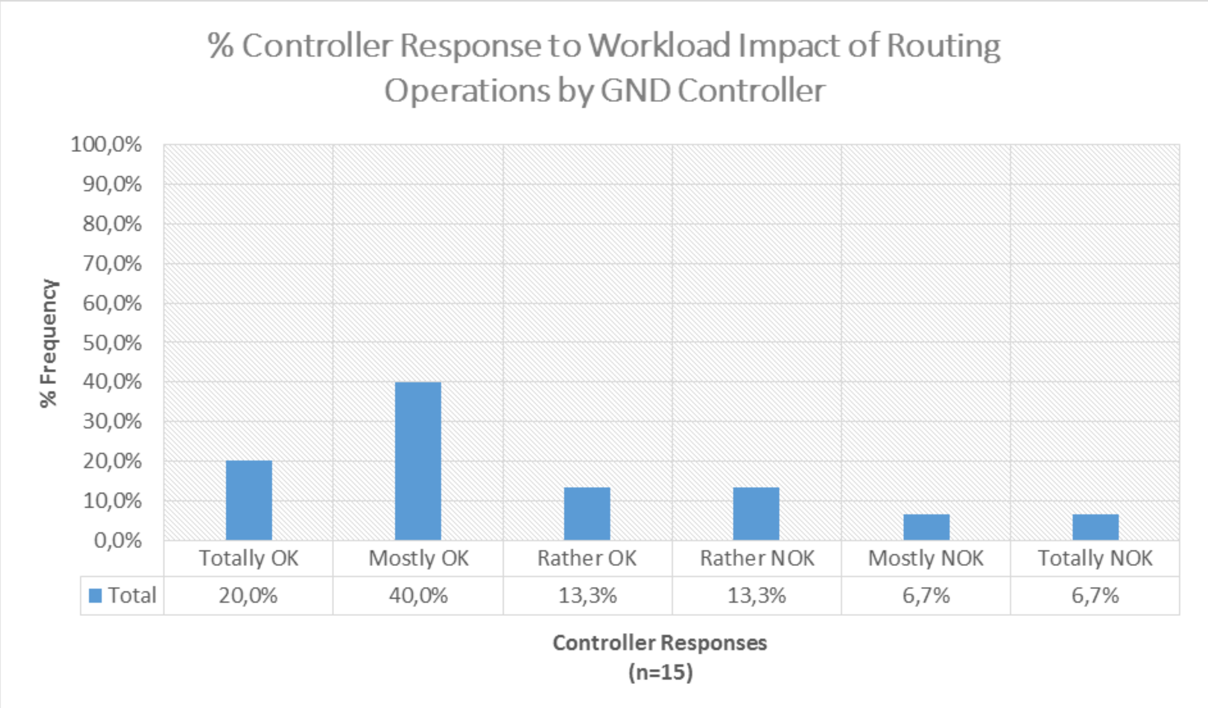


Figure Appendix A-11: Questionnaire - % Controller Response to Workload Impact of Routing Operations by GND Controller

Controller workload due to routing and planning was assessed as mostly OK (Figure Appendix A-11) although certain irregularities were noted:

- the passive shadow mode implied that ATCOs had to reproduce clearance patterns and decisions which were not taken by themselves - in most cases, this led to catching-up on operational actions, despite normal traffic densities. Thus, less workload was imparted due to a lack of operational decision-making or verbal clearances, although counterbalanced by having to catch-up with route modifications and generally keeping the system coherent with the on-going situation,
- Certain failed route modifications were not retried since the controller judged it unnecessary as the taxiing aircraft re-joined the route segment defined in the system, thus nullifying any route deviation alerts. The workload perceived in those cases spiked while former route modifications were attempted but dropped as the action was abandoned,
- Certain routing solutions were unavailable in the system until the aircraft had started moving past certain intersections, implying that controllers had to delay other tasks while waiting. In heavy traffic situations, putting actions on hold, means that more catching-up actions had to be performed afterwards.

As a means of collecting a higher granularity of workload data across runs and controller groups, an ISA sub-system was used. During runs, controllers had to complete their own level of workload every 3 minutes. The dataset was collected, and we have provided an average of workload level (Figure Appendix A-12). ISA data from runs occurring on the 19th of April were ignored due to several system crashes.

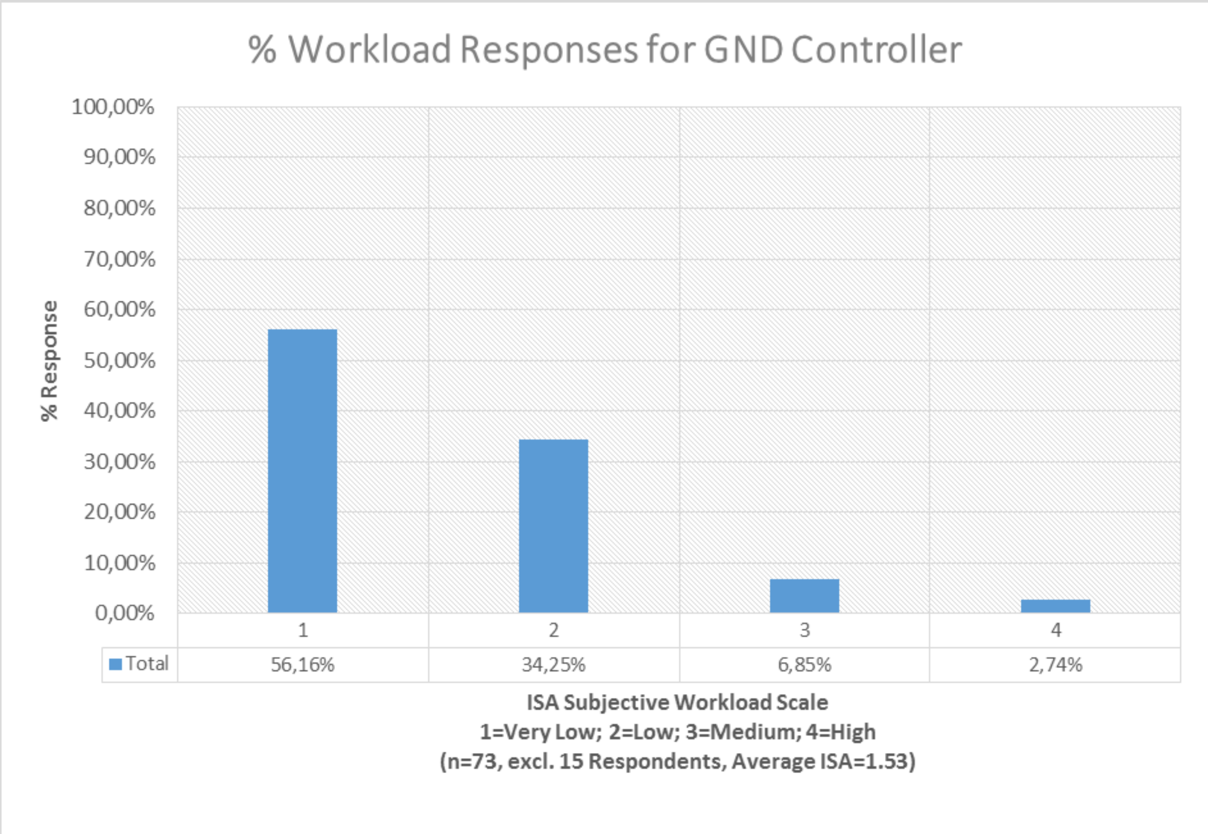


Figure Appendix A-12: ISA - % Workload Responses due to Planning and Routing Functions for GND Controller

Data collected mostly show a low reported workload due to the global control activity, including the routing level (56.16% of ground controllers estimated their workload as 'very low').

Due to the issues reported and as a result of questionnaire and ISA responses, the workload experienced by GROUND controllers concerning the routing and planning functions demonstrated was considered partially achieved.

A3.4.4.b EX1-CRT-VLD-28-004-002 - Positive evaluation of the workload of Runway Controllers due to planning and routing functions.

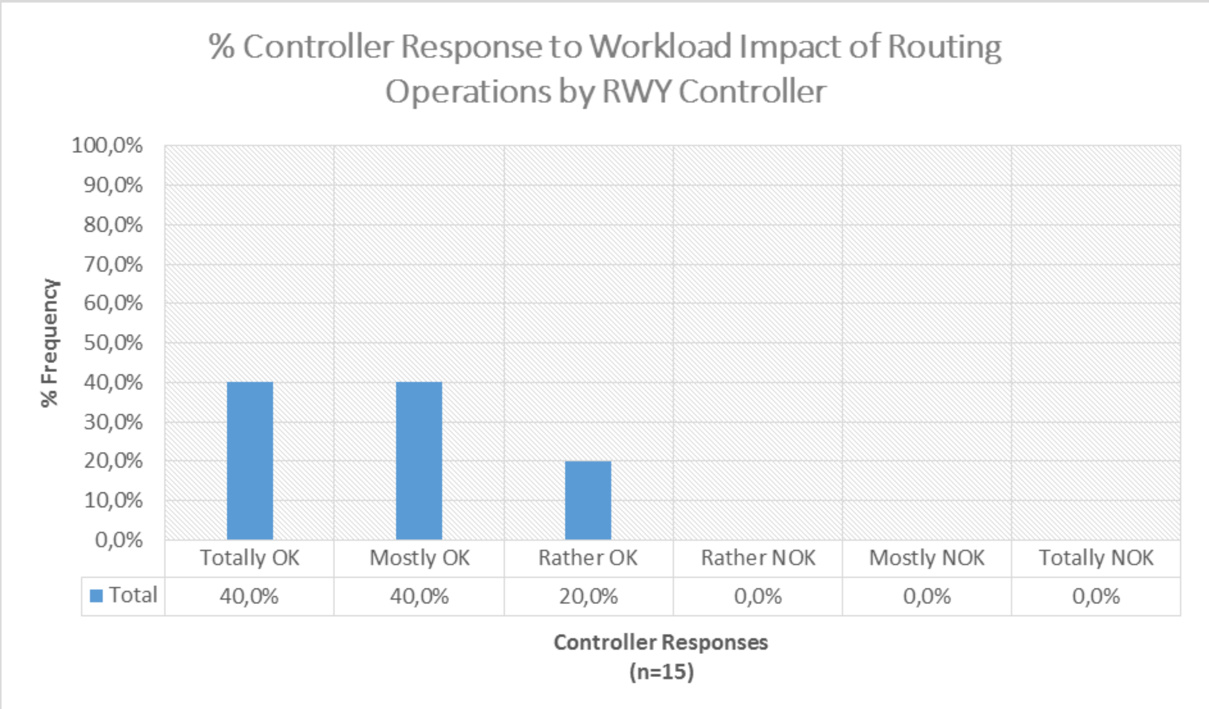


Figure Appendix A-13: Questionnaire - % Controller Response to Workload Impact of Routing Operations by RWY Controller

Runway controller provided a positive feedback concerning their workload (Figure Appendix A-13, Figure Appendix A-14). 78.26% of runway controllers estimated their workload as ‘very low’.

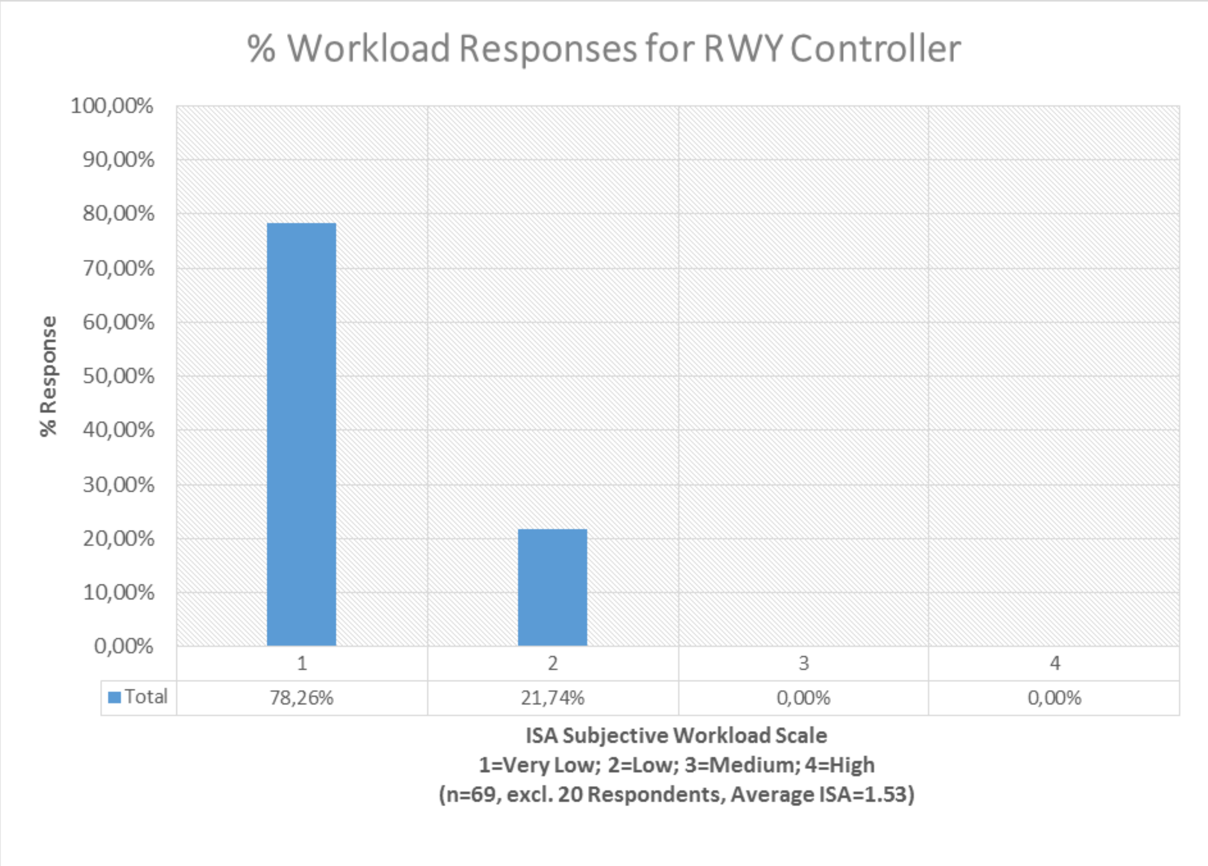


Figure Appendix A-14: ISA - % Workload Responses due to Planning and Routing Functions for GND Controller

The additional load of materialising holding points and parking modifications due to the sub-optimal parameterisation of the system, were artificially compounded to the operational workload. However, runway controllers had largely enough time to perform the actions without impacting their work.

As a result of questionnaire and ISA responses the workload experienced by runway controllers due to routing and planning functions was satisfactory.

A3.4.4.c EX1-CRT-VLD-28-004-003 - Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.

Clearances provided over radio by tower controllers were generally present in the VLD system and were successfully updated by VLD controllers (Figure Appendix A-15).

However, exceptions were noted which arose mostly from system bugs and lack of HMI proficiency rather than functional limitations:

- 2 flights were recorded as being absent from the HMI, and could not be controlled using the HMI,

- performance issues sometimes impacted the ability for the clearance button to accept clicks, which led to multiple retries and a time cost, from the controllers,
- further, the possibility of clearing multiple items though the label menu (e.g. LUP and TOF), was not always used by some controllers. Instead, the compound action was attempted using the clearance button, which does not propose such as functionality,
- the need to materialise certain clearances early due to increased traffic conditions, while the clearance button restricted the presentation of clearances to pre-defined positions on the surface, was a hindrance, e.g. VAC, LUP,
- the conditional line-up functionality was not always practiced by certain controllers, due to lack of experience with the HMI.

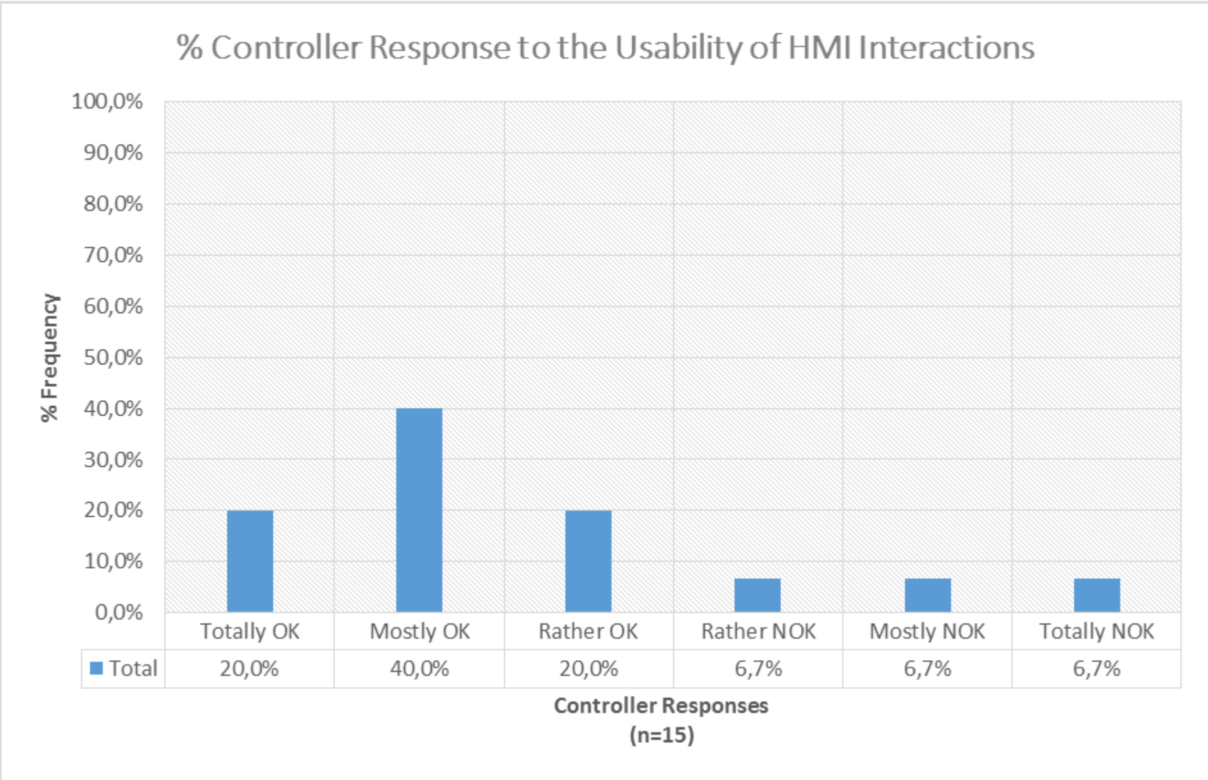


Figure Appendix A-15: Questionnaire - % Controller Response to the Usability of HMI Interactions

Given the multiple issues for updating the HMI with clearances heard over the VHF radio, a partial demonstration of the features has been achieved.

A3.4.5 EX1-OBJ-VLD-28-005 Results - Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.

A3.4.5.a EX1-CRT-VLD-28-005-001 - Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.

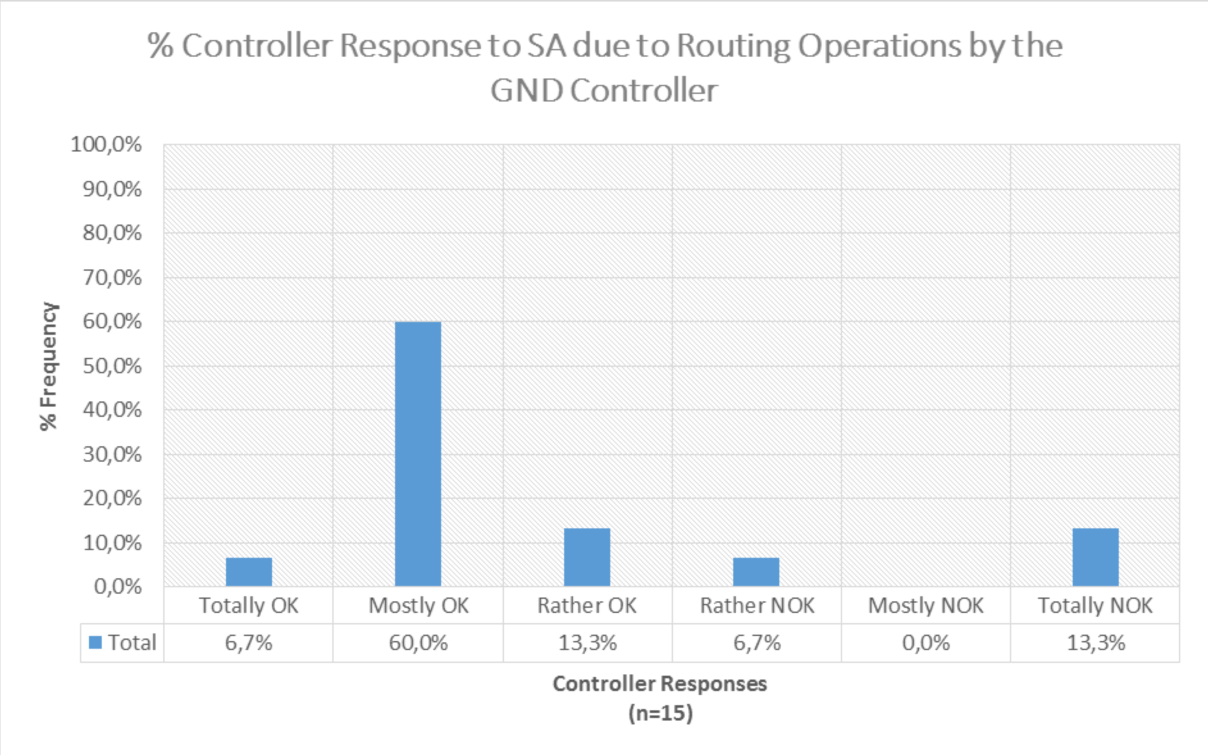


Figure Appendix A-16: Questionnaire – % Controller Response to SA due to Routing Operations by the GND Controller

For the ground controllers, an acceptable level of SA was achieved although it was observed that attention was too focused on the screen instead of the outside traffic and the awareness of the traffic was heavily impacted by several factors:

- The shadow-mode implied that operational decisions based on a detailed representation of the traffic conditions was not required, and thus VLD controllers were mostly copying the decisions taken by their tower counterparts,
- The numerous route modifications as well as issues arising from those, implied that ground controllers spent much more time interacting with the HMI than would be nominally required,
- The almost continuous taxiing of aircraft, with very few position holds and efficient frequency transfer-outs was hard to materialise in real-time without incurring an impact on work performances and situational awareness,
- Alerts, including sound alarms arising from such routing issues as reported in the previous points also incurred more VLD controller interactions with the HMI, than normally required.

The Situational Awareness experienced by GROUND controllers due to routing and planning functions was partially demonstrated (Figure Appendix A-16).

A3.4.5.b EX1-CRT-VLD-28-005-002 - Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.

RUNWAY ATCOs' situation awareness was good (Figure Appendix A-17). Frequent manual route modifications were not required by the RUNWAY controller and a higher Situational Awareness was reported than GROUND controllers.

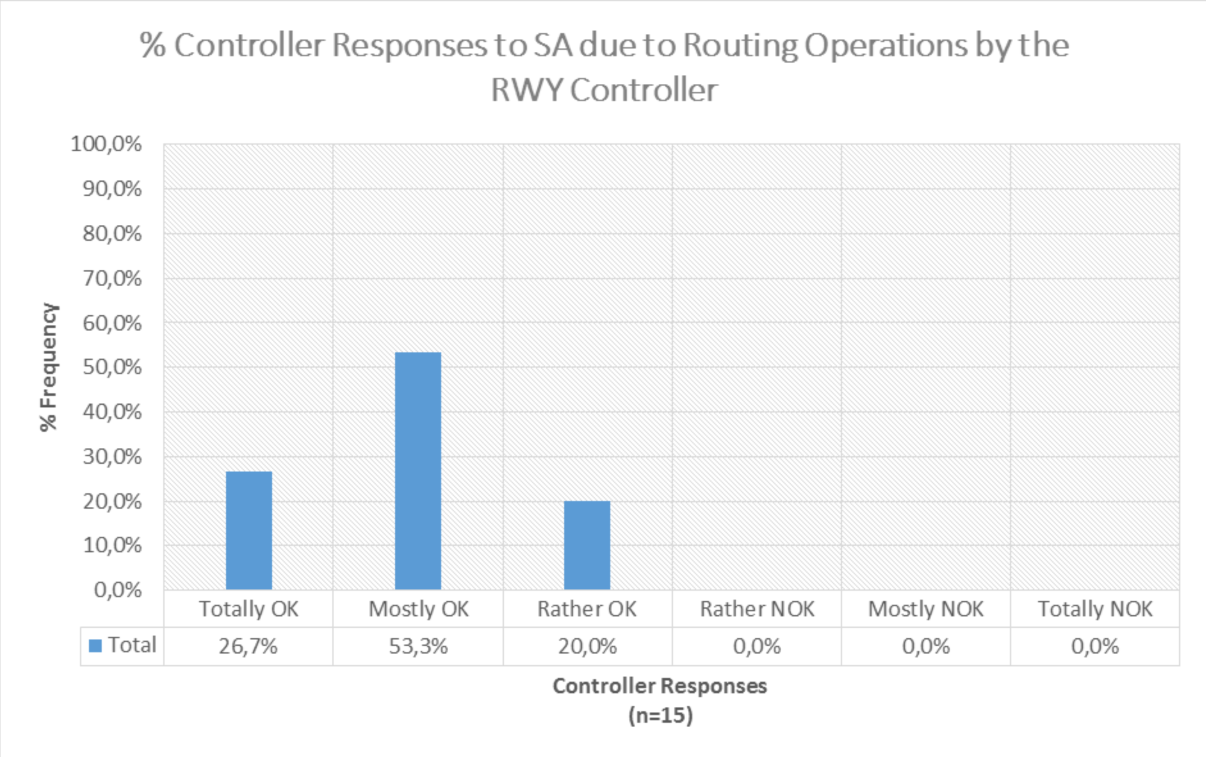


Figure Appendix A-17: Questionnaire – % Controller Responses to SA due to Routing Operations by the RWY Controller

The Situational Awareness experienced by RUNWAY controllers due to routing and planning functions was satisfactorily demonstrated.

A3.4.5.c EX1-CRT-VLD-28-005-003 - Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.

Cf. EX1-CRT-VLD-28-004-003

A3.4.6 EX1-OBJ-VLD-28-024 Results - Demonstrate utility of routing and planning functions in non-nominal conditions.

A3.4.6.a EX1-CRT-VLD-28-024-001 - Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operation in case of specific events (e.g. taxiway closure).

A certain number of non-nominal conditions were encountered during the VLD and observed by some of the controllers, in the form of: i) Counter-QFU operations due to adverse weather, Go-

Around of an aircraft, landing on departure runway. Further, a taxiway closure was simulated, and the resulting routing solutions observed by controllers.

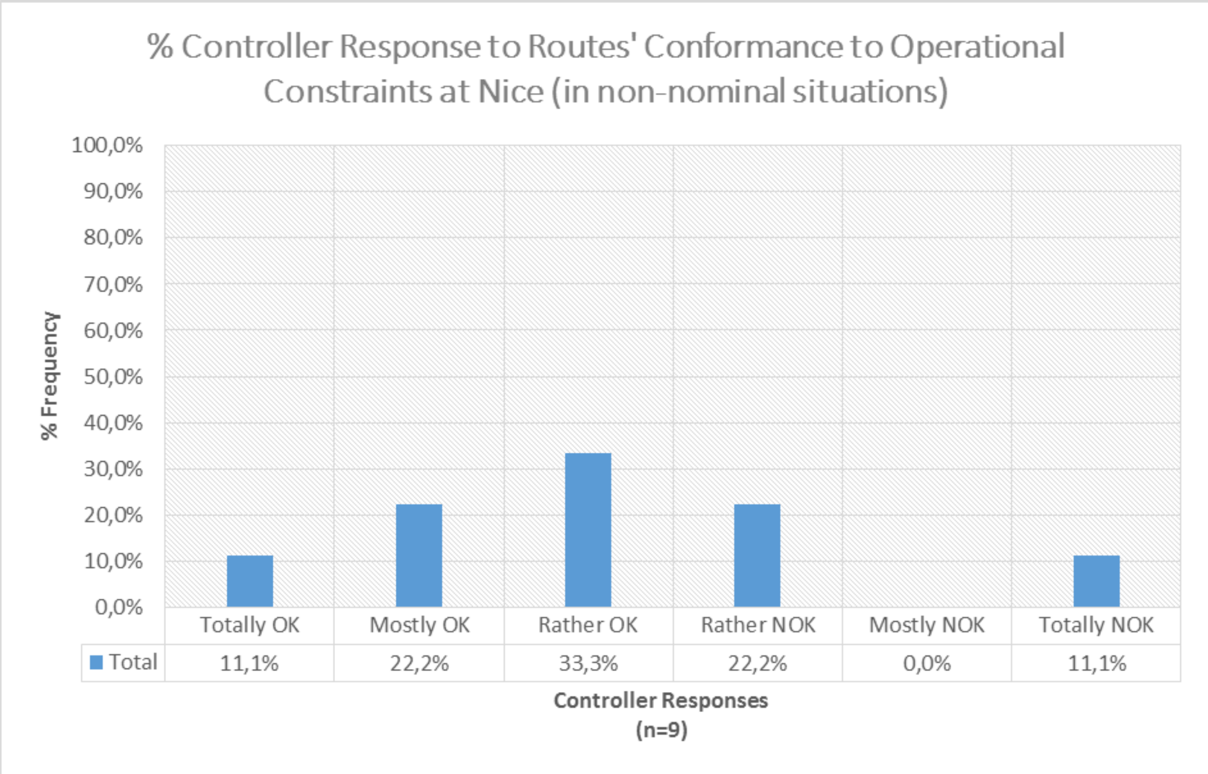


Figure Appendix A-18: Questionnaire - % Controller Response to Routes' Conformance to Operational Constraints at Nice (in non-nominal situations)

6 out of 15 respondents did not observe any non-nominal condition and were excluded from this chart (Figure Appendix A-18). 33.3% were rather OK with the calculated routes' conforming to operational needs while 22.2% were rather not OK. This can be explained by the system's lack of parametrisation concerning non-nominal conditions.

Given the calculated routes' lack of conformance to operational needs in non-nominal conditions, the utility of routing and planning functions in non-nominal conditions has been partially demonstrated.

A3.4.6.b EX1-CRT-VLD-28-024-002 - Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure).

A certain number of non-nominal conditions were encountered during the VLD and observed by some of the controllers, in the form of: i) Counter-QFU operations due to adverse weather, Go-Around of an aircraft, landing on departure runway. Further, a taxiway closure was simulated, and the resulting routing solutions observed by controllers.

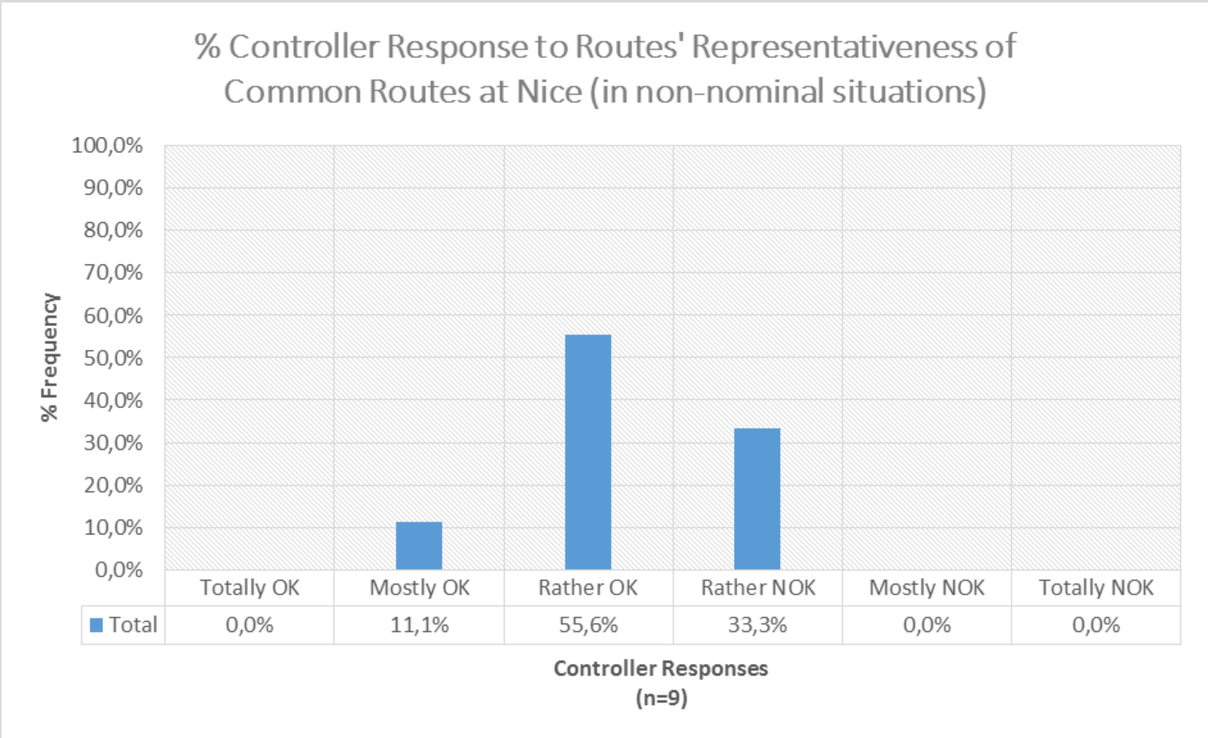


Figure Appendix A-19: Questionnaire - % Controller Response to Routes' Representativeness of Common Routes at Nice (in non-nominal situations)

6 out of 15 respondents did not observe any non-nominal condition and were excluded from this chart (Figure Appendix A-19). Results indicate that 55.6% of respondents were Rather OK and 33.3% were Rather Not OK. This can be explained by:

- the direction of a taxi being wrongly detected by the system, thus plotting wrong routing solutions, and
- the system's lack of parametrisation concerning non-nominal conditions.

Given the calculated routes' lacking relevance in certain non-nominal conditions, the utility of routing and planning functions in non-nominal conditions has been partially demonstrated.

A3.4.7 EX1-OBJ-VLD-28-006 Results - Demonstrate the utility of CATC alerts functions

A3.4.7.a EX1-CRT-VLD-28-006-001 - Positive evaluation of the utility of the CATC alerts functions when real surveillance data is used.

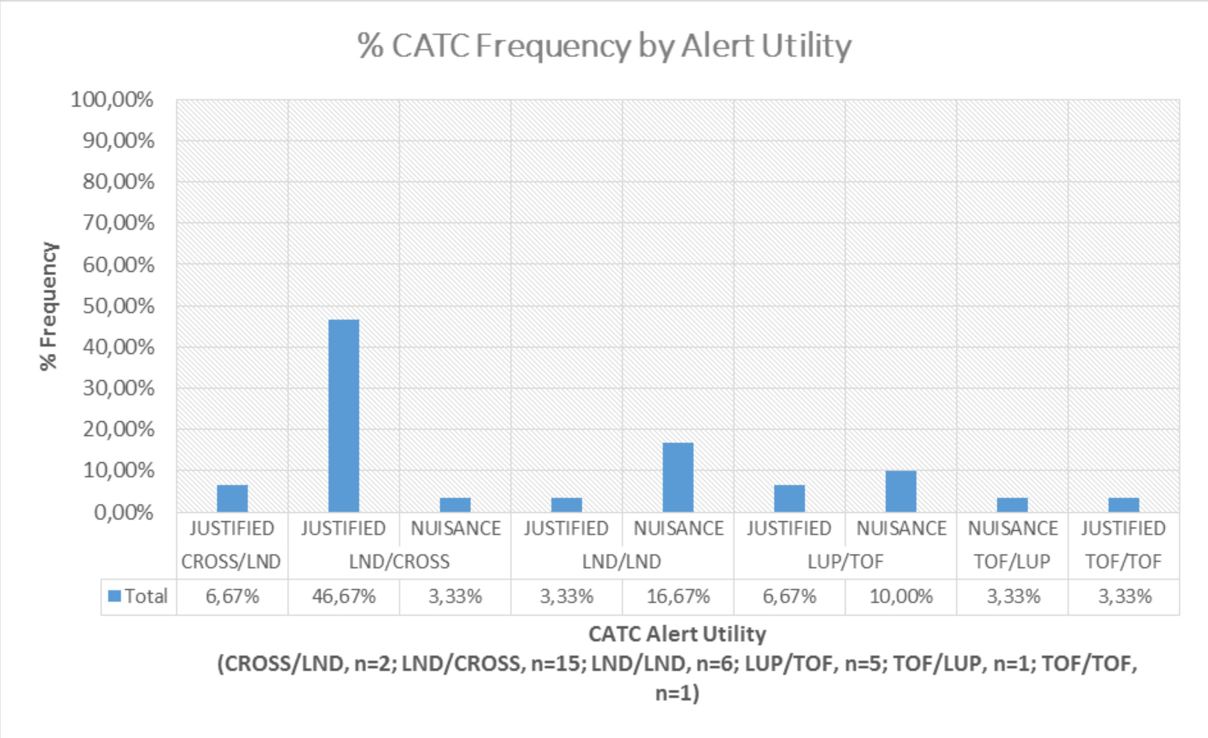


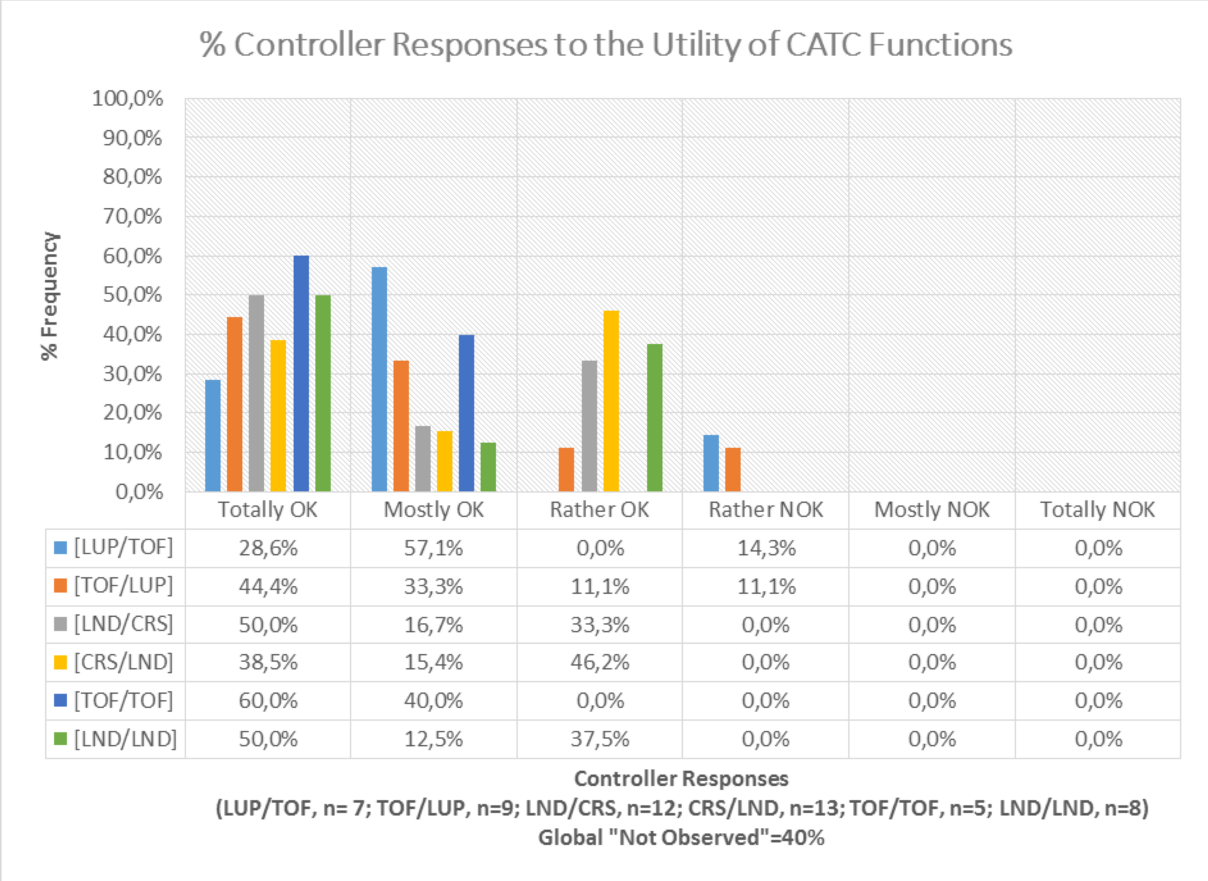
Figure Appendix A-20: Metrics - CATC Utility vs. Percentage of Total CATC

Figure Appendix A-20 shows the percentage of nuisance and justified CATC alerts logged by the system on all runs.

Nuisance CATC alerts were generally quite low for all CATC alerts. The LND/LND alerts had higher rate than other alerts. No false CATC alerts were logged.

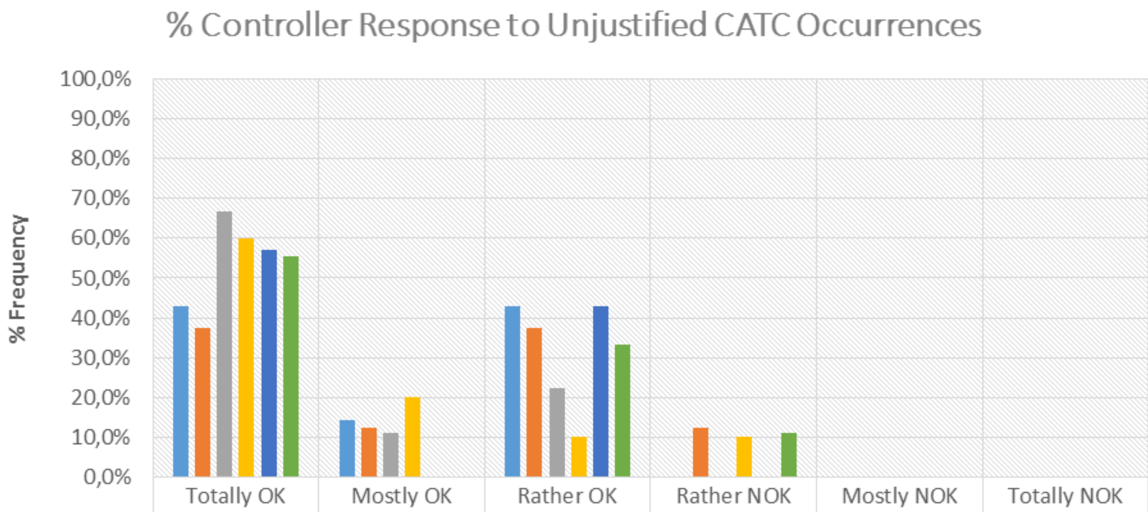
The LND/CROSS alert displayed the highest number of justified alerts since controllers experienced delays in inputting the CROSS clearance mainly due to the shadow-mode protocol impacting the reaction time of the controllers by a few seconds, thus leading to alert triggering before a clearance had been inputted on the HMI.

Out of the 15 LND/CROSS alerts, 3 were due to controllers' testing of the feature during a period of low traffic activity. A missed detection was also noted for a duration of 3 seconds.



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[LUP/TOF]	28,6%	57,1%	0,0%	14,3%	0,0%	0,0%
[TOF/LUP]	44,4%	33,3%	11,1%	11,1%	0,0%	0,0%
[LND/CRS]	50,0%	16,7%	33,3%	0,0%	0,0%	0,0%
[CRS/LND]	38,5%	15,4%	46,2%	0,0%	0,0%	0,0%
[TOF/TOF]	60,0%	40,0%	0,0%	0,0%	0,0%	0,0%
[LND/LND]	50,0%	12,5%	37,5%	0,0%	0,0%	0,0%

Figure Appendix A-21: Questionnaire - % Controller Responses to the Utility of CATC Functions



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[LUP/TOF]	42,9%	14,3%	42,9%	0,0%	0,0%	0,0%
[TOF/LUP]	37,5%	12,5%	37,5%	12,5%	0,0%	0,0%
[LND/CRS]	66,7%	11,1%	22,2%	0,0%	0,0%	0,0%
[CRS/LND]	60,0%	20,0%	10,0%	10,0%	0,0%	0,0%
[TOF/TOF]	57,1%	0,0%	42,9%	0,0%	0,0%	0,0%
[LND/LND]	55,6%	0,0%	33,3%	11,1%	0,0%	0,0%

Controller Responses
(LUP/TOF, n= 7; TOF/LUP, n=8; LND/CRS, n=9; CRS/LND, n=10; TOF/TOF, n=7; LND/LND, n=9)
Global "Not Observed"=44%

Figure Appendix A-22: Questionnaire – Unjustified CATC Acceptability

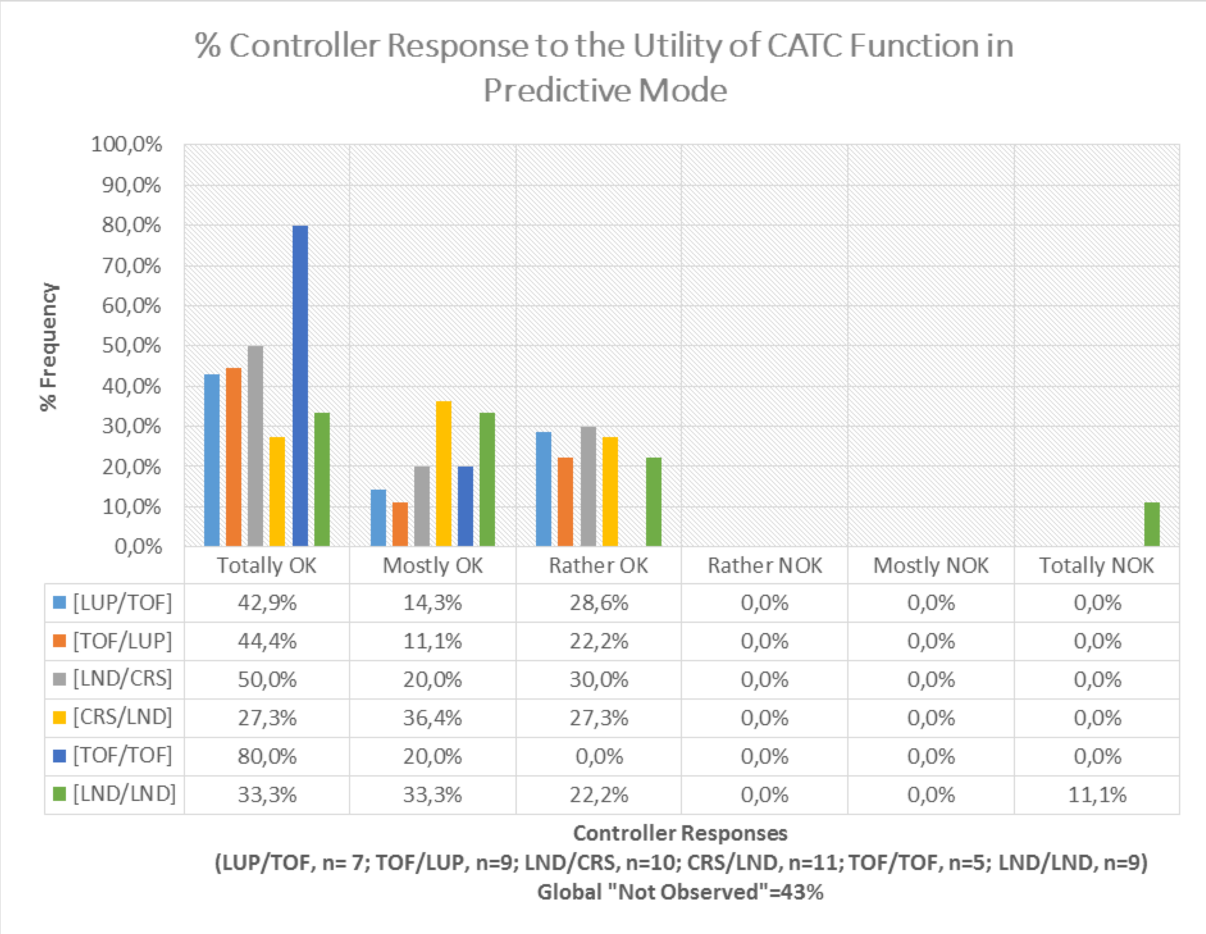
Certain exceptions were noted based mostly on the parameterisation of the system with regards to work practices at Nice:

- LND/LND triggering was estimated as being too conservative given that during heavy traffic, a LND is provided to a consecutive aircraft as long as the head aircraft starts vacating the concerned runway.

The utility of CATC functions was considered as having been positively demonstrated due to the low level of nuisance alerts and a lack of false alerts.

A3.4.8 EX1-OBJ-VLD-28-007 Results - Demonstrate the utility of CATC functions in predictive mode

A3.4.8.a EX1-CRT-VLD-28-007-001 - Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.



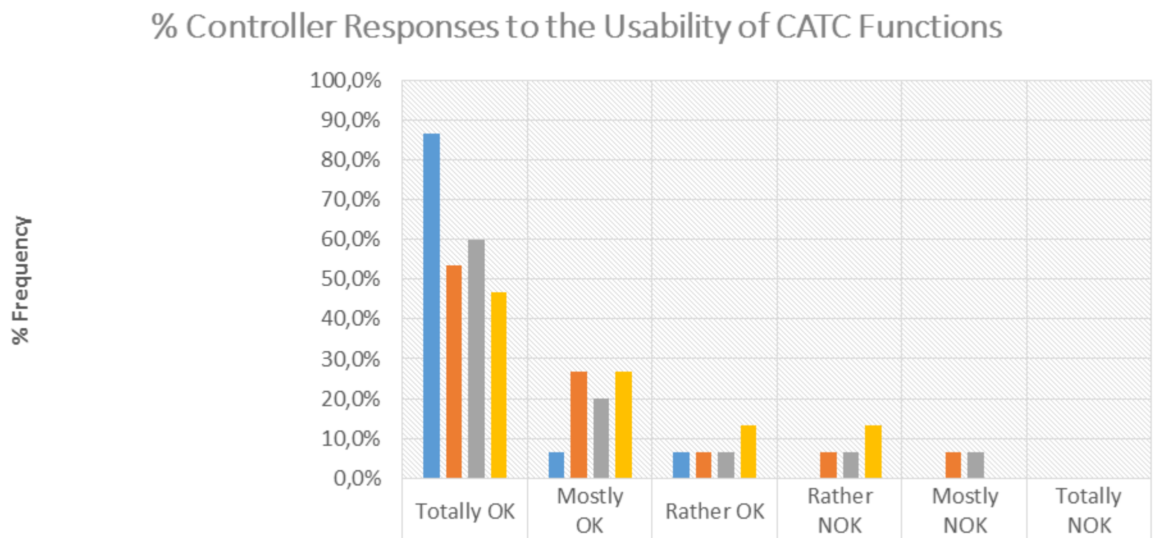
	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[LUP/TOF]	42,9%	14,3%	28,6%	0,0%	0,0%	0,0%
[TOF/LUP]	44,4%	11,1%	22,2%	0,0%	0,0%	0,0%
[LND/CRS]	50,0%	20,0%	30,0%	0,0%	0,0%	0,0%
[CRS/LND]	27,3%	36,4%	27,3%	0,0%	0,0%	0,0%
[TOF/TOF]	80,0%	20,0%	0,0%	0,0%	0,0%	0,0%
[LND/LND]	33,3%	33,3%	22,2%	0,0%	0,0%	11,1%

Figure Appendix A-23: Questionnaire - Predictive CATC Utility vs. Average Response Score

The utility of CATC functions was assessed as having been positively demonstrated due to the low level of nuisance alerts and a lack of false alerts.

A3.4.9 EX1-OBJ-VLD-28-008 Results - Demonstrate the usability of CATC functions

A3.4.9.a EX1-CRT-VLD-28-008-001 - Positive evaluation of the usability of CATC alerts functions



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[The visibility of CATC was effective]	86,7%	6,7%	6,7%	0,0%	0,0%	0,0%
[The CATC labels were understandable]	53,3%	26,7%	6,7%	6,7%	6,7%	0,0%
[The colour coding of CATC was effective]	60,0%	20,0%	6,7%	6,7%	6,7%	0,0%
[The interaction with CATC was effective]	46,7%	26,7%	13,3%	13,3%	0,0%	0,0%

Controller Responses (n=15)

Figure Appendix A-24: Questionnaire - CATC Usability vs. Average Response Score

The usability of CATC alerts was demonstrated through: i) Interaction with the alert labels, ii) colour coding of the CATC, iii) understandability of the alert label, and iv) visibility of the CATC, as shown in Figure Appendix A-24.

Controllers indicated that the usability of the CATC alerts was positive concerning all the variables demonstrated.

Certain minor exceptions were noted based mostly on the parameterisation of the system with regards to work practices at Nice.

Overall, the usability of the CATC alert functions was positively demonstrated.

A3.4.9.b EX1-CRT-VLD-28-008-002 - Positive evaluation of the usability of CATC functions in predictive mode

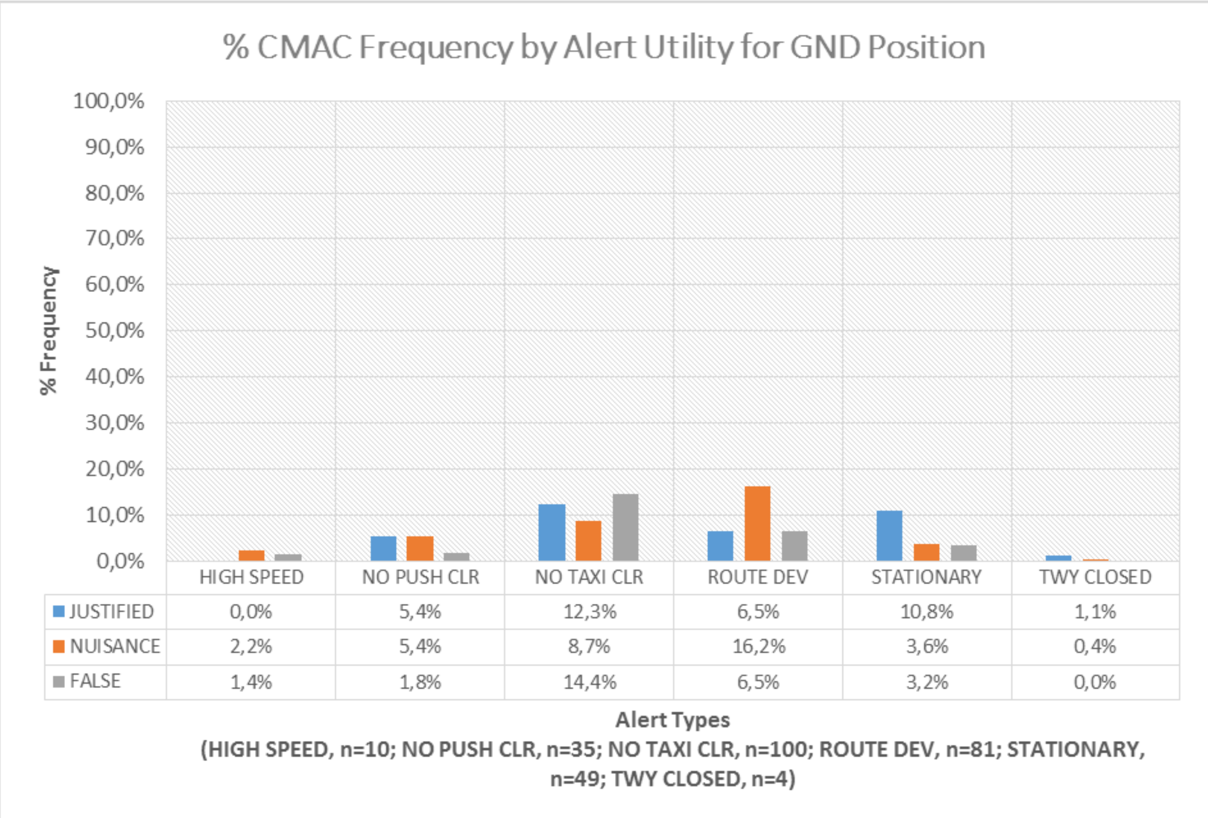
It is noted concerning this objective that the implementation of the predictive alert highly influences the resulting usability of the tool and results thereof. In the case of the system under demonstration at Nice, the predictive indicator tool is an evolution of the results from the SESAR 1 EXE-699 recommendations. While the EXE-699 system under test implemented two fields, materialising the current and next clearances, the current system has a unique dynamic field showing the current clearance by default, and the next clearance upon mouse hover. This implementation addressed the blinking predictive indicator issues encountered in EXE-699.

The usability of the predictive CATC functions was evaluated as part of the general CATC alert usability (cf. Figure Appendix A-24). The predictive indicator was visible, understandable to some controllers who also indicated that the colour coding of the design solution was appropriate. However, all controllers did not observe the predictive indicator for all alerts due mainly to a lack of conflicting situations during their runs, such that it is considered as being partially demonstrated.

A3.4.10 EX1-OBJ-VLD-28-009 Results - Demonstrate the utility of CMAC functions

A3.4.10.a EX1-CRT-VLD-28-009-001 - Positive evaluation of the utility of CMAC functions when real surveillance data is used.

GROUND POSITION

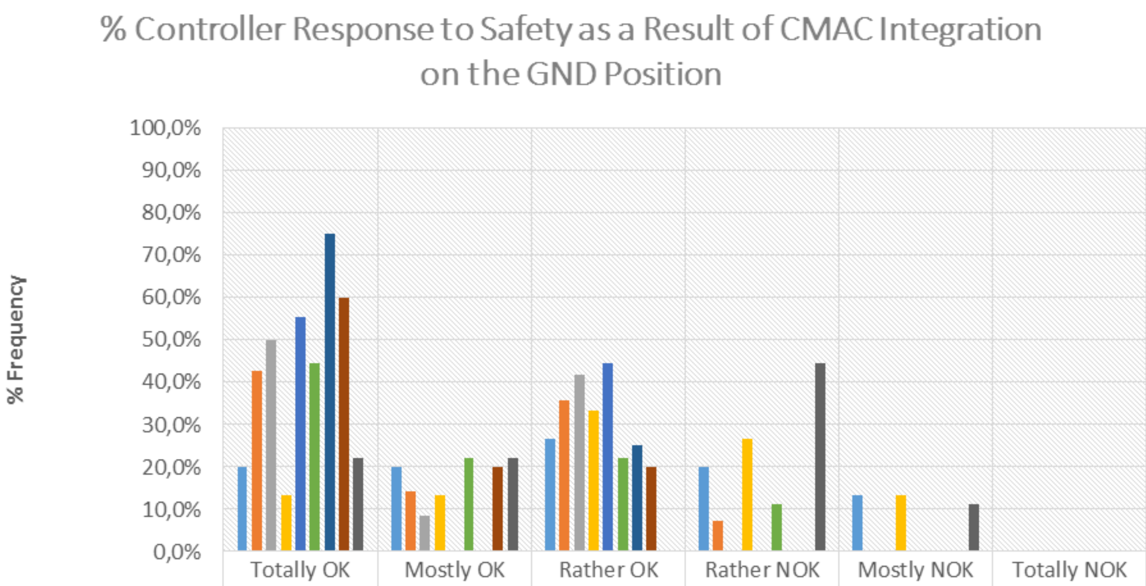


	HIGH SPEED	NO PUSH CLR	NO TAXI CLR	ROUTE DEV	STATIONARY	TWY CLOSED
JUSTIFIED	0,0%	5,4%	12,3%	6,5%	10,8%	1,1%
NUISANCE	2,2%	5,4%	8,7%	16,2%	3,6%	0,4%
FALSE	1,4%	1,8%	14,4%	6,5%	3,2%	0,0%

Figure Appendix A-25: Metrics – CMAC Utility for GROUND Position

Concerning the CMAC alerts logged for the GROUND position, there was:

- Higher count of justified alerts for the NO TAXI CLR alerts.

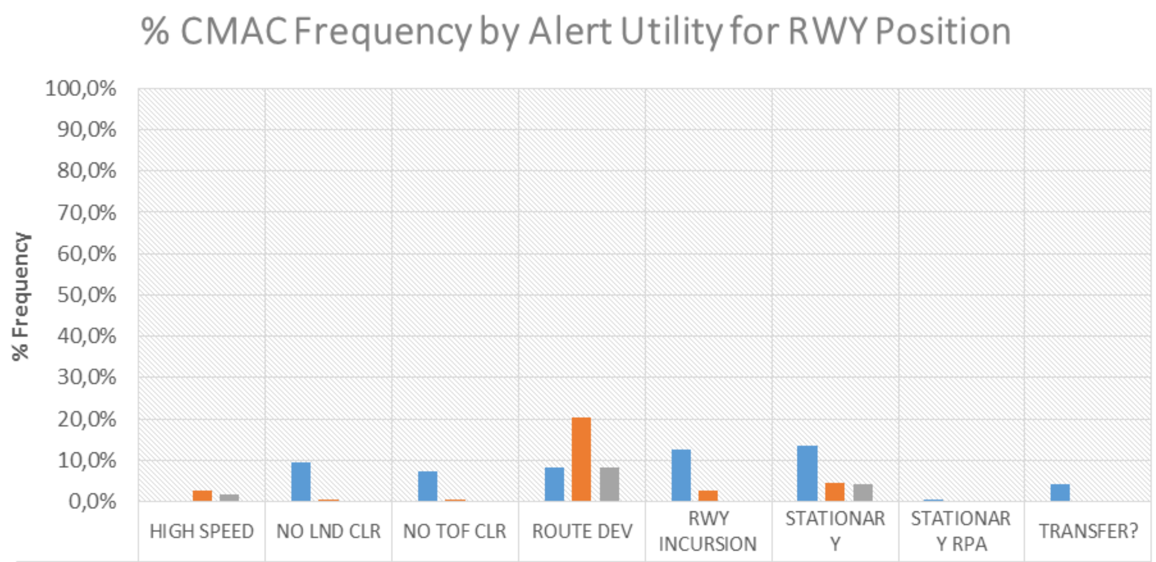


	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[ROUTE DEV]	20,0%	20,0%	26,7%	20,0%	13,3%	0,0%
[NO PUSH CLR]	42,9%	14,3%	35,7%	7,1%	0,0%	0,0%
[NO TAXI CLR]	50,0%	8,3%	41,7%	0,0%	0,0%	0,0%
[STATIONARY]	13,3%	13,3%	33,3%	26,7%	13,3%	0,0%
[No TRANSFER]	55,6%	0,0%	44,4%	0,0%	0,0%	0,0%
[RWY INCURSION]	44,4%	22,2%	22,2%	11,1%	0,0%	0,0%
[TWY TYPE]	75,0%	0,0%	25,0%	0,0%	0,0%	0,0%
[TWY CLOSED]	60,0%	20,0%	20,0%	0,0%	0,0%	0,0%
[HIGH SPEED]	22,2%	22,2%	0,0%	44,4%	11,1%	0,0%

Controller Responses
(ROUTE DEV, n=15; NO PUSH CLR, n=14; NO TAXI CLR, n=12; STATIONARY, n=15; TRANSFER, n=9; RWY INCURSION, n=9; TWY TYPE, n=4; TAXIWAY CLOSED, n=5; HIGH SPEED, n=9)
Global "Not Observed"=32%

Figure Appendix A-26: Questionnaire – CMAC Utility on GROUND Position

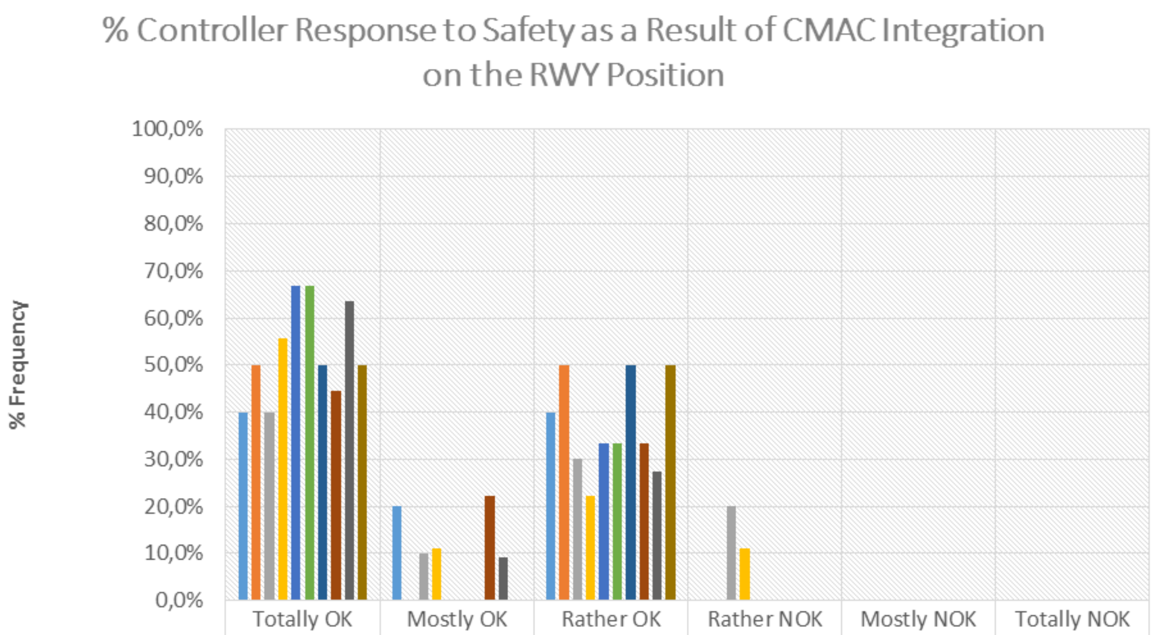
RUNWAY POSITION



	HIGH SPEED	NO LND CLR	NO TOF CLR	ROUTE DEV	RWY INCURSION	STATIONARY	STATIONARY RPA	TRANSFER?
JUSTIFIED	0,0%	9,4%	7,2%	8,1%	12,6%	13,5%	0,4%	4,0%
NUISANCE	2,7%	0,4%	0,4%	20,2%	2,7%	4,5%	0,0%	0,0%
FALSE	1,8%	0,0%	0,0%	8,1%	0,0%	4,0%	0,0%	0,0%

Alert Types
(HIGH SPEED, n=10; NO LND CLR, n=22; NO TOF CLR, n=17; ROUTE DEV, n=81; RWY INCURSION, n=34; STATIONARY, n=49; STATIONARY RPA, n=1; TRANSFER?, n=9))

Figure Appendix A-27: Metrics – CMAC Utility for RUNWAY Position



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[ROUTE DEV]	40,0%	20,0%	40,0%	0,0%	0,0%	0,0%
[NO TAXI CLR]	50,0%	0,0%	50,0%	0,0%	0,0%	0,0%
[STATIONARY]	40,0%	10,0%	30,0%	20,0%	0,0%	0,0%
[TRANSFER]	55,6%	11,1%	22,2%	11,1%	0,0%	0,0%
[RWY INCURSION]	66,7%	0,0%	33,3%	0,0%	0,0%	0,0%
[TWY TYPE]	66,7%	0,0%	33,3%	0,0%	0,0%	0,0%
[TWY CLOSED]	50,0%	0,0%	50,0%	0,0%	0,0%	0,0%
[NO TOF CLR]	44,4%	22,2%	33,3%	0,0%	0,0%	0,0%
[NO LND CLR]	63,6%	9,1%	27,3%	0,0%	0,0%	0,0%
[WRONG RWY]	50,0%	0,0%	50,0%	0,0%	0,0%	0,0%

Controller Responses
(ROUTE DEV, n=10; NO TAXI CLR, n=8; STATIONARY, n=10; NO TRANSFER, n=9; RWY INCURSION, n=9; TWY TYPE, n=3; TWY CLOSED, n=2; NO TOF CLR, n=9; NO LND CLR, n= 11; WRONG RWY, n=2)
Global "Not Observed"=51%

Figure Appendix A-28: Questionnaire – CMAC Utility on RUNWAY Position vs. Average Response Score

In general, the utility of CMAC functions was positive, although all VLD controllers did not witness the triggering of all CMAC alerts (Figure Appendix A-28), and the parameterisation of the alerts hindered controllers in their tasks as follows:

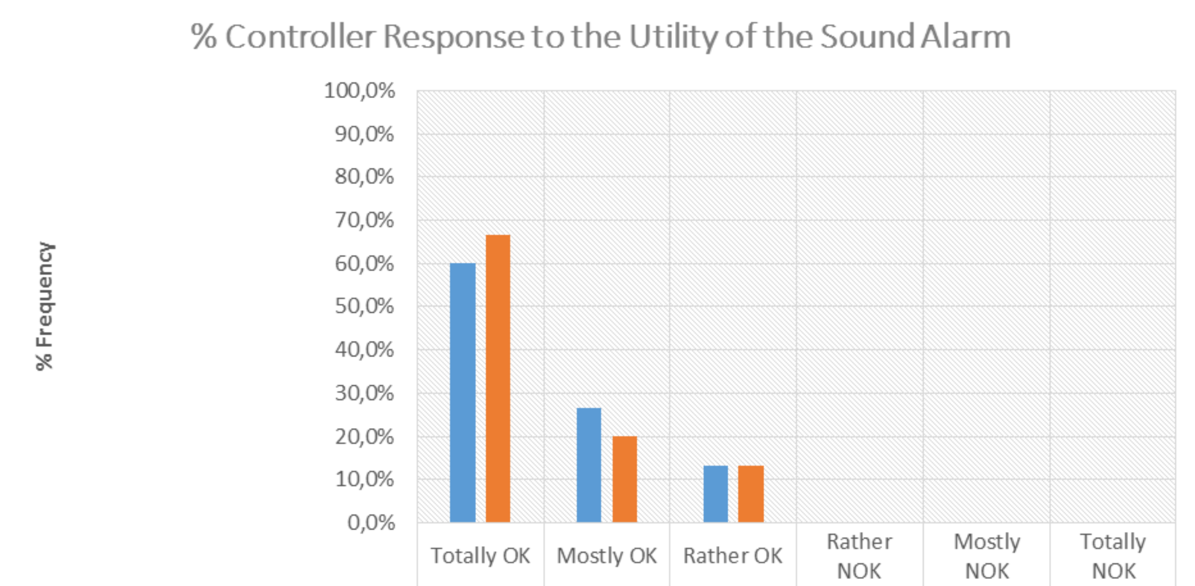
- The NO TOF CLR was detected too late for an effective CANCEL instruction to be provided by the controller,
- The triggering conditions of STATIONARY alerts were sometimes too restrictive with respect to the operational situation. At Nice, prioritised taxiing is practiced within the area of responsibility such that the STATIONARY alert posed a nuisance,

- In certain cases, the STATIONARY alert was triggered whereby the system detected the start of a PUSHBACK due to random movements of the radar track. Although the occurrences have been categorised as bugs, the non-justified triggering of the STATIONARY alert affected controllers' perceived utility of the function,
- The HIGH SPEED CMAC alert was triggered several times and was operationally unjustified. Controllers have indicated that higher than normal speeds can be beneficial to expedite the flow in heavy traffic situations, although within the bounds of safety,
- Many RTE DEVIATION alerts were triggered following the routing issues reported in 001 and 002, and the delay incurred by VLD controllers due to the shadow-mode protocol and issues with route modifications. Further, RTE DEVIATION alerts were systematic on the Runway controller's position due to arriving aircraft rarely stopping at the runway holding point upon exiting - in conformance with normal operations. However, the system under demonstration required a systematic GET action from the GROUND controllers which imparted a delay in operations.

Overall, the utility of CMAC functions was partially demonstrated due to the parameterization and system limitations encountered during the runs.

A3.4.11 EX1-OBJ-VLD-28-010 Results - Demonstrate the usability of CMAC functions

A3.4.11.a EX1-CRT-VLD-28-010-001 - Positive evaluation of the audio alarm



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[Indicated effectively that an alarm was in progress]	60,0%	26,7%	13,3%	0,0%	0,0%	0,0%
[Easily interrupted by the ATCO]	66,7%	20,0%	13,3%	0,0%	0,0%	0,0%

Figure Appendix A-29: Questionnaire – Audio Alarm Usability vs. Response Score

The sound alert was assessed (Figure Appendix A-29) as useful and efficient (60% totally OK) and the interaction was OK (66.7% totally OK), except in the following minor cases:

- One case of a controller reporting that the audio alarm can be surprising as the given NO LND CLR alert was already being monitored. However, this is the normal functioning of the system whereby any CMAC qualifying for an alarm status triggers the sound alarm, which should be interruptive although the controller can de-activate it,
- One case where the audio alert associated with a Runway Incursion while there were no immediate conflicts in the vicinity of the aircraft. In this situation, the design rules are such that any runway incursion triggers the CMAC in an alarm status.

The usability of the audio alarm associated with the CMAC function was positively demonstrated as being effective.

A3.4.11.b EX1-CRT-VLD-28-010-002 - Positive evaluation of the level of alerts generated (information or alarm)

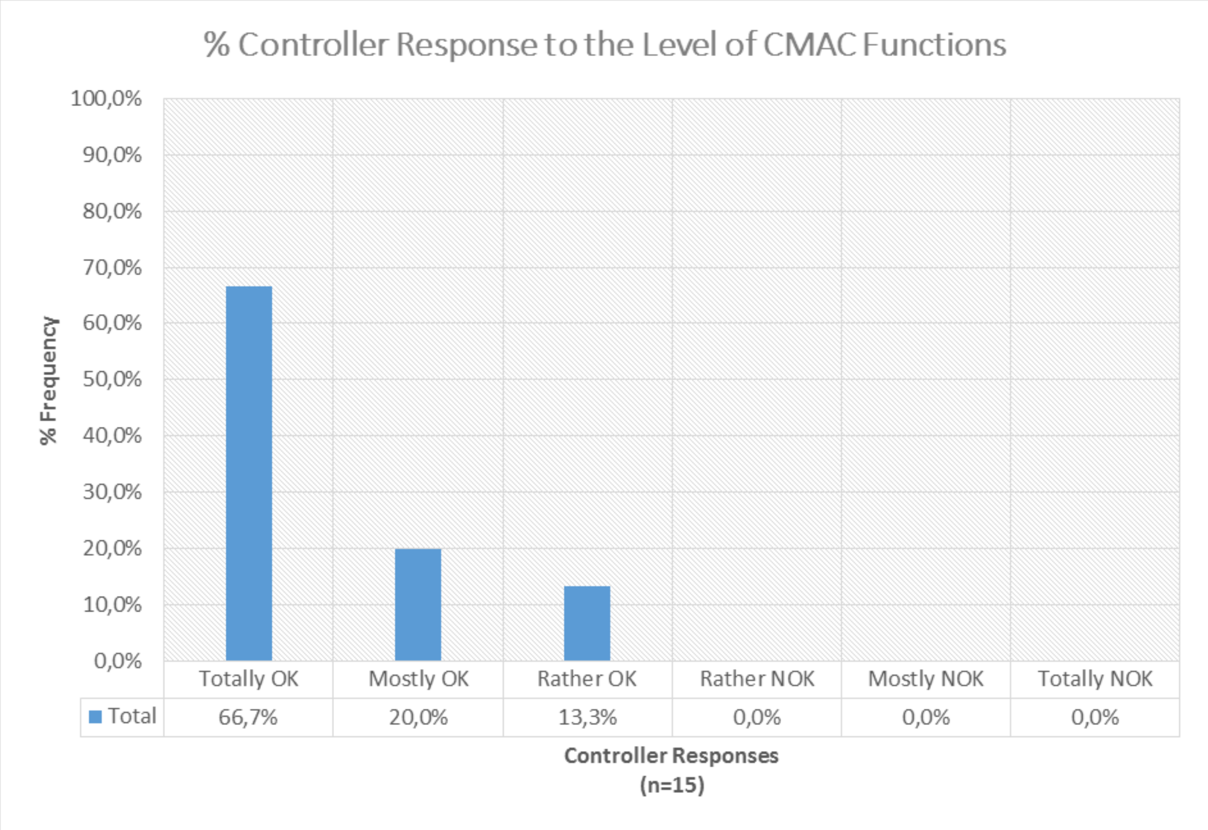


Figure Appendix A-30: Questionnaire – % Controller Response to the Level of CMAC Functions

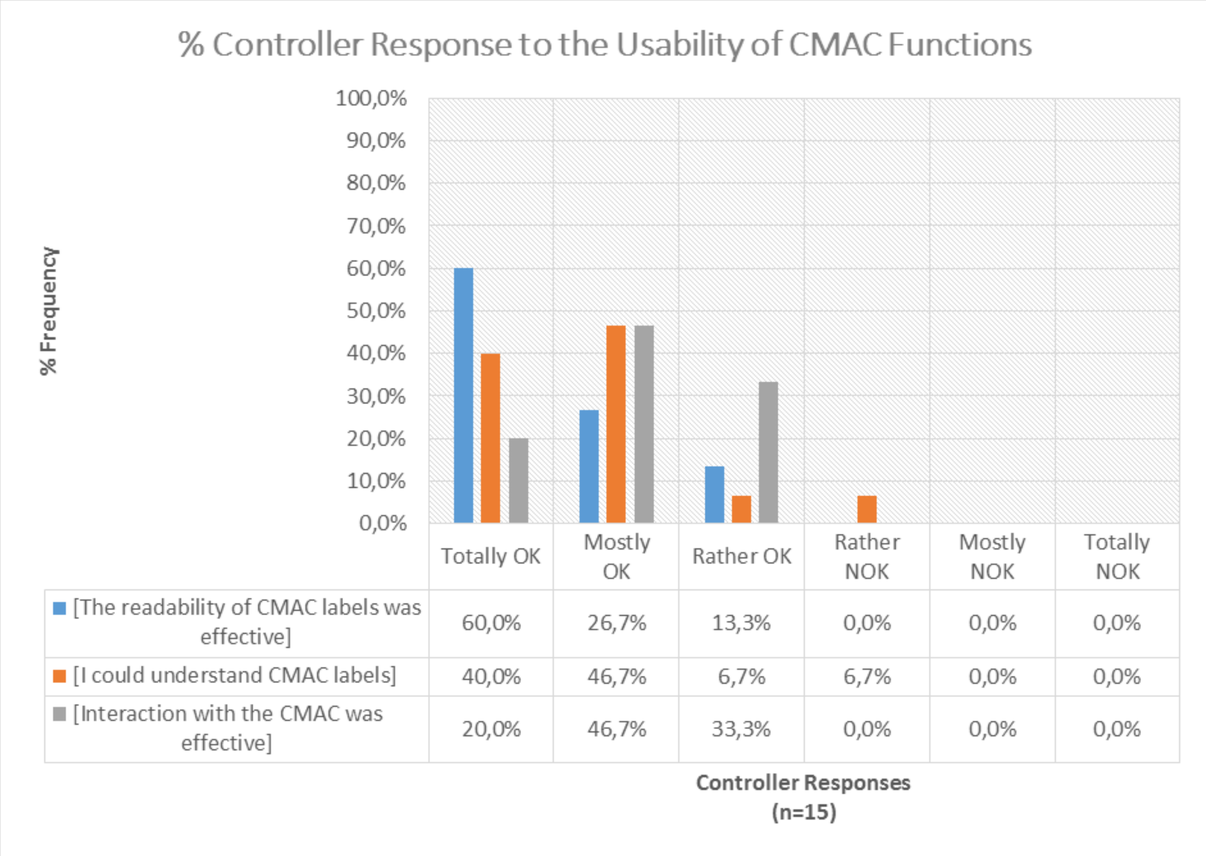
In general, the information and alarm levels of alerts generated was appropriate for controllers (Figure Appendix A-30).

The main exception concerning the alert level was with the NO LND CLR alert. Controllers indicated that the alert switched too rapidly from "information" to "alarm" level for the alert to be effective. Indeed, an information level alert is triggered at 1NM to minimise nuisance alerts and switches to an alarm level at 0,8 NM from the runway threshold.

Historically, the threshold between the Information and Alarm levels concerning the NO LND CLR has been modified according to controller feedback. However, it appears that in real surveillance conditions, a further adaptation must be parameterized for the NO LND CLR.

Overall, the effectiveness of the CMAC alert levels was partially demonstrated to the controllers given that the alert threshold of the NO LND CLR remains to be adjusted.

A3.4.11.c EX1-CRT-VLD-28-010-003 - Positive evaluation of the usability of CMAC alerts functions



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[The readability of CMAC labels was effective]	60,0%	26,7%	13,3%	0,0%	0,0%	0,0%
[I could understand CMAC labels]	40,0%	46,7%	6,7%	6,7%	0,0%	0,0%
[Interaction with the CMAC was effective]	20,0%	46,7%	33,3%	0,0%	0,0%	0,0%

Figure Appendix A-31: Questionnaire – % Controller Response to the Usability of CMAC Functions

In general, the usability of CMAC functions was positive (Figure Appendix A-31), although all VLD controllers did not witness the triggering of all CMAC alerts. Several usability issues were encountered and are reported:

- The comprehension of CMAC alert labels was an issue with controllers lacking experience with the acronyms and SESAR terminologies used,
- The usability of CMAC alerts was sometimes affected due to difficulties in acknowledging triggered alerts using the radar label. Certain technical slowdowns with the system might explain the behaviour,
- In other cases, the overlapping of labels did not provide enough space for controllers to materialise a click for acknowledging CMAC alerts, and in such cases, controllers did not attempt to acknowledge alerts through the alert window.

The overall usability of the CMAC functions was partially demonstrated to the controllers due to alert comprehension and interaction.

A3.4.12 Demonstrate that safety with regards to Airport operations is improved with the successful integration of CMAC

A3.4.12.a EX1-CRT-VLD-28-011-001 - Positive evaluation that the safety is improved with the successful integration of CMAC for the GROUND controller

The safety of CMAC integration in the exercise has been correlated with the rate of nuisance alerts occurring over the runs. Expert feedback was considered to determine whether the operational safety over the course of the exercise could have been affected, if controllers were interacting directly with the aircraft.

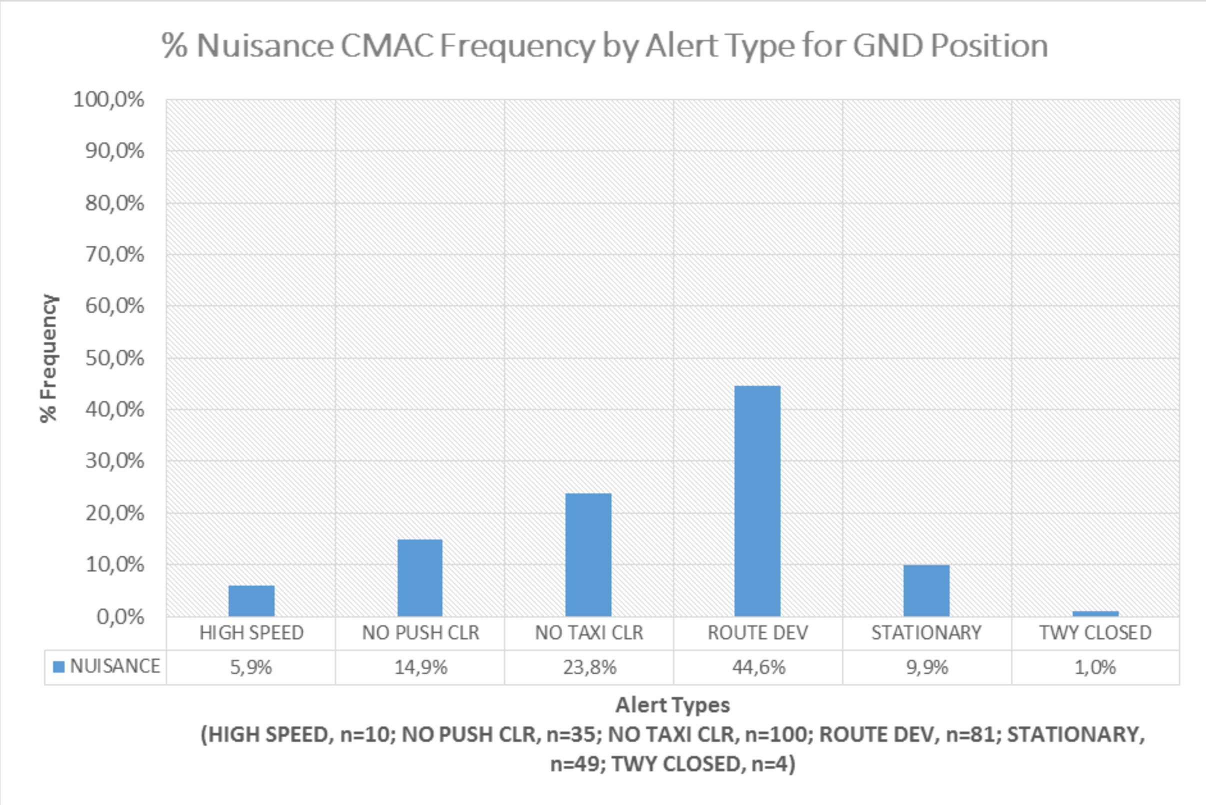


Figure Appendix A-32: Metrics – % Nuisance CMAC Frequency by Alert Type for GND Position

Overall, there was a relatively low rate of nuisance CMAC alerts (Figure Appendix A-32), namely 5 per day arising mostly due to the routing issues as reported in Solution #22 objectives.

Concerning the ROUTE DEVIATION alert which made up almost half of the nuisance CMAC, several of the occurrences were due to issues with the parking assignment (Parking K) such as re-routing calculations and label behaviours associated with the modification of the parking.

Due to issues reported with the routing function and certain design bugs (e.g. parking bugs or missing ID/labels for certain aircraft) the successful integration of CMAC and its associated safety improvement has been partially demonstrated.

A3.4.12.b EX1-CRT-VLD-28-011-002 - Positive evaluation that the safety is improved with the successful integration of CMAC for the RUNWAY controller

The safety of CMAC integration in the exercise has been correlated with the rate of nuisance alerts occurring over the runs. Expert feedback was considered to determine whether the operational safety over the course of the exercise could have been affected, if controllers were interacting directly with the aircraft.

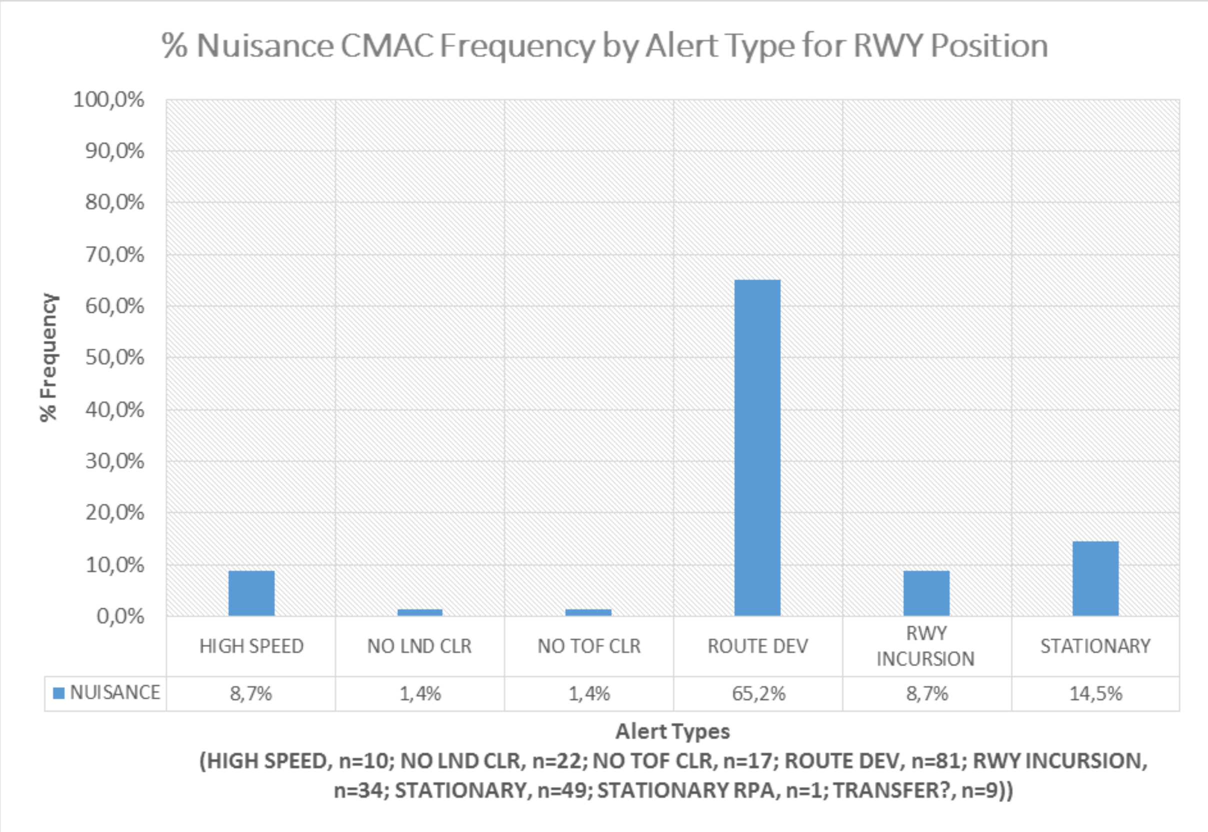


Figure Appendix A-33: Metrics - % Nuisance CMAC Frequency by Alert Type for RWY Position

Overall, there was a relatively low rate of nuisance CMAC alerts (Figure Appendix A-33), namely 2.8 per day arising mostly due to the routing issues as reported in Solution #22 objectives.

There was no observable negative impact on safety concerning the integration of CMAC for the runway controller. The CMAC for runway controllers were more justified and better integrated (much less nuisances and no false alerts) than ground CMAC because the runway perceived little impact from routing issues which might have arisen.

A3.4.13 Demonstrate that safety with regards to Airport operations is improved with the successful integration of CATC

A3.4.13.a EX1-CRT-VLD-28-012-001 - Positive evaluation that the safety is improved with the successful integration of CATC for the RUNWAY controller

The safety of CATC integration in the exercise has been correlated with the rate of nuisance alerts occurring over the runs. Expert feedback was considered to determine whether the operational safety over the course of the exercise could have been affected, if controllers were interacting directly with the aircraft.

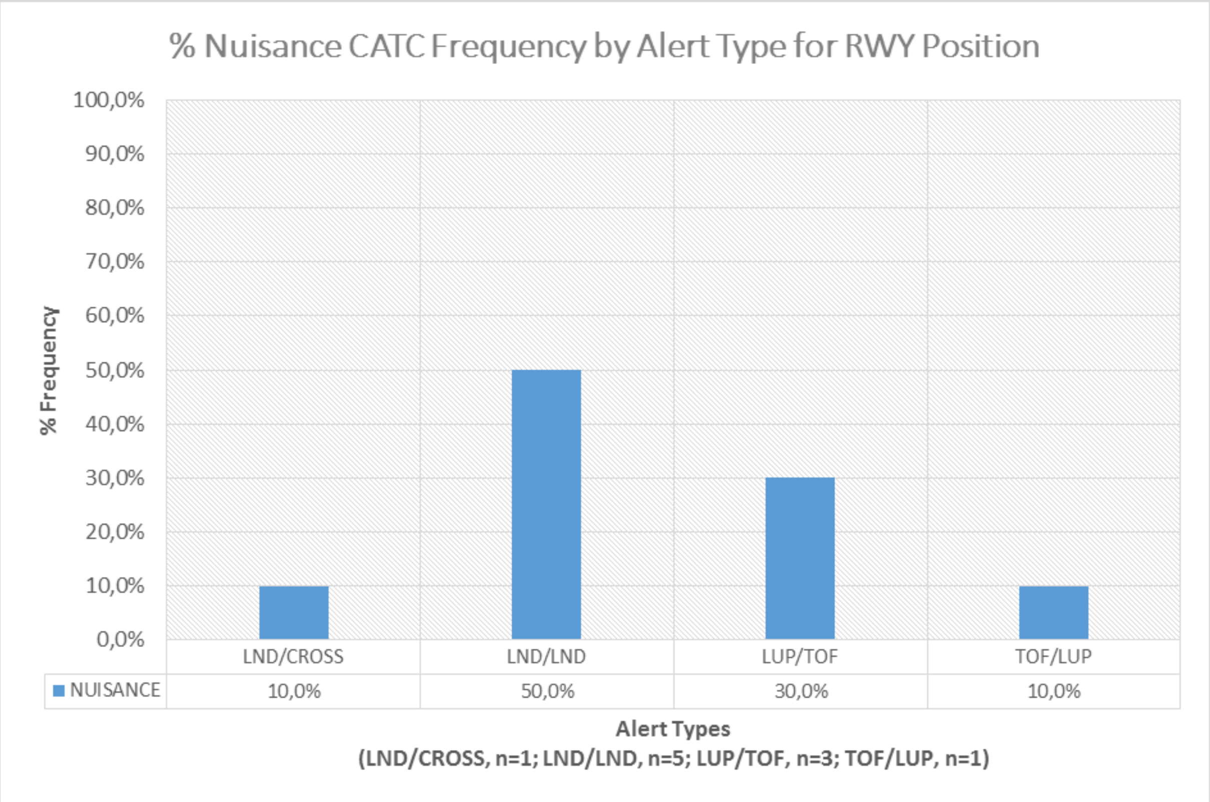


Figure Appendix A-34: Metrics – Nuisance CATC Alert Type on RUNWAY Position vs. Alert % of Total

Overall, there was a relatively low rate of nuisance CATC alerts (10 in total) of 2,5 per day (Figure Appendix A-34).

The LND/LND alerts accounted for half of the nuisance CATC alerts. This can be explained by the parameterisation of the alert for runway 22 which was not fine-tuned since the system was optimised for operation on runway 04. Thus, 7 out of the 10 nuisance CATC were due to the problem.

Otherwise, singular cases of nuisance CATC were:

- Lack of usage of the Conditional Line-up feature by the controller, leading to a LUP/TOF,
- System's over estimation of the time required to vacate the runway, leading to a LND/CROSS,
- Erroneous triggering of the TOF/LUP for an aircraft behind another.

Globally, CATC alerts were triggered as expected and there was no observable negative impact on safety concerning the integration of CATC. Safety experts agree that alerts were successfully triggered and were mostly justified.

A3.4.14 EX1-OBJ-VLD-28-013 Results - Demonstrate that the controller workload incurred due to integration of CMAC is acceptable

A3.4.14.a EX1-CRT-VLD-28-013-001 - Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable

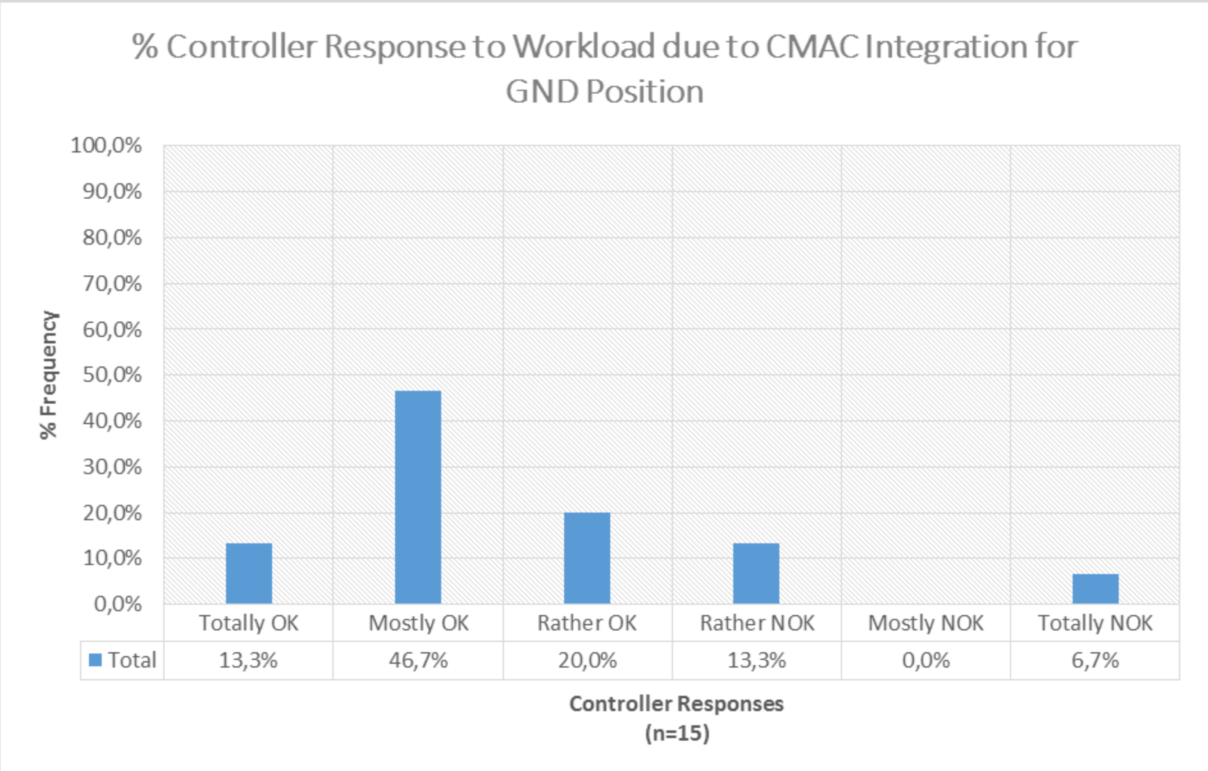


Figure Appendix A-35: Questionnaire – % Controller Response to Workload due to CMAC Integration for GND Position

The workload of GROUND controller due to the integration of CMAC was too high (Figure Appendix A-35) given that controllers estimated the traffic situation to be unexceptional, although the effort spent in managing the system was relatively higher than what they could experience in their current work environment.

- The number of un-justified alerts arising from routing issues was seen to be a critical factor in controllers' perceived workload and acceptance of the system.

The workload of GROUND controllers due to the integration of CMAC was negatively impacted by the amount of routing issues arising during the runs.

A3.4.14.b EX1-CRT-VLD-28-013-002 - Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable

The workload of RUNWAY controller due to the integration of CMAC was positively evaluated.

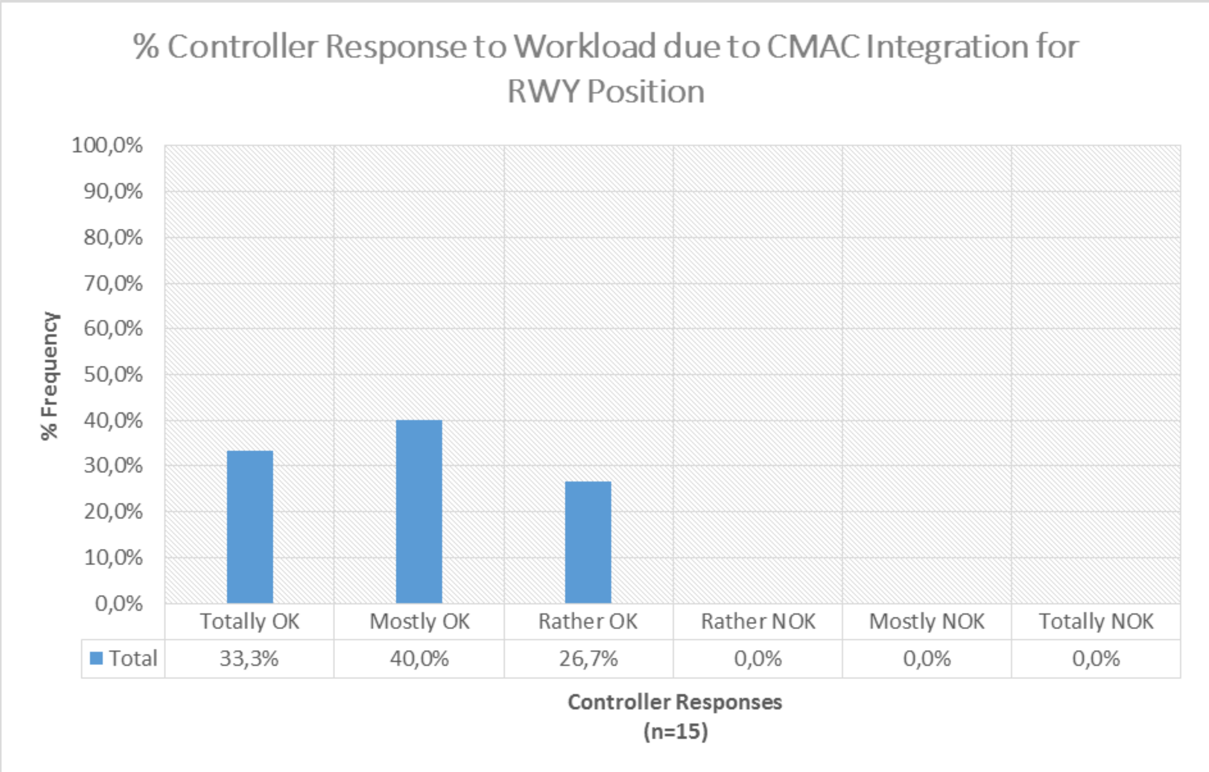


Figure Appendix A-36: Questionnaire – % Controller Response to Workload due to CMAC Integration for RWY Position

The workload of RUNWAY controllers due to the integration of CMAC was acceptable (Figure Appendix A-36) given that the issues arising due to routing were relevant mostly of the GROUND position and the tasks experienced by RUNWAY controllers are lower. The analysis is representative of the responses of controllers to the questionnaire probe as shown in Figure Appendix A-36.

Thus, the workload of the RUNWAY controller due to the integration of CMAC was positively demonstrated.

A3.4.15 EX1-OBJ-VLD-28-014 Results - Demonstrate that the controller workload incurred due to integration of CATC is acceptable

A3.4.15.a EX1-CRT-VLD-28-014-001 - Positive evaluation that the workload of RUNWAY controller due to the integration of CATC is acceptable

The workload of RUNWAY controllers due to the integration of CATC was acceptable given that the issues arising due to routing were relevant mostly of the GROUND position and the tasks experienced by RUNWAY controllers are lower. The analysis is representative of the responses of controllers to the questionnaire probe as shown in Figure Appendix A-37.

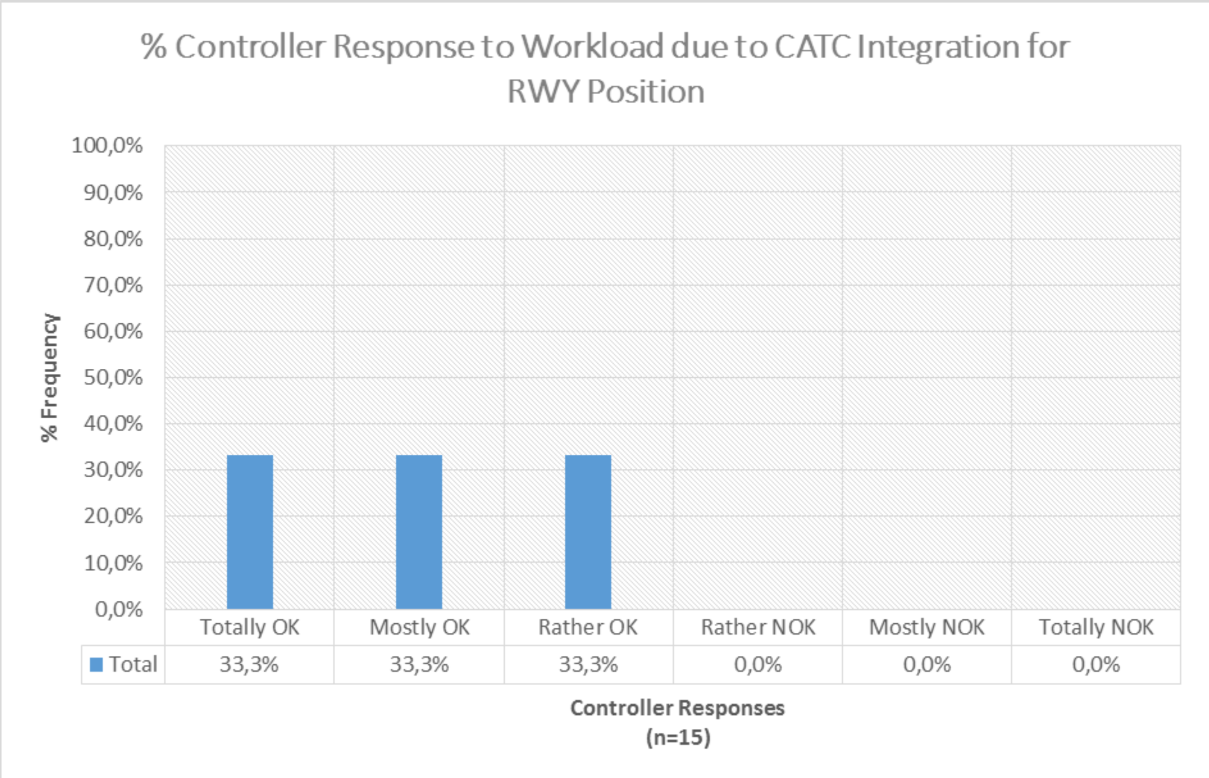


Figure Appendix A-37: Questionnaire – % Controller Response to Workload due to CATC Integration for RWY Position

Thus, the workload of the RUNWAY controller due to the integration of CATC was positively demonstrated.

A3.4.16 EX1-OBJ-VLD-28-015 Results - Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC

A3.4.16.a EX1-CRT-VLD-28-015-001 - Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved

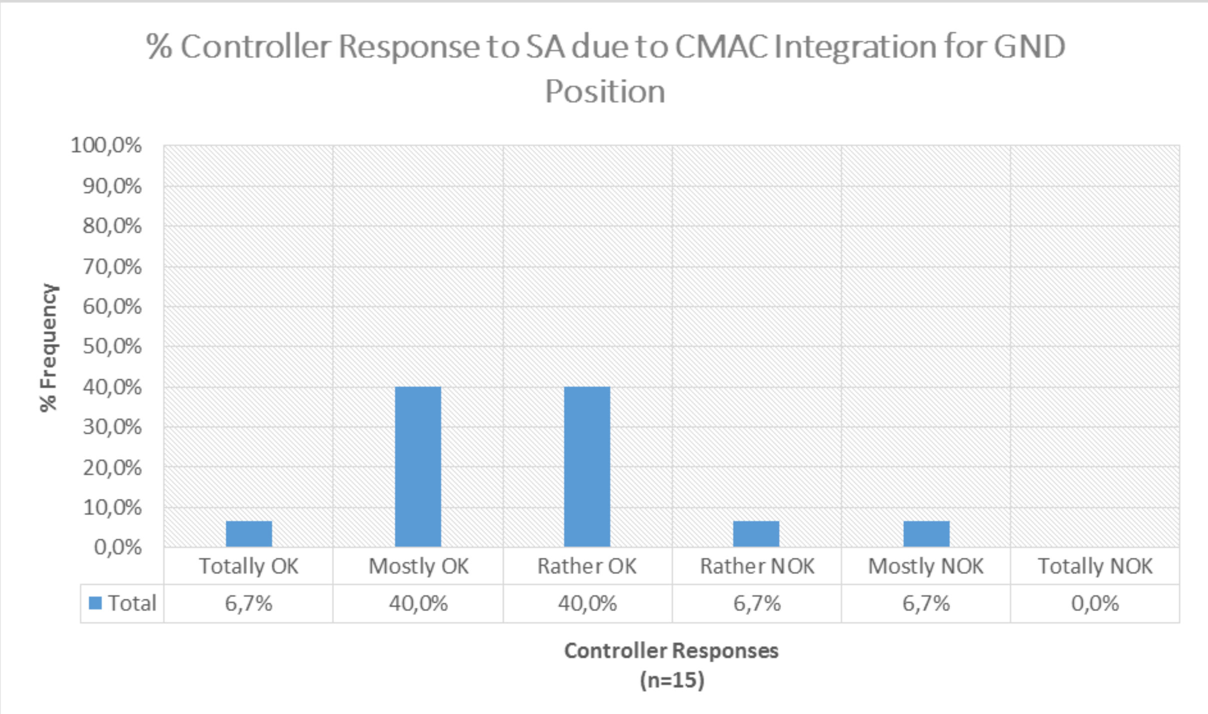


Figure Appendix A-38: Questionnaire – % Controller Response to SA due to CMAC Integration for GND Position

The situational awareness of Ground controllers due to the integration of CMAC is assessed "rather" to "mostly positive" (Figure Appendix A-38). However, 13,3% of controllers assessed their SA as not positive mainly due to the routing issues encountered. The necessity to inform the system (clearances, routing, safety net) require mental resources (especially at the ground position) and the following cases were noted:

- This was also expressed by the lack of time for GROUND controllers to observe real traffic through the window since their attention was tunnelled by the HMI,
- Some controllers indicated that the filtering out of mobiles such as helicopters and Flyco mobiles from the HMI led to a simplified traffic situation which otherwise could have improved their SA.

Thus, the SA of GROUND controllers with integration of CMAC was negatively impacted by the same routing issues as reported in EX1-CRT-VLD-28-013-001.

A3.4.16.b EX1-CRT-VLD-28-015-002 - Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved

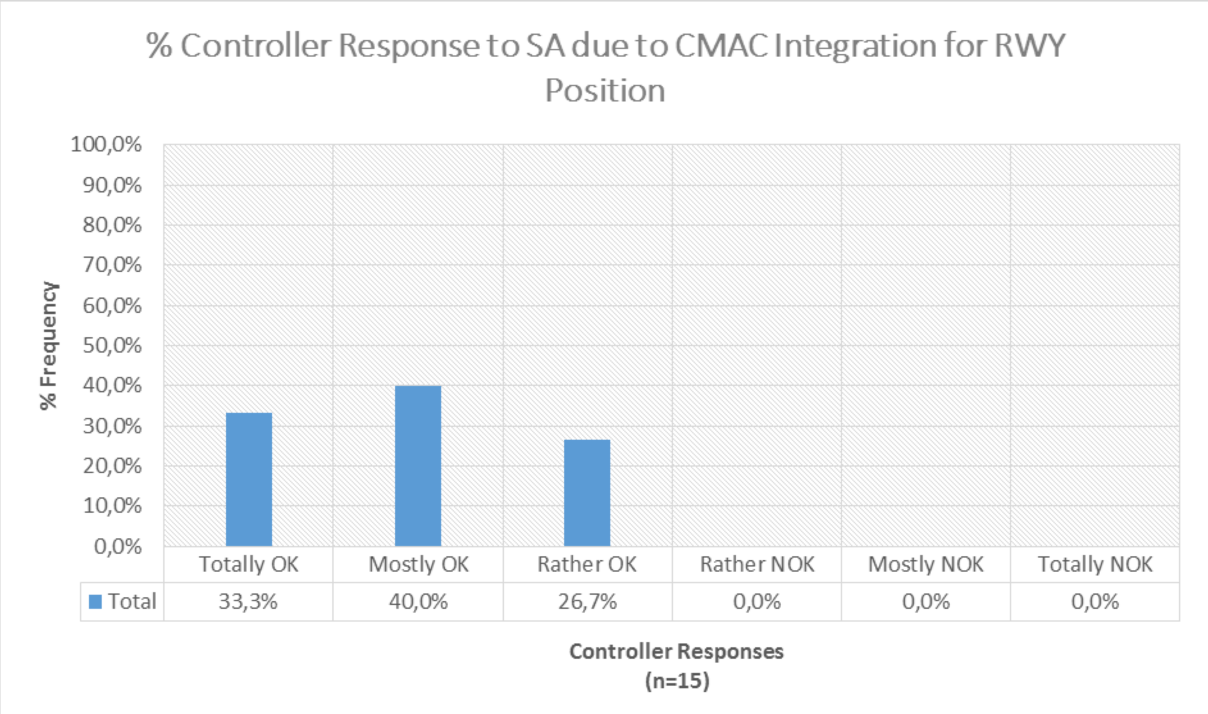


Figure Appendix A-39: Questionnaire – SA of RUNWAY ATCO due to CMAC vs. Av. Response Score

The SA of RUNWAY controllers due to the integration of CMAC was acceptable given that the issues arising due to routing were relevant mostly of the GROUND position and the tasks experienced by RUNWAY controllers are lower. The analysis is representative of the responses of controllers to the questionnaire probe as shown in Figure Appendix A-39.

Thus, the SA of RUNWAY controllers due to the integration of CMAC was positively demonstrated.

A3.4.17 EX1-OBJ-VLD-28-016 Results - Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC

A3.4.17.a EX1-CRT-VLD-28-016-001 - Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved

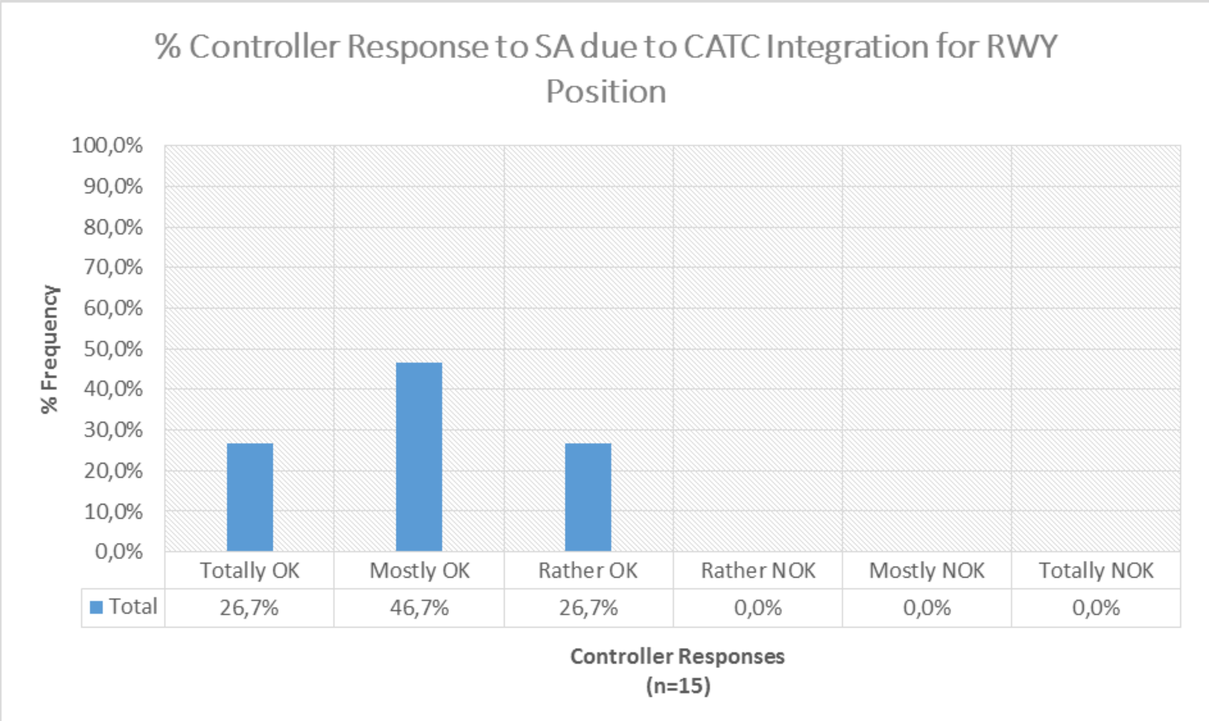


Figure Appendix A-40: Questionnaire – % Controller Response to SA due to CATC Integration for RWY Position

The SA of RUNWAY controllers due to the integration of CATC was acceptable given that the issues arising due to routing were relevant mostly of the GROUND position and the tasks experienced by RUNWAY controllers are lower. The analysis is representative of the responses of controllers to the questionnaire probe as shown in

Figure Appendix A-40.

Thus, the SA of RUNWAY controller due to the integration of CATC was positively demonstrated.

A3.4.18 EX1-OBJ-VLD-28-017 Results - Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions

A3.4.18.a EX1-CRT-VLD-28-017-001 - Positive evaluation of the utility of the CATC and CMAC integrated with RMCA

There were 4 counts of RMCA occurrences triggered by the system (Figure Appendix A-41) and all of them were false alerts (RMCA at the parking; RMCA while there is no effective conflict). Safety experts agree that from the perspective of a shadow-mode trial, the duration over which RMCA can be observed is too short and the chances of witnessing a true runway incursion Is quite small. Further, the artificial triggering of an RMCA through controller logs inserts experimental bias and deviations in other results concerning routing and safety nets.

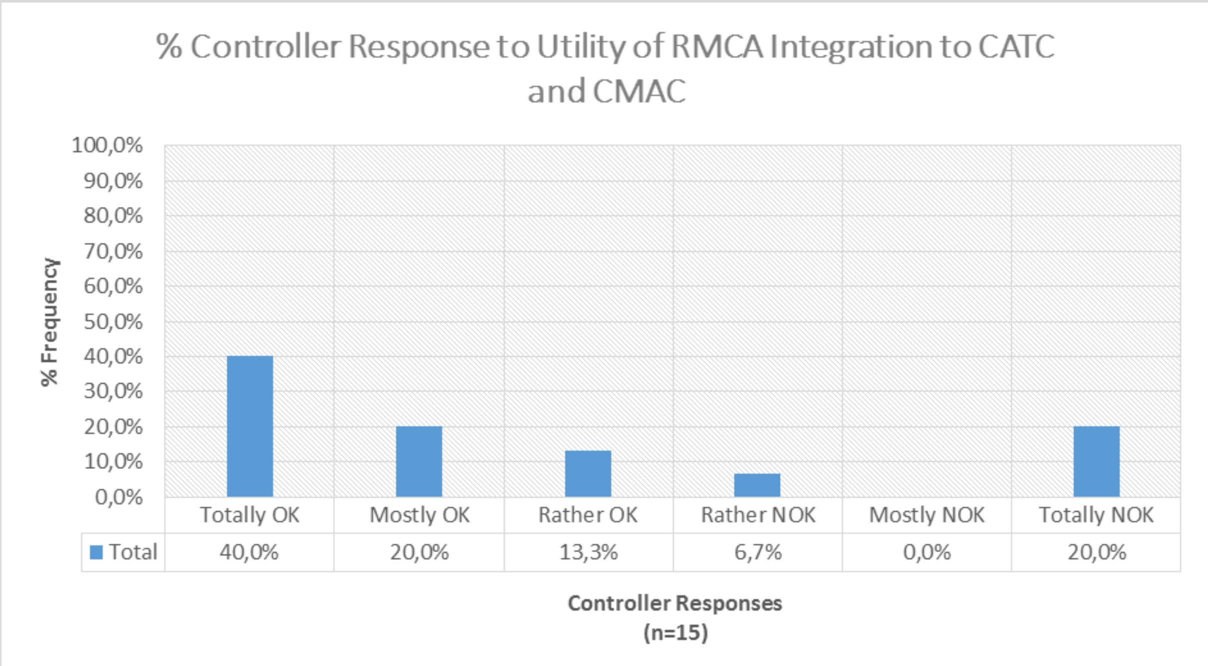


Figure Appendix A-41: Questionnaire – % Controller Response to Utility of RMCA Integration to CATC and CMAC

While there were false RMCA alerts, controllers indicated that it was still of use to have the alert integrated with CATC and CMAC given the criticality of runway incursions at Nice.

Overall, although controllers find a utility for integrating RMCA to CATC and CMAC, safety experts agree that the RMCA occurrences observed in the demonstration were unjustified and as such can be considered to have only been partially integrated with other alerts.

A3.4.18.b EX1-CRT-VLD-28-017-002 - Positive evaluation of the usability of the CATC and CMAC integrated with RMCA

There were 4 counts of RMCA occurrences triggered by the system and all of them were false alerts (RMCA at the parking, n=2; RMCA while there is no effective conflict, n=2).

Controllers indicated that they did not readily distinguish among alert types or did not need to do so.

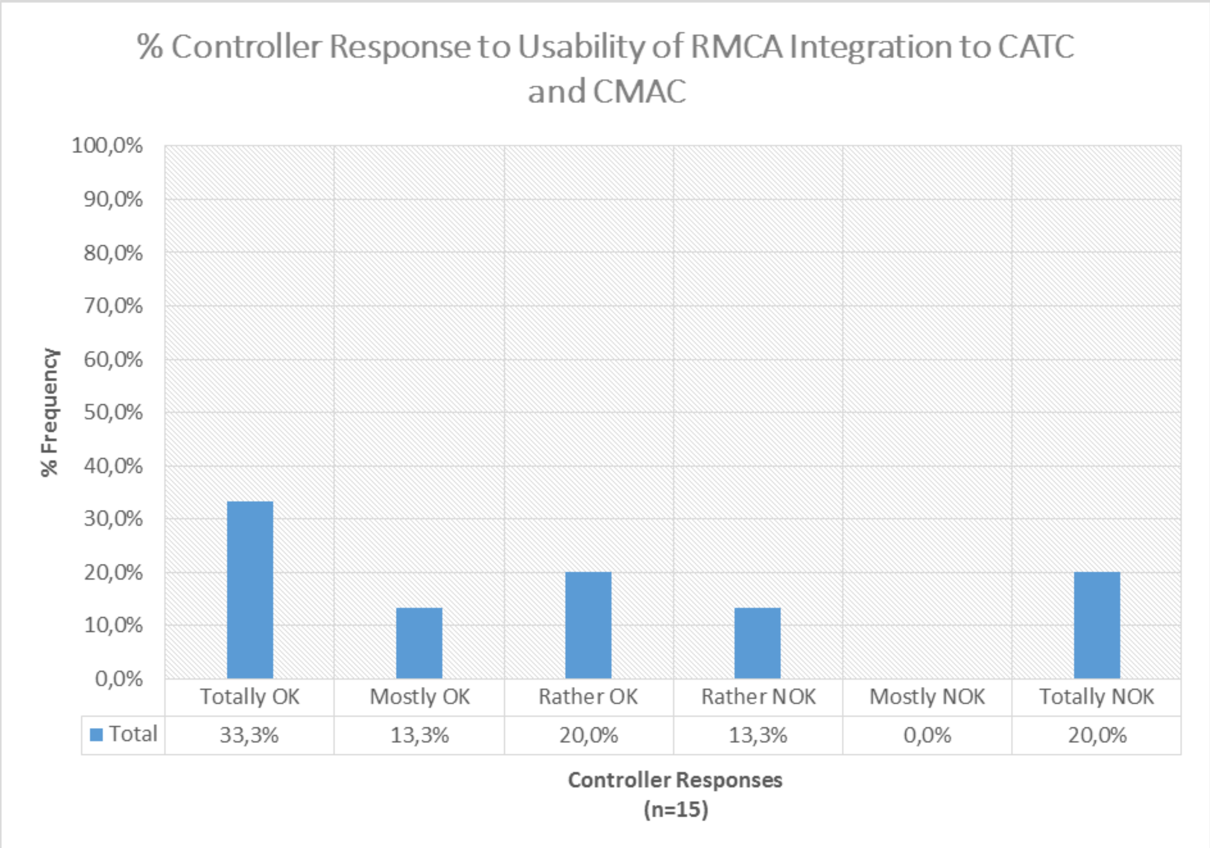


Figure Appendix A-42: Questionnaire – % Controller Response to Usability of RMCA Integration to CATC and CMAC

Overall, controllers and safety experts agree that the usability of the RMCA alert integrated with CMAC and CATC alerts was only partially achieved given that the observations concerned unjustified occurrences (Figure Appendix A-42).

A3.4.18.c EX1-CRT-VLD-28-017-003 - Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts

There were 4 counts of RMCA occurrences triggered by the system (Figure Appendix A-41) and all of them were false alerts (RMCA at the parking; RMCA while there was no effective conflict).

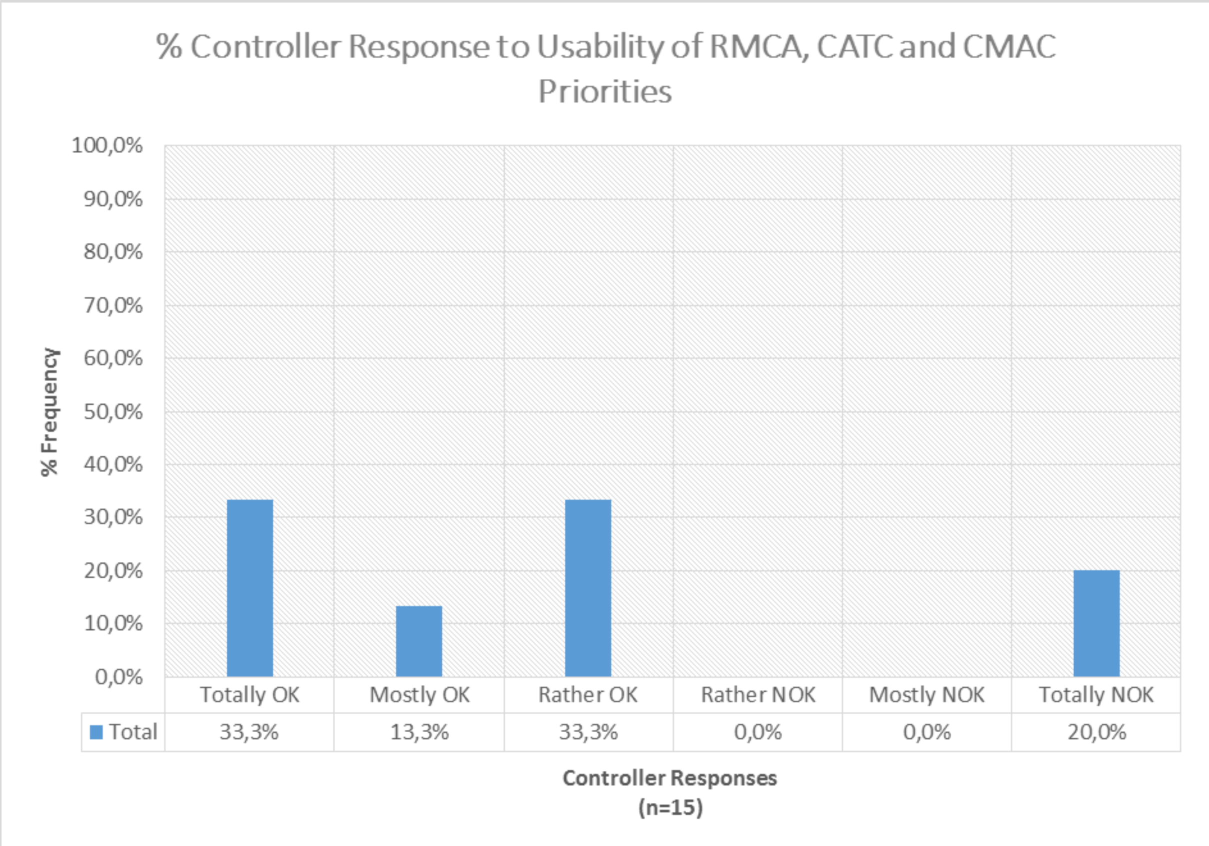


Figure Appendix A-43: Questionnaire – % Controller Response to Usability of RMCA, CATC and CMAC Priorities

Overall, controllers and safety experts agree that the prioritisation of the RMCA alert and CMAC and CATC alerts (Figure Appendix A-43) was partially achieved given that the observations concerned unjustified occurrences.

A3.4.19 EX1-OBJ-VLD-28-018 Results - Demonstrate the utility of DMAN functions supported by route planning

A3.4.19.a EX1-CRT-VLD-28-018-001 - Positive evaluation of the utility of the DMAN function supported by route planning

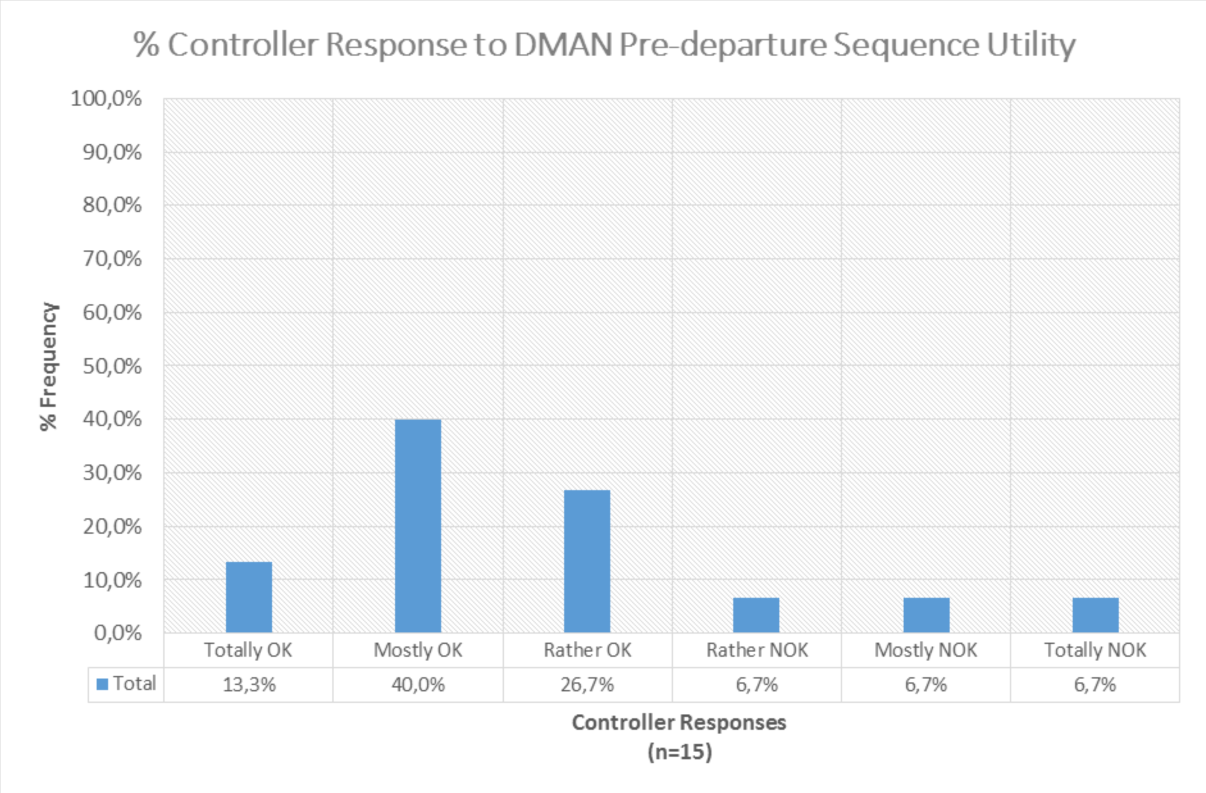


Figure Appendix A-44: Questionnaire – % Controller Response to DMAN Pre-departure Sequence Utility

The DMAN supported by routing and planning functionalities was functionally used to perform start-up actions and transfer the aircraft to the ground position for control.

The pre-departure sequence was partially demonstrated for the following reasons:

- All departing aircraft had an assigned TSAT value. However, the TSAT value was not updated when the pre-departure sequence was changed. Thus, all departure aircraft had an invariable TSAT throughout the runs,
- Certain departing aircraft had assigned TSAT values but were not visible on the DMAN HMI. Thus, the pre-departure sequence visualised by controllers were sometimes not coherent with the real situation across the airport's parking,
- Certain departing aircraft started taxiing well before the TSAT was reached,
- Certain departing aircraft appeared in DMAN with the TSAT value already expiring (colour coded in yellow).

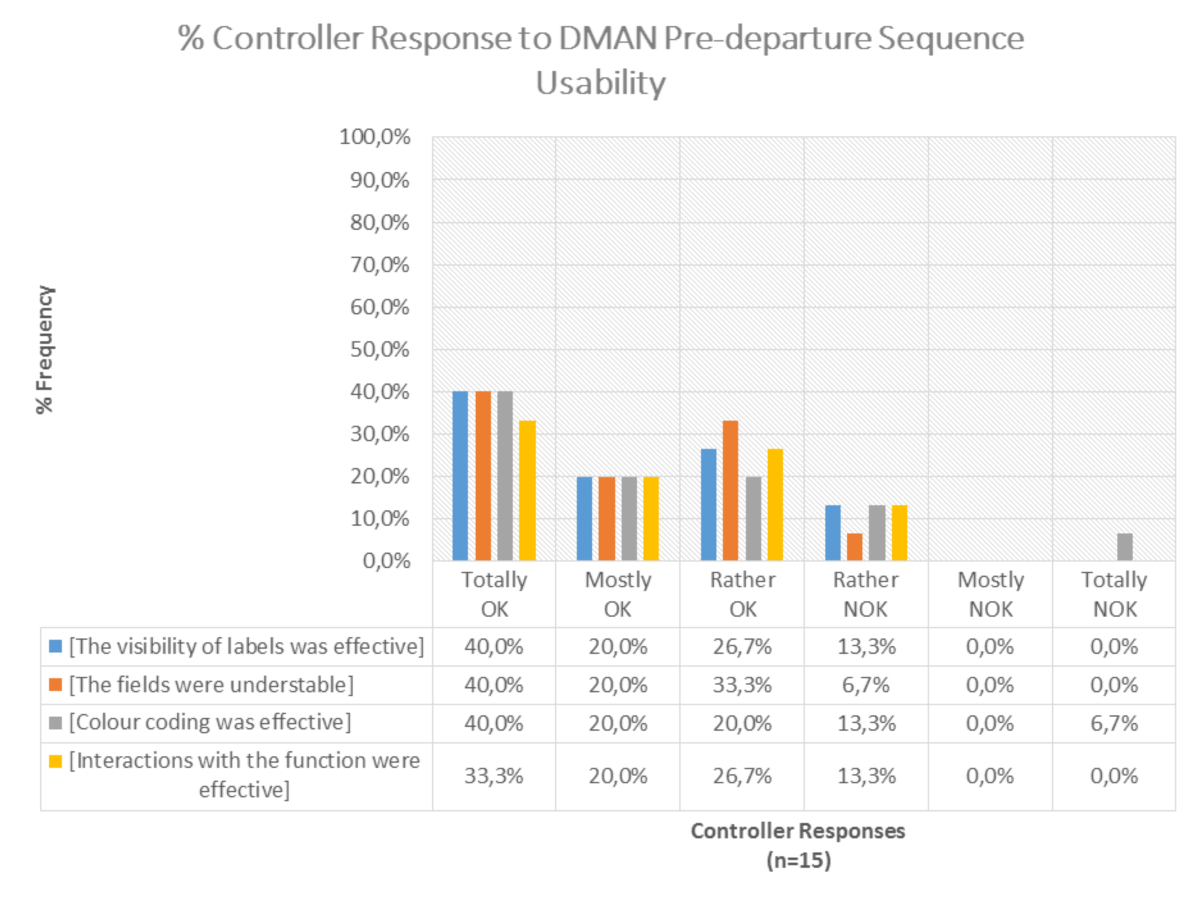
The principal limitation explaining the observations was that the sequence followed by the tower controllers was replicated operationally by the VLD controllers and deviated significantly from the TSAT-determined pre-departure sequence.

Further, aircraft start-up was forced though HMI sub-functions, which do not reflect a normal use of the DMAN HMI.

As such and given the lack of proper usage of the DMAN, the utility of its functions has not been appropriately demonstrated.

A3.4.20 EX1-OBJ-VLD-28-019 Results - Demonstrate the usability of DMAN functions supported by route planning

A3.4.20.a EX1-CRT-VLD-28-019-001 - Positive evaluation of the usability of the DMAN function supported by route planning



	Totally OK	Mostly OK	Rather OK	Rather NOK	Mostly NOK	Totally NOK
[The visibility of labels was effective]	40,0%	20,0%	26,7%	13,3%	0,0%	0,0%
[The fields were understable]	40,0%	20,0%	33,3%	6,7%	0,0%	0,0%
[Colour coding was effective]	40,0%	20,0%	20,0%	13,3%	0,0%	6,7%
[Interactions with the function were effective]	33,3%	20,0%	26,7%	13,3%	0,0%	0,0%

Figure Appendix A-45: Questionnaire – % Controller Response to DMAN Pre-departure Sequence Usability

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the usability of its functions has not been appropriately demonstrated.

A3.4.21 EX1-OBJ-VLD-28-020 Results - Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable

A3.4.21.a EX1-CRT-VLD-28-020-001 - Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable

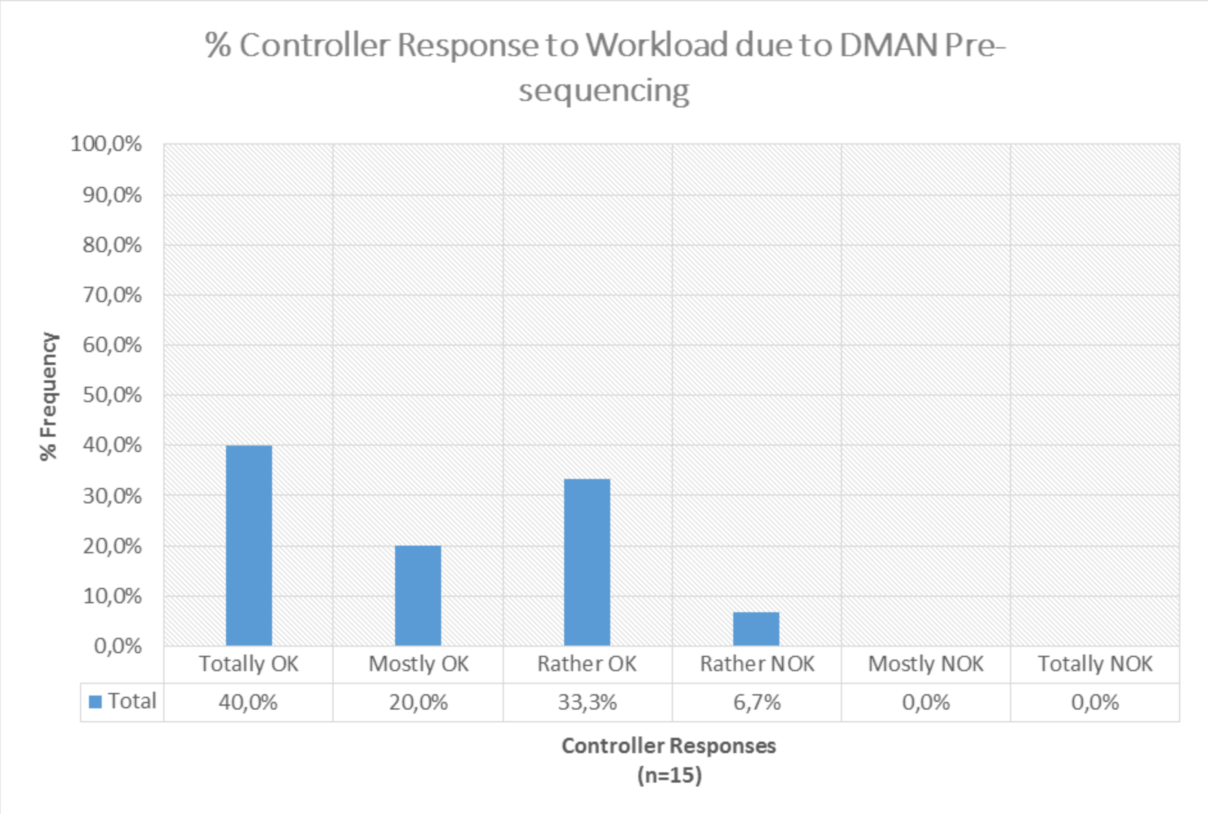


Figure Appendix A-46: Questionnaire – % Controller Response to Workload due to DMAN Pre-sequencing

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, and the regrouped positions, the workload incurred by the CLEARANCE DELIVERY controller due to its functions have not been appropriately demonstrated.

A3.4.21.b EX1-CRT-VLD-28-020-002 - Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable

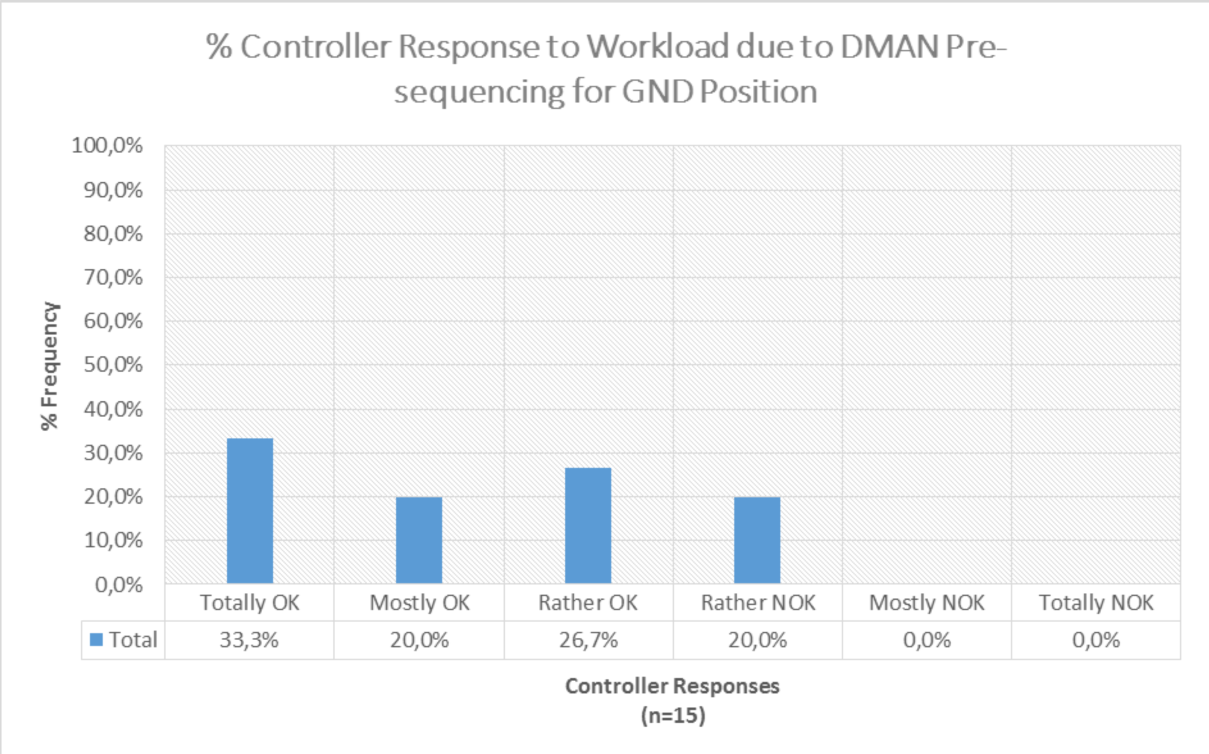


Figure Appendix A-47: Questionnaire – % Controller Response to Workload due to DMAN Pre-sequencing for GND Position

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the workload incurred by the GROUND controller due to its functions have not been appropriately demonstrated.

A3.4.21.c EX1-CRT-VLD-28-020-003 - Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable

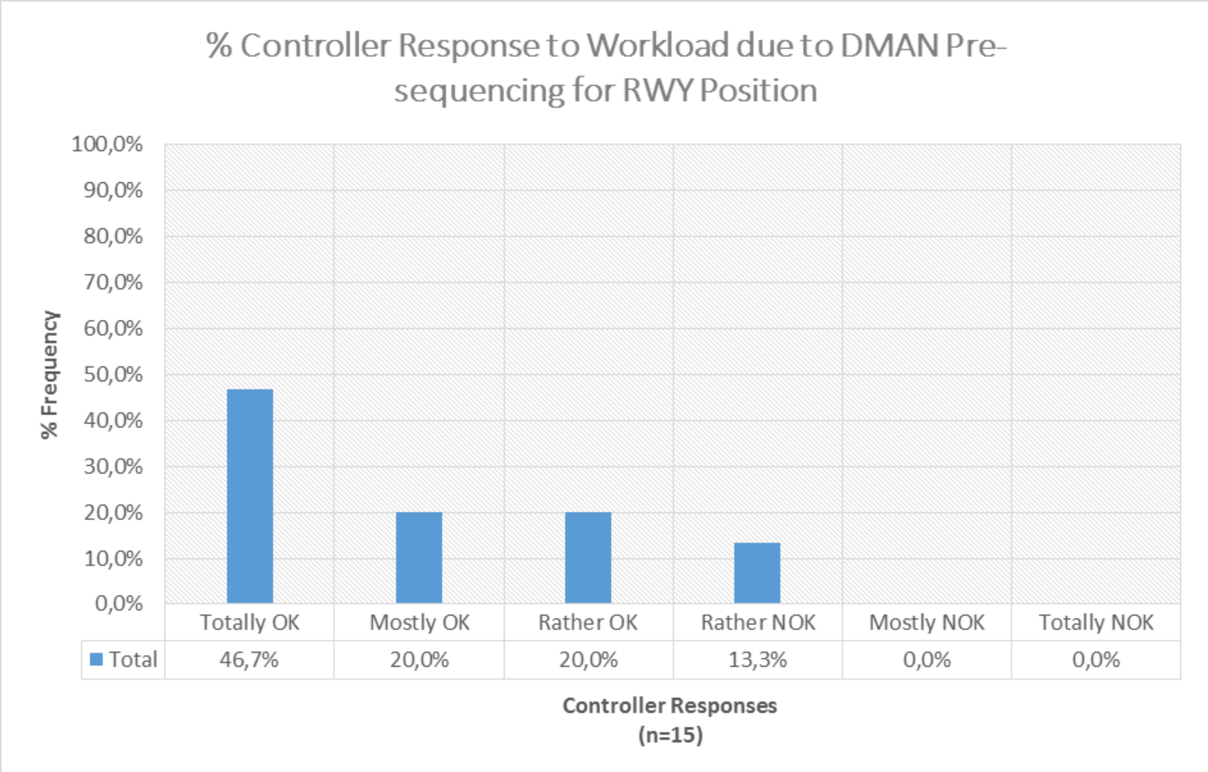


Figure Appendix A-48: Questionnaire – % Controller Response to Workload due to DMAN Pre-sequencing for RWY Position

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the workload incurred by the RUNWAY controller due to its functions have not been appropriately demonstrated.

A3.4.22 EX1-OBJ-VLD-28-021 Results - Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved

A3.4.22.a EX1-CRT-VLD-28-021-001 - Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved

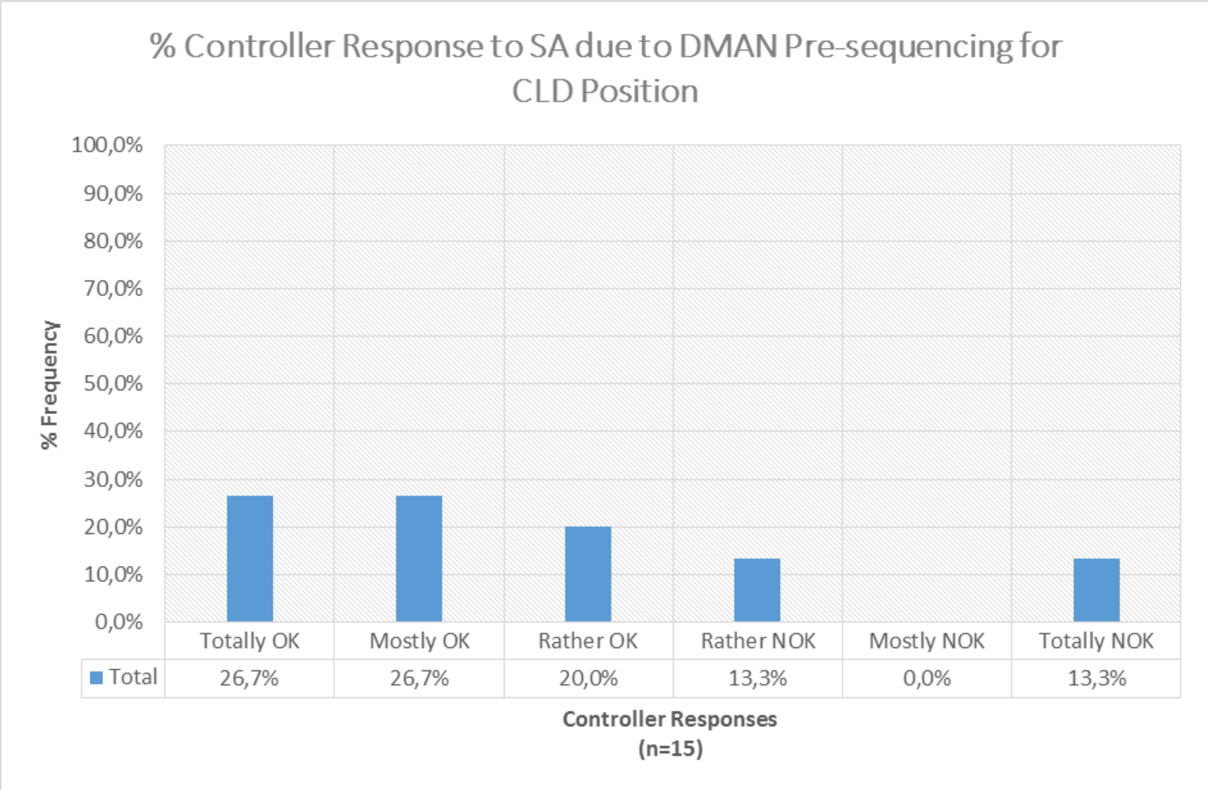


Figure Appendix A-49: Questionnaire – % Controller Response to SA due to DMAN Pre-sequencing for CLD Position

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the SA incurred by the CLEARANCE DELIVERY controller due to its functions have not been appropriately demonstrated.

A3.4.22.b EX1-CRT-VLD-28-021-002 - Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved

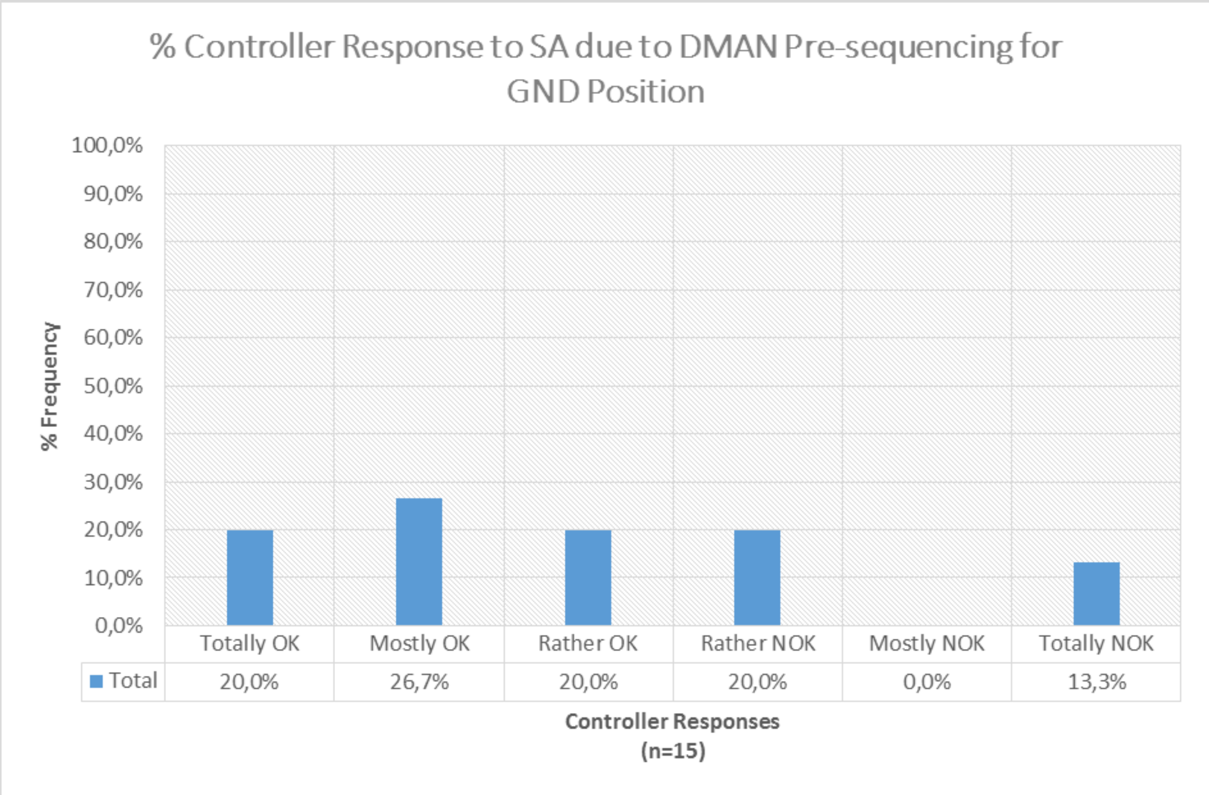


Figure Appendix A-50: Questionnaire – % Controller Response to SA due to DMAN Pre-sequencing for GND Position

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the SA incurred by the GROUND controller due to its functions have not been appropriately demonstrated.

A3.4.22.c EX1-CRT-VLD-28-021-003 - Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved

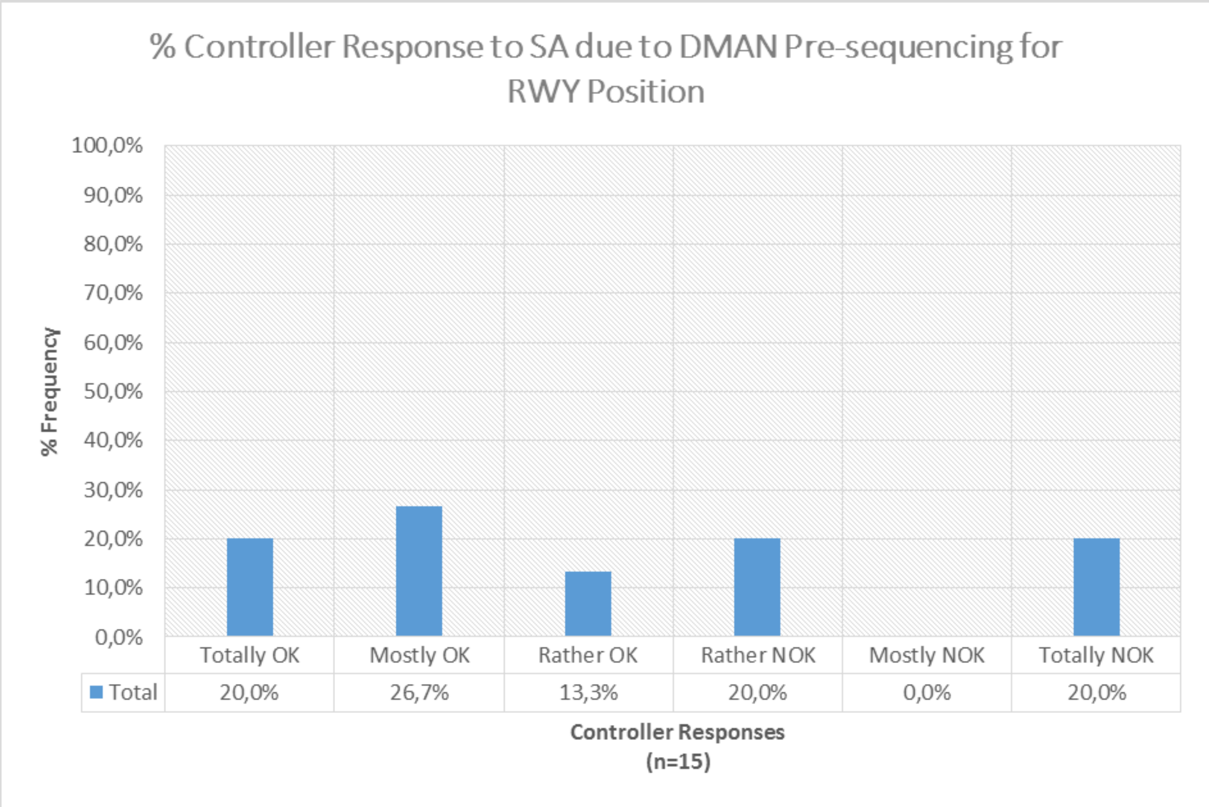


Figure Appendix A-51: Questionnaire – % Controller Response to SA due to DMAN Pre-sequencing for RWY Position

Given the lack of a baseline DMAN and the arguments listed in EX1-CRT-VLD-28-018-001, the SA incurred by the RUNWAY controller due to its functions have not been appropriately demonstrated.

A3.4.23 EX1-OBJ-VLD-28-022 Results - Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

A3.4.23.a EX1-CRT-VLD-28-022-001 - Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

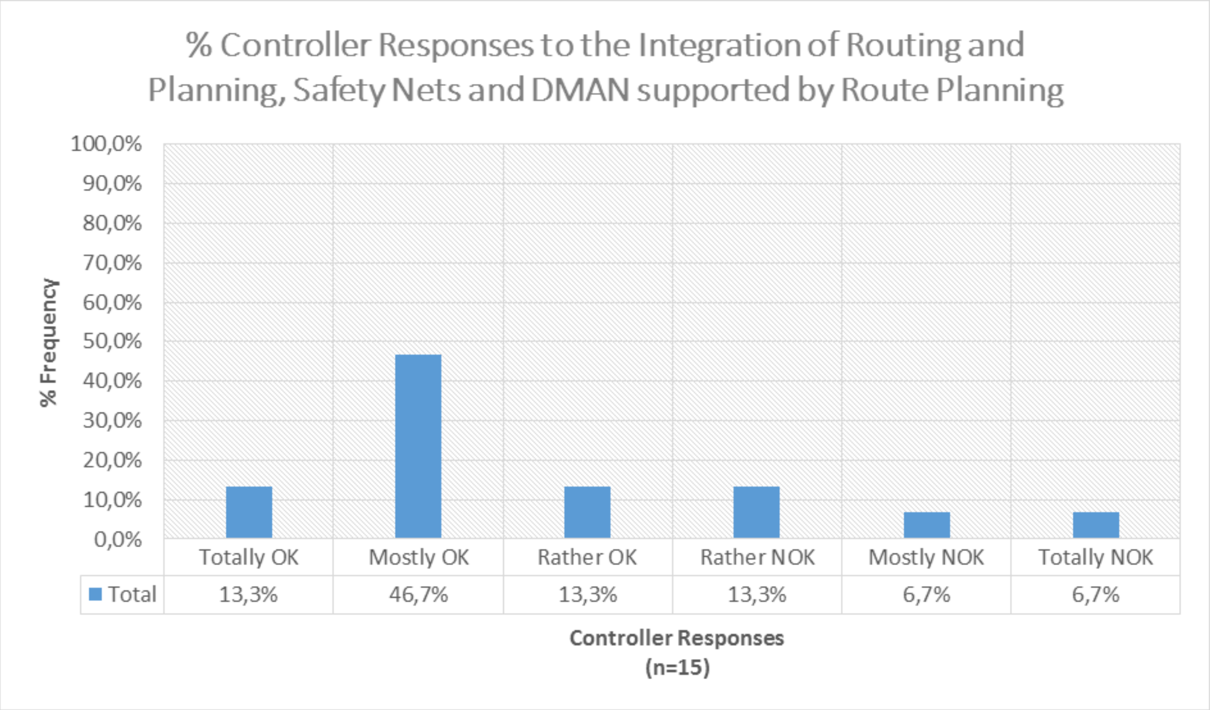


Figure Appendix A-52: Questionnaire - % Controller Responses to the Integration of Routing and Planning, Safety Nets and DMAN supported by Route Planning

Although routing and safety nets were appropriately integrated, the lack of a baseline DMAN for comparison as well as the arguments listed in EX1-CRT-VLD-28-018-001, only a partial integration of the solutions have been appropriately demonstrated.

A3.5 Unexpected Behaviours/Results

The following events were considered unexpected behaviours and results:

- The controllers have encountered several unusual situations, such as a meteorological situation imposing counter-QFU take-offs and landings, an aircraft going around and coming back to land after a circling pattern, and an aircraft landing on the departure runway. These situations were not properly handled by the system under test, due to a focus on nominal conditions,

- Concerning Solution #22:

- the initial routes proposed by the system when Nice is operating in a single-runway configuration due to adverse meteorological conditions were not optimal. This artificially increased the workload of controllers,
- precise aircraft positions and directions were sometimes affected by the system's limitations with regards to real surveillance data feeds. In such cases, false aircraft movements could be triggered along with alerts, and calculated routes were incoherent,

- Several aircraft were not represented on the HMI such that controllers had to track their surface movements through the tower window,

Tower radio frequencies, broadcast in the VLD room from handheld receivers, were sometimes garbled or of reduced clarity.

A3.6 Confidence in the Demonstration Results

A3.6.1 Level of significance/limitations of Demonstration Exercise Results

Demonstration objectives and success criteria were all addressed and have a high level of significance ensured by expert review of controllers reported outcomes.

Additionally, solutions demonstrated a high integration level needed to fulfil performance expectations as follows:

- Both Solutions strongly rely on airport layout static information,
- Both Solutions strongly rely on CDM information such as stand name, occupation, TSAT, TOBT, etc.

The significance of results is further ensured though the experimental protocol as follows:

- There was a full participation of planned controllers through all runs. 15 controllers with a valid license and unit endorsement at Nice participated in the VLD. They all took part in the training sessions.
- The controller working positions were counterbalanced within each controller group (ground and runway positions),
- There was enough qualitative (Situation Awareness questionnaires) and quantitative (metrics, workload) data gathered during the demonstration, including multiple, unique data sources for corroborating information,
- Safety net experts and human factors specialists participated actively in the conduct of this demonstration, in the analysis of the data and the consolidation of results and recommendations.

The following limitations of the results were encountered:

- The demonstration platform did not handle dynamic configuration changes. In case of a QFU change, the platform needed to be stopped and restarted with the updated configuration,

- Only fixed-wing aircraft were within the scope of the demonstration and displayed on the controller HMI. Other mobiles were not demonstrated, which simplified controller tasks (cf. Table 4, ASS-03b.01-V2-VALP-001.0003.),
- Helicopter traffic was noninterfering with fixed-wing traffic due to their respective geographical segregation,
- Certain aircraft were towed from parking to parking. This operation was not materialised in the system under demonstration, so these mobiles did not show on the HMI,
- Certain aircraft were put on hold into a “holding stand” between push-back time and their CTOT. This operation was not forecast in the system under demonstration, so the routing of these aircraft could be erroneous, VFR flights were not considered, i.e. they did not appear on the CWP as they were not associated to an IFR Flight Plan. However, the only VFR flights that took place at Nice during the demonstration runs were rotorcraft movements (see above).
- Participating ATCOs were not familiar with electronic environments at the beginning of the training sessions, and the limited time available for bringing controllers up to speed with electronic environment concepts as well as demonstration objectives adversely impacted the usage of more advanced function on the HMI as well as during high traffic situations,
- ISA tool had a granularity of 3 minutes, which could not be used to analyse precise operational events and their impact on workload.

A3.6.2 Quality of Demonstration Exercise Results

We can assert a high level of quality in the demonstration results given that:

- Data from multiple sources (Questionnaires, Metrics, Expert Feedback, ISA, SA) was used for answering each success criterion, as per experimental protocol,
- The data was collected mostly during high traffic periods of the day which explains the small window available for participant intervention.

A3.6.3 Significance of Demonstration Exercises Results

The following statistical factors were taken into consideration concerning the significance of our results:

- Participating controller were 15 in all, and fully qualified, with a valid license and unit endorsement. Each controller has both the RUNWAY and GROUND roles as they were permuted across both positions. The CLEARANCE DELIVERY position was regrouped with the GROUND position,
- All participating controllers responded fully to the questionnaire with a 100% response rate. When controllers could not respond to a few questions due to a lack of observation of the functions under demonstration (e.g. some CATC alert triggering), this was indicated explicitly in the questionnaire.

The following operational factors were taken into consideration concerning the significance of our results:

- The nature of the traffic present during the VLD exercise was very varied, including private jets, airline operated aircraft, business aircraft, Antonov and A380 aircraft, among others. The variety of aircraft encountered ensures that the results were not biased towards a single type of aircraft,
- There were degraded meteorological conditions during the first few days of the VLD exercise during which holding patterns and frequent QFU changes were in effect at LFMN. The variety of meteorological conditions ensures that the results were not biased towards optimal flying conditions,
- Nice LFMN is a recognised PCP airport due to the complexity of its layout regarding parallel runways and short taxiways,
- The variety of alerts covered by the Nice exercise included CATC in predictive and alert modes as well as CMAC. There were 18 alerts out of 32 which were developed and parameterised with safety experts. This provided a significant coverage and variety of alerts towards our results (Note: The demonstrated alerts are not an indicator of the alerts which will be operationally deployed at Nice),

Regarding taxi times and integration with DMAN, the planned taxi times that were used were unimpeded taxi times (e.g. no delay at the holding points, no delay after a push or taxi clearance, no hold-short). Thus, the average planned taxi-time was lower than the average actual taxi-time (no representativeness of the actual taxi-time). Taxi-time results were affected by this limitation.

A4 Conclusions

The summary of Nice VLD results are as follows, categorised by solution:

Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.

Concerning CATC and CMAC utility:

- Nuisance CATC alerts were generally quite low and no false alerts were observed. Short delays in HMI input due to the shadow-mode[5] account for observed CATC alerts. In general, the utility of CATC functions was considered as having been positively demonstrated,
- The utility of the predictive CATC has been positively demonstrated to some of the controllers,
- The utility of CMAC functions was partially demonstrated due to the parameterization and VLD platform limitations concerning the NO TOF CLR, STATIONARY, HIGH SPEED and RTE DEVIATION alerts on the RUNWAY position,

Concerning CATC and CMAC usability:

- CATC alert usability was positively demonstrated through multiple factors namely, interaction, colour coding, comprehension of labels and visibility,

[5] Delays in HMI input during a shadow-mode can be explained by the prolonged reaction time of controllers who must wait for a clearance to be heard over radio before materialising it on the HMI, thereby increasing the probability that a CATC alert will be triggered.

- Predictive CATC alert usability was partially demonstrated due to a few controllers not having experienced the alert during their respective runs,
- The usability of the audio alarm associated with the CMAC function was positively demonstrated as being effective both in terms of interaction and auditory notification,
- The usability of the CMAC alert levels was partially demonstrated to the controllers given that the alert threshold from "information" to "alarm" of the NO LND CLR remains to be adjusted to minimise nuisances,
- Global CMAC alert usability was partially demonstrated mainly due to technical system slowdowns negatively impacting controllers' interactions with CMAC alerts through the flight label.

Concerning the improvement of safety to airport operations with the successful integration of CATC and CMAC:

- CATC alerts were effectively integrated in the system and positive alerts were mostly justified. There was no negative impact on safety observed due to CATC alert integration,
- Due to issues reported with the routing function and certain design bugs (e.g. parking bugs or missing ID/labels for certain aircraft) the successful integration of CMAC and its associated safety improvement has been partially demonstrated.

Concerning controller workload incurred due to CATC and CMAC integration:

- For GROUND controllers,
  - The workload of controller due to CMAC integration was not acceptable, given the number of unjustified alerts arising due to routing issues reported (cf. EX1-CRT-VLD-28-013-001),
- For RUNWAY controllers,
  - The acceptability of the workload due to CATC integration was positively demonstrated,
  - The acceptability of the workload due to CMAC integration was positively demonstrated.

Concerning the improvement of situational awareness with the integration of CATC and CMAC:

- For GROUND controllers,
  - The situational awareness due to CMAC integration was negatively impacted by the routing service issues reported (cf. EX1-CRT-VLD-28-013-001),
- For RUNWAY controllers.
  - The situational awareness due to CATC integration was positively demonstrated,
  - The situational awareness due to CMAC integration was positively demonstrated.

Concerning the effectiveness of integrating RMCA with CATC and CMAC:

- Safety experts analysed all the RMCA occurrences observed in the demonstration as unjustified occurrences. Therefore, although controllers witnessed RMCA, its integration can be considered to have only been partially demonstrated,
- Controllers and safety experts agree that the usability of the RMCA alerts integrated with CMAC and CATC alerts was only partially achieved given that the observations concerned mostly unjustified RMCA occurrences,

- Controllers and safety experts agree that the prioritisation of the RMCA alert over CMAC and CATC alerts was partially achieved given that the observations concerned unjustified RMCA occurrences.

Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing.

The effectiveness of the routing and safety net algorithms is highly dependent on the accuracy of the layout data of the airport, which in the case of Nice VLD was not provided (LFMN underwent numerous changes to the airport layout over the winter period preceding the VLD exercise).

Concerning routing and planning utility in nominal conditions:

- There are no standard routes defined at Nice which incurred that routes proposed by the system were not always appropriate for individual controller preferences,
- It was observed that calculated routes conformed in certain cases to operational needs/rules for managing certain surface operations but were less effective in the following situations:
  - Departure routing - the hold point used for crossing the internal runway was not dependent on the ILS or RNAV configuration in effect, which did not allow the system to optimally route aircraft, and
  - Arrival routing - the practiced exit route used for a specific runway was not proposed by the system. Instead, less optimal routing solution was proposed before the aircraft vacated the runway,
- Routes' relevance was generally appropriate although certain systematic issues resulted in non-optimal routing solutions:
  - Miss-calculated initial routes due to the late detection by the system of the routing direction of an aircraft,
  - Non-optimal routing proposed from specific parking stands, as compared to the practiced routes at Nice, and
  - Routing solutions for pushing aircraft did not take as a condition other push clearance of aircraft in the vicinity,
- A certain number of non-nominal conditions were encountered during the VLD and observed by some of the controllers, in the form of: i) Counter-QFU operations due to adverse weather, ii) Go-Around of an aircraft, and iii) landing on departure runway. 40% of controllers did not observe non-nominal conditions. The system under demonstration:
  - lacked some of the parametrisation to properly handle non-nominal conditions, and
  - wrongly detected the direction of taxi of certain aircraft and provided irrelevant routing solutions.

Concerning utility and usability of route modifications:

- Issues with erroneous routes, sub-optimal routing solutions and performance lags negatively impacted the usability of manual route modification capabilities with real surveillance,
- the use of manual route modifications outside of controllers' respective areas of responsibility was partially demonstrated only given that the work practice at Nice does not current support it,

- the effectiveness of routes' representation was partially demonstrated given that technical bugs (flickering) and performance lags were encountered due to the real surveillance.
- In general, the system under demonstration lacked the required resolution of surveillance information for providing effective routing solutions in some of the operational situations encountered. However, the underlying causes have not been investigated for lack of time.

Concerning the accuracy of A-SMGCS taxi-time:

- The planned taxi times that were used were unimpeded taxi times (e.g. no delay at the holding points, too short delay after a push, no delay taxi clearance, no hold-short, pilot delays, individual airline policies), while in actual operations, these variables account for added delays which are included as part of the taxi calculations. Thus, the average planned taxi-time was lower than the average actual taxi-time,

Concerning the workload due to routing and planning:

- The workload experienced by GROUND controllers concerning the routing and planning functions demonstrated was considered partially achieved,
- The workload experienced by RUNWAY controllers due to routing and planning functions was satisfactorily demonstrated.

Concerning the situational awareness due to routing and planning:

- The Situational Awareness experienced by RUNWAY controllers due to routing and planning functions was satisfactorily demonstrated,
- The Situational Awareness experienced by GROUND controllers due to routing and planning functions was satisfactorily demonstrated.

Solution #53 — Pre-Departure Sequencing supported by Route Planning

The DMAN supported by routing and planning functionalities was functionally used to perform start-up actions and transfer the aircraft to the ground position for control. Several functional hypotheses were not observed, which negatively impacted the demonstration of DMAN functionalities:

- A strong hypothesis was made during project preparation in terms of the availability of the basic DMAN at Nice by the time the VLD was to be conducted. A direct comparison of the baseline DMAN and the VLD DMAN was expected. However, the lack of the baseline DMAN impacted negatively DMAN observations. The pre-departure sequence followed by the tower controllers was replicated operationally by the VLD controllers on the VLD DMAN and deviated significantly from the TSAT-determined pre-departure sequence,
- Further, the improvement of taxi-time estimates has not been successfully demonstrated in our case due to the issues concluded in Solution #22 above. As such, the hypothesis that DMAN pre-departure sequences would be improved, could not be demonstrated,
- As a means of sticking to the tower issued pre-departure sequence, aircraft start-up was forced though HMI sub-functions, which do not reflect a normal use of the VLD DMAN HMI.

As such and given the lack of proper usage of the DMAN, the demonstration of its functions has not been appropriately achieved.

A5 Recommendations

A5.1 Recommendations for industrialization and deployment

General recommendations applicable to all solutions:

With reference to the Solution #02 contextual note recommendation, “Additional activities, particularly with real airport surveillance data and during a sufficiently long period are recommended in order to verify the assumption made on the airport surveillance performance and the validation of performance requirements”, the following recommendation is issued:

EX1-RECOM-VLD-28-001. Adapt the deployed platform’s integration with realistic conditions found at the given airport. The following use cases were considered:

a. An aircraft arriving, and departing a few minutes later with the same call sign,

b. An aircraft going around (whatever the height) and diverting to another airfield,

c. An aircraft circling to land on an opposite QFU, or on a departure runway, due to unforeseen meteorological parameters,

d. An aircraft aborting take-off, then returning to holding point to take off again, or returning to its stand, or to another stand,

e. An aircraft, taxiing or towed, from a stand to another one, with or without a specific call sign.

<u>Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.</u>

With reference to the Solution #02 contextual note, the following recommendations are confirmed:

- The benefit in human performance strongly relies on the Human Machine Interface usability (HMI). HMI shall facilitate the clearance input the ATC System in a timely manner, without increasing the controller workload. Attention will be paid to the HMI usability as means to input clearances in the ATC System,

- Only the most relevant alerts to the local operational context should be selected as the full set of alerts described in this solution may not be required,

- The deployment of alerts should be progressive, starting with a limited set of alerts among the full set of alerts described in this solution.

Additionally, the recommendations emerging from the VLD exercise are:

EX1-RECOM-VLD-28-002. Implement predictive indicators linked to CATC alerts (in “What-If” mode on busy airports), to minimize the risk of a Controller giving conflicting clearances to aircraft, EX1-RECOM-VLD-28-003. Fine-tune the parameterisation of the system to ensure the relevant triggering of alerts and an adapted alert threshold (to reduce nuisances and false alarms),

EX1-RECOM-VLD-28-004. Ensure that safety, workload and situation awareness level for the ground controller with a better CMAC integration (to avoid nuisances).

Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing.

With reference to the Solution #22 contextual note, the following recommendations are confirmed:

- The efficiency of its HMI and its integration in the CWP be considered as critical for the acceptability of Solution #22 by controllers,
- the working methods of controllers be adapted if needed, and the controllers be trained on these new working methods,
- Local operations and procedures (e.g. existing baseline, runway and taxiway configuration management, use of alternative parallel taxiway routing, de-icing operations …) be considered in order to adapt the route generation algorithm to local needs and thus to improve the efficacy of the support it provides to controllers.

Additionally, the recommendations emerging from the VLD exercise are:

EX1-RECOM-VLD-28-005. Improve the robustness and completeness of routing functionalities to ensure the enhancement of safety, workload and SA for the ground controller (e.g. add common route usually used at the given airport, provide routes for non-nominal cases, check initial routes coherence and avoid lags during manual routing and shortcuts),

EX1-RECOM-VLD-28-006. If necessary, for a given airport, improve the estimation of predicted taxi-times given the added airport constraint of departing aircraft having to cross intermediate runway(s).

Solution #53 — Pre-Departure Sequencing supported by Route Planning

EX1-RECOM-VLD-28-007. A proven effectiveness of the dynamic taxi-time as compared to heuristic or statistical taxi-time calculations should be established for surface operations such as Nice. The number of uncertainties in daily operations (e.g. pilot delays, weather issues, and so on) can rapidly negate any of the advantages of dynamic taxi-time calculations,

EX1-RECOM-VLD-28-008. An adapted experimental protocol should be elicited as a means of enabling the demonstration of pre-departure sequencing function (DMAN). More specifically, a protocol allowing the direct comparison of actual operational pre-departure sequences and DMAN issued sequences should be elicited,

The availability of a robust routing solution should be a strong pre-requisite before any attempts at demonstrating the current solution

A5.2 Recommendations on regulation and standardisation initiatives

EX1-RECOM-VLD-28-001. A formal mutual agreement should be established between the airport operator and the ANSP to facilitate the provision of up-to-date and standardised layout (ASRN[6]) data and related information as a means of enabling the effectiveness of routing solutions and, by extension, safety net and DMAN solutions.

For long term changes, such as the opening of a new runway or taxiway or the definitive closure thereof, the AIRAC cycle could provide an effective means of triggering the dissemination of up to date airport layout information. As for middle /short term changes, such as planned runway or taxiway closures or restrictions, the integration of NOTAM information could be useful. Moreover, the HMI should provide a means to dynamically modify the available layout (real-time closures, including runways, taxiways and apron stands) to adapt to the live airport environment.

The recommendation should be addressed within the framework of European regulation, given that it is directly linked to the PCP.

[6] Aerodrome Surface Routing Network.

Appendix B Demonstration Exercise #02 (ADS-B)

B1 Summary of the Demonstration Exercise #02 Plan

As in PJ28_D1_1_Demo_Plan_03_00_00.

B1.1 Exercise description and scope

WP3 demonstration exercise which corresponds to Exercise #02 addressed on board traffic alerting system. The alerting algorithms of the system of the own aircraft receives ADS-B information and uses it to display traffic on airport moving map and to determine whether a flight crew alert should be triggered.

Since the on board traffic alerting system uses ADS-B technology to get information about surrounding traffic, it is obvious that ADS-B data performance is a key enabler for not only proper on board traffic alerting functions, but also for the overall Airport Safety Nets concept deployment. This demonstration provided evidence, that the above explained challenges of ADS-B employment for Safety Net application can be overcome to provide a sound usage of this technology for the intended purpose.

The Wave 1 demonstration covered the data logging on a large scale approach and the analysis of those data to provide evidence that the technical challenges are manageable. As the successor, the full demonstration of the on board traffic alerting system, including the display of the alerts in the cockpit for the flight crews during regular passenger operations is expected to take place in Wave 2 of the VLD.

In order to meet the demonstration objectives, following approach was used:

Five A320 family aircraft of three airlines were provided with logging equipment to enable recording of own and received traffic ADS-B data during their regular flights conducted mainly in ECAC region. The data collection campaign ran from March 2018 through April 2019. The data collected comprised 2582 ownship operations, 207 639 traffic operations, 23 679 distinct traffics with filled ADS-B position messages, and over 3 billions (1E9) ADS-B messages from 150 international airports. The relevant traffic filtering (section 4.2) resulted in 2575 ownship operations, 5288 traffic operations, 9200 distinct traffics, and nearly 39 million ADS-B messages for the analysis. It is assumed that the data covering different operational scenarios in wide spectrum of operating environment including both more and less complex airports and various visibility conditions.

After the data collection, the data was analysed to assess that its performance supports correct function of the on board traffic alerting system. ADS-B update interval, RF shielding, and impact of long update intervals on alerting have been identified as key aspects to be analysed.

B1.2 Summary of Demonstration Exercise #02 Demonstration Objectives and success criteria

Demonstration Objective	Demonstration Success criteria)	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise 2 Objectives	Demonstration Exercise 2 Success criteria
OBJ-VLD-28-023	CRT-VLD-28-023-001	Fully covered	ADS-B data analysis delivered to PJ03b-05.	EX2-CRT-VLD-28-023-001 Real ADS-B data successfully collected.
	CRT-VLD-28-023-002			EX2-CRT-VLD-28-023-002 ADS-B data analysis performed and report created.

Table Appendix B-1: Demonstration Objectives and Criteria overview

B1.3 Summary of Validation Exercise #02 Demonstration scenarios

As the WP3 demonstration in the Wave 1 covered the ownship and traffic ADS-B data logging and subsequent analysis, there are no specific scenarios which can be determined as Reference Scenario(s) nor Solution Scenario(s).

B1.4 Summary of Demonstration Exercise #02 Demonstration Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-EXE02-001	Aircraft equipped with ADS-B transponders	Aircraft Equipage/Technology	It is assumed that all relevant traffic is equipped with ADS-B transponders.	If the relevant traffic is not equipped with ADS-B transponders, then is not logged and taken in account.	Airport and approach.	Safety Human Performance	Expert	N/A	Solution project.	Low
ASS-EXE02-002	ADS-B non-compliant environment	Aircraft Equipage/ Technology	It is assumed that results of analysis carried out within the demonstration will not be negatively affected by non-compliant environment. The results will be positively affected.	Current environment is not compliant with upcoming ADS-B mandate.	Airport and approach.	Safety Human Performance	Expert	N/A	Solution project.	Medium
ASS-	Non-aircraft	Aircraft	All surface vehicles	It is assumed that the	Airport and	Safety	Expert	N/A	Solution	Low

EXE02 -003	vehicles filtered	Equipage/ Technology	filtered out and not taken into analysis.	system will not take into account surface vehicles in the first stage of the system deployment.	approach.	Human Performance			project.	
ASS-EXE02 -004	Data include dense traffic airports	Traffic Characteristics and Airport Characteristics	Dense traffic environment is considered worst case. Analysis results are applicable on less dense environment.	Analysis done on dense traffic data can be extrapolated on less dense environment.	Airport and approach.	Safety Human Performance	Expert	N/A	Solution project.	Low
ASS-EXE02 -005	Large scale data	Traffic Characteristics and Airport Characteristics	Large scale data will be recorded and analysed.	Large scale of data is needed for the best significance and most representative results?	Airport and approach.	Safety Human Performance	Expert	N/A w	Solution project.	Low

Table Appendix B-2: Demonstration Assumptions overview

B2 Deviation from the planned activities

N/A

B3 Demonstration Exercise #02 Results

B3.1 Summary of Demonstration Exercise #02 Demonstration Results

Demonstration Objective ID	Demonstration Objective Title	Success Criterion ID	Success Criterion	Sub-operating environment	Exercise Results	Demonstration Objective Status
OBJ-VLD-28-023	ADS-B data performance	CRT-VLD-28-023-001	Real time ADS-B data successfully collected.	High Utilisation Complex layout	2575 ownship operations and 207639 traffics successfully collected	OK
		CRT-VLD-28-023-002	ADS-B data analysis performed and report created.	High Utilisation Complex layout	ADS-B data analysis performed, report created and deliver to PJ03b-05	OK

Table Appendix B-3: Exercise 2 Demonstration Results

B3.2 Results per KPA

N/A

B3.3 Results impacting regulation and standardisation initiatives

N/A

B3.4 Analysis of Exercises Results per Demonstration objective

B3.4.1 EX2-OBJ-VLD-28-023 Results – ADS-B data analysis delivered to PJ03b-05

B3.4.1.a CRT-VLD-28-023-001 - Real time ADS-B data successfully collected

The data collection campaign ran from March 2018 through April 2019. Data was collected by 3 airlines, by 5 aircraft of Airbus A320 family. The data collected comprised 2582 ownship operations, 207 639 traffic operations, 23 679 distinct traffics with filled ADS-B position messages, and over 3 billions (1E9) ADS-B messages from 150 international airports. The relevant traffic filtering (section B.3.4.1.b.1) resulted in 2575 ownship operations, 5288 traffic operations, 9200 distinct traffics, and nearly 39 million ADS-B messages for the analysis. Operation count, whether for ownship or traffic, is determined as the number of observed changes from on ground to off ground or vice versa divided by two. In the filtered data, the distinct traffic count is higher than the traffic operation count since it includes taxiing traffics not observed to land or take off via change of the on ground state.

B.3.4.1.a.1 Airports

Ownship aircraft were logging data from routes involving mainly Europe and Middle East. There were 150 visited international airports.

The visited airports, the ownship operation counts, the traffic operation counts and traffic counts in collected data after filtering away traffic irrelevant for surface alerting are shown in Table Appendix B-4:. In the table, operation count, whether for ownship or for traffic, is determined as the number of observed changes from on ground to off ground or vice versa divided by two. The distinct traffic counts are often much higher than the traffic operation counts since they include taxiing traffics not observed to land or take off via change of the on ground state.

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
BKPR	Pristina	Kosovo	43	15	96
DAAG	Algiers	Algeria	3	1	4
DAOO	Oran	Algeria	1	0	0
DTTA	Tunis	Tunisia	5.5	1.5	47
EBBR	Brussels	Belgium	20.5	29.5	430
EDDB	Berlin Schönefeld	Germany	1	0	5

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
EDDC	Dresden	Germany	1	0	2
EDDF	Frankfurt	Germany	6	22.5	276
EDDH	Hamburg	Germany	40.5	66	601
EDDK	Cologne Bonn	Germany	2	3	31
EDDL	Dusseldorf	Germany	85	211.5	1016
EDDM	Munich	Germany	6	7	188
EDDN	Nuremberg	Germany	10.5	3	72
EDDS	Stuttgart	Germany	12.5	13.5	135
EDDT	Berlin Tegel	Germany	61.5	176	803
EDDV	Hannover	Germany	14	4	100
EDDW	Bremen	Germany	36	8.5	117
EFHK	Helsinki	Finland	1	0.5	21
EGBB	Birmingham	U.K.	2	0.5	30
EGCC	Manchester	U.K.	4	6.5	68
EGLL	London Heathrow	U.K.	30	113	850
EHAM	Amsterdam	Netherlands	33.5	96	901
EIDW	Dublin	Ireland	2	3	51
EKCH	Copenhagen	Denmark	24	51	561
ELLX	Luxembourg	Luxembourg	1	1	15
ENGM	Oslo	Norway	3	4	105
EPWA	Warsaw	Poland	4	1	49
EPWR	Wroclaw	Poland	1	0	2
ESGG	Gothenburg	Sweden	2	0	14
ESOE	Orebro	Sweden	1	0	0
ESSA	Stockholm Arlanda	Sweden	29	41.5	429
GCFV	Fuerteventura	Canary Islands (Spain)	1	1.5	9
GCLP	Gran Canaria	Canary Islands (Spain)	5	3.5	77

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
GCRR	Lanzarote	Canary Islands (Spain)	1	1.5	7
HEBA	Alexandria	Egypt	1	0	3
HECA	Cairo	Egypt	9	4.5	100
HEGN	Hurghada	Egypt	5	0.5	21
HESH	Sharm el-Sheikh	Egypt	3	0	7
LCEN	Ercan	Cyprus	35	15.5	77
LCPH	Paphos	Cyprus	2	0	3
LDSP	Split	Croatia	1	2	9
LDZA	Zagreb	Croatia	4	0	20
LEAL	Alicante	Spain	1	1.5	17
LEAM	Almeria	Spain	2	1	3
LEBB	Bilbao	Spain	5	1	32
LEBL	Barcelona	Spain	5	11.5	150
LEIB	Ibiza	Spain	0.5	0.5	9
LEMD	Madrid	Spain	5	12.5	247
LEMG	Malaga	Spain	8	6	137
LEPA	Palma de Mallorca	Spain	23	40.5	647
LEST	Santiago de Compostela	Spain	4	1.5	11
LEVC	Valencia	Spain	21.5	8	144
LFLL	Lyon	France	1	0.5	11
LFML	Marseille	France	1	0	13
LFMN	Nice	France	26.5	23	409
LFPG	Paris	France	23.5	65.5	580
LFSB	Basel Mulhouse Freiburg	Multiple	13	39	174
LGAV	Athens	Greece	10	10.5	120
LGIR	Heraklion	Greece	2.5	8.5	30
LGKO	Kos	Greece	5	12.5	38

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
LGKR	Corfu	Greece	3	3.5	15
LGRP	Rhodes	Greece	1	2.5	19
LGSM	Samos	Greece	1	0	0
LGTS	Thessaloniki	Greece	4	2.5	34
LGZA	Zakynthos	Greece	1	0.5	2
LHBP	Budapest	Hungary	7.5	3	92
LIBD	Bari	Italy	1	0	5
LIBR	Brindisi	Italy	1	0	4
LICC	Catania	Italy	1	3.5	14
LICJ	Palermo	Italy	7	1.5	74
LIEE	Cagliari	Italy	1	0	8
LIMC	Milan	Italy	7	7.5	163
LIPE	Bologna	Italy	1	6.5	16
LIPX	Verona	Italy	1	0	4
LIPZ	Venice	Italy	12	12.5	139
LIRF	Rome	Italy	21	62.5	557
LIRN	Naples	Italy	6	25.5	98
LIRP	Pisa	Italy	1	0	10
LJLJ	Ljubljana	Italy	1	0	3
LKPR	Prague	Czech Republic	20.5	16.5	395
LLBG	Ben Gurion	Israel	35.5	20.5	457
LMML	Malta	Malta	2	0.5	18
LOWW	Vienna	Austria	32.5	49.5	555
LPFR	Faro	Portugal	1	1	12
LPPR	Porto	Portugal	8	3	77
LPPT	Lisbon	Portugal	1	1.5	29
LQSA	Sarajevo	Bosnia and Herzegovina	2	0	0
LROP	Bucharest	Romania	12	2.5	122

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
LSGG	Geneva	Switzerland	39	67	665
LSZH	Zurich	Switzerland	616.5	1869	2611
LTAC	Ankara	Turkey	70	45.5	301
LTAF	Adana	Turkey	25.5	1.5	66
LTAI	Antalya	Turkey	50.5	39	469
LTAJ	Gaziantep	Turkey	18.5	4.5	24
LTAN	Konya	Turkey	17.5	1.5	17
LTAP	Merzifon	Turkey	3	0	0
LTAR	Sivas	Turkey	7	0	0
LTAS	Zonguldak	Turkey	2	0	0
LTAT	Malatya	Turkey	5.5	0	1
LTAU	Kayseri	Turkey	20	7.5	39
LTAY	Çardak	Turkey	3	0	2
LTAZ	Nevşehir	Turkey	7	0.5	2
LTBA	Istanbul	Turkey	496.5	1710.5	1548
LTBJ	Izmir	Turkey	19	9.5	110
LTBS	Dalaman	Turkey	7	1	28
LTBZ	Zafer	Turkey	1	0	0
LTCB	Ordu-Giresun	Turkey	1	0.5	2
LTCC	Diyarbakır	Turkey	2.5	0	4
LTCD	Erzincan	Turkey	3	0	2
LTCE	Erzurum	Turkey	2	0	1
LTCF	Kars	Turkey	3	0	5
LTCG	Trabzon	Turkey	18	23	45
LTCI	Van	Turkey	1	0	0
LTCJ	Batman	Turkey	6.5	0.5	7
LTCK	Muş	Turkey	6	0	0
LTCP	Adıyaman	Turkey	1	0	0
LTCR	Mardin	Turkey	4	0	2

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
LTCS	Şanlıurfa	Turkey	3	0	2
LTCT	Iğdır	Turkey	2	0	1
LTDA	Hatay	Turkey	5	0.5	3
LTFD	Balikesir	Turkey	3	0	0
LTFE	Milas-Bodrum	Turkey	11	8.5	49
LTFG	Gazipasa	Turkey	1	0	3
LTFH	Samsun	Turkey	18.5	2.5	9
LTFJ	Istanbul Sabiha Gökçen	Turkey	4	11	102
LTFM	Istanbul	Turkey	15	21.5	422
LUKK	Chișinău	Moldova	1	0.5	2
LWSK	Skopje	Rep. of Macedonia	6	1.5	6
LYBE	Belgrade	Serbia	26	5.5	84
LYNI	Nis	Serbia	1	0	1
LYPG	Podgorica	Montenegro	1	0	0
OEJN	Jeddah	Saudi Arabia	25	28.5	266
OEMA	Medina	Saudi Arabia	15	2.5	100
OEYN	Yanbu	Saudi Arabia	1	0	0
OITT	Tabriz	Iran	1	0	0
OLBA	Beirut	Lebanon	4	1	45
ORBI	Baghdad	Iraq	3	3	10
ORER	Erbil	Iraq	3	0.5	5
ORMM	Basra	Iraq	3	0	5
ORSU	Sulaimaniyah	Iraq	1	0	2
UBBB	Baku	Azerbaijan	1	0	14
UGTB	Tbilisi	Georgia	6	0.5	26
UKBB	Kiev	Ukraine	3	1.5	36
UKHH	Kharkiv	Ukraine	1	0	0

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
UKOO	Odesa	Ukraine	5	0	5
ULLI	St. Petersburg	Russia	11	8.5	236
UMMS	Minsk	Belarus	1	0	5
UTAA	Ashgabat	Turkmenistan	1	0	1
UUDD	Moscow Domodedovo	Russia	30	30.5	362
UUWW	Moscow Vnukovo	Russia	2	0.5	16

Table Appendix B-4: Operation and traffic counts in filtered ADS-B data, for visited airports

The top 10 airports by number of seen distinct traffics from Table Appendix B-4: are shown in Table Appendix B-5.

ICAO	Title	Country	Ownship Operation Count	Traffic Operation Count	Distinct Traffic Count
LSZH	Zurich	Switzerland	616.5	1869	2611
LTBA	Istanbul	Turkey	496.5	1710.5	1548
EDDL	Dusseldorf	Germany	85	211.5	1016
EHAM	Amsterdam	Netherlands	33.5	96	901
EGLL	London Heathrow	U.K.	30	113	850
EDDT	Berlin Tegel	Germany	61.5	176	803
LSGG	Geneva	Switzerland	39	67	665
LEPA	Palma de Mallorca	Spain	23	40.5	647
EDDH	Hamburg	Germany	40.5	66	601
LFPG	Paris	France	23.5	65.5	580

Table Appendix B-5: Operation and traffic counts in filtered ADS-B data, for top 10 visited airports

B.3.4.1.a.2 Data processing

Aircraft logged the data into PCMCIA cards within traffic computers. Data was retrieved from the aircraft once or twice a week, depending on airline. As a consequence, the PCMCIA cards were sometimes filled to their maximum capacity, leading to some data loss. This data loss was considered to be acceptable.

For exchange of data between involved project partners, Microsoft Azure cloud storage was used. A cloud uploader application was developed to make it easier for the airlines to transfer data from the

PCMCIA cards to the cloud. The application took care of formatting an empty card, zipping the data on the filled card, uploading the zip archive to the cloud, and emptying the card after upload.

For the analysis, ADS-B messages were decoded from extended squitter data. As requested by the data owner, ADS-B data above 1000 ft Above Ground Level (AGL) and flight IDs were removed.

B.3.4.1.a.3 ADS-B Out Airports Environment

B.3.4.1.a.4 ADS-B Out data

To provide a picture of the quality and accuracy of data available via ADS-B In to aircraft operating in airport environments, an analysis of the accuracy parameters NACp and NUCp reported by the traffic operating in such environments was made. What was analysed was the received ADS-B data from traffic on the airport surface except for surface vehicles and from airborne traffic below 1000 ft above ground level, filtered with the use of the traffic relevance criteria specified in section B.3.4.1.b.1.

The choice of the accuracy parameter to be used for position qualification depends on the version of Minimum Operational Performance Standards (MOPS) for 1090 MHz Extended Squitter ADS-B used by the transmitter. MOPS Version Zero is RTCA DO-260, MOPS Version One is RTCA DO-260A and MOPS Version Two is RTCA DO-260B [27]. For Version Zero, applications use the reported NUCp value, obtained from the message type code of the surface position messages and airborne position messages. For Version One and Version Two, applications use the NACp value reported in the Aircraft operational status messages.

Percentages and counts of relevant traffic that use various DO-260B versions are shown in Figure Appendix B-1: . The counts indicated in the figure are counts of distinct traffic ICAO addresses.

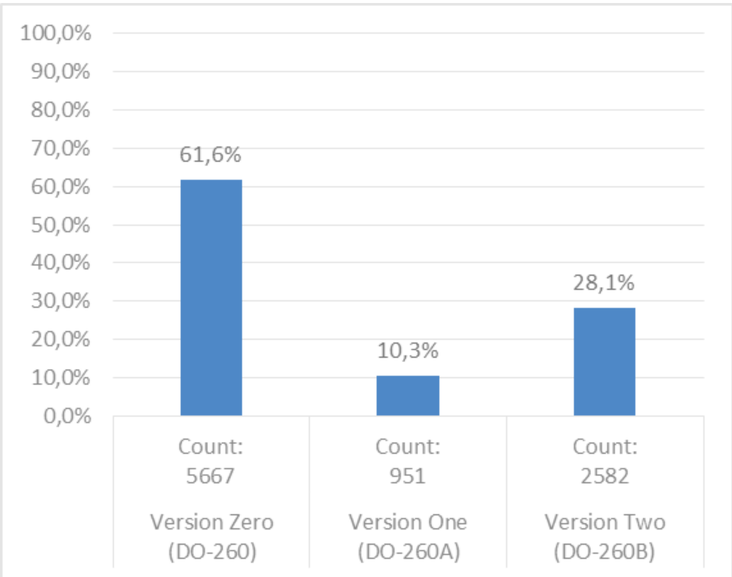


Figure Appendix B-1: Percentages of relevant traffic that use different ADS-B versions

Percentages and counts of relevant traffic per emitter category are shown in Figure Appendix B-2: . The counts indicated in the figure are counts of distinct traffic ICAO addresses. The traffic in Space /

Trans-atmospheric vehicles category was investigated and was all found to be helicopters; nevertheless, they are shown in the figure as the category actually received, to show what is in the raw data.

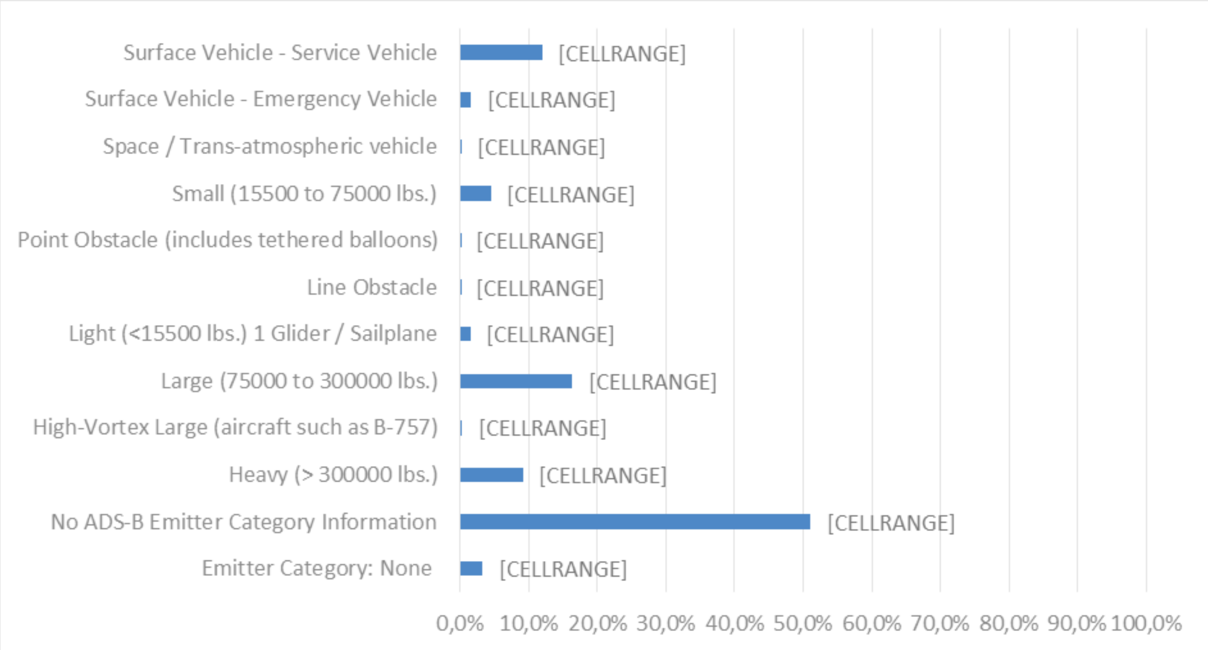


Figure Appendix B-2: Percentages of relevant traffics per emitter category

B.3.4.1.a.5 ADS-B Version Zero (NUCp)

Figure Appendix B-3: provides statistics of ADS-B Out Version Zero (RTCA DO-260) for surface and airborne relevant traffic. The NUCp quality indicator can be interpreted as per Table 2-200 of RTCA DO-260B when received by Version One or above of ADS-B receiving system, including derivation of NACp from NUCp. For surface traffic on ground, NUCp of 6 indicates unknown quality. The counts indicated in the figure are counts of distinct traffic ICAO addresses, with the caveat that a traffic that has multiple NUCp values in the data is counted to each of its NUCp values as a fraction matching the fraction of messages of the NUCp for that traffic. Thus, if 2/3 of the messages of a particular traffic show NUCp 7 while 1/3 shows NUCp 8, the fraction 2/3 is counted in the traffic count for NUCp 7 and the fraction 1/3 is counted in the traffic count for NUCp 8. The NUCp value of 6 is separated for surface (6s) and airborne (6a) messages.

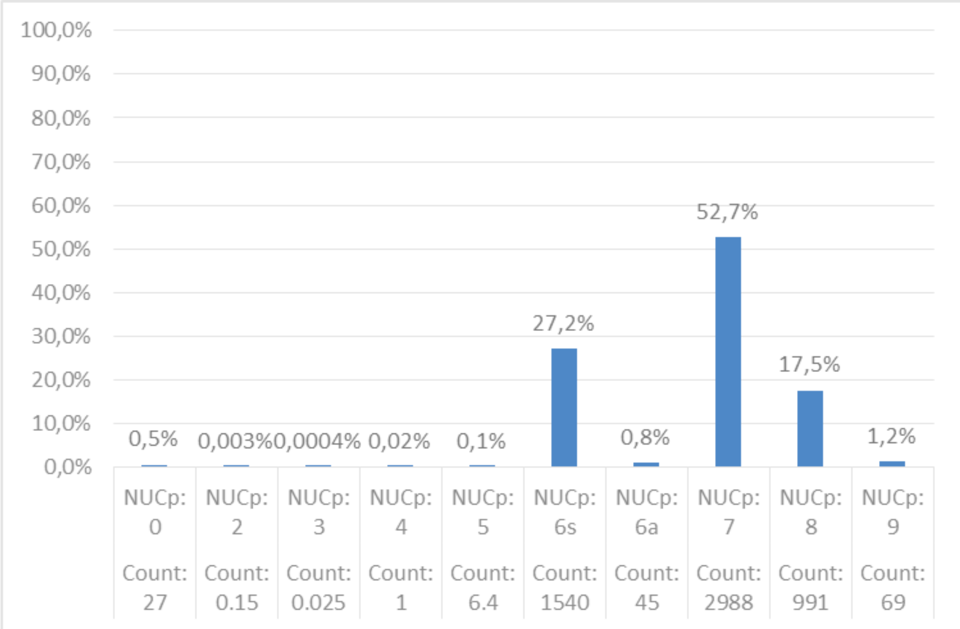


Figure Appendix B-3: NUCp for ADS-B Version Zero for relevant traffics

B.3.4.1.a.6 ADS-B Version One (NACp)

Figure Appendix B-4 shows NACp percentages and counts for relevant traffic that use ADS-B Out Version One (RTCA DO-260A). The counts indicated in the figure are counts of distinct traffic ICAO addresses, with the caveat that multi-NACp traffics are distributed among NACp values in a fashion similar to that for NUCp.

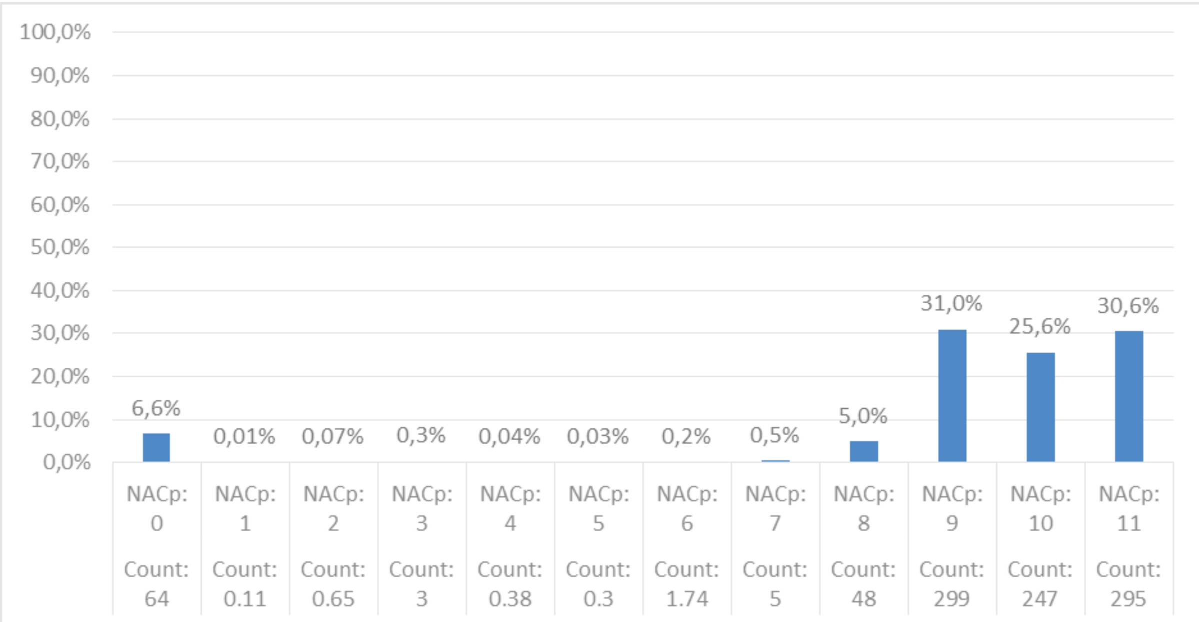


Figure Appendix B-4: NACp for ADS-B Version One for relevant traffics

B.3.4.1.a.7 ADS-B Version Two (NACp)

Figure Appendix B-5 shows NACp percentages and counts for relevant traffic that use ADS-B Out Version Two (RTCA DO-260B [27]). The counts indicated in the figure are counts of distinct traffic ICAO addresses, with the caveat that multi-NACp traffics are distributed among NACp values in a fashion similar to that for NUCp.

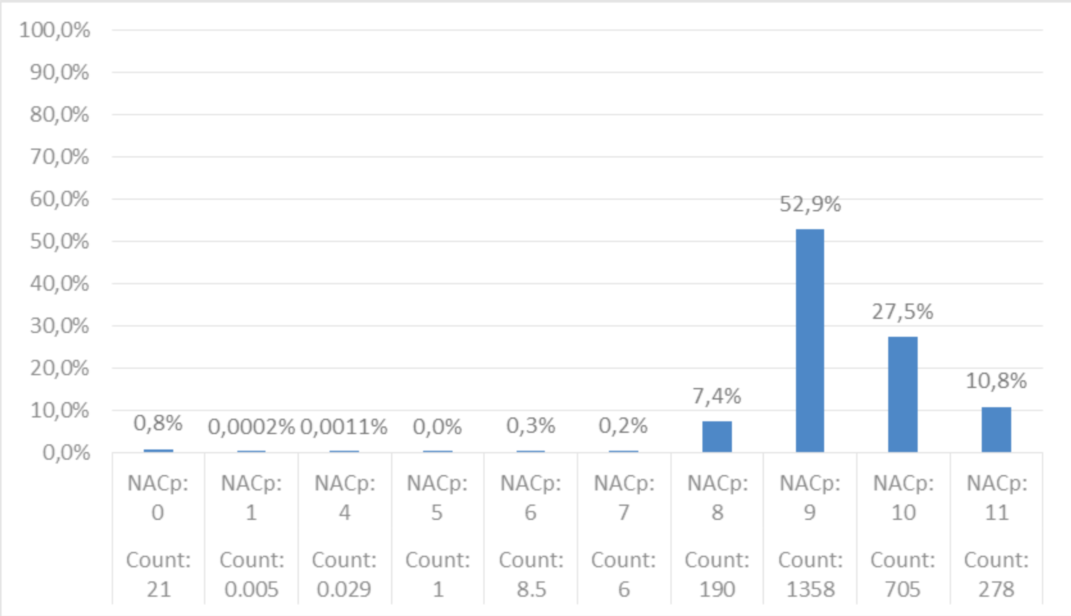


Figure Appendix B-5: NACp for ADS-B Version Two for relevant traffics

B.3.4.1.a.8 ADS-B Out data assessment

The collected data shows that, in the data relevant for surface indication and alerting, there is still a majority of ADS-B Version Zero traffic, over 60%. Within that ADS-B Version Zero traffic, over 70% of traffic has NUCp 7 (corresponds to NACp 8) and higher. NUCp less than 7 indicates very poor quality and is disregarded by the applications based on existing requirements in RTCA DO-317B. It is assumed that future deployment of indication and alerting applications will require Version Two and higher. In the data of ADS-B Version One and Version Two, the vast majority, over 85%, had NACp 9 or higher, a positive indication for compliance with future mandatory requirements on aircraft ADS-B Out equipment.

The relevant traffic with NUCp of 6 in surface messages, indicating a very poor quality, was investigated in more detail. An investigation of a set of 50 randomly chosen traffics meeting that criteria looked into whether the position data was actually fine or whether it had sawtooth or shifted trajectories. The investigation found that nearly 30% of the traffics in the set had sawtooth or shifted trajectories while the rest was fine. The aircraft type in that set that had sawtooth or shifted trajectories included Airbus A320, Boeing 737, Boeing 757, Boeing 767, Fokker 70, Ilyushin IL76 and Learjet 55.

B3.4.1.b CRT-VLD-28-023-002 - ADS-B data analysis performed and report created

The ADS-B In detection analysis aimed to assess how the limitations of available radio frequency (RF) bandwidth and radio wave transmission impact the update interval of ADS-B messages received by an aircraft on or near the airport surface during landing, takeoff and taxiing. The analysis is relevant to the impact of the update interval on runway indication and alerting application and on possible future taxiway indication and alerting application.

Two separate analyses were made: one for runway-related movement of ownship and one for taxiway movement of ownship. Each analysis limited the input data to that relevant to it, with the use of filtering described in section B.3.4.1.b.1. For runway-related movement, phases landing, takeoff and crossing of the filtering are relevant; for taxiway movement, phase taxiing of the filtering is relevant.

B.3.4.1.b.1 Filtering of relevant traffic

Before the analysis, the data was filtered with the broad intent to disregard items not relevant to surface indication and alerting applications, whether for runways or for taxiways. The filtering algorithm chosen is as follows and uses the notion of runway engagement zone (REZ) specified below the algorithm. Two kinds of REZ were used, one for taxiing and one for landing, takeoff and crossing.

1. For ownship, keep only data that belong to one of the phases landing, taxiing, takeoff and crossing:
    a. *Landing*: Ownship is inbound, below 1000 ft AGL (above ground level) while inside the landing REZ.
    b. *Taxiing*: Ownship is on ground while outside all taxiing REZs of the relevant airport.
    c. *Takeoff*: Ownship is outbound, below 1000 ft AGL while inside the takeoff REZ.
    d. *Crossing*: Ownship is on ground while inside any REZ other than the landing or the takeoff one, unless inside the taxiing REZ of the landing or takeoff runway.
2. For traffic, keep only data that is relevant to one of the ownship phases landing, taxiing, takeoff and crossing:
    a. Traffic data is relevant to ownship *landing* if it occurs within ownship landing time, and the traffic is below 1000 ft AGL while inside any of the relevant REZ of the relevant airport extended by 500 ft; once the stated criterion is fulfilled for a traffic the first time, keep including the data for that traffic until it is fulfilled the last time for that traffic in the same ownship landing time block.
    b. Traffic data is relevant to ownship *taxiing* if it occurs within ownship taxiing time, and the traffic is below 1000 ft AGL while horizontally closer than 1200 ft to ownship.
    c. Traffic data is relevant to ownship *takeoff* if it occurs within ownship takeoff time, and the traffic is below 1000 ft AGL while inside any of the relevant REZ of the relevant airport extended by 500 ft; once the stated criterion is fulfilled for a traffic the first time, keep including the data for that traffic until it is fulfilled the last time for that traffic in the same ownship takeoff time block.

d. Traffic data is relevant to ownship *crossing* if it occurs within ownship crossing time, and the traffic is below 1000 ft AGL while inside any of the relevant REZ of the relevant airport extended by 500 ft; once the stated criterion is fulfilled for a traffic the first time, keep including the data for that traffic until it is fulfilled the last time for that traffic in the same ownship crossing time block.

Note that the definition of crossing used above is different from the one used in SURF IA application: it disregards whether the ownship is lined up to the runway.

For the above purposes, a *runway engagement zone (REZ)* is defined as follows. This definition is distinct from any definition used in SURF IA application.

1. All REZ are rectangular.
2. Two kinds of REZ are distinguished, one for taxiing and one for landing, takeoff and crossing.
3. REZ for taxiing:
    a. REZ width := 2 * runway width
    b. REZ length := runway length + 2 * runway width
4. REZ for landing, takeoff and crossing:
    a. REZ width := 3 * runway width
    b. REZ length := runway length + side-dependent elongations:
    c. short one-sided elongation: 1.5 * runway width
    d. long one-sided elongation: 3 nm (nautical miles) or, for a vehicle on ground, 1.5 * runway width

Example ownship filtering REZ are shown in Figure Appendix B-6:, the smaller REZ rectangles for taxiing filtering in yellow, the larger REZ rectangles for landing, takeoff and crossing filtering in blue.

Figure Appendix B-6: Example ownship filtering REZ in Zurich

B.3.4.1.b.2 Update interval analysis

The update interval frequencies extracted from the collected data for the relevant traffic filtered as per section B.3.4.1.b.1, with further filters applied, are shown in Figure Appendix B-7, Figure Appendix B-8:, Figure Appendix B-9:, and Figure Appendix B-10:. In that sequence, a figure with a normal y-axis is followed by a figure with a logarithmic y-axis to make visible the frequency of long update intervals.

The further filters applied were as follows:

1. The traffic situations with traffic ground speed <= 1 kt were removed. Rationale: The position message broadcast rate prescribed by DO-260B, Table 2-79, is only once per five seconds for vehicles that are not moving, compared to twice per second for moving vehicles.
2. Ground vehicles (surface vehicles) and ADS-B transmitters identifying themselves as obstacles via emitter category were removed.
3. The traffic situations with NACp equal to zero were removed. Thereby, also some situations with NUCp equal to 0 and 6 were removed, based on NACp determined from NUCp the mapping in DO-260B, Table 2-200. Such situations contained a disproportionate number of shifted or gridded traffic trajectories, indicating use of outdated ADS-B Out devices by the transmitting vehicles.
4. Situations in which the ownship was not moving (ground speed < 1 kt) and was in *standing apron* were removed; for more on standing apron, see below.
5. The update intervals resulting from a traffic temporarily ceasing to meet the main filtering criteria of section B.3.4.1.b.1 were removed. Such update intervals are merely a consequence of the filtering in the data processing and do not reflect actually occurring update intervals in the received ADS-B messages.
6. The update intervals relevant in principle to runway alerting such that the traffic location at the beginning of the interval and the traffic location at the end of the interval were both outside of runway engagement zone not extended by 500 ft were removed. Such update intervals made it past the filter of section B.3.4.1.b.1 due to the criteria for traffic inclusion reckoning with REZ extended by 500 ft; this extension is useful to register long gaps starting outside of unextended REZ and ending inside unextended REZ, but it leads to inclusion of gaps that are outright irrelevant for runway alerting, those being removed.

The notion of a *standing apron* was chosen to be narrower than an apron and excludes locations of the apron that is a *passage apron*, in which aircraft is not expected to stand for an extended period of time. It turned out the removal of update intervals for non-moving ownship in standing apron impacted solely taxiway movement statistics and not runway-related movement statistics, as was expected. The rationale for excluding such situations is that they include countless very long update intervals that have no bearing on indication and alerting to prevent collisions. The constraint to aprons was there since excluding all situations in which ownship is standing would also exclude situations in which ownship stopped during taxiing, and such situations are actually relevant to indication and alerting.

In the figures, the values larger than 30 s were cut off. The number of cut off values for runway-related movement is 129; for taxiway movement, it is 98. The maximum cut off value for runway-related movement is 438 s; for taxiway movement, it is 199 s.

Given the filtering per section B.3.4.1.b.1 and the further filters described above, the statistics were as follows:

a) For the runway-related ownship movement:
    a. The average (arithmetic mean) update interval: 0.72 s.

b. 90% of all update intervals were within 1.1 s.

c. 99% of all update intervals were within 3.4 s.

b) For the taxiway ownship movement:

a. The average (arithmetic mean) update interval: 0.69 s.

b. 90% of all update intervals were within 1 s.

c. 99% of all update intervals were within 3.9 s.

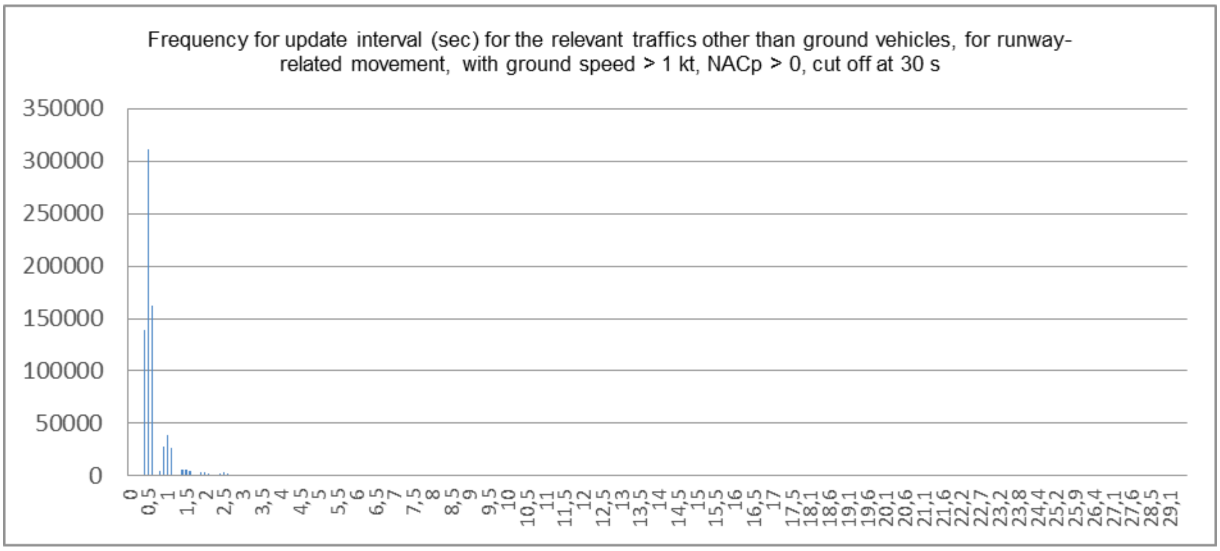


Figure Appendix B-7: Update interval for runway-related movement

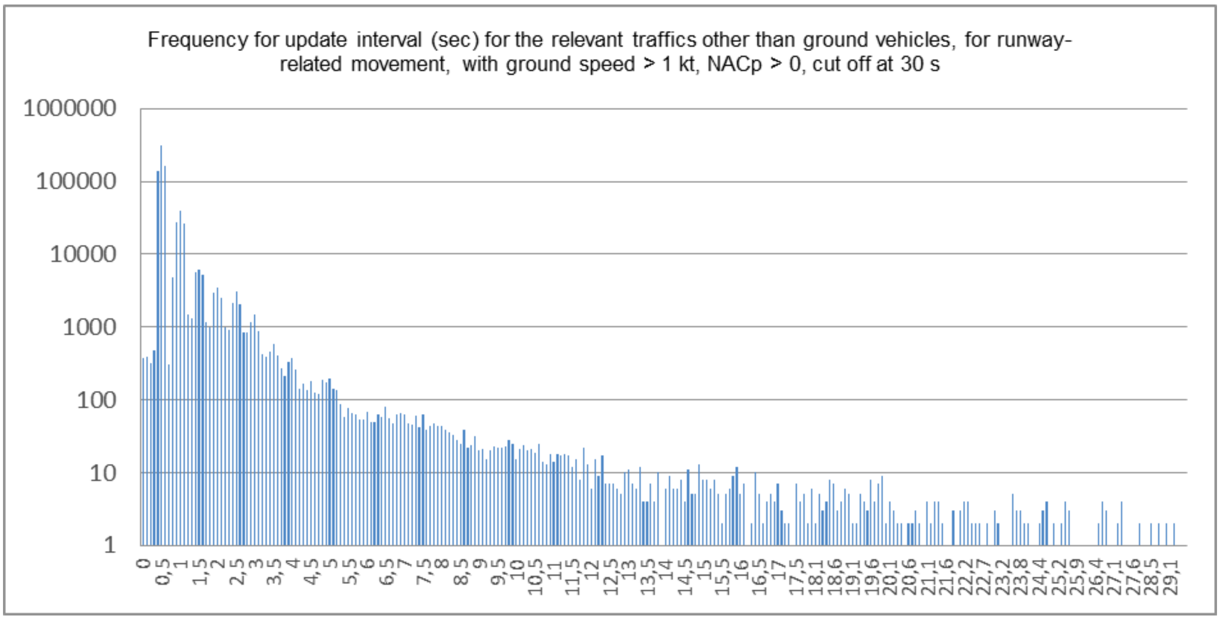


Figure Appendix B-8: Update interval for runway-related movement, with logarithmic y-axis

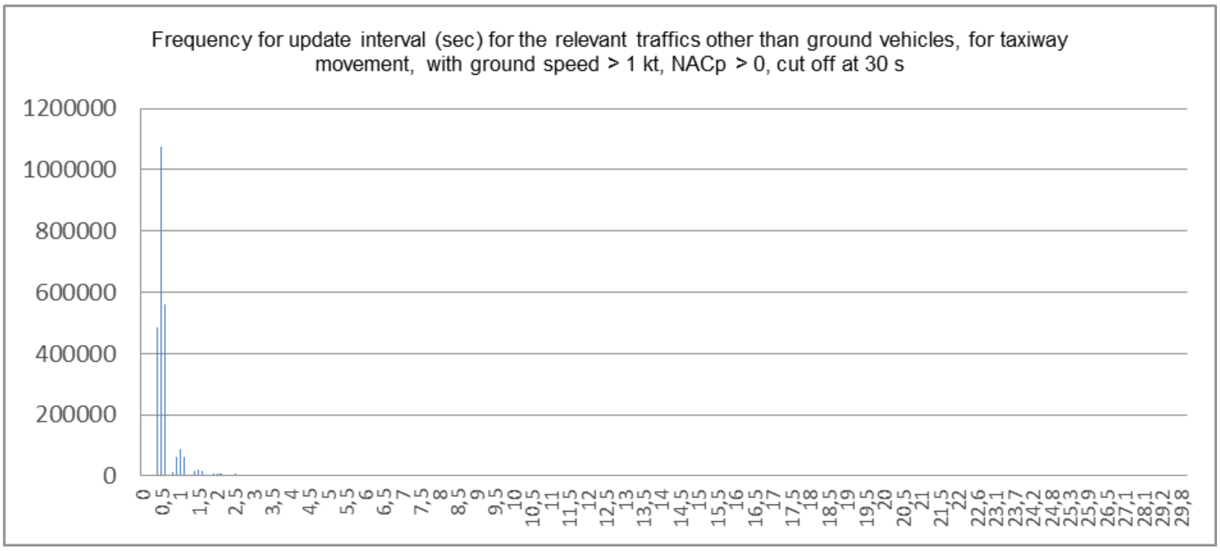


Figure Appendix B-9: Update interval for the relevant traffic for taxiway movement

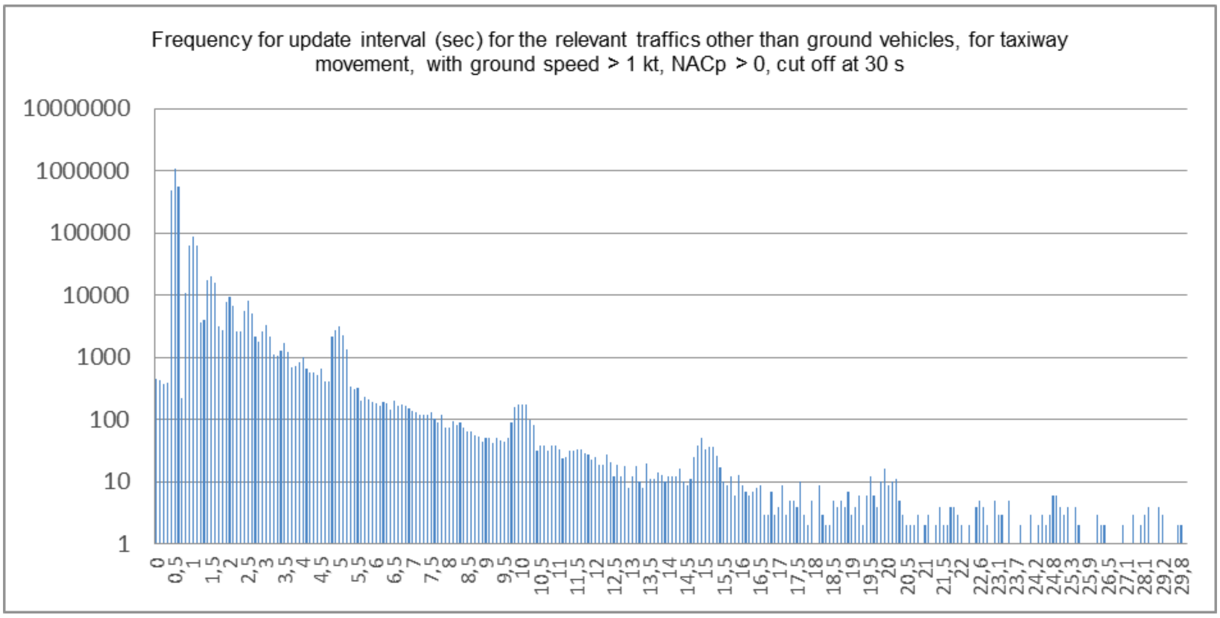


Figure Appendix B-10: Update interval for the relevant traffic for taxiway movement, with logarithmic y-axis

B.3.4.1.b.3 RF signal shielding and impact on alerting analysis

The following set of screenshots shows various examples of the identified Radio Frequency (RF) signal shielding events in various European airports. For all situations, the update interval (gap) length is more than 25 s. In each screenshot, the positions of ownship and traffic are displayed in a time window sufficient to show the relevant portion of the aircraft movement before and after the event.

The following symbols are used in the figures of long update interval (gap) situations:

■	(green square)	Last known position of traffic before the gap
■	(blue square)	First known position of traffic after the gap
✈	(green aircraft icon)	The position of ownship when the last position of traffic before the gap was received
✈	(blue aircraft icon)	The position of ownship when the first position of traffic after the gap was received
●	(blue circle)	Coordinates received from traffic via ADS-B position messages during the time window
—	(orange line)	Trajectory of ownship during the time window

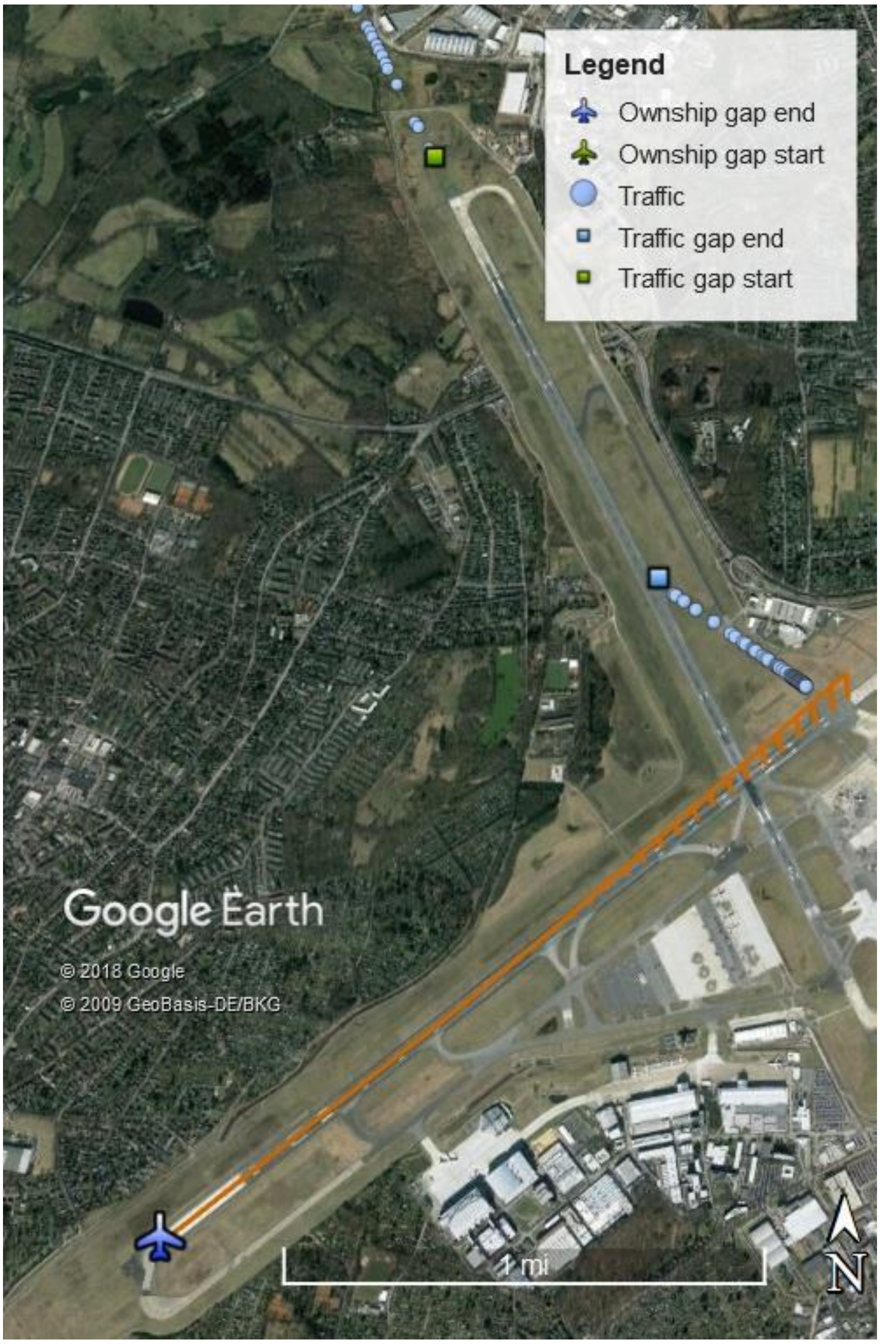


Figure Appendix B-11: Airport Hamburg (EDDH), gap length 49.4 s

In Figure Appendix B-11:, ownship is holding before taking off. Green aircraft icon is missing, because it is covered by the blue one. Traffic is landing on the crossing runway. During the whole landing manoeuvre, ownship does not receive position messages from the traffic. After the traffic takes fast exit from the runway, ownship starts taking off. Ownship is airborne when the trajectories cross.

The long update interval in Figure Appendix B-11: has *no impact on alerting* since it took ownship 40 s to reach the location where the runways intersect, longer than 30 s, and therefore, ownship was never in operationally relevant alert situation during the update interval.

Figure Appendix B-12: Airport Heathrow (EGLL), gap length 27.3 s

In Figure Appendix B-12:, ownship is taking off and traffic is landing on a parallel runway at the same time. Airport terminal is blocking RF connection between both aircraft.

The long update interval in Figure Appendix B-12: has obviously *no impact on alerting*.

Figure Appendix B-13: Airport Amsterdam (EHAM), gap length 25.1 s

In Figure Appendix B-13:, ownship is landing on a runway which is quite far from the airport terminal. Traffic is taking off from another runway. The terminal lies between the aircrafts and blocks the radio transmission. The long update interval in Figure Appendix B-13: has obviously *no impact on alerting*.

Figure Appendix B-14: Airport Istanbul (LTBA), gap length 32.3 s

In Figure Appendix B-14:, ownship is landing in one runway and traffic is taking off from another runway that is neither parallel nor intersecting. Terminal buildings shield transmission from traffic.

The long update interval in Figure Appendix B-14: has obviously *no impact on alerting*.

Figure Appendix B-15: Airport Charles De Gaule Paris (LFPG), gap length 26.4 s

In Figure Appendix B-15:, both traffic and ownship are taking off from different parallel runways. Terminal 2E shields transmission from traffic.

The long update interval in Figure Appendix B-15: has obviously *no impact on alerting*.

Figure Appendix B-16: Airport Zurich (LSZH), gap length 155 s

In Figure Appendix B-16:, ownship is taking off from runway 10. At the same time the traffic is taxiing to runway 16 and also takes off when ownship passes the crossing point of both runways. Ownship does not receive any transmission from traffic (and probably vice versa) until it (ownship) passes the crossing point of both runways. The transmission is probably shielded by terrain between both aircrafts.

The long update interval in Figure Appendix B-16: has no impact on alerting since traffic was just beginning to line up with its takeoff runway at the end of the update interval, at which point the ownship was past the runway intersection, leading to no chance of collision within 30 s, or in fact any collision at all.

Figure Appendix B-17: Airport Zurich (LSZH), gap length 36.4 s

In Figure Appendix B-17:, ownship is approaching runway 14 to land. Although it has direct visibility to traffic which is taxing to runway 28, there is about 36 s gap in reception of the ADS-B messages. Reception is restored before the ownship lands.

The long update interval in Figure Appendix B-17: has obviously *no impact on alerting*.

Figure Appendix B-18: Airport Zurich (LSZH), gap length 25.2 s

In Figure Appendix B-18:, ownship is holding before traffic takes off; the green aircraft icon is missing because it is covered by the blue one. After the traffic takes off, the ownship also takes off. Two additional gaps visible in the figure are substantially shorter, 3.7 s and 3.6 s.

Unlike in the previously described situations, the long update interval in Figure Appendix B-18: *did have an impact on alerting*. Ownship was on hold on runway 10 (west-east) while the traffic was taking off from runway 16, which intersects the ownship runway. At the end of the 25.2 s long update interval, the traffic was in a takeoff with ground speed 110 kt, 2430 ft along the runway, 19 s remaining to runway intersection. The ownship did not start to accelerate for takeoff before the traffic was past the runway intersection; at the point of the traffic moving past the runway intersection, the traffic was 130 ft above ground. The ownship had no chance to become airborne at the runway intersection. However, had the ownship started to accelerate, which could have happened if the situation was out of control of the tower, and had the traffic aborted the takeoff, there could have been a collision within 30 s of the end of the update interval and yet an alert would not have been given during the long update interval, and would be missed.

All update interval occurrences longer than 25 seconds were analysed for cause and impact on alerting. The choice of 25 second threshold was driven by update intervals longer than that resulting in track termination according to ADS-B specification. There were 188 update interval occurrences longer than 25 seconds relevant in principle to runway alerting and 167 such occurrences relevant in principle to taxiway alerting; this is for 2575 ownship operations and 5288 traffic operations as indicated in section B1.1. A subset of that were update intervals longer than 25 seconds for traffic moving faster than 40 kt; there were 33 such update interval occurrences.

From the runway configuration standpoint, the update intervals longer than 25 seconds were for the following situations:

1. Ownship and traffic were in a situation potentially relevant for taxiway alerting. This made up about 47.0% of occurrences.
2. Ownship was engaged in (taking off from or landing on) one runway and the traffic was engaged in another non-intersecting and non-parallel runway, e.g. as in Figure Appendix B-13:. This made up about 35.8% of occurrences.
3. Ownship was engaged in a runway parallel to the one with which the traffic was engaged, e.g. as in Figure Appendix B-12:. This made up about 9.6% of occurrences.
4. Ownship was engaged in one runway and the traffic was engaged in the same runway. This made up about 4.8% of occurrences.
5. Ownship was engaged in one runway and the traffic was engaged in an intersecting runway, e.g. as in Figure Appendix B-11:. This made up about 2.8% of occurrences.

The cause analysis revealed that about 83.4% of update interval occurrences longer than 25 s were caused by RF signal being obstructed (shielded) by a physical structure such as a terminal building. In the remaining 16.6% of such update interval occurrences, the ownship could directly see the traffic without an obstacle that is a building; in some cases, there was another shielding traffic between the ownship and the traffic; in other cases, this could have been caused by multipath issues.

Concentration of long update intervals by airport was analysed. The following airports had higher proportion of long gaps (longer than 25 seconds) than the proportion of operations:

1. Zurich (LSZH) accounted for 47.6% of long gaps but only for 23.9% of all operations.
2. Istanbul (LTBA) accounted for 28.7% of long gaps but only for 19.3% of all operations.
3. London Heathrow (EGLL) accounted for 7.6% of long gaps but only for 1.2% of all operations.
4. Amsterdam (EHAM) accounted for 3.1% of long gaps but only for 1.3% of all operations.
5. Moscow Domodedovo (UUDD) accounted for 1.4% of long gaps but only for 1.2% of all operations.
6. Palma de Mallorca (LEPA) accounted for 1.1% of long gaps and for 0.9% of all operations.

The above observation is likely explained by airport layout, the way airport operations are run, and the traffic density.

The impact of update intervals longer than 25 s on alerting as for potential missed alerts was analysed. What was sought were update intervals for which at least one of the traffic position updates missed during the update interval corresponds to a situation in which there is a significant possibility of collision between ownship and traffic in 30 seconds. Such an impact was found in 1 occurrence for runway alerting and in no occurrence for taxiway alerting, for 2575 ownship operations. In all other occurrences of these update intervals, there was no impact on alerting. An example situation of a longer update interval having no impact on runway alerting is ownship in one runway and traffic in another runway, parallel one and not closely spaced one, the long interval being caused by buildings between the two runways. The one occurrence that had an impact on runway alerting is shown in Figure Appendix B-18:, and described below it.

Another analysis was made for update intervals longer than 6 seconds for traffic moving more than 40 kt. There were 1125 such occurrences, of which 988 were likely caused by RF shielding. The following categories of scenarios were observed:

1. Ownship was engaged in (taking off from or landing on) one runway and the traffic was engaged in another non-intersecting and non-parallel runway, e.g. as in Figure Appendix B-13:. This made up about 65.6% of occurrences.
2. Ownship was engaged in a runway parallel to the one with which the traffic was engaged, e.g. as in Figure Appendix B-12:. This made up about 20.3% of occurrences.
3. Ownship was holding or lining up at a runway end while the traffic was departing from an intersecting runway, e.g. as in Figure Appendix B-18:. This made up about 7.8% of occurrences.
4. Ownship was preparing for takeoff while the traffic is in takeoff from the same runway. This made up about 1.7% of occurrences.
5. Ownship was crossing a runway while traffic was landing into or taking off from an intersecting runway. This made up about 1.3% of occurrences.
6. Ownship was taxiing on a runway after landing while the traffic was landing into an intersecting runway. This made up about 1.2% of occurrences.
7. All other cases, which made up about 2.1% of occurrences.

The update intervals longer than 6 seconds for traffic moving more than 40 kt were analysed for impact on alerting as for potential missed alerts, whether on runway alerting or taxiway alerting. One occurrence with an impact was found, on runway alerting, the same one as in the analysis for update intervals longer than 25 s above (Figure Appendix B-18:). The criteria for impact on alerting were the same as used above in the analysis of impact of intervals longer than 25 s.

B3.5 Unexpected Behaviours/Results

N/A

B3.6 Confidence in the Demonstration Results

B3.6.1 Level of significance/limitations of Demonstration Exercise Results

The collected data and results are reasonably representative for Europe and Middle East since both regions are covered by a significant number of ownship operations and a variety of airports from both regions are covered. The collected data and results are not necessarily representative worldwide since they do not significantly cover Africa and Russia and they do not cover Americas and Asia Pacific at all.

B3.6.2 Quality of Demonstration Exercise Results

The accuracy of the results for indicators NACp and NUCp, for MOPS version and of update interval histogram is good as a consequence of sufficient volume of collected data. By contrast, the ratio of long gap occurrences that have an impact on potential missed alerts to the number of ownship operations is based on a single occurrence with an impact, and is therefore inaccurate, subject to significant deviation from the true underlying value.

B3.6.3 Significance of Demonstration Exercises Results

As for operational significance, the data was collected by aircraft during normal aircraft operation on a variety of airports with various runway configurations, including busy airports, providing good operational realism.

B4 Conclusions

The analysis of causes of long update intervals (gaps) showed the overwhelming majority was caused by RF shielding by airport buildings and hills, and a small minority was caused by RF shielding by traffic or could have been caused by multipath issues. Airports in Zurich, Istanbul (LTBA), and London Heathrow accounted for 83.9% of all detected long gaps, and each of these airports accounted for a higher portion of long gaps than its portion of ownship operations and than its portion of traffic operations. The large majority of the long gaps found in Zurich was caused by RF shielding by airport buildings and hills; the long gaps relevant for runway alerting were for the most part for ownship in one runway and traffic in a non-intersecting and non-parallel runway, to a lesser extent, in an intersecting runway and, even less so, in the same runway. The large majority of the long gaps in Istanbul was caused by RF shielding by an airport building; the long gaps relevant for runway alerting were for the most part for ownship in one runway and traffic in a non-intersecting non-parallel runway and, to a lesser extent, in the same runway; the long gaps in the same runway were often caused by another shielding traffic between the ownship and the traffic while the runway was used as a taxiway. All except two long gaps in London Heathrow were caused by RF shielding by an airport building; the long gaps relevant for runway alerting were for ownship in one runway and traffic in a parallel runway. For the layout of Zurich, Istanbul (LTBA) and London Heathrow airports (see Figure Appendix B-12, Figure Appendix B-14, Figure Appendix B-16).

In general, the shielding of RF signals on or near the airport surface may result in reduced benefit for some ADS-B In applications used on the airport surface, such as SURF IA: the RF shielding may lead to missed alerts, including delayed alerts. The RF shielding seems unlikely to result in nuisance alerts.

Analysis of impact on potential missed alerts of update intervals over 25 s, and of those over 6 s for traffics with ground speed over 40 kt disclosed only one occurrence with an impact, for 2575 ownship operations.

B5 Recommendations

B5.1 Recommendations for industrialization and deployment

From industrialization and deployment and regulation and standardisation perspectives it is recommended to collect data also form non-Europe environment. Collecting of such data and its analysis is of significant benefit to upcoming demonstration and deployment of the SURF A system. This complementary collection campaign is to mitigate the risk that the PJ03B-05 solution does not work under some specific operational conditions in other regions of the world. In parallel with preparing a large demonstration in the European environment, it is recommended to monitor the global interoperability risk which was not addressed in PJ03B and should not be addressed in the VLD either due to the focus on European airlines short range carriers.

If issues were detected early enough, the implementation could embark mitigation strategies in the certified solution so as to ensure that future long range carriers implementing the SESAR solution can operate internationally.

If this additional collection campaign was not performed, or delayed, the PJ03B-05 solution would still be validated for use in the European environment. It is not on the critical path of VLD or deployment, however, it is considered that addressing the global interoperability risk too late could result in a significant industrial cost, probably preventing corrections at a late stage, and thus limiting adoption of the SESAR solution in other regions of the world.

B5.2 Recommendations on regulation and standardisation initiatives

No recommendation on regulation and standardisation has been taken within PJ28 WP3. Regulation and standardisation initiatives are managed under PJ03b-05.

Appendix C Demonstration Exercise #03 (LHBP)

C1 Summary of the Demonstration Exercise #03 Plan

As in PJ28_D1_1_Demo_Plan_03_00_00.

C1.1 Exercise description and scope

Operational Scope

The demonstration corresponding to WP04 took place in Budapest Ferenc Liszt Airport in April 2019. The Very Large Scale Demonstration was performed by using passive shadow mode operation. By using real time surveillance, the demonstration was addressed several functionalities very sensitive to surveillance errors which could not be fully addressed in SESAR 1 via real time simulations, such as re-routing or surveillance based safety net. Those functionalities were routing and planning functions, airport safety nets and departure planning.

The main actors were the Tower Controllers: Clearance delivery, Ground and Runway. Clearance Delivery and Ground positions were combined as Ground Controller.

Key Demonstration Objectives and Scenarios

The SESAR1 solutions covered in this demonstration were:

- SESAR Solution #02 "Airport Safety Nets: Conformance Monitoring Alerts and Conflicting ATC Clearances", consisting on two different sets of alerts as safety support tools for the controllers:
    - A set of Conflicting ATC Clearance (CATC) alerts for runway operations, detecting contradictory clearances input by the controller to the system
    - A set of Conformance Monitoring (CMAC) alerts, which detect and warn the controllers of non-conformance to instructions or clearances by aircraft or vehicles

  The use of real live surveillance information in shadow mode is a key element in de-risking the deployment of the different solutions, particularly for Solution #02. The different Solution #02 alerts will be interacting with the already deployed RMCA set of alerts, following SESAR1 recommendations.

- SESAR Solution #22 "Automated Assistance to Controller for Surface Movement Planning and Routing", consisting on the use of a Routing function to support controllers managing the taxi phase. The Routing function calculates suitable routes for any mobile in the surface according to any constraint (wingspan, taxiways configuration, etc.) and displays it in the controller HMI. The controller can interact with the system to edit the routes and to input clearances
- SESAR Solution #53 "Pre-Departure Sequencing supported by Route Planning", consisting on improving the runway departure sequence provided by the DMAN with pre-departure sequencing using TSAT and with the use of routing and planning information

Demonstration Technique and Platform

The demonstration was performed using two different modes:

1) Passive shadow mode

2) Shadow mode with manipulation, to trigger special events, e.g. different alerts

The controllers had access to all the necessary controls, including communications, lighting control and access to flight and meteorological information. Passive shadow mode ensured that there was no influence on the live operation. The main objective of the demonstration was to disseminate and to de-risk the deployment of different SESAR1 solutions at Budapest

The demonstration platform was built on SESAR1 solutions installed in the facilities presently used for contingency, but it was to meet the requirement of the demonstration. Demonstration platform provides full duplication of the operational tower completed with a visualization system. Visual reproduction of the "out of the window" aerodrome view was provided.

The industrial platform that was used is InNOVA. It is the evolution of the NOVA A-SMGCS product, which is currently in use in Budapest. InNOVA brought several innovations to LHBP controllers based on the SESAR solutions to be demonstrated:

- Full scope of automation: from surveillance and detection to clearance monitoring and automatic routing.
- Automatic support for workflow definition using ground and air mobile movements with enhanced setup of responsibilities
- The new functions aim to reduce the controller's workload whilst providing excellent situational awareness.
- An integrated HMI solution saves time and gives the controllers a clearer view of everything that is happening and that could affect traffic movement.

Analysis method

All the success criteria have been assessed using qualitative and quantitative data, by means of:

- Questionnaires. Controllers fill in specific questionnaires distributed at the end of each run.
- Post-Run Debriefing. Controllers under evaluation made comments and observations for the specific run.
- Final Debriefing. Controllers made final comments, observations and overall impressions about the validation exercise.
- Observers. All the runs had one over-the-shoulder observer that supported the controllers and gave additional feedback.
- Recordings. Recording and Playback Sub-System used to record the Controller Working Positions

C1.2 Summary of Demonstration Exercise #03 Demonstration Objectives and success criteria

Demonstration Objective	Demonstration Success criteria	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise 3 Objectives	Demonstration Exercise 3 Success criteria
OBJ-VLD-28-001	CRT-VLD-28-001-001	Fully covered	EX3-OBJ-VLD-28-001 Demonstrate the utility of routing and planning functions	EX3-CRT-VLD-28-001-001 Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations
	CRT-VLD-28-001-002	Fully covered		EX3-CRT-VLD-28-001-002 Positive evaluation of the calculated routes' relevance
OBJ-VLD-28-002	CRT-VLD-28-002-001	Fully covered	EX3-OBJ-VLD-28-002 Demonstrate the utility and usability of route modification capabilities.	EX3-CRT-VLD-28-002-001 Positive evaluation of route modification capabilities when real surveillance data is used
	CRT-VLD-28-002-003	Fully covered		EX3-CRT-VLD-28-002-003 Positive evaluation of the routes representation (e.g. different status)
OBJ-VLD-28-003	CRT-VLD-28-003-001	Fully covered	EX3-OBJ-VLD-28-003 Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	EX3-CRT-VLD-28-003-001 Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.
OBJ-VLD-28-004	CRT-VLD-28-004-	Fully covered	EX3-OBJ-VLD-28-004	EX3-CRT-VLD-28-

	001		Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable	004-001 Positive evaluation of the workload of Ground Controllers due to planning and routing functions.
	CRT-VLD-28-004-002	Fully covered		EX3-CRT-VLD-28-004-002 Positive evaluation of the workload of Runway Controllers due to planning and routing functions.
	CRT-VLD-28-004-003	Fully covered		EX3-CRT-VLD-28-004-003 Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.
OBJ-VLD-28-005	CRT-VLD-28-005-001	Fully covered	EX3-OBJ-VLD-28-005 Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	EX3-CRT-VLD-28-005-001 Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.
	CRT-VLD-28-005-002	Fully covered		EX3-CRT-VLD-28-005-002 Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.
	CRT-VLD-28-005-003	Fully covered		EX3-CRT-VLD-28-005-003

				Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.
OBJ-VLD-28-006	CRT-VLD-28-006-001	Fully covered	EX3-OBJ-VLD-28-006 Demonstrate the utility of CATC alerts functions	EX3-CRT-VLD-28-006-001 Positive evaluation of the utility of the CATC alerts functions when real surveillance data is used.
OBJ-VLD-28-007	CRT-VLD-28-007-001	Fully covered	EX3-OBJ-VLD-28-007 Demonstrate the utility of CATC functions in predictive mode	EX3-CRT-VLD-28-007-001 Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.
OBJ-VLD-28-008	CRT-VLD-28-008-001	Fully covered	EX3-OBJ-VLD-28-008 Demonstrate the usability of CATC functions.	EX3-CRT-VLD-28-008-001 Positive evaluation of the usability of CATC alerts functions.
	CRT-VLD-28-008-002	Fully covered		EX3-CRT-VLD-28-008-002 Positive evaluation of the usability of CATC functions in predictive mode
OBJ-VLD-28-009	CRT-VLD-28-009-001	Fully covered	EX3-OBJ-VLD-28-009 Demonstrate the utility of CMAC functions	EX3-CRT-VLD-28-009-001 Positive evaluation of the utility of CMAC functions when real surveillance data is used.
OBJ-VLD-28-010	CRT-VLD-28-010-001	Fully covered	EX3-OBJ-VLD-28-010 Demonstrate the usability of CMAC	EX3-CRT-VLD-28-010-001 Positive evaluation

			functions	of the audio alarm
	CRT-VLD-28-010-002	Fully covered		EX3-CRT-VLD-28-010-002: Positive evaluation of the level of alerts generated (information or alarm)
	CRT-VLD-28-010-003	Fully covered		EX3-CRT-VLD-28-010-003: Positive evaluation of the usability of CMAC alerts functions
OBJ-VLD-28-013	CRT-VLD-28-013-001	Fully covered	EX3-OBJ-VLD-28-013 Demonstrate that the controller workload incurred due to integration of CMAC is acceptable	EX3-CRT-VLD-28-013-001 Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable
	CRT-VLD-28-013-002	Fully covered		EX3-CRT-VLD-28-013-002 Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable
OBJ-VLD-28-014	CRT-VLD-28-014-001	Fully covered	EX3-OBJ-VLD-28-014 Demonstrate that the controller workload incurred due to integration of CATC is acceptable	EX3-CRT-VLD-28-014-001 Positive evaluation that the workload of RUNWAY controller due to the integration of CATC is acceptable
OBJ-VLD-28-015	CRT-VLD-28-015-001	Fully covered	EX3-OBJ-VLD-28-015 Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC	EX3-CRT-VLD-28-015-001 Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved
	CRT-VLD-28-015-	Fully covered		EX3-CRT-VLD-28-

	002			015-002 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved
OBJ-VLD-28-016	CRT-VLD-28-016-001	Fully covered	EX3-OBJ-VLD-28-016 Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC	EX3-CRT-VLD-28-016-001 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved
OBJ-VLD-28-017	CRT-VLD-28-017-001	Fully covered	EX3-OBJ-VLD-28-017 Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions	EX3-CRT-VLD-28-017-00 Positive evaluation of the utility of the CATC and CMAC integrated with RMCA
	CRT-VLD-28-017-002	Fully covered		EX3-CRT-VLD-28-017-00 Positive evaluation of the usability of the CATC and CMAC integrated with RMCA
	CRT-VLD-28-017-003	Fully covered		EX3-CRT-VLD-28-017-003 Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts
OBJ-VLD-28-018	CRT-VLD-28-018-001	Fully covered	EX3-OBJ-VLD-28-018 Demonstrate the utility of DMAN functions supported by route planning	EX3-CRT-VLD-28-018-001 Positive evaluation of the utility of the DMAN function supported by route planning
OBJ-VLD-28-019	CRT-VLD-28-019-001	Fully covered	EX3-OBJ-VLD-28-019 Demonstrate the usability of DMAN	EX3-CRT-VLD-28-019-001 Positive evaluation

			functions supported by route planning	of the usability of the DMAN function supported by route planning
OBJ-VLD-28-020	CRT-VLD-28-020-001	Fully covered	EX3-OBJ-VLD-28-020 Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable	EX3-CRT-VLD-28-020-001 Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable
	CRT-VLD-28-020-002	Fully covered		EX3-CRT-VLD-28-020-002 Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable
	CRT-VLD-28-020-003	Fully covered		EX3-CRT-VLD-28-020-003 Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable
OBJ-VLD-PJ28-021	CRT-VLD-28-021-001	Fully covered	EX3-OBJ-VLD-PJ28-021 Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved	EX3-CRT-VLD-28-021-001 Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved
	CRT-VLD-28-021-002	Fully covered		EX3-CRT-VLD-28-021-002 Positive evaluation

				that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved
	CRT-VLD-28-021-003	Fully covered		EX3-CRT-VLD-28-021-003 Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved
OBJ-VLD-PJ28-022	CRT-VLD-28-022-001	Fully covered	EX3-OBJ-VLD-PJ28-022: Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	EX3-CRT-VLD-28-022-001: Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

Table Appendix C-1: Summary Demonstration Objectives and Criteria Exercise #03

C1.3 Summary of Validation Exercise #03 Demonstration scenarios

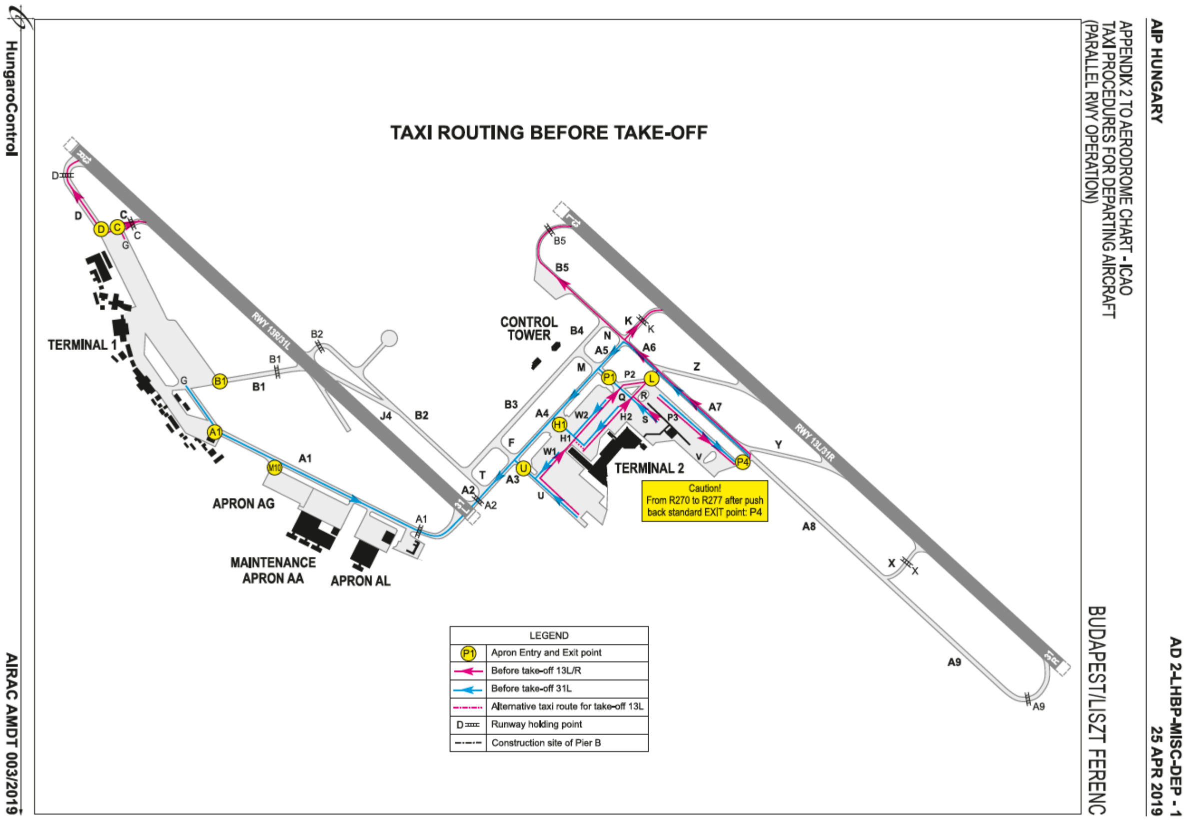


Figure Appendix C-1: LHBP Departure taxi routes

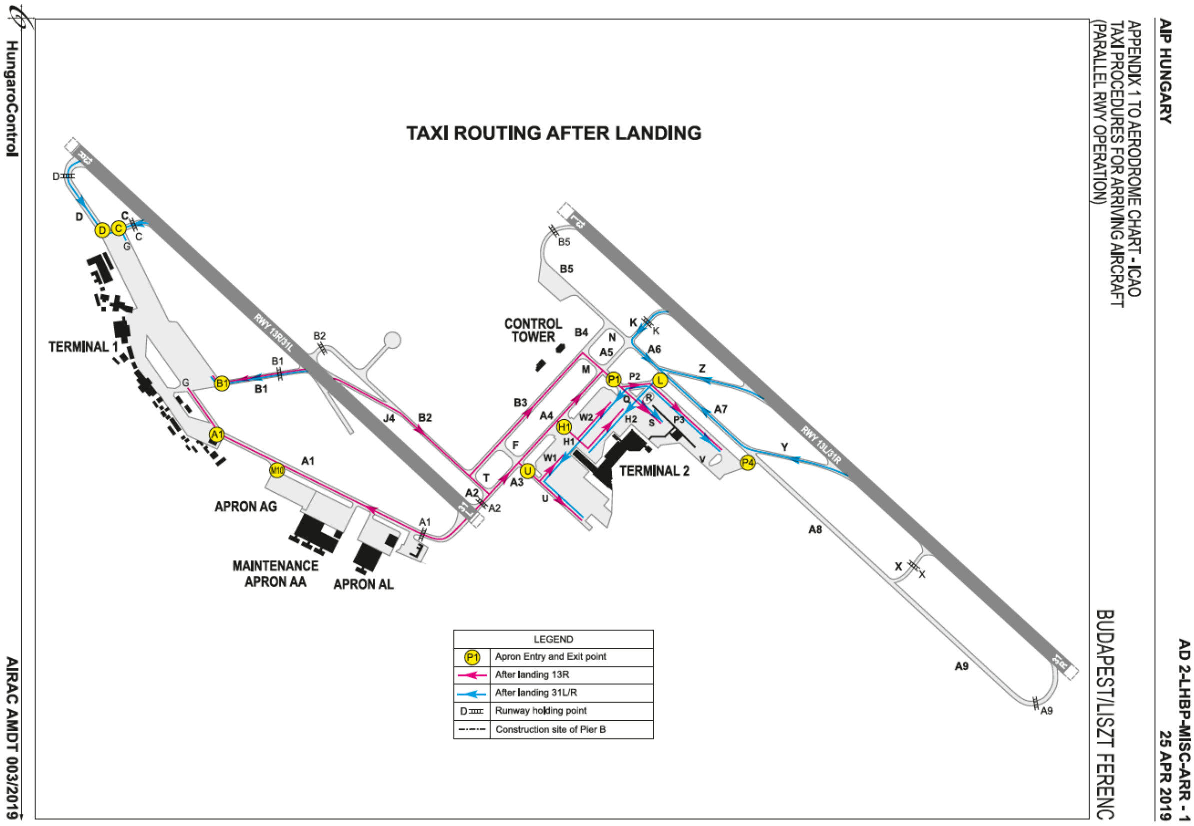


Figure Appendix C-2: LHBP Arrival taxi routes

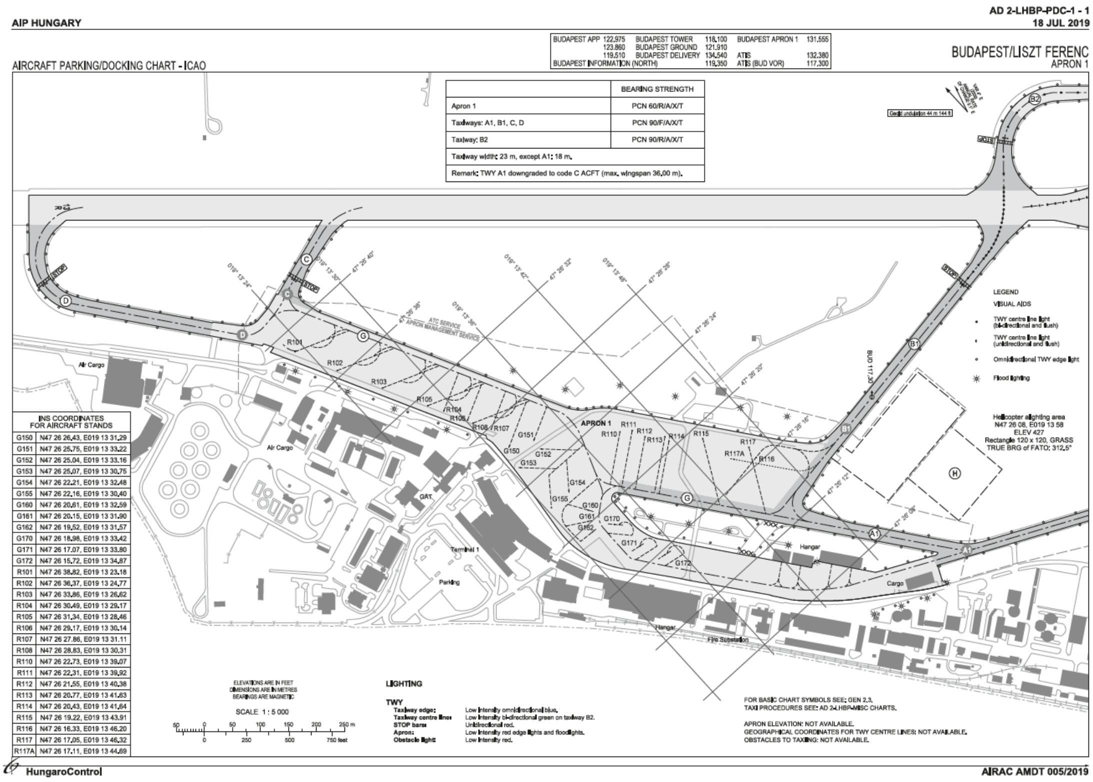


Figure Appendix C-3: LHBP Parking Areas Apron 1

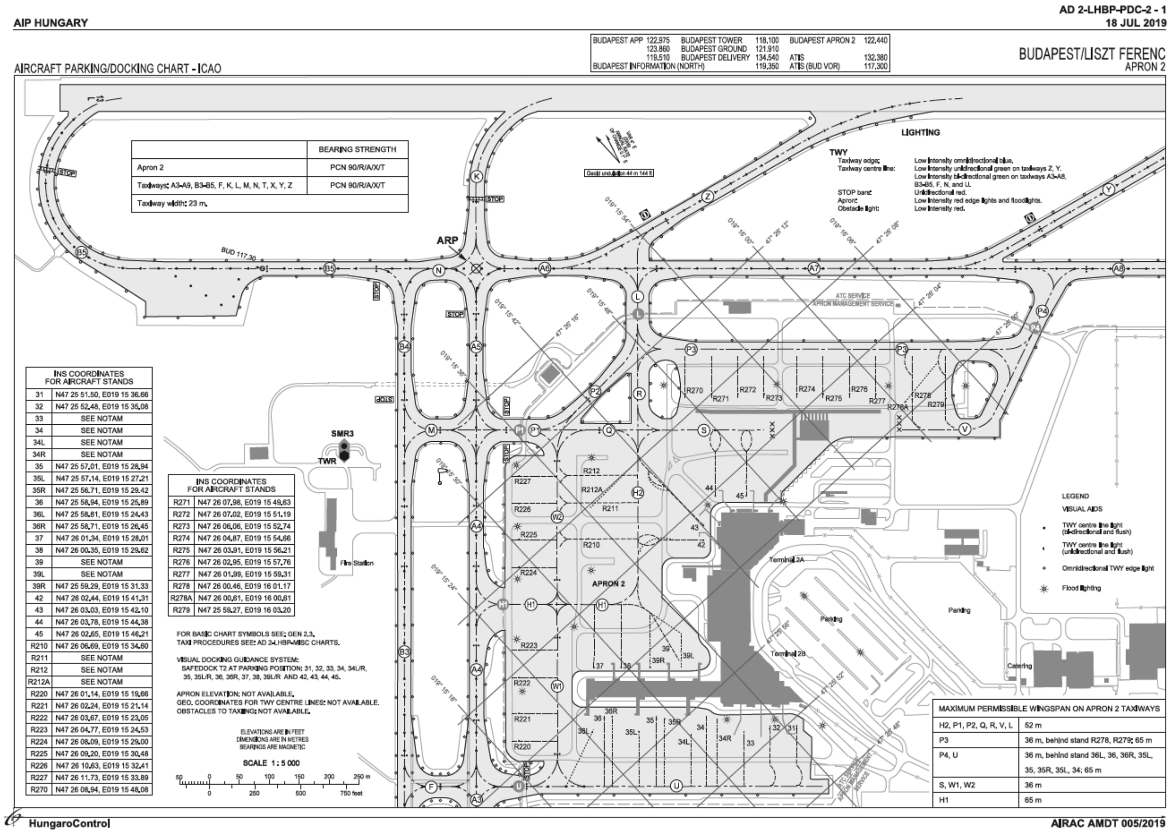


Figure Appendix C-4: LHBP Parking Areas Apron 2

Reference scenario

The reference scenario with regards to the current state at Budapest airport is as follows:

The working environment

Budapest is a medium sized airport with two parallel but dependent runways (13L-31R and 13R-31L) that are used simultaneously. Runway configuration may change according to the wind direction but the default direction is 31, default landing runway is 31R, default departure runway is 31L

When the direction is 13, default landing runway is 13R, default departure runway is 13L and landing traffic for Runway 13L is restricted due to noise regulation

During night time (22:00 - 06:00 local time), the use of the airport by aircraft is restricted by regulations

The main Terminal Apron is located in between the two parallel runways and is composed of a mix of pushback contact stands and remote stands. Certain restrictions regarding maximum wingspan exist for certain taxiways and for certain parking stands.

Dedicated Aprons for General Aviation / Cargo / Maintenance are located West of Runway 13R/31L. In order to proceed to or from these Aprons, runway 13R/31L has to be crossed.

Controller roles and tools

The current Tower operation at Budapest airport is paperless. Clearance Delivery, Ground and Aerodrome controllers are using a label based ATM system to input clearances. The labels (arrival) and lists (departure) are updated manually each time a flight clearance has been given or automatically if updated information received (i.e. CTOT). All positions, including Tower Supervisor is equipped with A-SMGCS for ground surveillance. All instructions are given by R/T – No datalink in use. The service is provided on a continuous basis, the number of working jobs is determined by TWR Supervisor. During the demonstration, there will be two CWPs set to test the system with the following role configuration: “CDC+GRC” & “ADC”.

Aerodrome Controller (ADC)

The areas of competence are Budapest airport control area (CTR), the runways and their safety strips. ADC controls aircraft within the CTR and issues clearances for the runways and safety strips including speed control and landing clearance for arrival aircraft as well as line-up and take-off clearance for departing aircraft. ADC is also responsible for runway crossing both for aircraft and vehicle.

Currently Aerodrome Controller mainly use the following systems at Budapest airport:

Radar screen – Controller is using to input clearances. Contains all flight plan information in the label and in the flight list and a traffic situational display shows the current position of airborne aircraft.

A-SMGCS – used to display the current airport traffic including both aircraft and vehicles

Aerodrome Controller will be one of the used positions during the demonstration

Airport Planning Controller (TPC)

TPC supports ADC and GRC in the operational planning and proactive in organising airport traffic, helping to identify and resolve conflict. TPC may perform the task of CDC in accordance with sectorization. Currently Airport Planning Controller mainly uses A-SMGCS at Budapest airport to monitor the airport traffic including both aircraft and vehicles.

Ground Controller (GRC)

GRC area of competence is the manoeuvring area of the aerodrome including taxiways and their safety strips including apron taxiways and traffic path. GRC issues engine start-up and push back clearances according to the current slot, and also provides taxi clearances to the runway holding point for departure aircraft as well as taxi clearances from the runway exit to the assigned gate for arrival aircraft. GRC may perform the task of CDC or TPC in accordance with sectorization.

Currently Aerodrome Controller mainly use the following systems at Budapest airport:

- A-SMGCS – used to display the current airport traffic including both aircraft and vehicles. Also provides information about the correct use of SSR codes. GRC is responsible to check SSR code – callsign association as well as availability and exactness of downlinked callsign for departure aircraft.

- Radar screen – Controller is using to input clearances. Contains all flight plan information in the flight list.

Ground Controller will be one of the used positions during the demonstration

Clearance Delivery Controller (CDC)

CDC gives departure clearances for departure aircraft via R/T according to the current slot and informs pilots of their alterations. Currently datalink is not available.

Currently Clearance Delivery Controller mainly uses Radar screen with flight list to indicate that ATC clearance was issued and monitor the state of the flight plan

Solution Scenarios:

The SESAR Solutions addressed are:

- Solution #02 "Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances" includes the automatic detection of non-conformance to clearances and instruction (CMAC alerts) and pairs of conflicting clearances (CATC alerts)
- Solution #22 "Automated Assistance to Controller for Surface Movement Planning and Routing" includes the automatic proposal of a surface route by the system and the ability to modify it and provide clearances/instruction via the HMI. Differently from the reference scenario, clearances are input to the system via the label instead of via EFS
- Solution #53 "-Departure Sequencing supported by Route Planning" includes a runway sequence window in the system with pre-departure sequencing functionalities, based on the information managed through the routing and planning system.

The different solution scenarios are defined as follows:

- Scenario (Run) 1 – main focus to demonstrate Solution #2
- Scenario (Run) 2 – main focus to demonstrate Solution #2, Solution #22 and Solution #53
- Scenario (Run) – main focus to demonstrate Solution #22 and Solution #53

Start	End	Monday	Start	End	Tuesday	Start	End	Wednesday
09:00	09:30	Introduction / Preparation	09:00	09:30	Introduction / Preparation	09:00	09:30	Introduction / Preparation
09:30	11:00	Run 1 *	09:30	11:00	Run 3	09:30	11:00	Run 2
11:00	11:15	Questionnaire	11:00	11:15	Questionnaire	11:00	11:15	Questionnaire
11:15	12:00	Lunch	11:15	12:00	Lunch	11:15	12:00	Lunch
12:00	14:00	Run 2	12:00	14:00	Run 1	12:00	14:00	Run 3
14:00	14:15	Questionnaire	14:00	14:15	Questionnaire	14:00	14:15	Questionnaire
14:15	15:00	Debriefing	14:15	15:00	Debriefing	14:15	15:00	Debriefing

* 06:00 – 09:00 UTC 13L31R CLOSED

Figure Appendix C-5: Example of the day-to-day agenda

C1.4 Summary of Demonstration Exercise #03 Demonstration Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-03b.03-V2-VALP-001.00013.	Vehicles	Platform constraint	(SUT) There is no control over vehicles	Vehicles are controlled at Budapest within the manoeuvring area but SUT is not prepared to handle clearances or create route for vehicles	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-03b.03-V2-VALP-001.00014.	Helicopters	Platform constraint	(SUT) There is no control over helicopters	SUT is not prepared to handle helicopter traffic	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-03b.03-V2-VALP-001.00015.	TOBT	Nominal Operations	(SUT) TOBT is not available in the SUT	There is no interface between AODB (airport system, responsible for TOBT), all calculations based on TOBT = EOBT	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Medium

ASS-03b.03-V2-VALP-001.00016.	Combined Jurisdictions	Nominal Operations	Clearance Delivery and Ground Controller positions are combined	SUT is prepared to handle combined jurisdictions	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Low
ASS-03b.03-V2-VALP-001.00017.	Functional Alerts	Nominal Operations	(SUT) RIMCAS alerts are not in operation	RIMCAS alerts are not in operational use, SUT is not properly configured	Airport and approach.	Safety Human Performance	Experts	N/A	Solution project.	Medium

Table Appendix C-2: Demonstration Assumptions overview

C2 Deviation from the planned activities

The following Demonstration Objectives were not or just partially demonstrated compared with C1.2:

Solution #2

- OBJ-VLD-28-010

  EX3-CRT-VLD-28-010-001 - Positive evaluation of the audio alarm

  Audio Alarm is not used in Budapest; demonstration objectives related to this function were not demonstrated

- OBJ-VLD-28-017

  EX3-CRT-VLD-28-017-001 - Positive evaluation of the utility of the CATC and CMAC integrated with RMCA

  EX3-CRT-VLD-28-017-002 - Positive evaluation of the usability of the CATC and CMAC integrated with RMCA

  EX3-CRT-VLD-28-017-003 - Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts

  RIMCAS alerts are part of the system but not in operational use in Budapest, therefore the platform is not properly configured so CATC and CMAC integrated with RMCA function was not demonstrated.

The following alerts were not demonstrated compared with DEMOP Chapter 5 (Alert Coverage):

- Cross or Enter vs Cross or Enter
- No Transfer
- Lining Up on the wrong runway
- Runway or Taxi Type
- Runway Closed
- High Speed

Solution #53

- Real start-up sequence deviated from the VLD DMAN sequence because of the missing real TOBT

The following events were considered deviations from the planned activities:

- No screen recordings are available (in common video format), all recordings could be played by using the Recording and Playback Sub-System
- Due to a missing Human Performance Expert resource in the exercise, separate Human Performance Result could not be presented.

C3 Demonstration Exercise #03 Results

C3.1 Summary of Demonstration Exercise #03 Demonstration Results

The following table summarises the results of the Demonstration Exercise compared to the success criteria identified within the Demonstration Plan per demonstration objective.

The following nomenclature has been used:

- OK
  - Demonstration objective achieves the expectations
- NOK
  - Demonstration objective does not achieve the expectations
- Partially OK
  - Demonstration objectives does not fully achieves the expectation
- N/A
  - Demonstration objectives out of scope of the demonstration, as identified by deviations from objectives in C.2

Demo Obj. ID	Demo Objective Title	Success Criterion ID	Success Criterion	Sub-operating environment	Exercise Results	Demo Obj. Status
OBJ-VLD-28-001	Demonstrate the utility of routing and planning functions	CRT-VLD-28-001-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.	High Utilisation Complex layout	It was demonstrated that the calculated routes generally conformed to operational needs/rules for managing certain surface operations in nominal cases.	Ok
		CRT-VLD-28-001-002	Positive evaluation of the calculated routes' relevance.	High Utilisation Complex layout	It was demonstrated that the calculated routes' relevance generally acceptable.	Ok
OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.	CRT-VLD-28-002-001	Positive evaluation of route modification capabilities when real surveillance data is used	High Utilisation Complex layout	The usability of manual route modification capabilities with real surveillance are evaluated positively even some issues were encountered which could have negative impact on the usability.	Ok
		CRT-VLD-28-002-003	Positive evaluation of the routes representation (e.g. different status)	High Utilisation Complex layout	Routes representation was introduced during the training phase and it was evaluated positively.	Ok
OBJ-VLD-28-003	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	CRT-VLD-28-003-001	Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.	High Utilisation Complex layout	The A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point was mainly evaluated positively even the planned taxi times were not taken into account different variables (delay on line up, slow start up procedure or slow taxiing) which has impact on the accuracy. Average planned taxi-time was lower than the average actual taxi-time.	Partially Ok

OBJ-VLD-28-004	Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable	CRT-VLD-28-004-001	Positive evaluation of the workload of Ground Controllers due to planning and routing functions.	High Utilisation Complex layout	The workload experienced by the Ground Controllers due to routing and planning functions was evaluated positively	Ok
		CRT-VLD-28-004-002	Positive evaluation of the workload of Runway Controllers due to planning and routing functions.	High Utilisation Complex layout	The workload experienced by the Runway Controllers due to routing and planning functions was evaluated positively	Ok
		CRT-VLD-28-004-003	Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.	High Utilisation Complex layout	Updating the HMI with clearances after/meanwhile heard on the VHF radio by the Runway Controllers were satisfactory. Ground Controllers rated the input methods also on the positive scale even some comments were issued.	Ok
OBJ-VLD-28-005	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	CRT-VLD-28-005-001	Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.	High Utilisation Complex layout	The Situational Awareness experienced by the Ground Controllers due to routing and planning functions remained at an acceptable level at all times.	Ok
		CRT-VLD-28-005-002	Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.	High Utilisation Complex layout	The Situational Awareness experienced by Runway Controllers due to routing and planning functions remained at an acceptable level at all times.	Ok
		CRT-VLD-28-005-003	Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.	High Utilisation Complex layout	See CRT-VLD-28-004-003	OK
OBJ-VLD-28-006	Demonstrate the utility of CATC	CRT-VLD-28-006-	Positive evaluation of the utility of the CATC alerts functions when real	High Utilisation Complex layout	The utility of the CATC functions was considered as positively demonstrated	Ok

	alerts functions	001	surveillance data is used.			
OBJ-VLD-28-007	Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used	CRT-VLD-28-007-001	Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.	High Utilisation Complex layout	The utility of the CATC functions in predictive mode when real surveillance data is used was considered as positively demonstrated	Ok
OBJ-VLD-28-008	Demonstrate the usability of CATC functions	CRT-VLD-28-008-001	Positive evaluation of the usability of CATC alerts functions.	High Utilisation Complex layout	Controllers confirm adequate usability of CATC alert functions	Ok
		CRT-VLD-28-008-002	Positive evaluation of the usability of CATC functions in predictive mode.	High Utilisation Complex layout	Controllers confirm adequate usability of CATC functions in predictive mode. The predictive indicator was visible and understandable for the Controllers	Ok
OBJ-VLD-28-009	Demonstrate the utility of CMAC functions	CRT-VLD-28-009-001	Positive evaluation of the utility of CMAC functions when real surveillance data is used.	High Utilisation Complex layout	The utility of the CMAC functions when real surveillance data is used was positively demonstrated	Ok
OBJ-VLD-28-010	Demonstrate the usability of CMAC functions	CRT-VLD-28-010-001	Positive evaluation of the audio alarm.	High Utilisation Complex layout	Audio alarm was not evaluated due to system limitations. This function is not used in Budapest and the necessary hardware (loudspeaker) was not available.	N/A
		CRT-VLD-28-010-002	Positive evaluation of the level of alerts generated (information or alarm).	High Utilisation Complex layout	The level of alerts generated (information or alarm) was considered as partly demonstrated positively. Issues were reported due to alert prioritization	Partially Ok

		CRT-VLD-28-010-003	Positive evaluation of the usability of CMAC alerts functions.	High Utilisation Complex layout	Controllers confirm adequate usability of CATC alert functions. Alert threshold, delay, activate/inactive time, speed limits need to be further adjusted but the overall usability of the CMAC function was positively demonstrated	Ok
OBJ-VLD-28-013	Demonstrate that the controller workload incurred due to integration of CMAC is acceptable	CRT-VLD-28-013-001	Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable.	High Utilisation Complex layout	Workload of the Ground Controller due to the integration CMAC remained on an acceptable level most of the times but due to the number of nuisance No Taxi alert on the apron, this objective was considered as demonstrated partly positively.	Partially Ok
		CRT-VLD-28-013-002	Positive evaluation that the workload of RUNWAY controller due to the integration of CMAC is acceptable.	High Utilisation Complex layout	Workload of the Runway Controller due to the integration CMAC is at an acceptable level	Ok
OBJ-VLD-28-014	Demonstrate that the controller workload incurred due to integration of CATC is acceptable	CRT-VLD-28-014-001	Positive evaluation that the workload of RUNWAY controller due to the integration of CATC is acceptable	High Utilisation Complex layout	Workload of the Runway Controller due to the integration CATC is at an acceptable level	Ok
OBJ-VLD-28-015	Demonstrate whether the Situational Awareness of controllers is improved with the integration of	CRT-VLD-28-015-001	Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved.	High Utilisation Complex layout	The Situational Awareness experienced by the Ground Controllers due to the integration of CMAC remained at an acceptable level at all times	Ok
		CRT-VLD-28-015-	Positive evaluation that the situational awareness of Runway	High Utilisation Complex layout	The Situational Awareness experienced by the Runway Controllers due to the integration of	Ok

	CMAC	002	Controllers due to the integration of CMAC is improved.		CMAC remained at an acceptable level at all times	
OBJ-VLD-28-016	Demonstrate whether the Situational Awareness of controllers is improved with the integration of CATC	CRT-VLD-28-016-001	Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CATC is improved.	High Utilisation Complex layout	The Situational Awareness experienced by the Runway Controllers due to the integration of CMAC remained at an acceptable level at all times	Ok
OBJ-VLD-28-017	Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions	CRT-VLD-28-017-001	Positive evaluation of the utility of the CATC and CMAC integrated with RMCA.	High Utilisation Complex layout	CATC and CMAC integrated with RMCA was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest	N/A
		CRT-VLD-28-017-002	Positive evaluation of the usability of the CATC and CMAC integrated with RMCA.	High Utilisation Complex layout	CATC and CMAC integrated with RMCA was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest	N/A
		CRT-VLD-28-017-003	Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts.	High Utilisation Complex layout	CATC and CMAC integrated with RMCA was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest	N/A
OBJ-VLD-28-018	Demonstrate the utility of DMAN functions supported by route planning	CRT-VLD-28-018-001	Positive evaluation of the utility of the DMAN function supported by route planning.	High Utilisation Complex layout	The utility of the DMAN function was considered as partially demonstrated	Partially Ok
OBJ-VLD-	Demonstrate the	CRT-VLD-	Positive evaluation of the usability of	High Utilisation	DMAN function mainly evaluated positively but	Ok

28-019	usability of DMAN functions supported by route planning	28-019-001	the DMAN function supported by route planning.	Complex layout	issues were encountered which could have negative impact on the usability	
OBJ-VLD-28-020	Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable	CRT-VLD-28-020-001	Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable.	High Utilisation Complex layout	The workload of the Clearance Delivery Controller was not demonstrated separately due to the use of combined jurisdiction (combined Clearance Delivery and Ground Controller position was used during the demonstration)	N/A
		CRT-VLD-28-020-002	Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable.	High Utilisation Complex layout	Workload of the Ground Controller due to the DMAN function supported by route planning is at an acceptable level at all time	Ok
		CRT-VLD-28-020-003	Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable.	High Utilisation Complex layout	Workload of the Runway Controller due to the DMAN function supported by route planning is at an acceptable level most of the time	Ok
OBJ-VLD-28-021	Demonstrate that the controllers 'situational awareness due to DMAN supported by route planning is improved.	CRT-VLD-28-021-001	Positive evaluation that the situational awareness of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is improved.	High Utilisation Complex layout	The situational awareness of the Clearance Delivery Controller was not demonstrated separately due to the use of combined jurisdiction (combined Clearance Delivery and Ground Controller position was used during the demonstration)	N/A
		CRT-VLD-28-021-002	Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is	High Utilisation Complex layout	The Situational Awareness experienced by the Runway Controllers due to DMAN function supported by route planning remained at an acceptable level at most of the time	Partially Ok

			improved			
		CRT-VLD-28-021-003	Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved.	High Utilisation Complex layout	The Situational Awareness experienced by the Runway Controllers due to DMAN function supported by route planning remained at an acceptable level at most of the time	Partially Ok
OBJ-VLD-28-022						Ok

Table Appendix C-3: Exercise 3 Demonstration Results

C3.2 Results per KPA

The results per KPA were as follows:

- Situational Awareness: Situational awareness of controllers was positively evaluated. Concerning the level of situational awareness, only slight differences occurred according to the different tasks of the controller roles.
- Safety: the demonstration objectives had no negative impact on safety. Shadow mode operation ensured that live operation was not impacted.

C3.3 Results impacting regulation and standardisation initiatives

This section provides, per demonstration objective, a consolidated analysis of the demonstration exercise results.

Each subsection collects:

- all the success criteria used to assess the demonstration objective indicated
- the analysis, detailing comments and observations
- the conclusion for each success criterion

The analysis of results for all solutions is presented next, in the following format:

- Results concerning “Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing” are generally presented as a percentage of the controller responses from questionnaire and data collection
- Results concerning “Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances” are generally presented with a percentage from the questionnaire and data collection
- Results concerning “Solution #53 - Pre-Departure Sequencing supported by Route Planning” are generally presented as a percentage of the controller responses from questionnaire and data collection

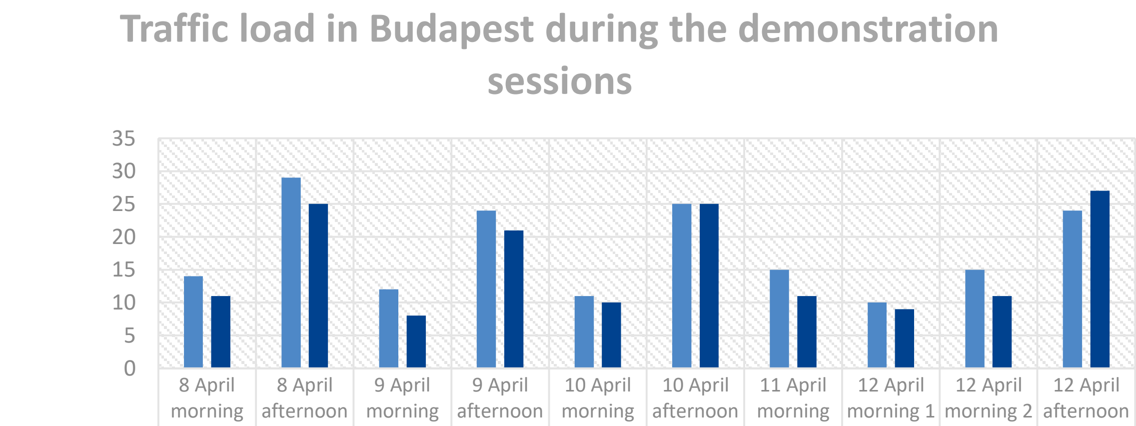
During the demonstration Controllers was asked to not follow real operation and give or not give clearances or update routes accordingly. This was needed:

- To monitor route deviation
- To create situations where CMAC and CATC alerts could be observed

C3.4 Analysis of Exercises Results per Demonstration objective

C3.4.1 EX3-OBJ-VLD-28-001 Results – Demonstrate the utility of routing and planning functions

C3.4.1.a EX3-CRT-VLD-28-001-001 - Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations



	8 April morning	8 April afternoon	9 April morning	9 April afternoon	10 April morning	10 April afternoon	11 April morning	12 April morning 1	12 April morning 2	12 April afternoon
Departures (n)	14	29	12	24	11	25	15	10	15	24
Arrivals (n)	11	25	8	21	10	25	11	9	11	27

Figure Appendix C-6: Metrics – Traffic load in Budapest during the demonstration sessions

Based on data collection of peak traffic runs:

- Max. 5 departing aircraft taxiing at the same time
- Max. 3 aircraft at A2 holding point RWY31L
- Max. 2 departing aircraft waiting at the holding point due to inbound traffic, in case of single runway operation

This objective aimed to demonstrate the utility of the routing and planning function.

The evaluation of the calculated routes conforming to operational needs/rules for managing surface operations in nominal cases was generally positive.

Some exceptions were observed:

- The system was not configured to properly cover every possible route variation. In case of single runway operation, i.e. arrivals on RWY 31L performed backtrack after landing
- Each controller has his/her own preferences for single runway operation
- Published standard routes are often not used by the controllers

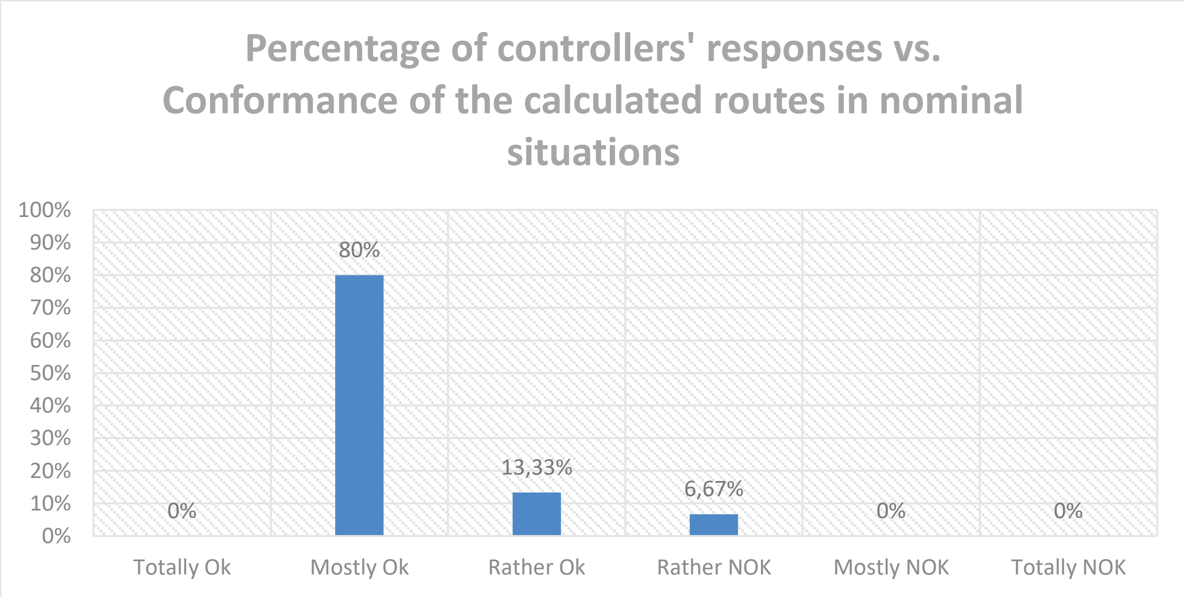


Figure Appendix C-7: Questionnaire - Percentage of controllers' responses vs. conformance of the calculated routes in nominal situations

The calculated routes conforming to operational needs/rules for managing surface operations was positively demonstrated by the controllers.

Demonstration Objective Status: Ok

C3.4.1.b EX3-CRT-VLD-28-001-002 - Positive evaluation of the calculated routes' relevance

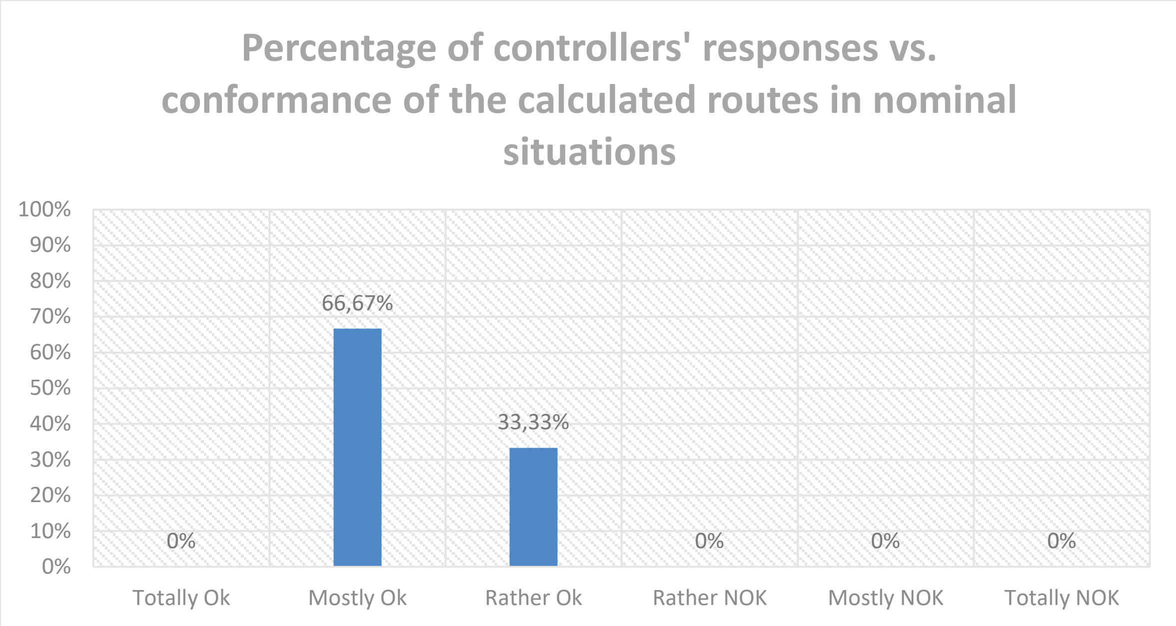


Figure Appendix C-8: Questionnaire - Percentage of controllers' responses vs. calculated routes' relevance in nominal situations

Some suggestions for improvement were noted. One general comment was that the system prefers the shortest route instead of the simplest. The route with less turns is preferred, especially in the apron area. In addition, controllers suggested to use rapid exit taxiway as default for runway exit.

In general, the relevance of the calculated routes was appropriate and demonstrated positively to the controllers.

Demonstration Objective Status: Ok

C3.4.2 EX3-OBJ-VLD-28-002 Results - Demonstrate the utility and usability of route modification capabilities.

C3.4.2.a EX3-CRT-VLD-28-002-001 - Positive evaluation of route modification capabilities when real surveillance data is used

The controllers mainly evaluated route modification capabilities positively.

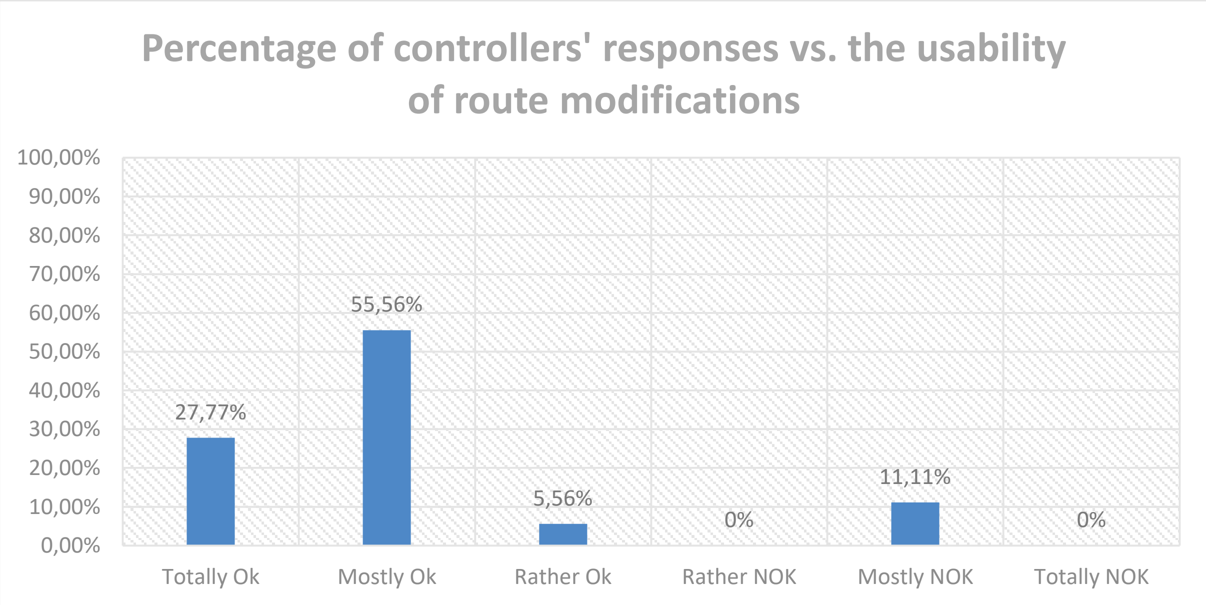


Figure Appendix C-9: Questionnaire - Percentage of controllers' responses vs. the usability of route modifications

There are several different way to modify a route in the system. Each controller has his/her own preferences which one to use. Although there was a training day for the controllers, it took some time to get familiar with the different route modification capabilities. This improved from day to day.

The 11,11% "Mostly NOK" result came from the first day of the demonstration from the same controller. The investigation – during the debriefing session on Monday – revealed that the zoom level used by that controller was inappropriate to perform proper route modification. Together with the controller, a new HMI setup was created to be able to both monitor the ground traffic and to support performing manual route modification. After that, no issues were reported regarding the usability of route modification, therefore the objective was evaluated positively.

Demonstration Objective Status: Ok

C3.4.2.b EX3-CRT-VLD-28-002-003 - Positive evaluation of the routes' representation (e.g. different status)

The representation of the routes was positively assessed by the controllers.

Different types of routes and their graphical representation (using colour coding) were highly appreciated by the controllers. After the training session where the controllers got familiar with the meaning of the different colour representations no issue was reported regarding the route presentation, thus the effectiveness of the routes' representation was positively demonstrated.

C3.4.3 EX3-OBJ-VLD-28-003 Results - Demonstrate the accuracy of A-SMGCS taxi time from off-block to runway holding point.

C3.4.3.a EX3-CRT-VLD-28-003-001 - Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.

The controllers considered the planned taxi times accepted (see Figure Appendix C-10).

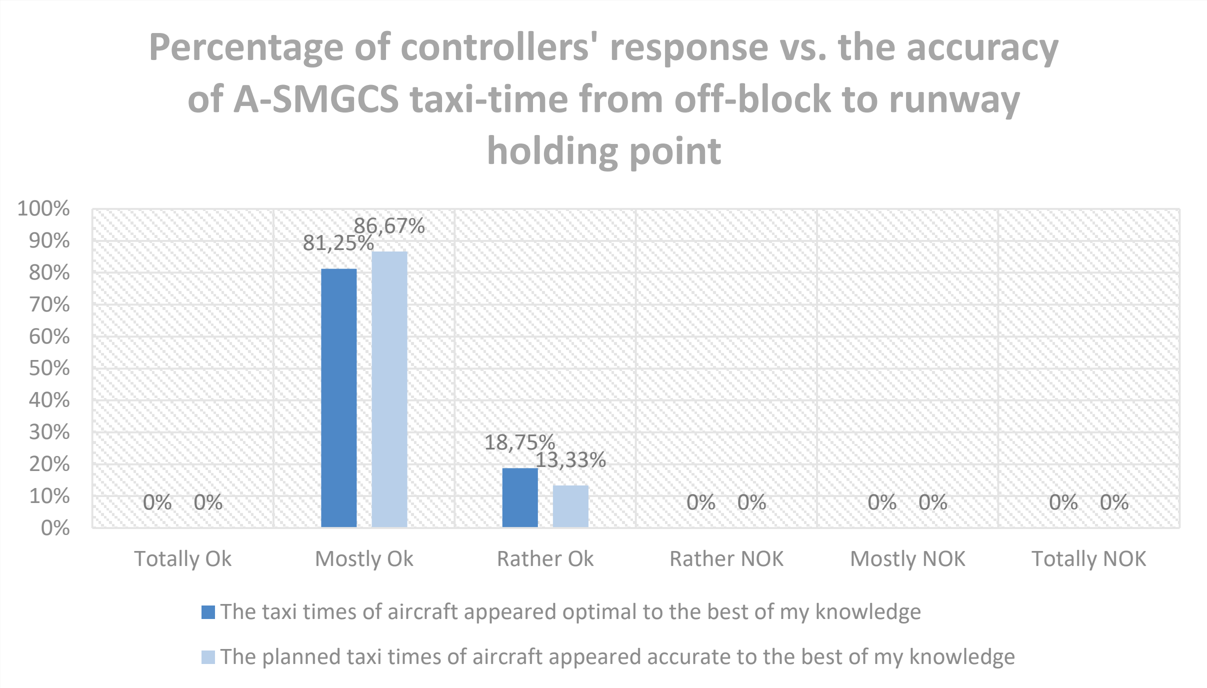


Figure Appendix C-10: Questionnaire - Percentage of controllers' responses vs the accuracy of A-SMGCS taxi time from off-block to runway holding point

System metrics are also used providing an objective basis for evaluation:

Sample	**51 departure flights, measured during three demo sessions**
Operation	• 31 departure flights under parallel runway operation (departure runway 31L) • 20 departure flights under 31L single RWY operation
Available data from data collection	• Proposed Taxi Time [mm:ss] (by InNOVA) • Actual Off Block Time [mm:ss] (AOBT) • Actual Taxi Time [mm:ss] (start time after push back, end time at the holding point) • Variable Taxi Time [hh:mm] (reference static data)
Calculated data	• Actual taxi time from off-block to runway holding point per flight [mm:ss] • Difference between Proposed Taxi Time and Actual

	Taxi Time from off-block to runway holding point per flight [mm:ss] • Average taxi time difference [mm:ss] • Median taxi time difference [mm:ss] • Actual Push Back Time for WTC M per flight [mm:ss] (AOBT – Taxi Start Time) • Average Actual Push Back time [mm:ss] • Median Push Back Time [mm:ss]

Table Appendix C-4: Metrics – Average Taxi Time Comparison

The average taxi time difference is 2 min 5 sec, the proposed taxi times were under-estimated compared to the actual taxi time. The median difference is 1 min 40 sec.

The proposed taxi times that were used include Push Back time as a configurable system parameter (3 min for WTC M).

The average Actual Push Back Time is 4 min 38 sec. The configurable push back time parameter was under-estimated compared to the actual push back time. The median Push Back Time is 4 min 24 sec.

The following variables were identified during real operation that affected the taxi time and have a negative impact on the accuracy:

- Waiting time on holding point (departure queue or waiting for arrival)
- Slow taxiing
- Slow start up procedures (new aircraft type i.e. A320 Neo or inexperienced flight crew)
- Single Runway Operation

These were not part of the taxi time calculation of the SUT during the demonstration. Improved taxi time calculation will be needed to support operational use.

Based on data evaluation and the controllers' response, the average taxi time difference is on an acceptable level, but taking into consideration the limitations mentioned above, A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point was partially demonstrated positively.

Demonstration Objective Status: Partially Ok

C3.4.4 EX3-OBJ-VLD-28-004 Results - Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable

C3.4.4.a EX3-CRT-VLD-28-004-001 - Positive evaluation of the workload of GROUND controllers due to planning and routing functions

The workload assessed was limited by the passive shadow mode environment. Some controller tasks that were not part of the demonstration may increase workload and thus affect situational awareness at times.

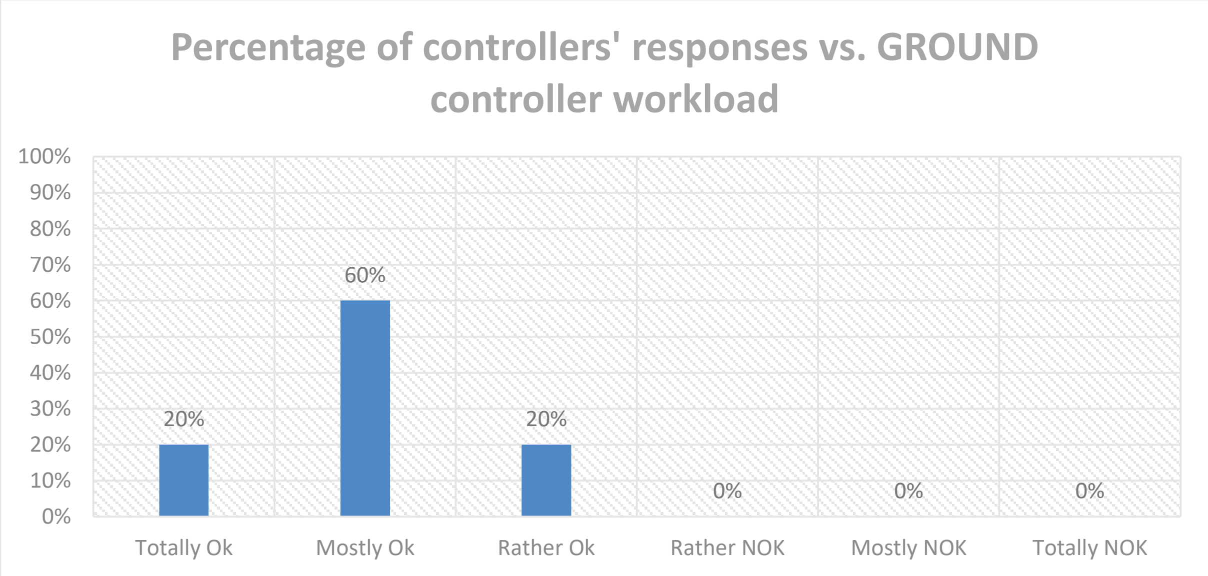


Figure Appendix C-11: Questionnaire - Percentage of controllers' responses vs. GROUND controller workload

The controllers were unfamiliar with the routing and planning concept. Although there was a training day for all the controllers, they used some time during the demonstration scenarios to get familiar with the system. This improved with practice.

The workload experienced by the GROUND controllers due to routing and planning functions was evaluated positively, although it was reported that heads down time increased compared to their "normal" operation due to the need to feed the system with clearances and necessary routing updates.

Demonstration Objective Status: Ok

C3.4.4.b EX3-CRT-VLD-28-004-002 - Positive evaluation of the workload of RUNWAY controllers due to planning and routing functions

The workload assessed was limited by the passive shadow mode environment. Some controller tasks that were not part of the demonstration may increase workload and thus affect situational awareness at times.

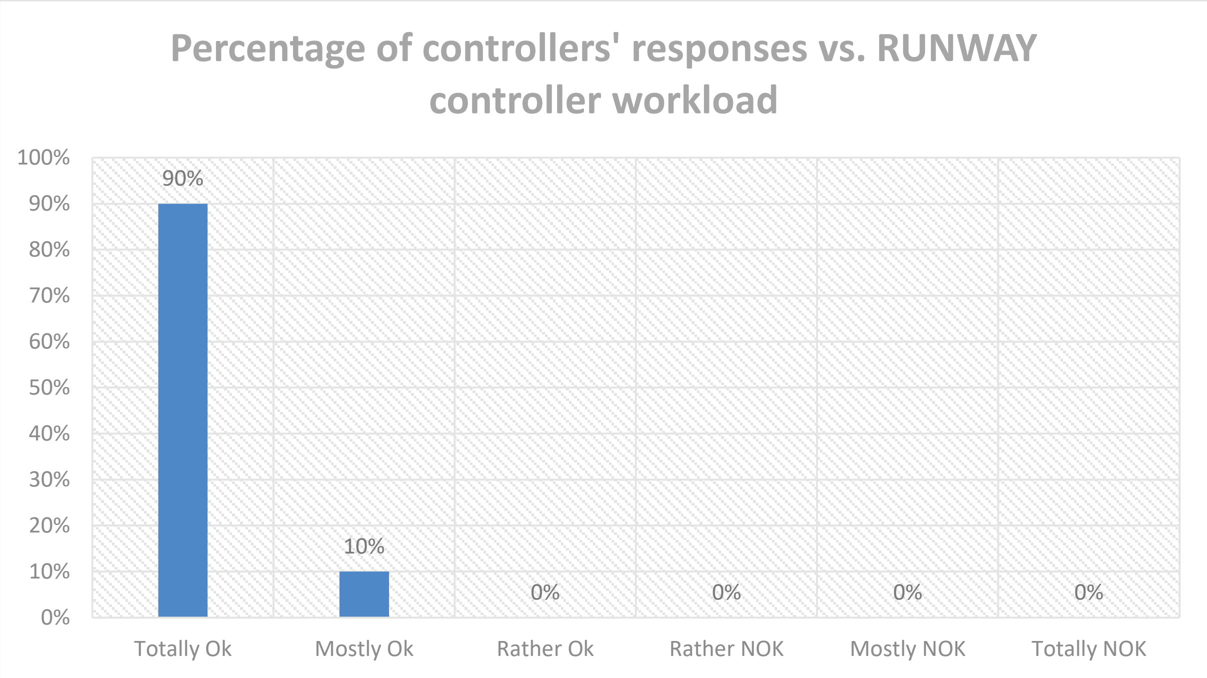


Figure Appendix C-12: Questionnaire - Percentage of controllers' responses vs. RUNWAY controller workload

All controllers stated that working as a RUNWAY controller was much easier than working as a GROUND controller regarding the routing and planning function.

The workload experienced by the RUNWAY controllers due to routing and planning functions was evaluated positively.

Demonstration Objective Status: Ok

C3.4.4.c EX3-CRT-VLD-28-004-003 - Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers

Updating the HMI with clearances was successfully demonstrated.

The RUNWAY controllers' overall opinion about using the system to input clearances was positive. Exceptions due to lack of system configuration:

- Missing Conditional Line Up clearance

Those issues had a minor impact on the controllers' workload during the demonstration and were not considered during evaluation (see Figure Appendix A-12).

The GROUND controllers also rated the input methods on the positive scale, however, some comments were issued:

- Proper configuration is a key element to help the controller updating the HMI in an efficient way. This includes:

- Standard routes
- Push back procedures
- RWY entry/exit point
- Return to stand
- Backtrack
- Calculations should take into account A/C Type and/or airline

- Modifying a ground route in a fast and efficient way requires practice and good understanding of the system.
- Some functions (i.e. manual route modification) could be reached in many ways, which is positive in one way but also makes the system more complex. Training and practice help to find the optimal way of using it.
- The Taxi-To function needs improvement and routing point allocation on the taxiway system should be reconsidered.
- Silent coordination (vacate via, taxi to holding point) was missing.

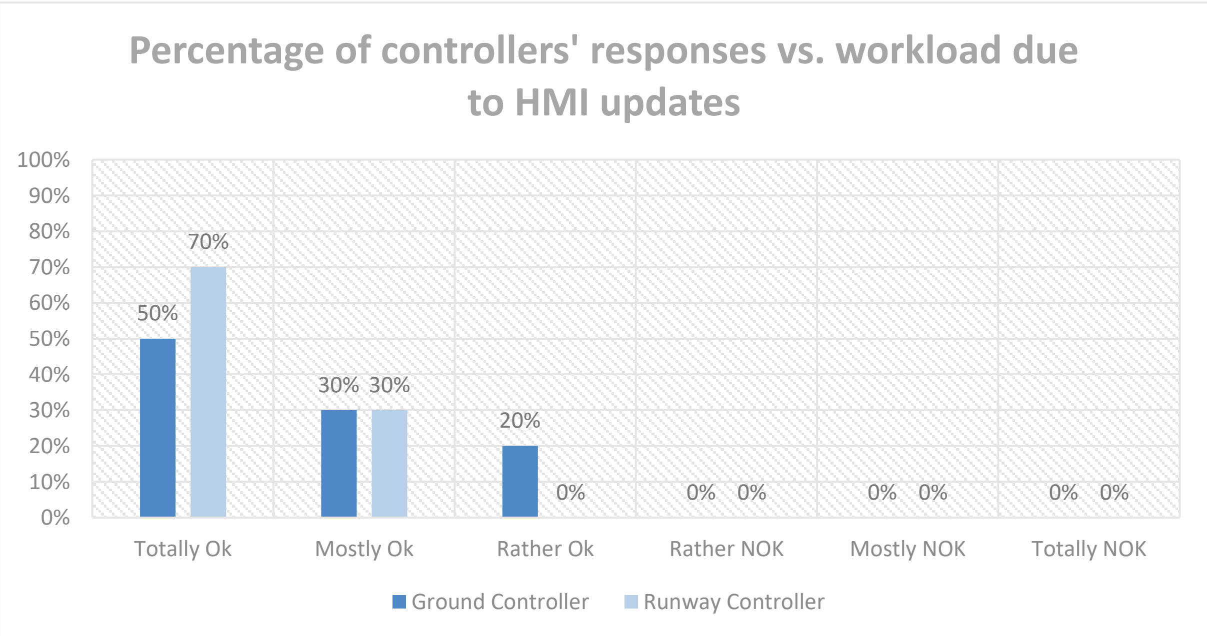


Figure Appendix C-13: Questionnaire - Percentage of controllers' responses vs. workload due to HMI updates

The controllers' declared that with the current information displayed they were able to perform their tasks. The HMI did not increase the potential for human error.

The overall acceptance by the controllers is clearly positive, thus the demonstration of the features for updating the HMI with clearances heard over VHF radio was successfully achieved.

Demonstration Objective Status: Ok

C3.4.5 EX3-OBJ-VLD-28-005 Results - Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.

C3.4.5.a EX3-CRT-VLD-28-005-001 - Positive evaluation of the situational awareness of GROUND controllers due to the integration and operation of routing and planning functions

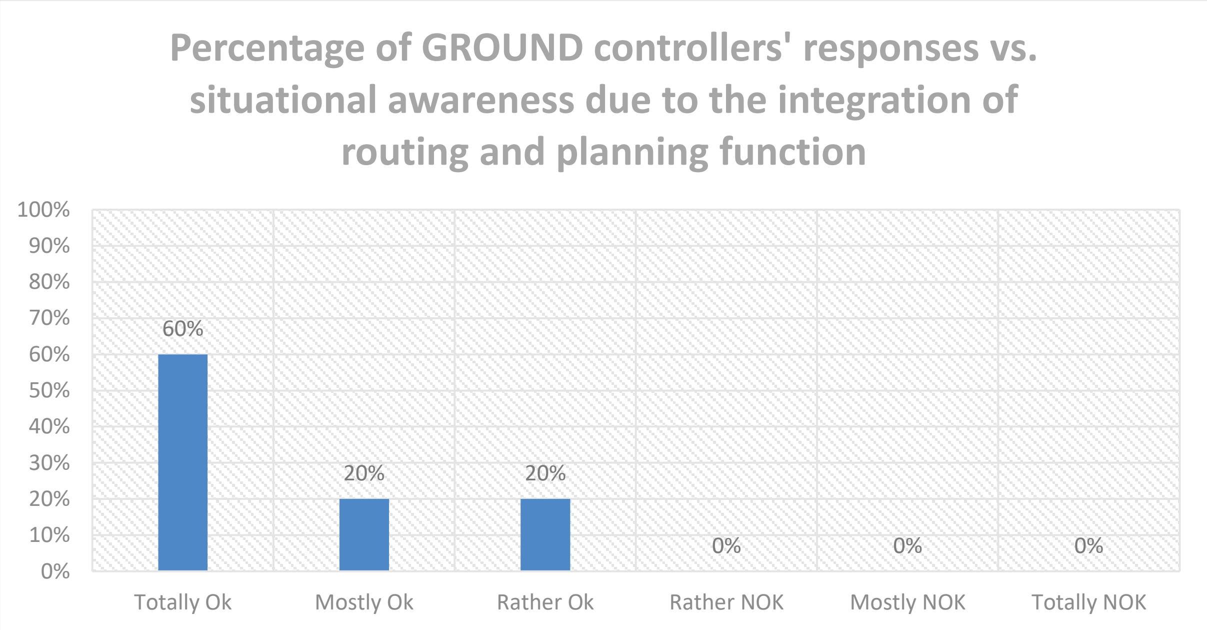


Figure Appendix C-14: Questionnaire - Percentage of GROUND controllers' responses vs. situational awareness due to the integration of routing and planning function

Some GROUND controllers stated that initially they needed more time to feed the system (more clicks than before) but operating the system improved from run to run and improved the situational awareness.

Regarding the system design of the routing and planning function, none of the GROUND controllers felt that the current design would affect their situational awareness, although some specific improvements were suggested based on their experience that would enhance the way to operate the system (silent coordination between jurisdictions, one-click modification possibility).

The GROUND controllers managed to maintain situational awareness during each demonstration session, and stated that their situational awareness was at an acceptable level at all times.

Demonstration Objective Status: Ok

C3.4.5.b EX3-CRT-VLD-28-005-002 - Positive evaluation of the situational awareness of RUNWAY controllers due to the A-SMGCS routing and planning functions

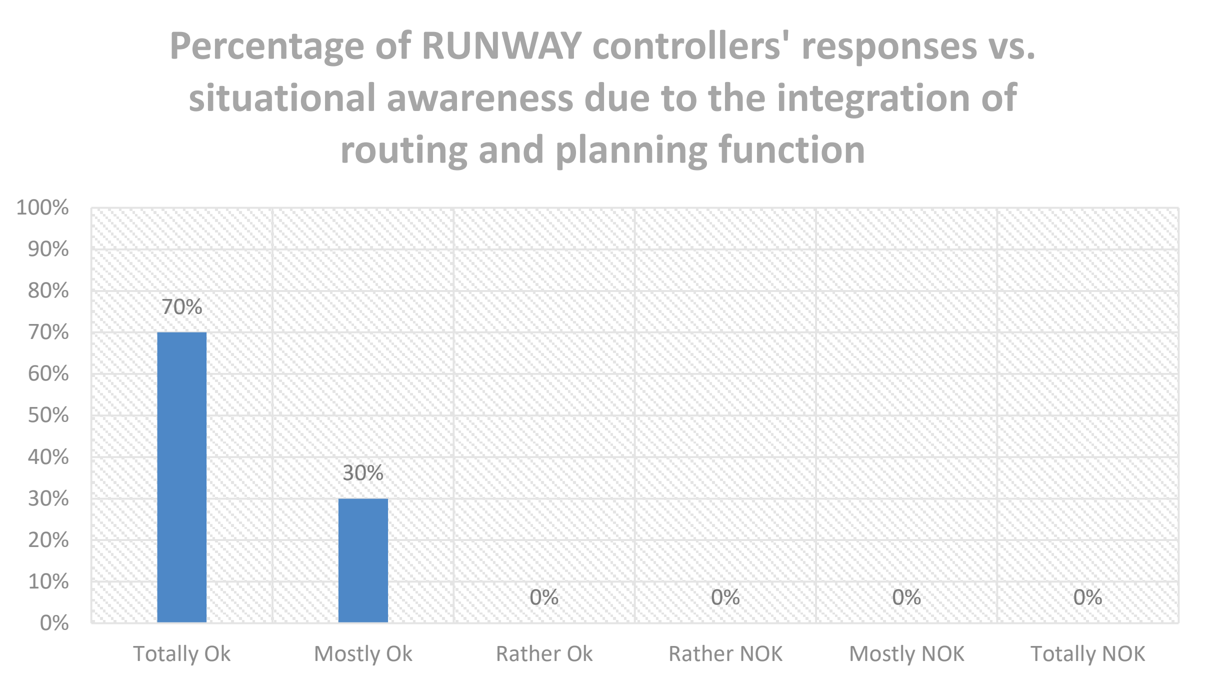


Figure Appendix C-15: Questionnaire - Percentage of RUNWAY controllers' responses vs. situational awareness due to the Integration of Routing and Planning Function

The RUNWAY controllers were less affected by the routing and planning function, their general responses are better than GROUND controllers' response.

The design of the system provided positive feedback from the RUNWAY controllers. It was easy to get used to operating the system, although they suggested some improvement to enhance the usability.

All the RUNWAY controllers rated their situational awareness with respect to the task from "Totally Ok" to "Mostly Ok" and stated that their situational awareness was at an acceptable level at all times.

Demonstration Objective Status: Ok

C3.4.5.c EX3-CRT-VLD-28-005-003 - Positive evaluation that all required information and clearances given by VHF radio can be effectively updated on the HMI by the controllers.

EX3-CRT-VLD-28-004-003

C3.4.6 EX3-OBJ-VLD-28-006 Results - Demonstrate the utility of CATC alerts functions

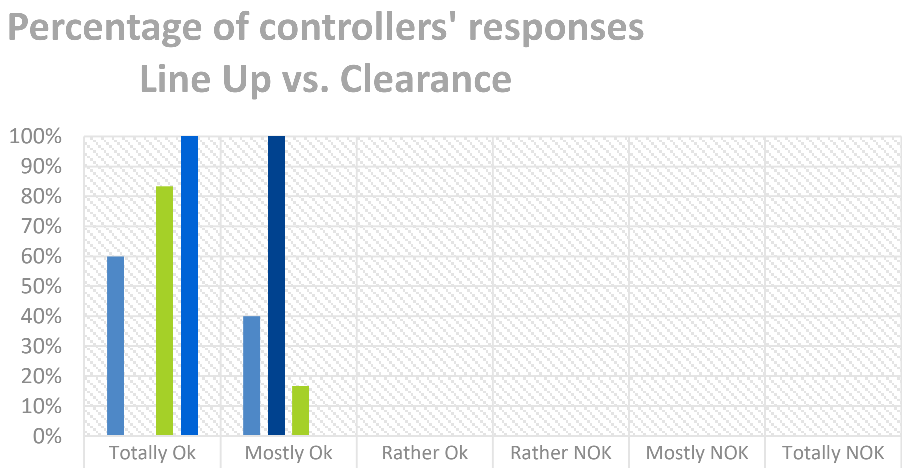
C3.4.6.a EX3-CRT-VLD-28-006-001 - Positive evaluation of the utility of the CATC alerts functions when real surveillance data is used

Safety Net – Alert Coverage

The following table gives an overview of the demonstrated CATC alerts:

Identifier	Title	Budapest LHBP
	Alerts Coverage	Parallel Dependent
3.2.2	Conflicting ATC Clearances (CATC)	
3.2.2.1	Line Up vs Line Up	Yes
3.2.2.2	Line Up vs Cross or Enter	Yes
3.2.2.3	Line Up vs Take Off	Yes
3.2.2.4	Line Up vs Land	Yes
3.2.2.5	Cross or Enter vs Line Up	Yes
3.2.2.7	Cross or Enter vs Take Off	Yes
3.2.2.8	Cross or Enter vs Land	Yes
3.2.2.9	Take Off vs Line Up	Yes
3.2.2.10	Take Off vs Cross or Enter	Yes
3.2.2.11	Take Off vs Take Off	Yes
3.2.2.12	Take Off vs Land	Yes
3.2.2.13	Land vs Line Up	Yes
3.2.2.14	Land vs Cross or Enter	Yes
3.2.2.15	Land vs Take Off	Yes
3.2.2.16	Land vs Land	Yes

Table Appendix C-5: Safety Net – Alert Coverage CATC



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Line Up vs. Line Up [LUP vs. LUP]	60%	40%	0%	0%	0%	0%
Line Up vs. Cross [LUP vs. CROSS]	0%	100%	0%	0%	0%	0%
Lineup vs. Takeoff [LUP vs. TOF]	83,33%	16,67%	0%	0%	0%	0%
Line Up vs. Land [LUP vs. LND]	100%	0%	0%	0%	0%	0%

Figure Appendix C-16: Questionnaire - Percentage of controllers' responses, Line Up vs. Clearance

Line Up vs. Clearance alerts were generally highly accepted by the RUNWAY controllers (see Figure Appendix C-16). They considered the occurrence of the alert adequate, with one general comment. The “Line Up vs. Take Off” alert is less relevant if the holding points are the same. The controllers felt more that this alert was more useful if one aircraft has a full runway length for take-off and another aircraft receives a Line Up clearance from an intersection holding point. This case was not particularly tested due to the runway direction during the demonstration. Using 31L as the default departure runway, there is no possibility for an intersection line up (see figure below).

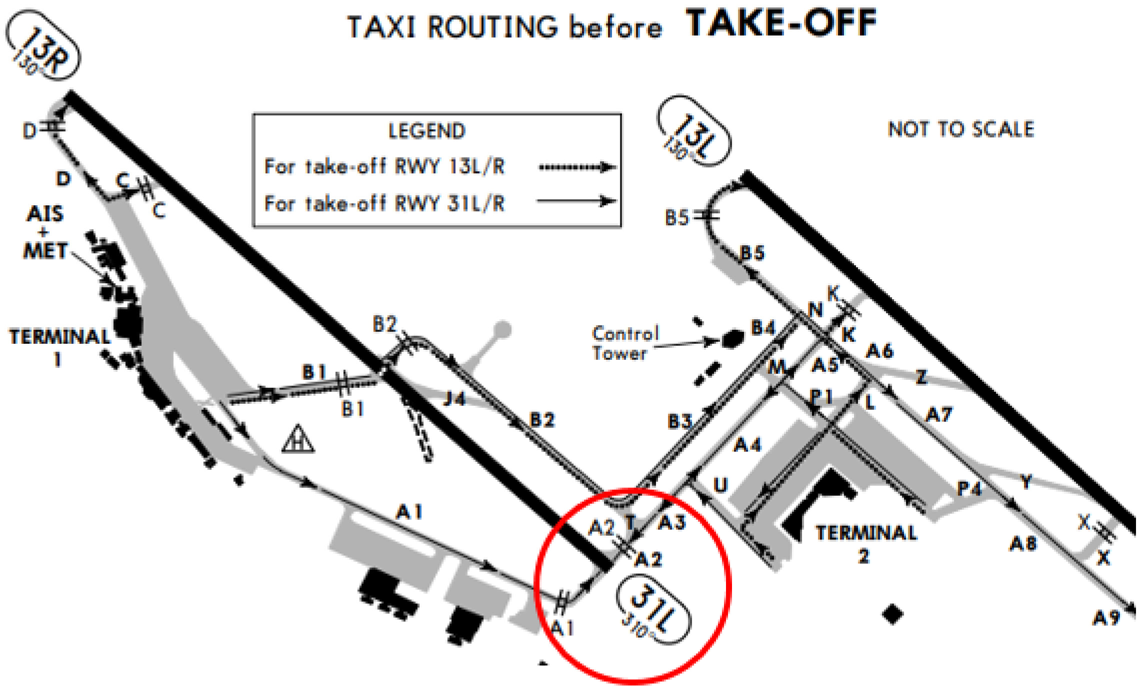
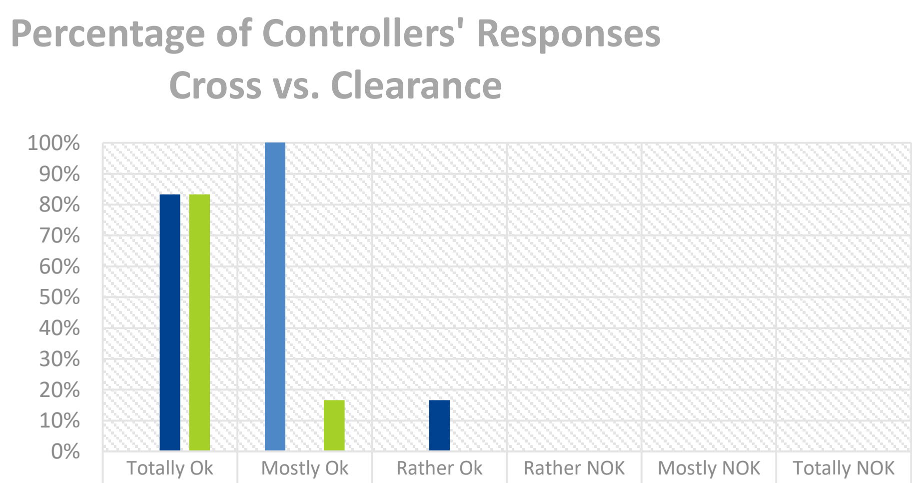


Figure Appendix C-17: LHBP Ground Chart – TAXI ROUTING before TAKE-OFF

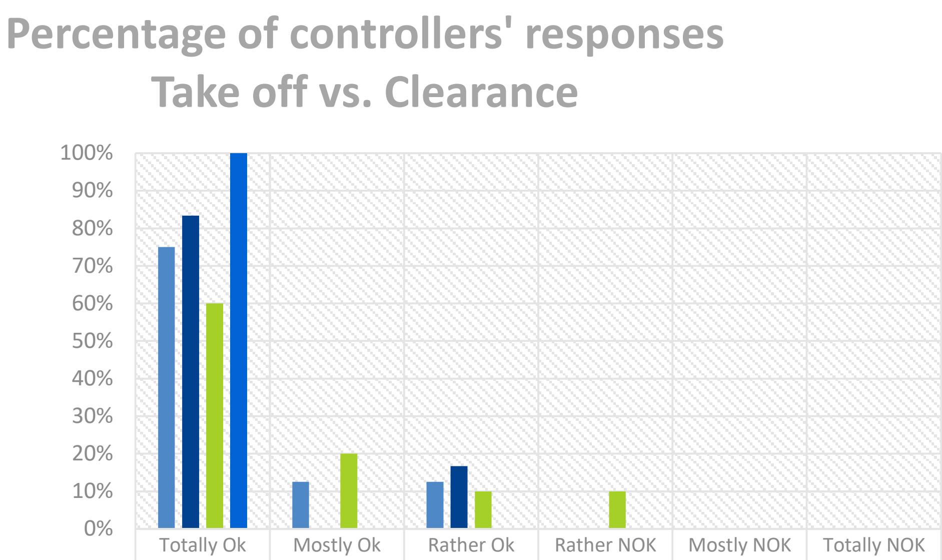


	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Cross vs. Line Up [CROSS vs. LUP]	0%	100%	0%	0%	0%	0%
Cross vs. Take Off [CROSS vs. TOF]	83,33%	0%	16,67%	0%	0%	0%
Cross vs. Land [CROSS vs. LND]	83,33%	16,67%	0%	0%	0%	0%

Figure Appendix C-18: Questionnaire - Percentage of Controllers' Responses, Cross vs. Clearance

Cross related alerts were difficult to demonstrate due to the runway direction (31) but the controllers stated that the alerts are helpful.

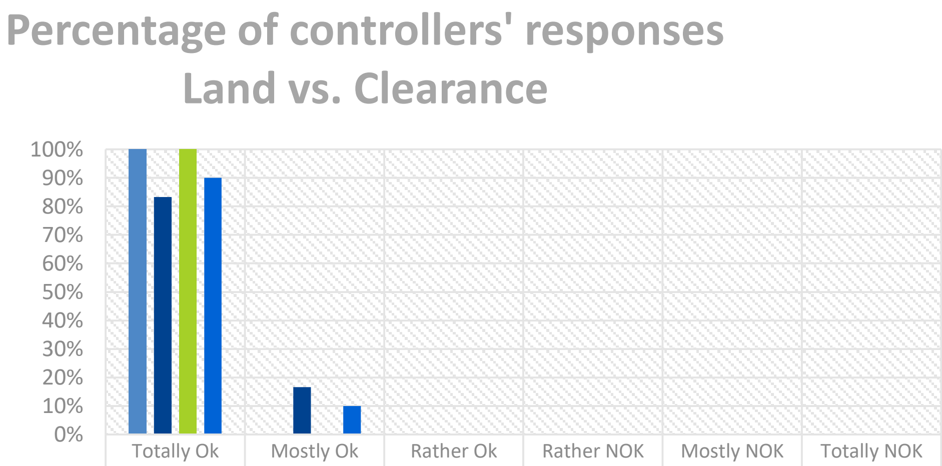
Some controllers felt that the crossing area – which was used to raise the alert if an aircraft is entering with Cross as next clearance – is too big and needs to be reconsidered. Due to the limited number of cross alerts, this should be assessed further.



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Take Off vs. Line Up [TOF vs. LUP]	75%	12,50%	12,50%	0%	0%	0%
Take Off vs. Cross [TOF vs. CROSS]	83,33%	0%	16,67%	0%	0%	0%
Take Off vs. Take Off [TOF vs. TOF]	60%	20%	10%	10%	0%	0%
Take Off vs. Land [TOF vs. LND]	100%	0%	0%	0%	0%	0%

Figure Appendix C-19: Questionnaire - Percentage of controllers' responses, Take off vs. Clearance

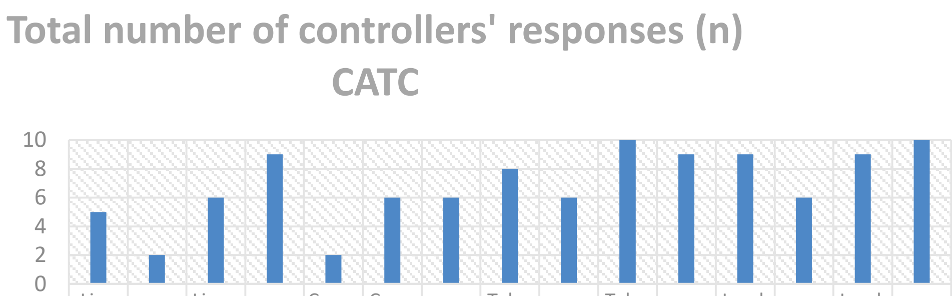
Most of the Take Off related alerts were considered useful by the controllers, although Take Off vs. Take Off clearance was stated as less relevant using the current configuration. The controllers suggested using it to ensure departure separation by taking into account the airborne route after departure (SID). This alert already exists (Conflicting SID) but it was not part of the demonstration.



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Land vs. Line Up [LND vs.LUP]	100%	0%	0%	0%	0%	0%
Land vs. Cross [LND vs. CROSS]	83,33%	16,67%	0%	0%	0%	0%
Land vs. Take Off [LND vs. TOF]	100%	0%	0%	0%	0%	0%
Land vs. Land [LND vs. LND]	90%	10%	0%	0%	0%	0%

Figure Appendix C-20: Questionnaire - Percentage of controllers' responses, Land vs. Clearance

Generally, all alerts related to the landing clearance received the most positive Controllers' responses. The acceptance of these alerts was very high, with over 90% "Totally Ok".



	Line Up vs. Line Up	Line Up vs. Cross	Lineup vs. Takeoff	Line Up vs. Land	Cross vs. Line Up	Cross vs. Take Off	Cross vs. Land	Take Off vs. Line Up	Take Off vs. Cross	Take Off vs. Take Off	Take Off vs. Land	Land vs. Line Up	Land vs. Cross	Land vs. Take Off	Land vs. Land
Controllers' responses (n)	5	2	6	9	2	6	6	8	6	10	9	9	6	9	10

Figure Appendix C-21: Questionnaire - Total Number of controllers' responses (n), CATC

Global "Not Observed" = 35,33%

Due to the runway configuration and direction, it was difficult to monitor all different cases and some alerts were not observed by all of the controllers during the demonstration (see Figure Appendix C-21).

False CATC alert did not occur and most of the alerts were created intentionally.

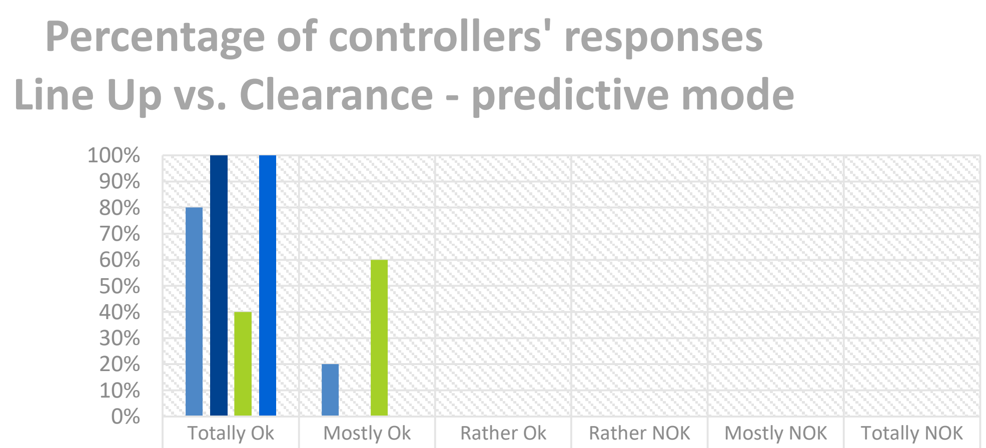
The utility of CATC functions has been positively demonstrated.

Demonstration Objective Status: Ok

C3.4.7 EX3-OBJ-VLD-28-007 Results - Demonstrate the utility of CATC functions in predictive mode

C3.4.7.a EX3-CRT-VLD-28-007-001 - Positive evaluation of the utility of CATC functions in predictive mode when real surveillance data is used.

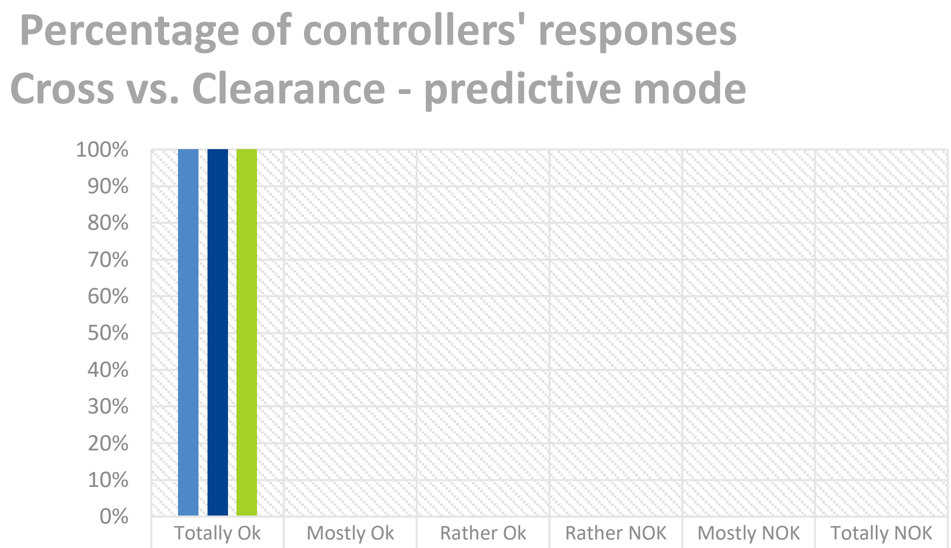
The use of the predictive indicator had high acceptance by the controllers. It was stated that the use of predictive mode improved their situational awareness and gave them more time to react in case of a possible conflict between two clearances.



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Line Up vs. Line Up [LUP vs. LUP]	80%	20%	0%	0%	0%	0%
Line Up vs. Cross [LUP vs. CROSS]	100%	0%	0%	0%	0%	0%
Lineup vs. Takeoff [LUP vs. TOF]	40%	60%	0%	0%	0%	0%
Line Up vs. Land [LUP vs. LND]	100%	0%	0%	0%	0%	0%

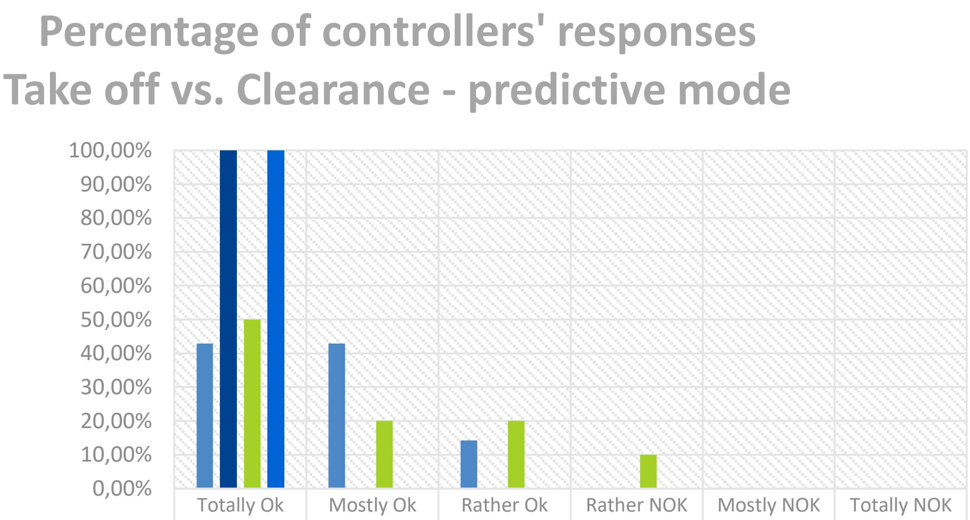
Figure Appendix C-22: Questionnaire - Percentage of controllers' responses, Line Up vs. Clearance – predictive mode

It was commented that more than one Line Up vs. Take off prediction (if more than one aircraft is waiting at the holding point and the second/third in line also waiting for Line Up clearance) could be confusing and should be assessed further.



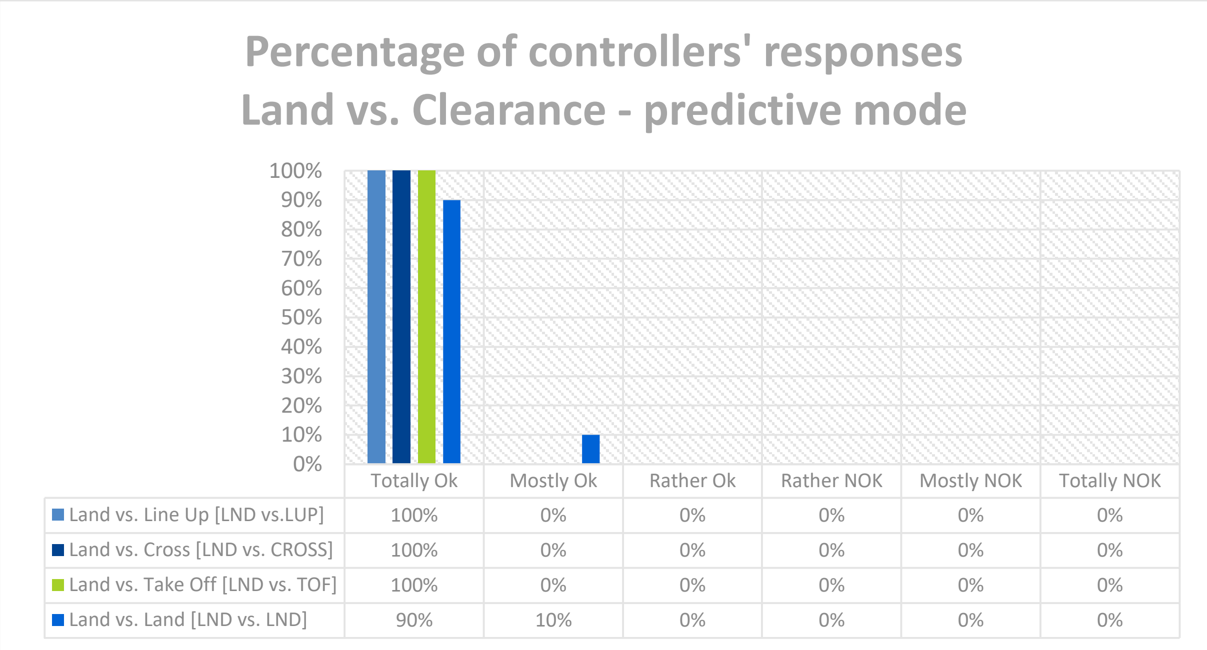
	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Cross vs. Line Up [CROSS vs. LUP]	100%	0%	0%	0%	0%	0%
Cross vs. Take Off [CROSS vs. TOF]	100%	0%	0%	0%	0%	0%
Cross vs. Land [CROSS vs. LND]	100%	0%	0%	0%	0%	0%

Figure Appendix C-23: Questionnaire - Percentage of controllers' responses, Cross vs. Clearance – predictive mode



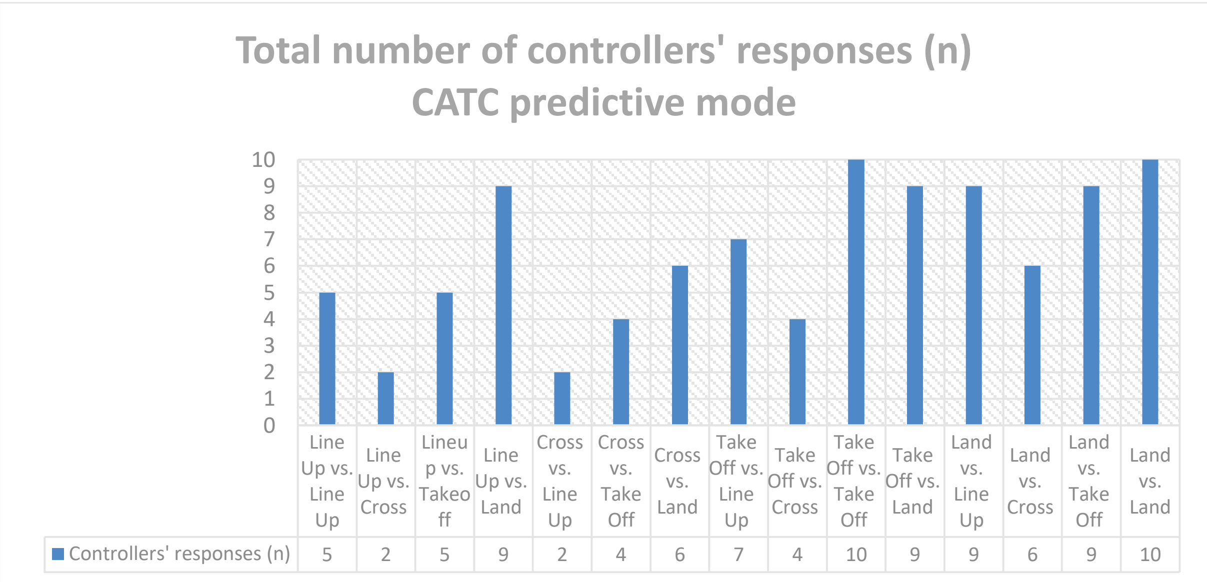
	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Take Off vs. Line Up [TOF vs. LUP]	42,86%	42,86%	14,28%	0%	0%	0%
Take Off vs. Cross [TOF vs. CROSS]	100%	0%	0%	0%	0%	0%
Take Off vs. Take Off [TOF vs. TOF]	50%	20%	20%	10%	0%	0%
Take Off vs. Land [TOF vs. LND]	100%	0%	0%	0%	0%	0%

Figure Appendix C-24: Questionnaire - Percentage of controllers' responses, Take off vs. Clearance – predictive mode



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
Land vs. Line Up [LND vs.LUP]	100%	0%	0%	0%	0%	0%
Land vs. Cross [LND vs. CROSS]	100%	0%	0%	0%	0%	0%
Land vs. Take Off [LND vs. TOF]	100%	0%	0%	0%	0%	0%
Land vs. Land [LND vs. LND]	90%	10%	0%	0%	0%	0%

Figure Appendix C-25: Questionnaire - Percentage of controllers' responses, Land vs. Clearance – predictive mode



	Line Up vs. Line Up	Line Up vs. Cross	Lineup vs. Takeoff	Line Up vs. Land	Cross vs. Line Up	Cross vs. Take Off	Cross vs. Land	Take Off vs. Line Up	Take Off vs. Cross	Take Off vs. Take Off	Take Off vs. Land	Land vs. Line Up	Land vs. Cross	Land vs. Take Off	Land vs. Land
Controllers' responses (n)	5	2	5	9	2	4	6	7	4	10	9	9	6	9	10

Figure Appendix C-26: Questionnaire - Total number of controllers' responses (n), CATC predictive mode

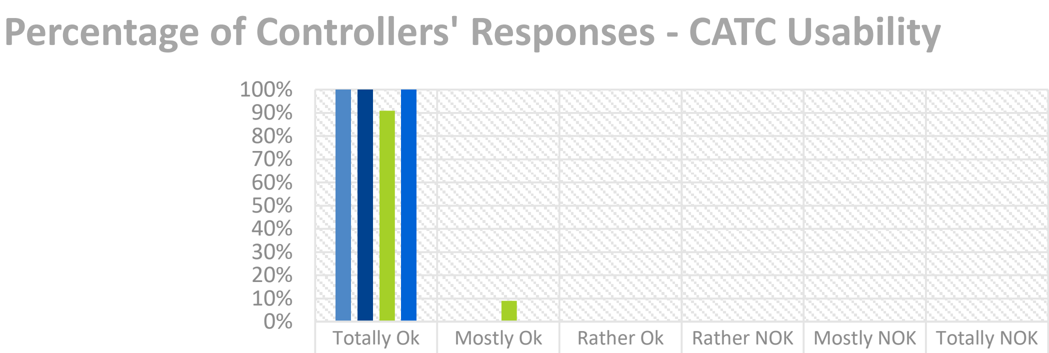
Global "Not Observed" = 35,33%

It was easy to observe predictive mode using live data and shadow mode operation. Based on the controllers' response this function is considered as a useful tool, which helps for the controllers during daily operation. The utility of CATC functions in predictive mode has been positively demonstrated.

Demonstration Objective Status: Ok

C3.4.8 EX3-OBJ-VLD-28-008 Results - Demonstrate the usability of CATC functions

C3.4.8.a EX3-CRT-VLD-28-008-001 - Positive evaluation of the usability of CATC alerts functions



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
VLD008001 [SQ01]. The CATC were useable according to the following criteria: [The CATC was clearly visible]	100%	0%	0%	0%	0%	0%
VLD008001 [SQ02]. The CATC were useable according to the following criteria: [CATC alerts were easy to understand]	100%	0%	0%	0%	0%	0%
VLD008001 [SQ03]. The CATC were useable according to the following criteria: [The colour coding of CATC alerts was effective]	91%	9%	0%	0%	0%	0%
VLD008001 [SQ04]. The CATC were useable according to the following criteria: [The interactions with the CATC alerts were effective]	100%	0%	0%	0%	0%	0%

Figure Appendix C-27: Questionnaire – Percentage of Controllers' Responses - CATC Usability

The controllers indicated that the usability of the CATC alerts was positive concerning all the variables demonstrated:

- Alerts were clearly visible (100% "Totally OK"),
- Alerts were understandable (100% "Totally OK"),
- Colour coding was effective (91% "Totally OK"), and
- The interaction with CATC was Ok (100% "Totally OK").

The usability of the CATC alert functions was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.8.b EX1-CRT-VLD-28-008-002 - Positive evaluation of the usability of CATC functions in predictive mode

The usability of the predictive CATC functions was evaluated as part of the general CATC alert usability (see figure 25). The controllers confirm adequate usability of the CATC functions in predictive mode. The predictive indicator was visible and understandable for the controllers.

Demonstration Objective Status: Ok

C3.4.9 EX3-OBJ-VLD-28-009 Results - Demonstrate the utility of CMAC functions

C3.4.9.a EX3-CRT-VLD-28-009-001 - Positive evaluation of the utility of CMAC functions when real surveillance data is used.

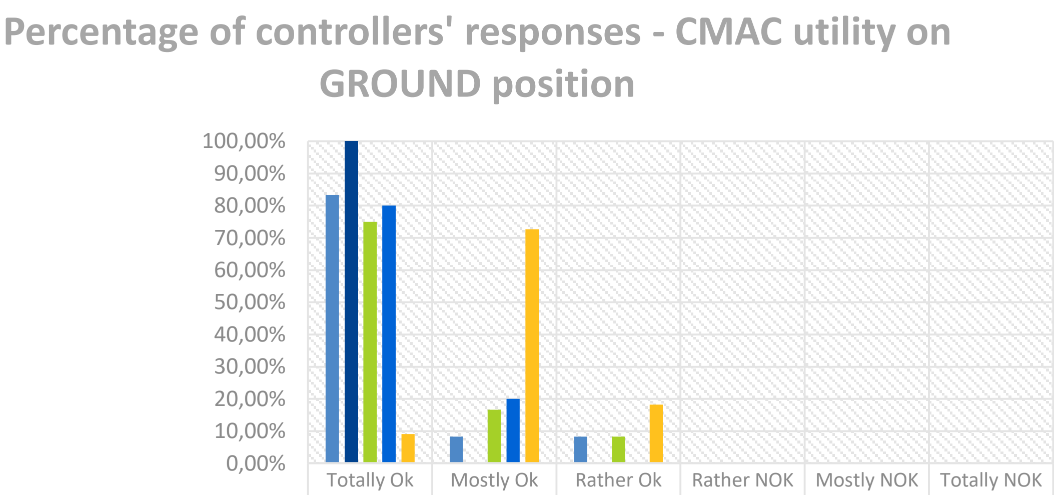
Safety Net – Alert Coverage

The following table gives an overview of the demonstrated CMAC alerts:

Identifier	Title	Budapest LHBP
	Alerts Coverage	Parallel Dependent
3.2.3	Conformance Monitoring Alerts for Controllers (CMAC)	
3.2.3.1	Route Deviation Alert (Instruction)	Yes
3.2.3.2	No Push Back approval (Instruction)	Yes
3.2.3.3	No Taxi approval (Instruction)	Yes
3.2.3.4	Stationary (Instruction)	Yes
3.2.3.5	No Contact (Instruction)	Yes
3.2.3.7	No Take Off Clearance (Instruction)	Yes
3.2.3.8	No Landing Clearance (Instruction)	Yes
3.2.3.9	Landing on wrong runway (Instruction)	Yes
3.2.3.12	Runway Incursion (Procedure or Instruction)	Yes
3.2.3.13	Runway or Taxi Type (Procedure)	Yes
3.2.3.15	Taxiway Closed (Procedure)	Yes

Table Appendix C-6: Safety Net – Alert Coverage CMAC

The utility of the CMAC functions was generally positive, although the Controllers reported some comments.



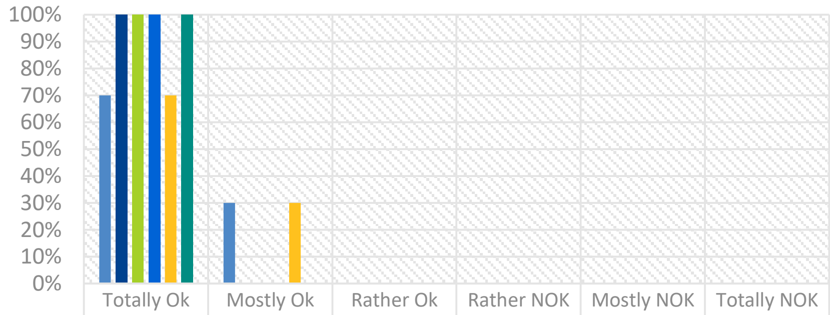
	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
VLD009001 [SEQ01]. The following CMAC were useful: [Route Dev.]	83,33%	8,33%	8,33%	0%	0%	0%
VLD009001 [SEQ02]. The following CMAC were useful: [NO PUSH]	100%	0%	0%	0%	0%	0%
VLD009001 [SEQ03]. The following CMAC were useful: [NO TAXI]	75%	16,67%	8,33%	0%	0%	0%
VLD009001 [SEQ04]. The following CMAC were useful: [STATIONARY] Ground	80%	20%	0%	0%	0%	0%
VLD009001 [SEQ10]. The following CMAC were useful: [TXW CLOSED]	9,10%	72,72%	18,18%	0%	0%	0%

Figure Appendix C-28: Questionnaire – Percentage of Controllers' Responses - CMAC utility on GROUND position

The GROUND controllers commented on the following:

- Unexpected "No Taxi" alerts were observed sometimes when an aircraft finished its push back procedure
  - On the main apron, there are push back stands where many different push back procedures could be applied. Some of these stands were not configured properly due to lack of information or too many different operational procedures and that caused the unexpected alerts.
- The "Taxiway Closed" alert should rather be a pre-warning. If the alert is raised when the aircraft already penetrated the restricted area, it is too late.

Percentage of controllers' responses - CMAC utility on RUNWAY position



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
VLD009001 [SEQ04]. The following CMAC were useful: [STATIONARY] Runway	70%	30%	0%	0%	0%	0%
VLD009001 [SEQ05]. The following CMAC were useful: [NO CONTACT]	100%	0%	0%	0%	0%	0%
VLD009001 [SEQ06]. The following CMAC were useful: [NO TOF]	100%	0%	0%	0%	0%	0%
VLD009001 [SEQ07]. The following CMAC were useful: [NO LND]	100%	0%	0%	0%	0%	0%
VLD009001 [SEQ08]. The following CMAC were useful: [LND ON WRONG RWY]	70%	30%	0%	0%	0%	0%
VLD009001 [SEQ09]. The following CMAC were useful: [RWY INCURSION]	100%	0%	0%	0%	0%	0%

Figure Appendix C-29: Questionnaire – Percentage of controllers' responses - CMAC utility on RUNWAY position

The RUNWAY controllers had commented the following:

- The “Landing on Wrong Runway” alert should be shown earlier based on the aircraft position when the system detects the aircraft on the wrong final to give the controllers time to take action.
    - To create this alert, the controller was asked to change the arrival runway in the flight plan for an arrival aircraft manually. Even when the flight was approaching the correct threshold, the system raised the “Landing on Wrong Runway” alert, incorrectly but intentionally.
- Stationary alerts should not be activated too early to give the cockpit crew time to comply with the instruction (Line Up and Take off Stationary).
    - To be able to create this type of alerts, stationary time parameters shorter than the Eurocontrol’s recommendation (Eurocontrol A-SMGCS Guideline Ch. 6.3.4.2 CMAC INFORMATION Alerts, Ch. 6.3.4.3 CMAC ALARM Alerts) were configured in the SUT.

During the training session, the controllers were informed that some alert configuration parameters are set to be able to create and observe alerts rather than to comply with the official recommendations.

Despite the comments mentioned above, based on the responses and the post-run briefing experiences, the utility of CMAC functions was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.10 EX3-OBJ-VLD-28-010 Results - Demonstrate the usability of CMAC functions

C3.4.10.a EX3-CRT-VLD-28-010-001 - Positive evaluation of the audio alarm

The audio alarm was not evaluated due to system limitations. This function is not used in Budapest and the necessary hardware (loudspeaker) was not available.

Demonstration Objective Status: N/A

C3.4.10.b EX3-CRT-VLD-28-010-002 - Positive evaluation of the level of alerts generated (information or alarm)

Alert level implementation is based on the Eurocontrol A-SMGCS Guideline document (Edition 01 March 2018). Two stages of alerts are defined as follows:

- Stage 1 alert – INFORMATION. This is used to inform the controller of a potentially hazardous situation. According to the situation, the controller may take a specific action to resolve the situation.
- Stage 2 alert – ALARM. This is used to inform the controller that a critical situation is developing requiring immediate action.

Depending on the detected situation, alerts may be triggered as follows:

- Stage 1 alert only
- A Stage 2 alert may follow a Stage 1 alert if the potentially hazardous situation becomes critical
- Stage 2 alert only

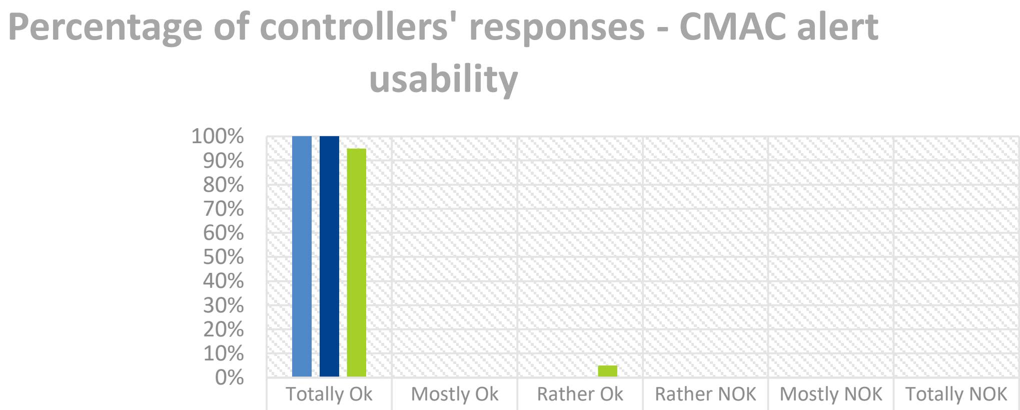
Information and Alarm level configuration was not in all cases followed the recommendation:

- Stationary alert – Information only
- No Take Off Clearance – Alert only
- No Land Clearance – Alert only
- Landing On Wrong Runway – Alert only
- Taxiway Closed – Information only

Overall, the effectiveness of the CMAC alert levels was partially demonstrated, because issues were reported due to alert prioritization.

Demonstration Objective Status: Partially Ok

C3.4.10.c EX3-CRT-VLD-28-010-003 - Positive evaluation of the usability of CMAC alerts functions



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
VLD010003 [SEQ01]. Concerning the usability of CMAC: [The readability of CMAC was effective]	100%	0%	0%	0%	0%	0%
VLD010003 [SEQ02]. Concerning the usability of CMAC: [The ATCO could effectively understand the meaning of CMAC labels]	100%	0%	0%	0%	0%	0%
VLD010003 [SEQ01]. Concerning the usability of CMAC: [Interactions with the CMAC alerts were effective]	95%	0%	5%	0%	0%	0%

Figure Appendix C-30: Questionnaire – Percentage of controllers' responses - CMAC alert usability

The usability of CMAC functions was very positively evaluated by the controllers. Most of the alerts were artificially created and this enabled the controllers to witness all the relevant alerts according to their role (Ground or Runway).

Overall, the usability of CMAC functions was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.11 EX3-OBJ-VLD-28-013 Results - Demonstrate that the controller workload incurred due to integration of CMAC is acceptable

C3.4.11.a EX3-CRT-VLD-28-013-001 - Positive evaluation that the workload of GROUND controller due to the integration of CMAC is acceptable

Generally, the workload of GROUND controllers was considered adequate and it was at an acceptable level during the demonstration. However, the controllers reported that the following issues/events have an impact on their workload:

- Unexpected “No Taxi” alerts after push back
- Alerts sometimes appeared for a short time only and it was difficult to observe and justify those alerts
- More than one alert could appear in the label (alert prioritisation)
- If a controller did not properly update the system with clearances, alerts appeared

The workload of GROUND controllers due to the integration of CMAC was partially demonstrated due to the reported cases.

Demonstration Objective Status: Partially Ok

C3.4.11.b EX3-CRT-VLD-28-013-002 - Positive evaluation that the workload of RUNWAY controllers due to the integration of CMAC is acceptable

Generally, the workload of RUNWAY controllers was evaluated positively and it was at an acceptable level at all times. The RUNWAY controllers stated that using CMAC functions had no relevant impact on their workload.

The workload of the RUNWAY controllers due to the integration of CMAC was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.12 EX3-OBJ-VLD-28-014 Results - Demonstrate that the controller workload incurred due to integration of CATC is acceptable

C3.4.12.a EX3-CRT-VLD-28-014-001 - Positive evaluation that the workload of RUNWAY controllers due to the integration of CATC is acceptable

The RUNWAY controllers stated that using CATC functions had no relevant impact on their workload, the only exception was when the controllers were asked to create situations to be able to observe alert. This had a minor impact on the workload and was not considered during evaluation.

Thus, the workload of the Runway controller due to the integration of CATC was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.13 EX3-OBJ-VLD-28-015 Results - Demonstrate that the situational awareness of controllers is improved with the integration of CMAC

C3.4.13.a EX3-CRT-VLD-28-015-001 - Positive evaluation that the situational awareness of GROUND controllers due to the integration of CMAC is improved

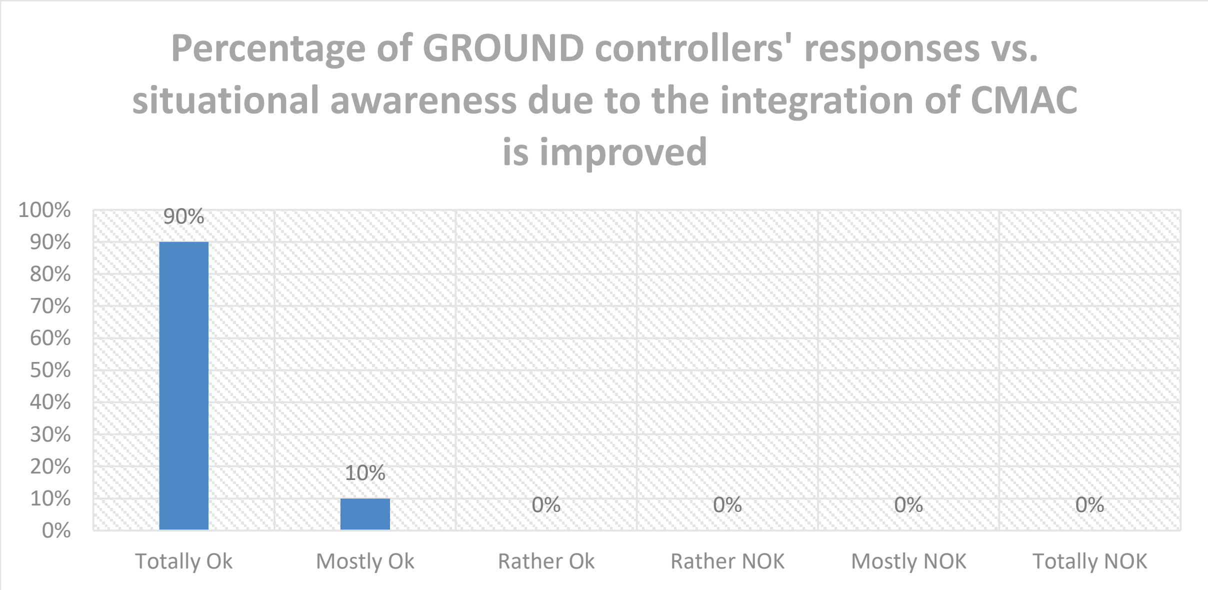


Figure Appendix C-31: Questionnaire – Percentage of GROUND controllers' responses vs. situational awareness due to the integration of CMAC is improved

The GROUND controllers managed to maintain situational awareness during each demonstration session, and stated that their situational awareness was at an acceptable level at all times.

Situational awareness of the GROUND controllers due to the integration of CMAC was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.13.b EX3-CRT-VLD-28-015-002 - Positive evaluation that the situational awareness of RUNWAY controllers due to the integration of CMAC is improved

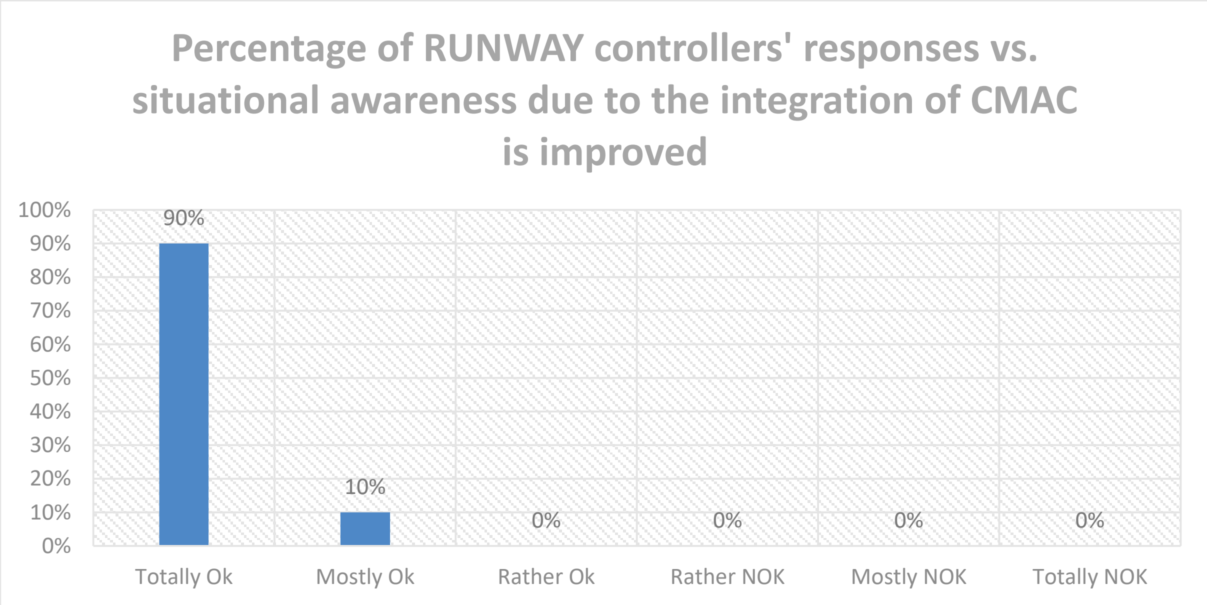


Figure Appendix C-32: Questionnaire – Percentage of RUNWAY controllers' responses vs. situational awareness due to the integration of CMAC is improved

The RUNWAY controllers managed to maintain situational awareness during each demonstration session, and stated that their situational awareness was at an acceptable level at all times.

Situational awareness of the RUNWAY controllers due to the integration of CMAC was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.14 EX3-OBJ-VLD-28-016 Results - Demonstrate that the Situational Awareness of controllers is improved with the integration of CATC

C3.4.14.a EX3-CRT-VLD-28-016-001 - Positive evaluation that the situational awareness of RUNWAY controllers due to the integration of CATC is improved

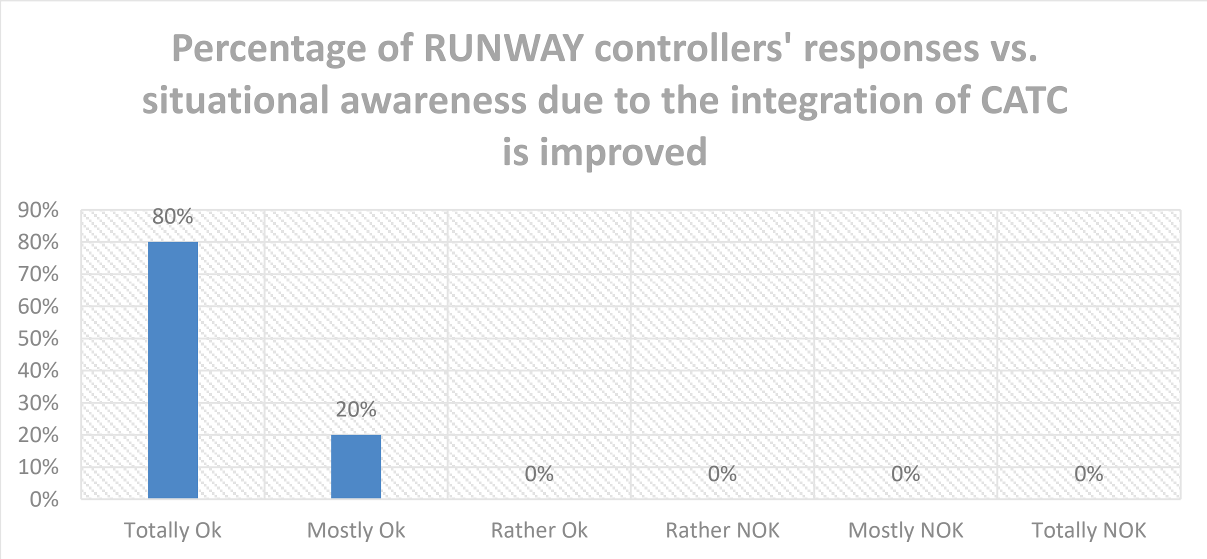


Figure Appendix C-33: Questionnaire – Percentage of RUNWAY controllers' responses vs. situational awareness due to the integration of CATC is improved

The RUNWAY controllers managed to maintain situational awareness during each demonstration session, and stated that their situational awareness was at an acceptable level at all times.

Situational awareness of the RUNWAY controllers due to the integration of CATC was positively demonstrated.

Demonstration Objective Status: Ok

C3.4.15 EX3-OBJ-VLD-28-017 Results - Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions

C3.4.15.a EX3-CRT-VLD-28-017-001 - Positive evaluation of the utility of the CATC and CMAC integrated with RMCA

Not demonstrated.

CATC and CMAC integrated with RMCA (RIMCAS in InNOVA) was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest

Demonstration Objective Status: N/A

C3.4.15.b EX3-CRT-VLD-28-017-002 - Positive evaluation of the usability of the CATC and CMAC integrated with RMCA

Not demonstrated.

CATC and CMAC integrated with RMCA was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest

Demonstration Objective Status: N/A

C3.4.15.c EX3-CRT-VLD-28-017-003 - Positive evaluation of the priority of RMCA alerts and CATC and CMAC alerts

Not demonstrated

CATC and CMAC integrated with RMCA was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest.

Demonstration Objective Status: N/A

C3.4.16 EX3-OBJ-VLD-28-018 Results - Demonstrate the utility of DMAN functions supported by route planning

C3.4.16.a EX3-CRT-VLD-28-018-001 - Positive evaluation of the utility of the DMAN function supported by route planning

The DMAN function supported by route planning was used to calculate TSAT and TTOT.

The GROUND controllers used the Tabular Window to observe pre-departure sequence and to compare TSAT with the operational start up sequence and interact with the system to change TSAT when it was needed.

Assumptions and limitations regarding pre-departure sequence calculation:

- Pre-departure sequence was based on TSAT and it was clearly visible in the Tabular Window
- Real TOBT was not available, all calculation was based on EOBT = TOBT
- TSAT changed to ASAT in the field and TTOT was updated, when:
  - The aircraft started to move out from the stand
  - Start Up clearance was given by the controller

The RUNWAY controllers used the Timeline Window to observe departure sequences calculated by DMAN supported by route planning, and compared it with the operational departure sequence and interact with the system to change TTOT when it was needed.

Assumptions and limitations regarding departure sequence calculation:

- Departure sequence was based on TTOT and it was clearly visible in the Timeline Window
- Taxi time calculated by the routing and planning function was used to calculate TTOT
- TTOT value was updated in the Timeline Window when:
  - The aircraft started to move out from the stand
  - Start Up clearance was given by the controller
- Past events were not editable, in some cases the controllers were not able to change TTOT, especially when calculated values were significantly different from real times
- After manual TTOT change, the system sometimes did not update the value correctly due to a system bug which was discovered during the demonstration

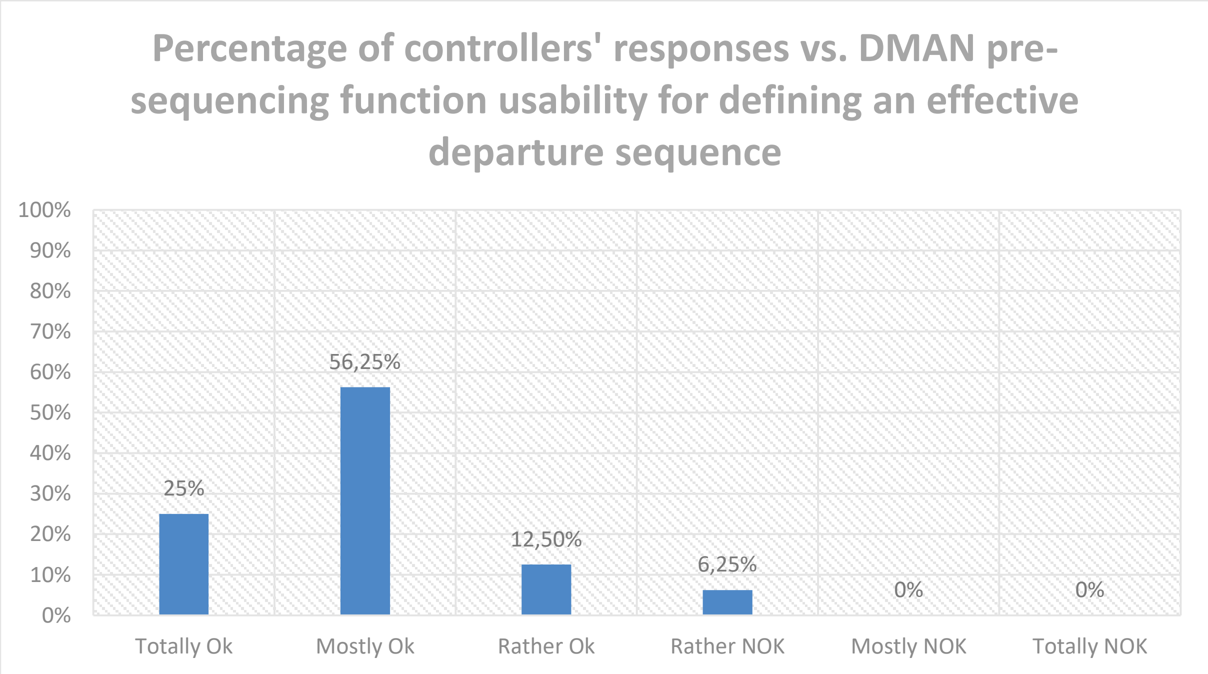


Figure Appendix C-34: Questionnaire – Percentage of controllers' responses vs. DMAN pre-sequencing function usability for defining an effective departure sequence

The GROUND controllers had no opportunity to compare real and calculated departure sequences, their answer reflect to the pre-departure sequence. 85,7% of them were satisfied with the result (Totally or Mostly Ok)

77,8% of the RUNWAY controllers reported the DMAN function usability as "Totally Ok" or "Mostly Ok". The result means that the controllers positively evaluated the utility of the DMAN function supported by route planning compared with the real departure sequence.

When comparing the accuracy of TTOT calculated by DMAN (supported by route planning) with TTOT coming from the CDM system in Budapest (using static taxi times), DMAN provides more accurate departure sequences.

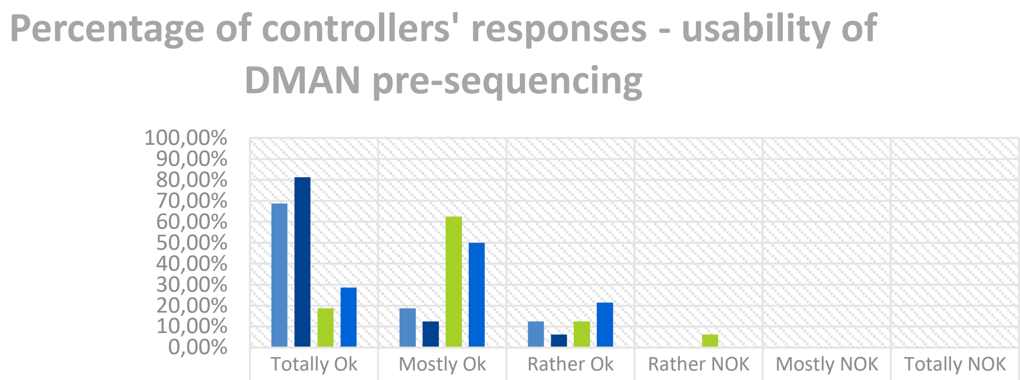
The DMAN function supported by route planning provided departure sequence with acceptable accuracy.

Generally, the utility of the DMAN function supported by route planning was positively evaluated by the controllers and confirmed by data collection. Nevertheless taking into consideration the assumptions and limitations, the overall result is that the objective has been partially demonstrated.

Demonstration Objective Status: Partially Ok

C3.4.17 EX3-OBJ-VLD-28-019 Results - Demonstrate the usability of DMAN functions supported by route planning

C3.4.17.a EX3-CRT-VLD-28-019-001 - Positive evaluation of the usability of the DMAN function supported by route planning



	Totally Ok	Mostly Ok	Rather Ok	Rather NOK	Mostly NOK	Totally NOK
VLD019001 [SEQ01]. The DMAN pre-sequencing function was usable considering the following criteria: [The readability of the fields was effective]	68,75%	18,75%	12,50%	0%	0%	0%
VLD019001 [SEQ02]. The DMAN pre-sequencing function was usable considering the following criteria: [The meaning of the fields was effective]	81,25%	12,50%	6,25%	0%	0%	0%
VLD019001 [SEQ03]. The DMAN pre-sequencing function was usable considering the following criteria: [The colour-coding was effective]	18,75%	62,50%	12,50%	6,25%	0%	0%
VLD019001 [SEQ04]. The DMAN pre-sequencing function was usable considering the following criteria: [Interactions with the pre-sequencing functions were effective]	28,57%	50%	21,43%	0%	0%	0%

Figure Appendix C-35: Questionnaire – Percentage of controllers' response - usability of DMAN pre-sequencing

Controllers' observations regarding the usability of DMAN:

- Too many data fields in the Tabular Window – the window has the same layout as the operational STU (Start Up) list
- Colour coding is not reflecting the actual status of the flight
- Sometimes there are significant differences between calculated and real times (real push back time is different from the calculated time)
- TTOT update only after Start Up clearance – updating TTOT after Taxi clearance is issued could cause a better sequence/more accurate TTOT

Controllers indicated that the usability of DMAN pre-sequencing was mainly positive concerning all the variables demonstrated:

- Readability of the fields was effective (87,5% "Totally or Mostly Ok")
- Meaning of the fields was effective (93,75% "Totally or Mostly Ok")
- Colour coding was effective (81,25% "Totally or Mostly Ok")

- The interaction with the pre-sequencing functions was effective (78,57% "Totally or Mostly Ok")

Demonstration Objective Status: Ok

C3.4.18 EX3-OBJ-VLD-28-020 Results - Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable

C3.4.18.a EX3-CRT-VLD-28-020-001 - Positive evaluation that the workload of CLEARANCE DELIVERY controller due to DMAN function supported by route planning is acceptable

The workload of the Clearance Delivery Controller was not demonstrated separately due to the use of combined jurisdiction (combined Clearance Delivery and Ground Controller position was used during the demonstration)

Demonstration Objective Status: N/A

C3.4.18.b EX3-CRT-VLD-28-020-002 - Positive evaluation that the workload of GROUND controller due to DMAN function supported by route planning is acceptable

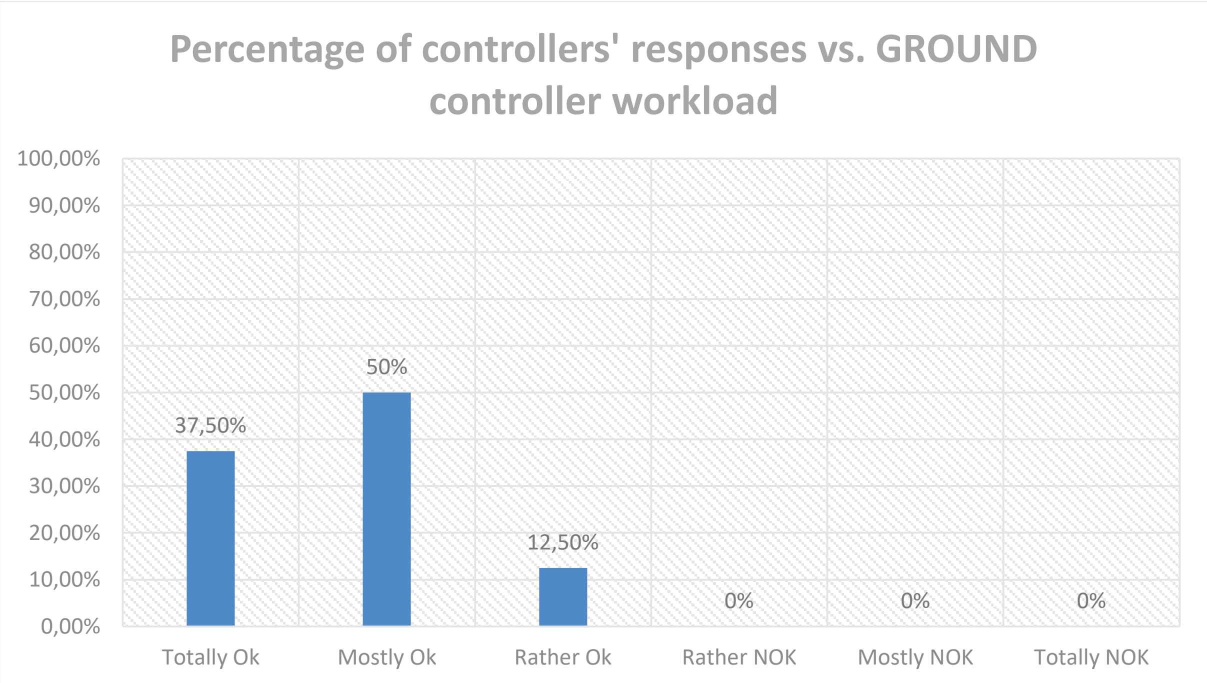


Figure Appendix C-36: Questionnaire – Percentage of controllers' responses vs. GROUND controller workload

The workload of the GROUND controller due to the DMAN function supported by route planning remained on an acceptable level at all times, based on the controllers' responses. It was stated that the DMAN function supported by route planning had no relevant impact on their workload.

The GROUND controllers were familiar with the layout of the Tabular Window and it was easy for them to operate the system although some improvements were suggested (colour coding according to the flight plan status).

Thus, the workload experienced by the GROUND controllers due to the DMAN function supported by route planning was evaluated positively, although in the Ground position, the controllers' responses could not reflect the integrated route planning.

Demonstration Objective Status: Ok

C3.4.18.c EX3-CRT-VLD-28-020-003 - Positive evaluation that the workload of RUNWAY controller due to DMAN function supported by route planning is acceptable

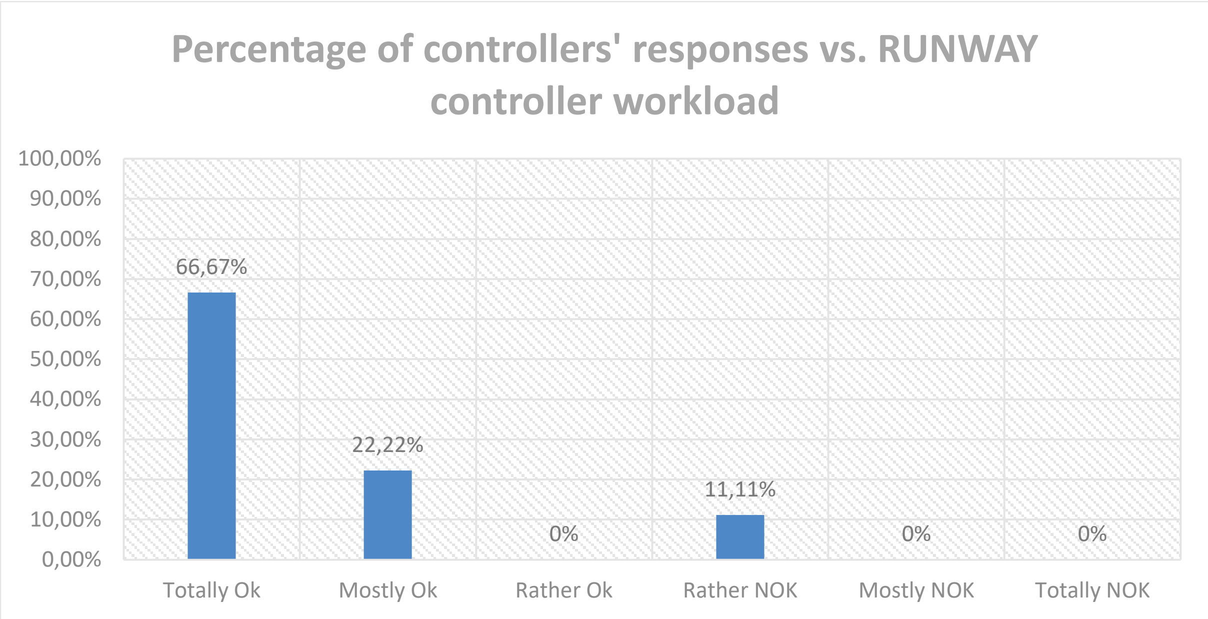


Figure Appendix C-37: Questionnaire – Percentage of controllers' responses vs. RUNWAY controller workload

The workload of the RUNWAY controller due to the DMAN function supported by route planning remained on an acceptable level most of the time, based on the controllers' responses.

The concept and implementation allowed the controllers to prioritise their tasks and follow both departure sequences provided by DMAN and real sequences created by the RUNWAY controller in the tower.

One controller felt that the workload was increased relatively ("Rather NOK" response) using DMAN Timeline in the beginning of the demonstration, because getting used to it took some time.

Although some situations were considered more demanding than others, all participants agreed that the workload during the simulation was considered adequate. Thus, the workload experienced by the RUNWAY controllers due to the DMAN function supported by route planning was evaluated positively.

Demonstration Objective Status: Ok

C3.4.19 EX3-OBJ-VLD-28-021 Results - Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved

C3.4.19.a EX3-CRT-VLD-28-021-001 - Positive evaluation that the situational awareness of CLEARANCE DELIVERY controllers due to DMAN function supported by route planning is improved

The situational awareness of the CLEARANCE DELIVERY controller was not demonstrated separately due to the use of combined jurisdiction (combined CLEARANCE DELIVERY and GROUND controller position was used during the demonstration).

Demonstration Objective Status: N/A

C3.4.19.b EX3-CRT-VLD-28-021-002 - Positive evaluation that the situational awareness of GROUND controllers due to DMAN function supported by route planning is improved

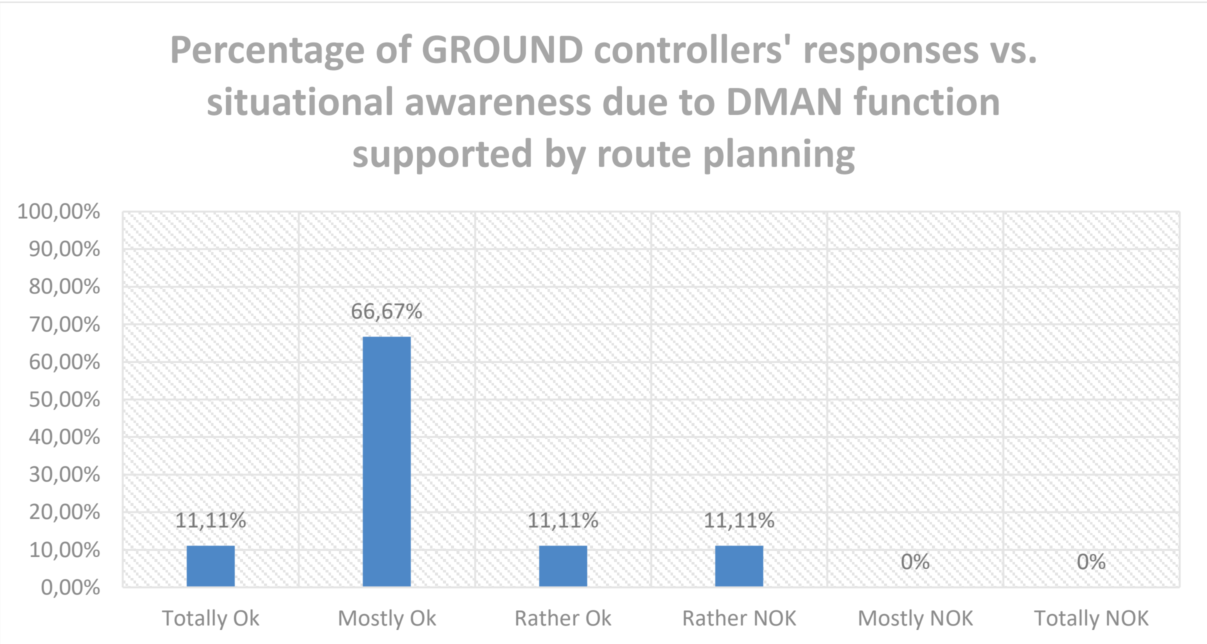


Figure Appendix C-38: Questionnaire – Percentage of GROUND controllers' responses vs. situational awareness due to DMAN function supported by route planning

Situational awareness of GROUND controllers due to the DMAN function supported by route planning was acceptable for all participants but there was no visible improvement. Thus, this objective is considered partially demonstrated.

Demonstration Objective Status: Partially Ok

C3.4.19.c EX3-CRT-VLD-28-021-003 - Positive evaluation that the situational awareness of RUNWAY controllers due to DMAN function supported by route planning is improved

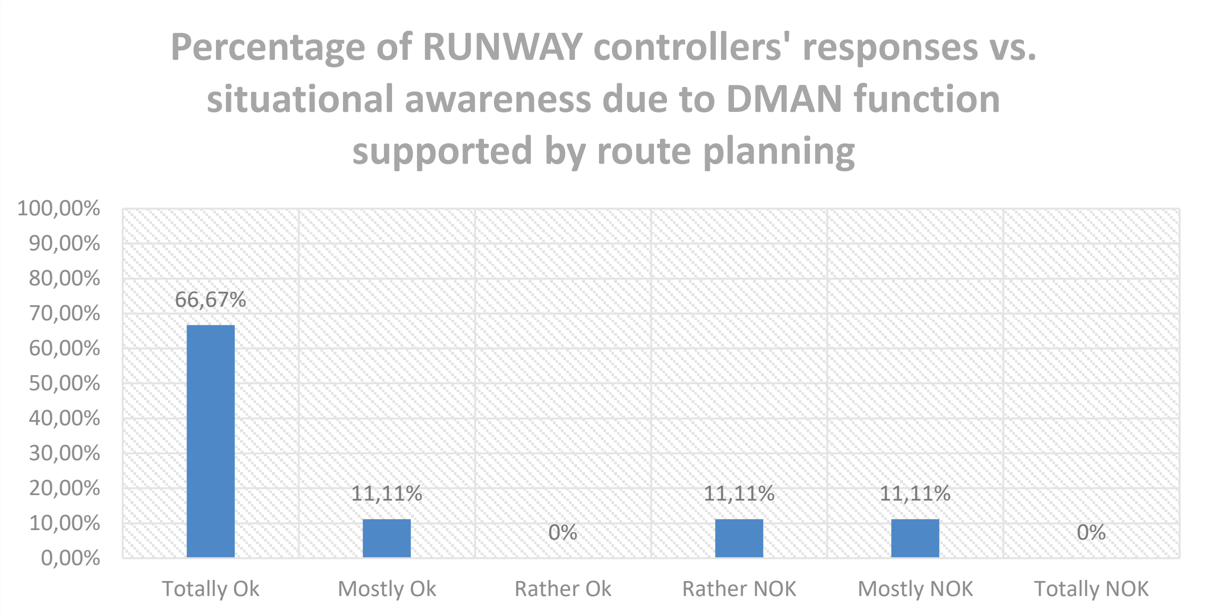


Figure Appendix C-39: Questionnaire – Percentage of RUNWAY controllers' responses vs. situational awareness due to DMAN function supported by route planning

The RUNWAY controllers were unfamiliar with the use of Timeline and reported some issues during the demonstration, which had an impact on their situational awareness:

- Degradation of situational awareness can mostly be attributed to the challenge of handling simultaneous actions on the limited size HMI
- Some of them prefer to concentrate on the radar screen and labels to judge the traffic situation

Situational awareness of the GROUND controllers due to the DMAN function supported by route planning was acceptable for all participants but improvement was not evincible. Thus, this objective is considered partially demonstrated.

Demonstration Objective Status: Partially Ok

C3.4.20 EX3-OBJ-VLD-28-022 Results - Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

C3.4.20.a EX3-CRT-VLD-28-022-001 - Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

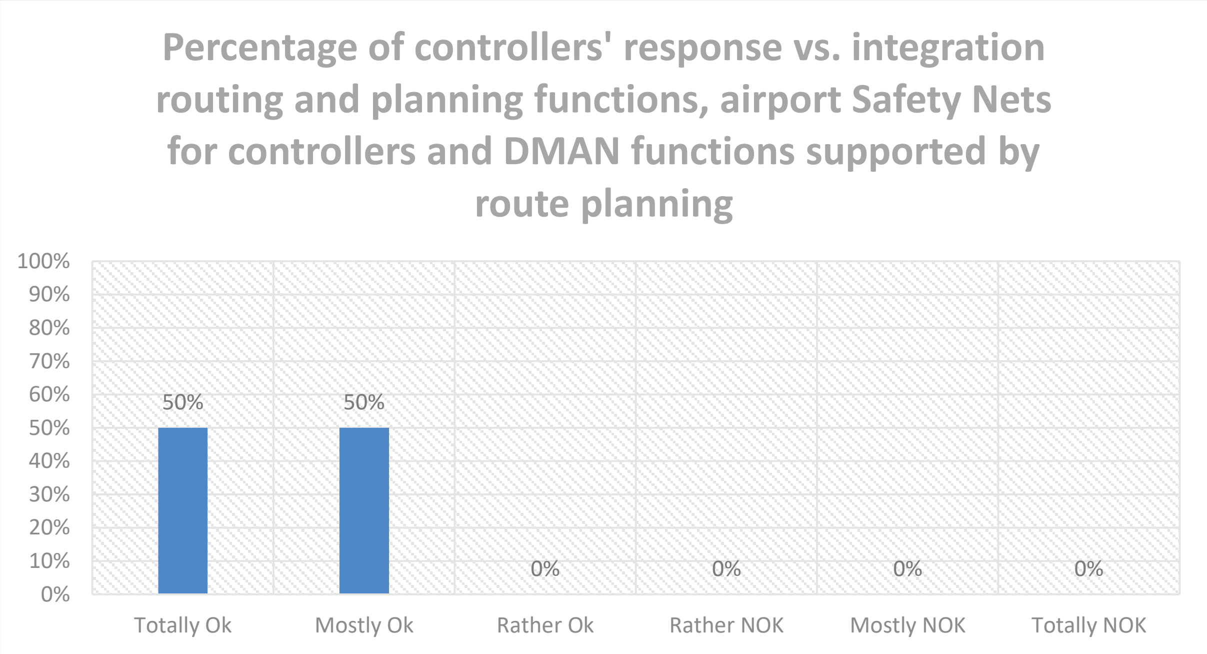


Figure Appendix C-40: Questionnaire – Percentage of controllers' response vs. integration routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

All Controllers considered that the objectives of the demonstration were successfully fulfilled. Therefore the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning were evaluated positively.

Demonstration Objective Status: Ok

C3.5 Unexpected Behaviours/Results

No specific unexpected behaviour was encountered.

C3.6 Confidence in the Demonstration Results

C3.6.1 Level of significance/limitations of Demonstration Exercise Results

Significance:

- 8 controllers participated in the training week (max. 2 controllers per training day) and 4 controllers assigned for the demonstration were available through all runs
- All controllers have a valid Tower license, complemented with Remoter Tower endorsement
- GROUND and RUNWAY positions were equally split between the participating controllers.
- Familiar working environment for the controllers. Contingency Tower is in regular use to maintain proficiency of the controllers. Only the monitors belonging to the InNOVA

system were replaced with other monitors (extra wide), all other equipment in the room remain untouched

Limitations:

- Limited number of controllers participating in the demonstration
- Simplified controller tasks according to the shadow mode demonstration, i.e.
  - Departure clearance was not given
  - No vehicle control
  - No coordination with other units
  - Following the traffic flow, not creating sequence
- System limitation
  - Missing configuration (i.e. standard routes, stand manoeuvres, clearances)
  - Missing TOBT
  - Only IFR traffic supported
  - No RIMCAS alerts (part of the software but not in operation in Budapest)

C3.6.2 Quality of Demonstration Exercise Results

The quality of results depends on many parameters such as:

- Traffic level
- Traffic complexity
- Traffic modes
- Aerodrome layout

Questionnaires, metrics and post-run debriefing were used for answering success criterion, the achieved results can be considered as realistic and accurate enough.

C3.6.3 Significance of Demonstration Exercises Results

Statistical significance is dependent on a number of runs and participants during the demonstration.

Participants:

- Totally 8 Tower controllers participated on the training week and 4 of them were available during the demonstration. All controllers are fully qualified and have a valid tower controller licence for Budapest
- The participating controllers responded to the questionnaires to the best of their knowledge with a 100% response rate. When a controller could not respond to a question due to a lack of observation, this is indicated by (N/A) in the questionnaire

Solution scenarios:

- 3 different solution scenarios were defined
- Scenarios were run totally 10 times during the demonstration week, one in the morning and one in the afternoon
- Each demo session length was between 1 and 2 hours
- Each demo session had both GROUND and RUNWAY controller roles
- During the demo sessions, traffic level and complexity covered the real operation:
  - both parallel and single runway operation,
  - runway direction 31,

- from low to high traffic load

The result from the questionnaires supported with data collection is positive, while the information gathered in the post-run debriefings and quotes from the participants indicate necessary improvement of the system configuration.

C4 Conclusions

The summary of Budapest VLD results are as follows, categorised by solution:

Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing.

Concerning routing and planning utility in nominal conditions:

- Calculated routes conformed to operational needs/rules for managing surface operations in nominal conditions with the following exceptions:
  - The system was not configured to properly cover every possible route variation
  - Standard routes defined in Budapest, but often not used by the controllers
  - Each controllers has his/her own preferences for single runway operation
  - Runway exit and entry points were not optimally proposed by the system
- Routes' relevance was generally appropriate but some suggestions for improvement were noted:
  - Simplest route is suggested instead of shortest route (less turns preferred)
  - Use of rapid exit taxiways as default runway exit point

Concerning utility and usability of route modifications:

- Route modification capabilities were mainly demonstrated positively
  - There are several different way to modify a route in the system. Each controller has his/her own preferences which one to use
  - It took some time for the controllers to get familiar with the different route modification capabilities
- The representation of the routes was positively assessed
  - Different types of routes have different colour representation, easy to recognize the status of the route on the HMI

Concerning the accuracy of A-SMGCS taxi-time:

- A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point was positively demonstrated
- The proposed taxi times were under-estimated compared to the actual taxi time. Based on data evaluation and the controllers' response, the average taxi time difference is on an acceptable level. Different variables were identified during real operation that affected the taxi time, calculation needs to be improved

Concerning the workload due to routing and planning:

- The workload experienced by the GROUND controllers due to routing and planning functions was evaluated positively
- The workload experienced by the RUNWAY controllers due to routing and planning functions was evaluated positively

Concerning the situational awareness due to routing and planning:

- The situational awareness experienced by the GROUND controllers due to routing and planning functions was evaluated positively
- The situational awareness experienced by the RUNWAY controllers due to routing and planning functions was evaluated positively

Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.

Concerning CATC and CMAC utility:

- The utility of CATC functions has been positively demonstrated
- False CATC alerts did not occur and most of the alerts were created intentionally
- The utility of CATC functions in predictive mode has been positively demonstrated
- CATC functions in predictive mode is considered a useful tool, which helps the controllers during daily operation
- The utility of the CMAC functions was positively demonstrated, although the controllers reported some comments:
    - Unexpected “No Taxi” alerts were observed sometimes when an aircraft finished its push back procedure
    - The “Taxiway Closed” alert should rather be a pre-warning. If the alert is raised when the aircraft already penetrated the restricted area, it is too late
    - General parametrization issues were reported due to the fact that some alert configuration parameters are set to be able to create and observe alerts rather than to comply with the official recommendations

Concerning CATC and CMAC usability:

- The usability of the CATC alert functions was positively demonstrated.
- The usability of the CATC alerts was positive concerning all the variables demonstrated: alerts were clearly visible, understandable colour coding was effective and the interaction with CATC was acceptable
- The usability of the predictive CATC functions was evaluated as part of the general CATC alert usability. Adequate usability of the CATC functions in predictive mode was confirmed. The predictive indicator was visible and understandable
- The usability of the audio alarm associated with the CMAC function was not demonstrated due to system limitations. This function is not used in Budapest and the necessary hardware (loudspeaker) was not available
- The usability of the CMAC alert levels was partially demonstrated, because issues were reported due to alert prioritisation
- The usability of CMAC functions was very positively demonstrated. Most of the alerts were artificially created and this enabled the controllers to witness all the relevant alerts according to their role (Ground or Runway)

Concerning controller workload incurred due to CATC and CMAC integration:

- The workload of GROUND controllers due to the integration of CMAC was partially demonstrated due to the reported cases
    - Unexpected “No Taxi” alerts after push back

  - Alerts sometimes appeared for a short time only and it was difficult to observe and justify those alerts
  - More than one alert could appear in the label (alert prioritisation)
  - If a controller did not properly update the system with clearances, alerts appeared
- The workload of the RUNWAY controllers due to the integration of CMAC was positively demonstrated
- The workload of the RUNWAY controllers due to the integration of CATC was positively demonstrated

Concerning the improvement of situational awareness with the integration of CATC and CMAC:

- Situational awareness of the GROUND controllers due to the integration of CMAC was positively demonstrated
- Situational awareness of the RUNWAY controllers due to the integration of CMAC was positively demonstrated
- Situational awareness of the RUNWAY controllers due to the integration of CATC was positively demonstrated

Concerning the effectiveness of integrating RMCA with CATC and CMAC:

- CATC and CMAC integrated with RMCA (RIMCAS in InNOVA) was not demonstrated due to missing system configuration. RIMCAS alerts are not in operational use in Budapest.

Solution #53 — Pre-Departure Sequencing supported by Route Planning

Concerning the utility of the DMAN function supported by route planning:

- The utility of the DMAN function supported by route planning was positively evaluated by the controllers and confirmed by data collection. Nevertheless taking into consideration the assumptions and limitations, the overall result is that the objective has been partially demonstrated
  - When comparing the accuracy of TTOT calculated by DMAN (supported by route planning) with TTOT coming from the CDM system in Budapest (using static taxi times), DMAN provides more accurate departure sequences.

Concerning the usability of the DMAN function supported by route planning:

- The usability of the DMAN function supported by route planning was mainly positive concerning all the variables demonstrated:
  - Readability of the fields was effective
  - Meaning of the fields was effective
  - Colour coding was effective
  - The interaction with the pre-sequencing functions was effective
- Observations regarding the usability of DMAN:
  - Too many data fields in the Tabular Window – the window has the same layout as the operational STU (Start Up) list
  - Colour coding is not reflecting the actual status of the flight
  - Sometimes there are significant differences between calculated and real times (real push back time is different from the calculated time)
  - TTOT update only after Start Up clearance – updating TTOT after Taxi clearance is issued could cause a better sequence/more accurate TTOT

Concerning the workload due to the DMAN function supported by route planning:

- The workload of the CLEARANCE DELIVERY controller was not demonstrated separately due to the use of combined jurisdiction (combined CLEARANCE DELIVERY and GROUND controller position was used during the demonstration)
- The workload experienced by the GROUND controllers due to the DMAN function supported by route planning was positively demonstrated, although in the Ground position, the controllers' responses could not reflect the integrated route planning
- The workload experienced by the RUNWAY controllers due to the DMAN function supported by route planning was positively demonstrated
  - The concept and implementation allowed the controllers to prioritise their tasks and follow both departure sequences provided by DMAN and real sequences created in the tower
  - Some situations were considered more demanding than others, all participants agreed that the workload during the simulation was considered adequate

Concerning the situational awareness due to the DMAN function supported by route planning:

- The situational awareness of the CLEARANCE DELIVERY controller was not demonstrated separately due to the use of combined jurisdiction (combined CLEARANCE DELIVERY and GROUND controller position was used during the demonstration).
- The situational awareness experienced by the GROUND controllers due to the DMAN function supported by route planning was partially demonstrated
  - Situational awareness was acceptable for all participants but improvement was not evincible
- The situational awareness experienced by the RUNWAY controllers due to the DMAN function supported by route planning was partially demonstrated
  - Situational awareness was acceptable for all participants but improvement was not evincible

Concerning the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning:

The objectives of the demonstration were successfully fulfilled. The integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning were positively demonstrated

C5 Recommendations

C5.1 Recommendations for industrialization and deployment

General recommendations applicable for all solutions:

HMI usability is a key factor and considered critical for the controllers:

- Information displayed on the HMI
  - graphical route representation and route modification capabilities
  - alert visualization, prioritization and predictive indicator
  - pre-departure and departure sequence

- Clearance input possibility

Solution #22 — Automated Assistance to Controller for Surface Movement Planning and Routing

With reference to the Solution #22 contextual note, the following recommendations are confirmed:

Deployment of a robust routing and planning functions is needed. Airport safety nets for controllers and DMAN supported by route planning are both based on routing and planning functions.

Improve the robustness and completeness of routing functionalities:

- Adapt the platform according to the following:
  - Airport static information, mainly published in the local AIP such as:
    - Airport layout
    - Stands
    - Standard routes
    - Restrictions
  - Local operations and procedures such as:
    - Push back procedures
    - Towing manoeuvres
    - De-icing procedures
  - Controllers' working procedures:
    - Implement commonly used routes
    - Support single runway operation
- Configure the system to ensure relevant parameters such as:
  - Standard routes, predefined runway exit and entry point, stand manoeuvres
  - Calculated taxi time should take into account different variables such as:
    - Waiting time on holding point
    - Slow start up procedures to improve push back time
    - Single Runway Operation
  - On site fine-tuning of system parameterisation to adapt to real conditions

Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances

With reference to the Solution #02 contextual note, the following recommendations are confirmed:

Configure the system to ensure the relevant parameters such as:

- Alert triggers
- Alert length
- Alert activation and end time
- Alert delay time
- Area configuration
- Alert prioritisation

Verify airport surveillance performance as airport safety nets rely on surveillance data

Solution #53 — Pre-Departure Sequencing supported by Route Planning

With reference to the Solution #53 contextual note, the following recommendations are confirmed:

- This solution strongly relies on CDM information. A robust solution requires:
- Accurate TOBT to calculate pre-departure sequence (TSAT)
- Accurate calculated taxi time to calculate departure sequence (TTOT)
- Parameters for departure sequencing (airline, aircraft type)
- HMI to support controllers' interaction

C5.2 Recommendations on regulation and standardisation initiatives

N/A

Appendix D Demonstration Exercise #04 Report

This exercise has not taken place.

The initial objective of the work package was the demonstration of the Manual Taxi Routing function. Increase in human performance & safety as well as improvements on situational awareness associated to the provision of manual taxi route to the flight crews on an Electronic Flight Bag (EFB) device should be demonstrated, using an airline and several taxiing aircraft. Due to the withdrawal of Thales from PJ28, the WP was terminated.

Work within the WP

The exercise preparation started by the preparation of the Deliverable D1.1 Demoplan [1]. Together with the partners the objectives of the VLD and in more detail the objectives for Exercise 4, Manual Taxi Routing Function, had been developed. The dedicated chapter for the exercise was prepared. Version 1 of the document was delivered in May 2017 with some limitations on the content, as the involvement of the AU was not defined at that state.

As a prerequisite for the exercise of demonstrating the manual taxi routing function an Airspace User needed to be involved. A dedicated support call (H2020-SESAR-2016-2) on the involvement was opened with a request for project proposals by May 2017. To make sure, that the requirements for the exercise are covered, Thales supported the proposal preparation. Effort has been spent to coordinate a common approach for the supporting project to also cover requirements of the other on-board related exercises. Unfortunately this common project approach was not successful resulting in two proposals for the PJ28 support.

For the proposal supporting the exercise of Thales [6], candidate airlines have been contacted and support was given in the preparation of the proposal. Some internal work has been done on impact scenarios on the outcome of the final decision of the AU Call.

Maturity of solution #26

As a result of the SESAR1 solution assessment, Solution#26, which was planned to be demonstrated in the exercise, was rated as not V3 validated. Based on this result Thales Avionics started an assessment to clarify the impact of the situation for PJ28.

Workshops with SJU have been held, to demonstrate, that the specific THALES implementation meets the maturity criteria. Additional documentation was internally prepared by THALES outside PJ28 and could support this. In agreement with the SJU, a V3 maturity gate was planned to fulfil the requirements for a VLD (only demonstrate solutions and functionalities that reached V3).

The maturity gate was planned for October 2017, taking the outcome of the supporting Call to include Airspace Users as a base. Due to the delayed selection process the activities for the gate preparation have been put on hold and have not been finished until the date of withdrawal.

Appendix E Demonstration Exercise #05 (EDDH)

E1 Summary of the Demonstration Exercise #05 Plan

E1.1 Exercise description and scope

The Demonstration Exercise #5, corresponding to WP6 of PJ28, took place at Hamburg Helmut Schmidt Airport.

It demonstrated parts of the sub-functionalities that have been developed and validated in SESAR 1:

- Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.
- Automated Assistance to Controller for Surface Movement Planning and Routing,
- Departure Management Integrating Surface Management Constraints.

The Airport Research and Innovation Facility (ARIF) from DLR (AT-One) at EDDH was used for the demonstration exercise in passive shadow mode, not interfering with live operations. However, the demonstration used live data as input. ARIF was integrated with the SINTEF ATC Optimization Service validated in SESAR 1. ARIF's A-SMGCS Traffic Situation Display was extended with ATCO interaction capabilities to communicate with the SINTEF ATC Optimization Service. This provided the technological enablers for demonstrating the benefits of parts of the following solutions:

- Solution #02 — Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances.
- Solution #22 (Automated Assistance to Controller for Surface Movement Planning and Routing),
- Solution #53 (Pre-Departure Sequencing supported by Route Planning).

Solution 02 (Airport Safety Nets) was part of the demonstrations at Hamburg Airport. The following points need to be taken into account for the evaluation of the trials:

- All functions, but especially Airport safety nets are highly dependent on HMI implementations. The current ARIF Display was adapted to demonstrate Safety Net Functions but has not been validated by SESAR1. Implementation work was done but there is a risk of biased feedback regarding functions itself and HMI capabilities.
- The main focus was on the conformance monitoring part of the safety net functions. Adaption of the SINTEF Optimization service related to the serious constructions work at Hamburg Airport has been done. However, some construction-specific operational procedures were missing.
- For the Hamburg Exercise it was proposed to demonstrate parts of the Solution #02 where only the conformance monitoring (CMAC) part should be addressed without the Conflicting ATC clearance alerts (CATC). Hamburg Exercise partners, Airport Hamburg and DFS have been in discussion on possibilities to include CATC. Due to resource and time limitations this could not be realized.

Figure Appendix E-1 shows a high-level overview of the platform and the systems involved with their interaction.

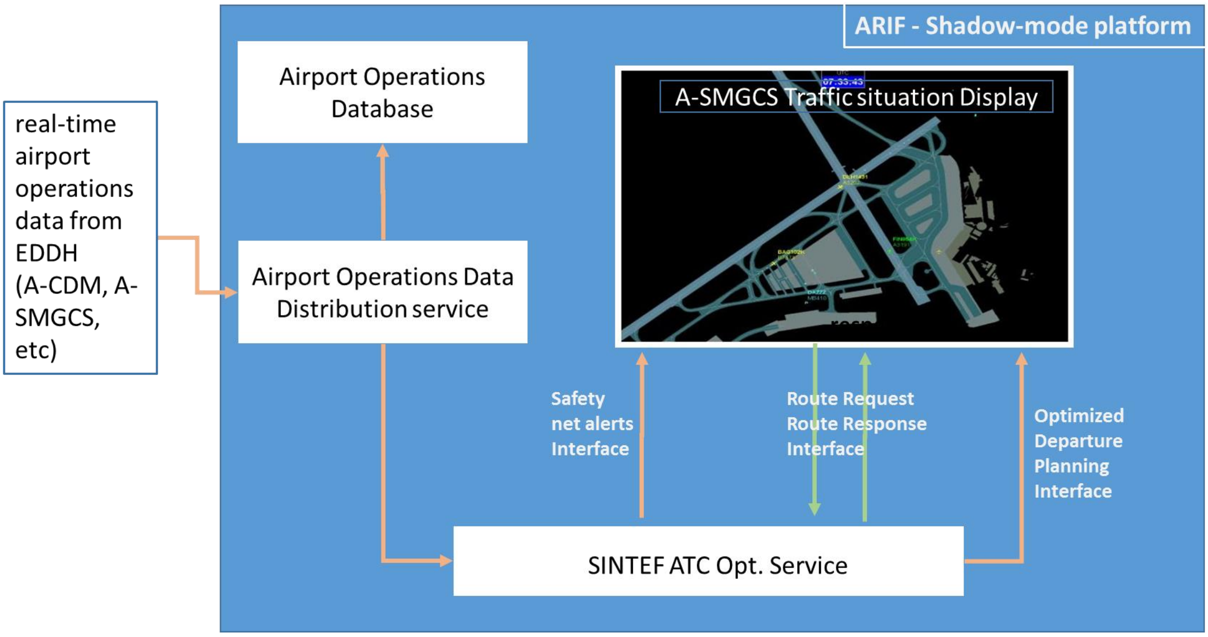


Figure Appendix E-1: Overview of platform and systems involved with their interaction

The **ARIF platform** has interfaces to the EDDH operational systems that provide real-time information on aircraft arrivals, departures, and surface movements (A-CDM database, A-SMGCS, Departure Planning Information). The live data can be accessed either in real-time through the Airport Operations Distribution Service, or the Airport Operations database, respectively. The ARIF platform was configured to support the necessary roles and working positions for the new operating method.

The **SINTEF ATC Optimization Service** for automated routing and departure planning was configured to the EDDH layout. The ATC Optimization Service automatically generates and maintains a current, optimized, ground based routing plan, with detailed taxi routing and timing information, for all arriving and departing aircraft at the airport. The optimizer was configured to generate routes that minimized the unimpeded taxi time, taking into account operational constraints. This service also can detect and resolve conflicts between aircraft. This functionality was used to account for the current traffic situation; that is, more aircraft would increase traffic time if they need to coordinate. The ATCOs also had the possibility to interact with service to ask for different routes when they see the need for it. Furthermore, this service used the available surveillance information to trigger safety net alarms in case of non-conformance.

The main focus of Exercise #05 was to demonstrate the utility of using the SINTEF ATC Optimization Service to maintain a current, optimized plan for *ground trajectories* – routing plans for all involved aircraft, with detailed timing information. By using real-time surveillance data at EDDH and a realistic platform, the demonstration delivered important learnings for a future deployment.

The working environment

Hamburg is a medium sized airport with two crossing dependent runways (23/05 and 15/33) that are used simultaneously.

In normal operation usually one runway is used for arrivals and one for departures. Mixed mode situations are also possible and have been experienced during the trials. Typical configuration is arrivals 23 and departures 33 or arrivals 15 and departures 23.

The main Terminal Apron is located between threshold 23 and threshold 33. A second apron is located between thresholds 33 and 05 covering long term parking and general aviation positions. Mainly Pushback Positions with a few additional roll-in-roll-out positions are used. As a special situation some of the positions are used as roll-in-roll-out positions for smaller aircraft and pushback positions for larger aircraft.

The airport (apron 1) is currently under construction which leads to restrictions on the use of some taxiways. The conditions changed several times during the project. The general airport layout as well as the construction information used for the trials is presented in the following figures

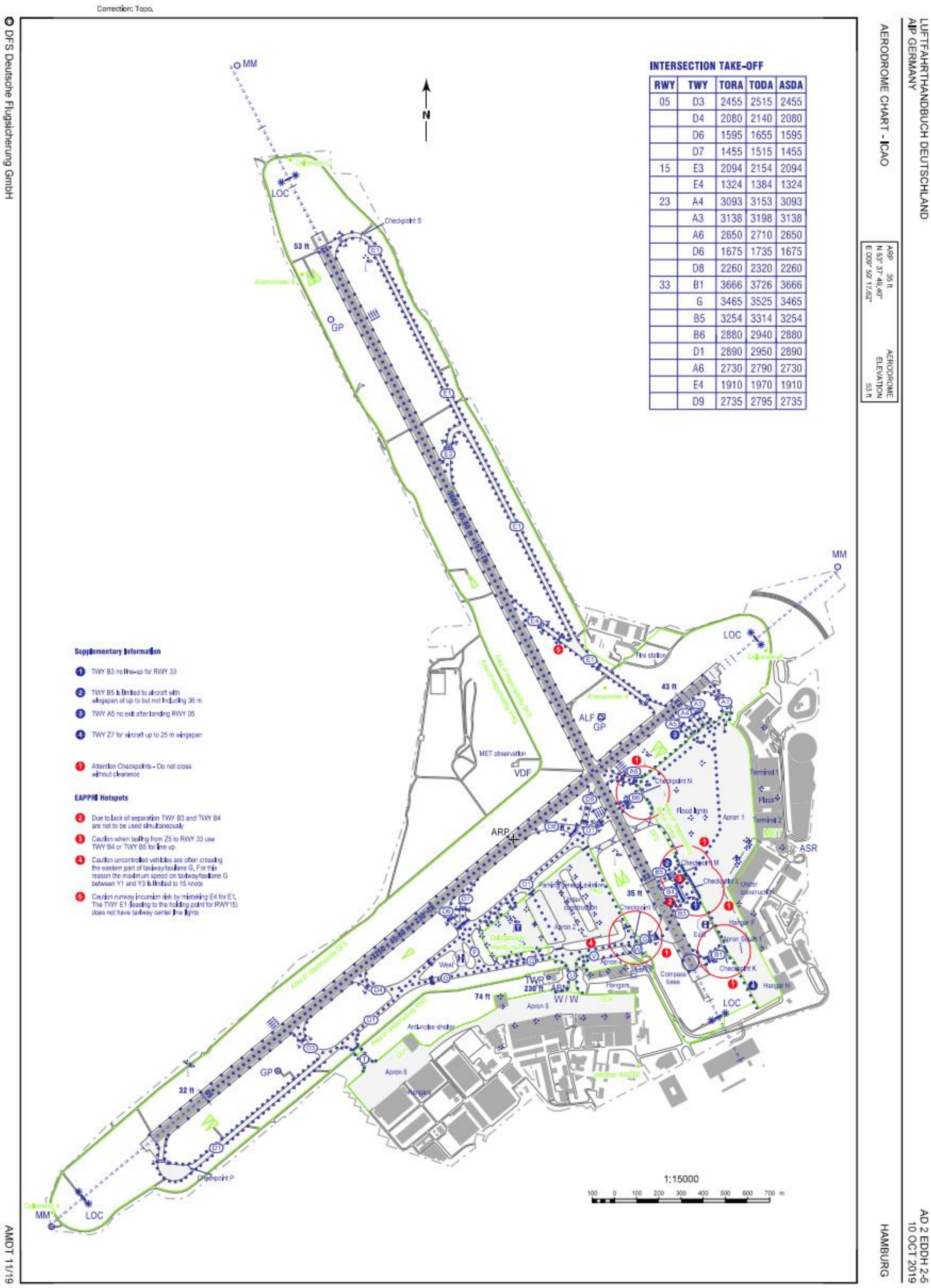


Figure Appendix E-2: Hamburg Airport Layout Overview

Figure Appendix E-3: Hamburg Airport - Construction area during demonstration execution

Controller roles and tools

Responsibilities at the airport are split between Hamburg Tower (operated by the German ANSP DFS) and Hamburg Apron (operated by Hamburg Airport). Hamburg Ground is responsible for initial calls and start-up requests. This position will not be covered in the tests.

During the demonstration, two CWPs have been set up to test the system with the following role configuration: “Tower” & “Apron”.

In the current environment, Tower and Apron have no system connection on the routing of aircraft on the surface. Information is shared on the A-CDM system in place and with direct R/T communication. A document covers operational principles for responsibilities and coordination of the airport operations.

In the test system both working positions are connected and share information on the operation directly on a system base.

Tower (TWR)

The Tower Controller has all operations on the runways (Landing, Take-Off, Line-Up as well as Runway Crossings) under his responsibility. In addition the Tower Controller handles Taxi operations until handover to the aprons that are controlled by the Hamburg Apron. Handovers take place at defined checkpoints on the airport layout.

During the exercise this position is covered by the test system. A combined traffic situation system with flight strips and sequencing information has been used.

Apron (APR)

Apron Controller will guide aircraft on the Apron until the Handover Points to Tower for Line-Up or runway crossings. Controller issue Pushback and Taxi Clearances and are responsible for all operations on the apron.

Apron Controllers currently use an electronic flight strip system for all information handling as well for issuing clearances under their responsibility. An A-SMGCS Display is available for information purposes but is currently not used as a controlling system.

During the exercise the position was covered by the test system. A combined traffic situation system with flight strips and sequencing information has been used.

Clearance Delivery (GRD)

The position is provided by DFS and responsible for issuing the TSAT times. The position was not separately provided by the system. The information on the operationally used TSAT (issued by real ground controller) as well as the TSAT/TTOT based on the SESAR solution was provided to the exercise participant via the electronic flight strip system. On one side by inserting the data on the flight strip and on the other hand by providing a timeline which could be toggled between the real airport systems and the SESAR1 solution algorithm data.

E1.2 Summary of Demonstration Exercise #05 Demonstration Objectives and success criteria

Demonstration Objective	Demonstration Success criteria		Demonstration Exercise 5 Objectives	Demonstration Exercise 5 Success criteria
OBJ-VLD-28-001	CRT-VLD-28-001-001	Fully covered	EX5-OBJ-VLD-28-001 Demonstrate the utility of routing and planning functions.	EX5-CRT-VLD-28-001-001 Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.
	CRT-VLD-28-001-002	Fully covered		EX5-CRT-VLD-28-001-002 Positive evaluation of the calculated routes' relevance.
OBJ-VLD-28-002	CRT-VLD-28-002-001	Fully covered	EX5-OBJ-VLD-28-002 Demonstrate the utility and usability of route modification capabilities.	EX5-CRT-VLD-28-002-001 Positive evaluation of route modification capabilities when real surveillance data is used
OBJ-VLD-28-003	CRT-VLD-28-003-001	Fully covered	EX5-OBJ-VLD-28-003 Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	EX5-CRT-VLD-28-003-001 Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.
OBJ-VLD-28-005	CRT-VLD-28-005-001	Fully covered	EX5-OBJ-VLD-28-005 Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	EX5-CRT-VLD-28-005-001 Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions.
	CRT-VLD-28-005-002	Fully covered	EX5-OBJ-VLD-28-005	EX5-CRT-VLD-28-005-002 Positive evaluation of the situational awareness of Runway controllers due to

				the A-SMGCS planning and routing functions.
OBJ-VLD-28-009	CRT-VLD-28-009-001		EX5-OBJ-VLD-28-009 Demonstrate the route deviation alerting of the CMAC	EX5-CRT-VLD-28-009-001 Positive evaluation of the route deviation alert when real surveillance data is used.
OBJ-VLD-28-015	CRT-VLD-28-015-001	Fully covered	EX5-OBJ-VLD-28-015 Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC	EX5-CRT-VLD-28-015-001 Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved
	CRT-VLD-28-015-002	Fully covered	EX5-OBJ-VLD-28-015	EX5-CRT-VLD-28-015-002 Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved
OBJ-VLD-28-018	CRT-VLD-28-018-001	Fully covered	EX5-OBJ-VLD-28-018 Demonstrate the utility of DMAN functions supported by route planning.	EX5-CRT-VLD-28-018-001 Positive evaluation of the utility of the DMAN function supported by route planning.
OBJ-VLD-28-021	CRT-VLD-28-021-002	Fully covered	EX5-OBJ-VLD-28-021 Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved.	EX5-CRT-VLD-28-021-002 Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved.
	CRT-VLD-28-021-003	Fully covered	EX5-OBJ-VLD-28-021	EX5-CRT-VLD-28-021-003 Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved.
OBJ-VLD-28-022	CRT-VLD-28-022-001	Fully covered	EX5-OBJ-VLD-28-022	EX5-CRT-VLD-28-022-001 Positive evaluation of the

			Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning	integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning
OBJ-VLD-28-024	CRT-VLD-28-024-001	Fully covered	EX5-OBJ-VLD-28-024 Demonstrate utility of routing and planning functions in non-nominal conditions.	EX5-CRT-VLD-28-024-001 Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations in case of specific events (e.g. taxiway closure).
	CRT-VLD-28-024-002	Fully covered	EX5-OBJ-VLD-28-024	EX5-CRT-VLD-28-024-002 Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure).

Table Appendix E-1: Summary Demonstration Objectives and Criteria Exercise #03

E1.3 Summary of Validation Exercise #05 Demonstration scenarios

Demonstration modes and scenarios

The demonstration was performed using two different modes:

1) Pure shadow mode

2) Shadow mode with manipulation, to trigger special, drastic events

There was no baseline scenario, as the system operated in real time on real data. As we did not want to interfere with live operations, there have been deviations between the current plan and the real situation, due to the real ATCOs taking decisions that were not according to the optimised plans generated automatically by the system. An example was the selection of taxi route for a given aircraft. In this way, the system showed some, primarily small plan deviations. Mode 2 ensured that the system has been exposed to pre-planned, drastic changes, such as closure of a taxiway.

Pure shadow mode

In pure shadow mode, the reference scenario is the real-life controller actions, and the resulting actual ground trajectories followed. As the exercise not directly involved the actual tower control, a direct comparison of performance (runway capacity, taxi times) was not possible in this mode.

Rather, the key objectives of system stability, reactivity, and user acceptance are in focus. However, the controllers and experts involved in the exercise provided an assessment of the routings and timings proposed by the optimized route planning service, whenever they differ from the actual ones.

Information on real tower controller actions, and the actual aircraft trajectories, are fed to the system in real time and hence provoke reactive plan maintenance from the system when the real situation differs significantly from the current plan.

Shadow mode with some manipulation to trigger special events

The situation is similar to the one for pure shadow mode. The difference is that, in addition to the automated reactive planning that takes place when real life deviates from the plan, a set of synthetic, unexpected major events (e.g. closing parts of taxiways, change of runway configuration, etc.) are generated up front. The shadow tower controller assessed the resulting system behaviour.

E1.4 Summary of Demonstration Exercise #05 Demonstration Assumptions

Participation of controllers and experts in the exercise

The participation of experienced Hamburg controllers is an important point for the Hamburg exercise. As Hamburg airport and DFS are not directly partners in PJ28, the involvement had to be done on another basis. There has been overall coordination and a general support agreement from all sides. Despite of effort to involve as much controllers as possible especially the involvement for ATC controllers was not as successful as planned. Due to limited resource availability only one tower controller could participate. There are limitations on the significance of the results for this position. The assumption on the apron controllers was fulfilled, as 13 different controllers took part in the demonstration.

Access to the decisions made by the actual controllers

Access to operational decisions has been clarified and can be taken as available during the exercises. To handle the system based on real instructions, R/T channels and operational systems were available and could be used (as input only)

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-EXE05-001	Controller involvement	Personal Availability	Controllers necessary for evaluation of solutions	Needed to decide on success criteria for objectives	N/A	Human Perform.	Expert	N/A	Exercise Lead	HIGH

			demonstrated							
ASS-EXE05-002	Access to operational decisions	Data Availability	Data are relevant to define the actual intentions and clearances of the controller in charge. Helps to understand VLD system status	Comparison of real Traffic situation and shadow mode system status	N/A	Human Perform.	Platform		Exercise Lead	MED

Table Appendix E-2: Demonstration Assumptions overview Exercise #05

E2 Deviation from the planned activities

The following are considered deviations from the planned activities:

- It was planned to work in each session with a runway controller from DFS and one Apron controller from Hamburg Airport. Both participants should work on their position as in real operations. Due to the lack of Runway controllers only one session could be handled in the planned setup. For the other sessions, experts from partners had to take over the runway positon and operate the system to support the Apron controller on his position.
- The following alerts were implemented but not demonstrated compared with DEMOP Chapter 5 (Alert Coverage):
    - Lining Up on the wrong runway
    - Runway Closed
- CRT-VLD-28-021-001 needed to be deleted, as no Clearance delivery was implemented as a separate working position
- Objective OBJ-VLD-28-002 was not planned for Hamburg in the Demoplan, but could assessed during the trials
- Objective OBJ-VLD-28-015 was not planned for Hamburg in the Demoplan, but could assessed during the trials

E3 Demonstration Exercise #05 Results

E3.1 Summary of Demonstration Exercise #05 Demonstration Results

Demo Obj. ID	Demo Objective Title	Success Criterion ID	Success Criterion	Sub-operating environment	Exercise Results	Demo Obj. Status
OBJ-VLD-28-001	Demonstrate the utility of routing and planning functions	CRT-VLD-28-001-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations.	Low Utilisation Simple Layout	The criterion was rated neutral with high variability by the controllers. An implementation error lead to negative feedback which can be relaxed by proper implementation.	POK
		CRT-VLD-28-001-002	Positive evaluation of the calculated routes' relevance.	Low Utilisation Simple Layout	Relevance and efficiency have been rated positively while the relevance for the pre-departure sequencing could not be demonstrated.	POK
OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.	CRT-VLD-28-002-001	Positive evaluation of route modification capabilities when real surveillance data is used	Low Utilisation Simple Layout	Given the status of the HMI as a prototype interface, controller rated the capabilities positively. The utility is routed ok but usability is highly dependent on HMI, traffic situation and number of necessary modifications (related to shadow mode)	POK
OBJ-VLD-28-003	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	CRT-VLD-28-003-001	Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point.	Low Utilisation Simple Layout	Even the subjective feedback of the controllers indicated acceptable taxi times, this could not be proven by the data. Real taxi times significantly higher. Pushback procedure times (including preparation for taxi) extremely variant.	NOK
OBJ-VLD-	Demonstrate that the	CRT-VLD-	Positive evaluation of the situational	Low	Apron controller rated SA on an acceptable	POK

28-005	situational awareness incurred by the integration and operation of routing and planning functions is improved.	28-005-001	awareness of Apron Controllers due to the integration and operation of routing and planning functions.	Utilisation Simple Layout	level. Due to shadow mode controllers spend too much time with the HMI and the real decisions.	
		CRT-VLD-28-005-002	Positive evaluation of the Situational Awareness of Runway controllers due to the A-SMGCS planning and routing functions.	Low Utilisation Simple Layout	There was only one RWY controller available. The criterion cannot be assessed in a sound and proper way	N/A
OBJ-VLD-28-009	Demonstrate the utility of CMAC functions	CRT-VLD-28-009-001	Positive evaluation of the utility of CMAC functions when real surveillance data is used.	Low Utilisation Simple Layout	In general, the participants considered the usability of CMAC alerts as positive.	POK
OBJ-VLD-28-015	Demonstrate whether the Situational Awareness of controllers is improved with the integration of CMAC	CRT-VLD-28-015-001	Positive evaluation that the situational awareness of Apron controllers due to the integration of CMAC is improved.	Low Utilisation Simple Layout	Apron controller agreed that they have maintained a sufficient level of situation awareness due to the integration of CMAC alerts. There were some shortcomings during (too time consuming) handling the alerts on the HMI.	POK
		CRT-VLD-28-015-002	Positive evaluation that the situational awareness of Runway Controllers due to the integration of CMAC is improved.	Low Utilisation Simple Layout	There was only one RWY controller available. The criterion cannot be assessed in a sound and proper way	N/A
OBJ-VLD-28-018	Demonstrate the utility of DMAN functions supported by route planning	CRT-VLD-28-018-001	Positive evaluation of the utility of the DMAN function supported by route planning.	Low Utilisation Simple Layout	As the core of this criterion was not part of the tasks of the participating controllers, the utility of its functions could not be appropriately demonstrated	N/A
OBJ-VLD-28-021	Demonstrate that the controllers	CRT-VLD-28-021-	Positive evaluation that the situational awareness of GROUND controller due	Low Utilisation	No significant difference in the SA could be demonstrated	NOK

	'situational awareness due to DMAN supported by route planning is improved.	002	to DMAN function supported by route planning is improved	Simple Layout		
		CRT-VLD-28-021-003	Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved.	Low Utilisation Simple Layout	There was only one RWY controller available. The criterion cannot be assessed in a sound and proper way	N/A
OBJ-VLD-28-022	Integration of routing and planning functions, airport Safety Nets and DMAN functions	CRT-VLD-28-022-001	Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	Low Utilisation Simple Layout	The participants considered the effectiveness of the PJ28 Exercise Hamburg Solutions as neutral to rather ok, While Safety Nets and routing have been rated partially ok, DMAN benefits could not be demonstrated	POK
OBJ-VLD-28-024	Routing and Planning Function non-nominal	CRT-VLD-28-024-001	Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operation in case of specific events (e.g. taxiway closure).	Low Utilisation Simple Layout	The controllers considered the utility of the calculated routes in non-nominal cases as rather ok for all four items.	POK
		CRT-VLD-28-024-001	Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure).	Low Utilisation Simple Layout	The majority of controllers considered the utility of the calculated routes in non-nominal cases as relevant and efficient.	POK

Table Appendix E-3: Exercise 5 Demonstration Results overview

E3.2 Results per KPA

Human Performance

- The shadow-mode operations influenced the controller performance, as there was a delayed operation based on the decision the real controller took.
- The HMI implementation was very basic with a focus on demonstrating only the solutions. Some operations like sorting/moving or modifying flighstrips where not available and influence the typical working environment.
- The used touch environment was new to the controllers and caused sometimes delays
- Workload was influenced due to higher number of necessary route modification (system proposals deviated from the decision of the real controller).

Safety

- The conflicting ATC clearances are not part of the Hamburg Exercise and have been not demonstrated.
- Conformance monitoring was rated very positively.
- Some issues have been identified in the handling of the alerts (related also to HMI implementation).

Efficiency

- The optimization criteria for the routing based on the shortest route approach. This was not the best criteria for Hamburg due to the airport layout. Especially on the tight apron with limited routing possibilities, controllers rated flexibility much higher. Proposed routings caused a higher number of route modifications which again impacted workload.

E3.3 Results impacting regulation and standardisation initiatives

The continuous construction works and the constantly changing airport layout at Hamburg airport led to a high effort of adaptions and tuning of the systems. Even some support tools have been generated to support the integration of the new situation this is time consuming and open to errors.

As an up to date and correct routing network (based on more static AIP information) but also temporary information provided by NOTAMs are essential for the solutions, a standardized approach should be taken for maintaining the correct baseline for the technical systems. In addition the quality of the data has to be given, especially in the context of safety nets when route deviations have to be detected

AIXM and AMXM are standardized models that could help to define and maintain the correct baseline data. Especially AMXM, defined by Eurocontrol, includes standardized objects for the routing network (ASRN[7] Nodes and ASRN Edges), especially designed for surface routing

This should also be taken into account for other solutions that are based on the routing and planning function as well as for connecting on-board and ground based solutions. When transferring route

[7] ASRN - Airport Surface Routing Network

information into the cockpit, a standardized and coordinated approach should be taken. EUROCAE WG41 A-SMGCS is currently investigating this in relation to the requirements for A-SMGCS systems.

E3.4 Analysis of Exercises Results per Demonstration objective

As described in chapter E1.4 14 Controllers (6 female; age: 25-51 years, mean 38,1) with 3 to 27 years of experience as controller (mean 11,9) took part in the demonstration.

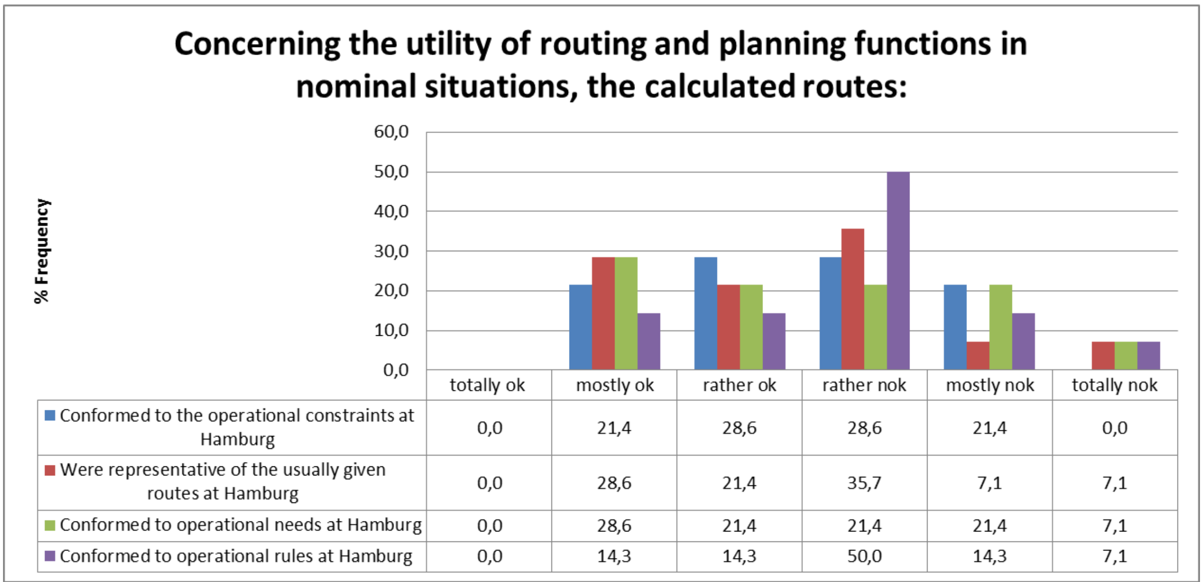
E3.4.1 EX5-OBJ-VLD-28-001 Routing and Planning Function

E3.4.1.a EX5-CRT-VLD-28-001-001: Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations

The first objective aimed to demonstrate the utility of routing and planning function. The calculated routes of the routing and planning function have been considered as utile. However, a high standard deviation in the answers of the controllers could be observed.

The evaluation is based on two assessments. The first was the routing workshop, where specific static situations have been discussed with controllers and compared with pre-calculated results of the routing algorithm. The second assessment was done during the working with the system. Both parts are included in the answers by the controllers.

The answers to the questionnaire items showed that the participants had an overall neutral position concerning the conformance of the calculated routes to operational constraints, needs and rules at Hamburg airport. This answer pattern applies also to the question if the calculated routes were representative of the usually given routes at Hamburg.

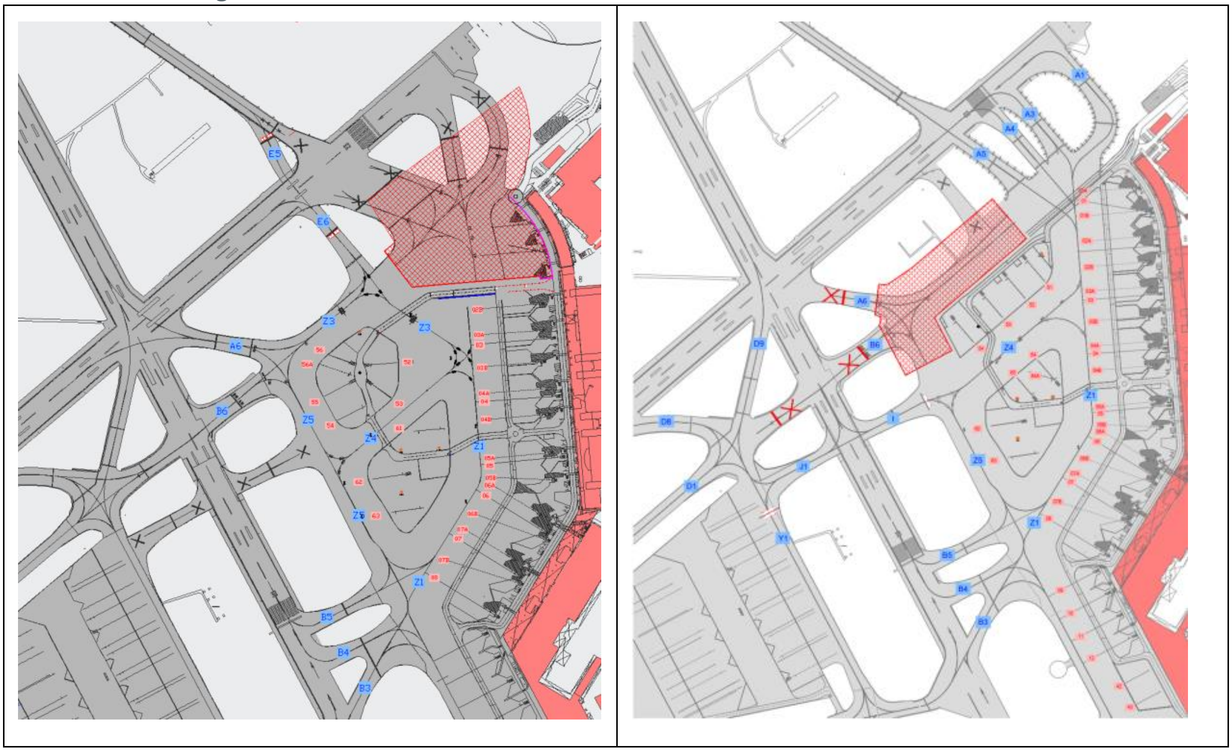


	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
Conformed to the operational constraints at Hamburg	0,0	21,4	28,6	28,6	21,4	0,0
Were representative of the usually given routes at Hamburg	0,0	28,6	21,4	35,7	7,1	7,1
Conformed to operational needs at Hamburg	0,0	28,6	21,4	21,4	21,4	7,1
Conformed to operational rules at Hamburg	0,0	14,3	14,3	50,0	14,3	7,1

Figure Appendix E-4: Controller Response to Routes' Conformance to Operational Constraints - Hamburg (in nominal situations)

The results can be traced back to some observations made during the exercise:

- The wingspan of the Boeing 757-300 was wrongly defined in the used aircraft performance database. Instead of category D the aircraft was handled as a category C aircraft. A limitation for the usage of the Runway Entry B5 is in place for maximum Code C aircraft. B757 as Code D would not be allowed to use the entry but as it was handled wrongly as Code C the algorithm calculated routes on this taxiway. Controller rated this significantly related to constraints and rules. The issue can be related to the implementation and can be relaxed in relation to the solution itself.
- The layout of the airport changed again significantly shortly before the exercise (1.2.2019 while exercise was executed on 25.3.2019). Runway entries at RWY 05 have been reopened and positions on apron 1 have been reorganised. Even with additional tests not all procedures that have been used by the controllers could be implemented to tune the algorithm.



- Due to the very limited space on the apron pushback procedures are extensively used for traffic de-conflicting and routing flexibility by the controller. The system was only implemented with a standard pushback point for the route calculation. The point could not be adapted as controller would need it in their day to day operation. This included pushback procedures to other stands or into taxi lanes. As these are not published standard procedures but used individually by each controller, this could not be handled by the algorithm during the demonstration.
- The routing algorithm was implemented with as much freedom of optimisation as possible. While optimising route distances and taxi times, controller mentioned that they can understand the solution but would not use it from their experience. Especially the usage of intersection points for Take-Off runs was critical evaluated regarding the usually given routes. Sometimes this also would require additional runway crossings and frequency changes, which is currently not reflected in the optimisation function enough.

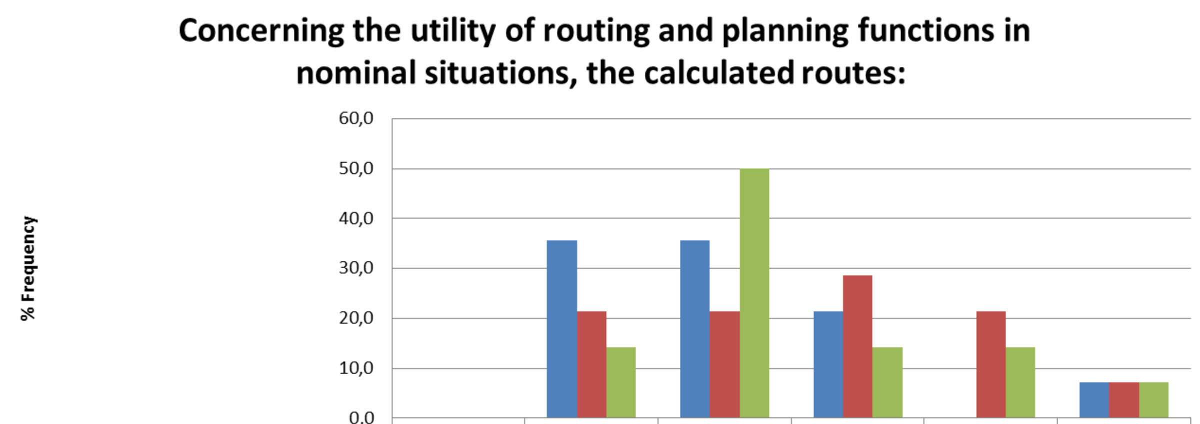
- Arrival routing - the actual runway exit differed sometimes from the calculated exit (variance in landing and breaking behaviour was observed due to weather, traffic situation, traffic separation, individual performance).
- The usage of available runway entries is used more flexible by the controller. Routes generated by the algorithm often used the shortest distance entry and adapted timings to limit the cue at a certain entry. Controllers often use all entries in parallel to give more flexibility to the Tower controller in the runway sequences.

The result of this criterion is rated as POK.

Some significant negative ratings can be fixed by correcting used data (wrong database entries). Some others require improvement in terms of adapting routes to operational peculiarities of each airport. To integrate the operational needs by the controllers (not published as standard procedures) into algorithms will be one of the challenges.

E3.4.1.b EX5-CRT-VLD-28-001-002: Positive evaluation of the calculated routes' relevance

The calculated routes were considered as relevant. Regarding the adherence to the pre-departure sequence and efficiency, the controllers had mixed opinions and no clear improvement (but also no decline) could be observed.



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
Are relevant (e.g. regarding time horizon, correct start and end point,...)	0,0	35,7	35,7	21,4	0,0	7,1
Helped me to adhere to the pre-departure sequence	0,0	21,4	21,4	28,6	21,4	7,1
Are efficient	0,0	14,3	50,0	14,3	14,3	7,1

Figure Appendix E-5: Controller Response to Routes' Relevance - Hamburg (in nominal situations)

Certain systematic routing issues were encountered and were of several types:

- Pushback procedures have not been adequately considered.
- The handover from the apron controller to the tower controller (and vice versa) is coordinated by a handover point. This point is available from the airport system. A standard value is set for arrivals well in advance but for departures the point is defined

late. Based on the actual situation the points are adapted directly before giving instruction. Route planning in advance therefore provided different routes.

- Algorithm should make more use of different available runway holding points.
- Algorithm mainly used timings for departure sequencing, while controller used available entries to allow for more flexibility.
- Optimization function with high priority to shortest route seems to be not the best from controller perspective. Other parameters like flexibility and avoidance of possible critical situations seem to be more relevant but very difficult to be covered by algorithms.

The result of this criterion is rated as POK.

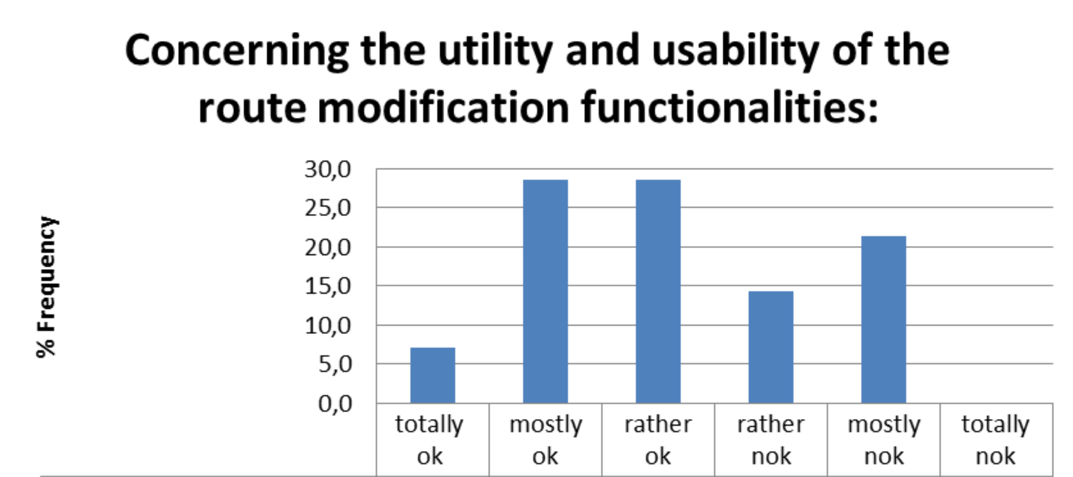
Relevance and efficiency have been rated positively while the relevance for the pre-departure sequencing could not be demonstrated.

E3.4.2 EX5-OBJ-VLD-28-002 Route Modification Capabilities

E3.4.2.a EX5-CRT-VLD-28-002-001: Positive evaluation of route modification capabilities when real surveillance data is used

The system used for the demonstrations is at a prototype stage and not comparable with an industrial system. The HMI was adapted to operate the SESAR solutions and allow interactions with the system and was not validated within SESAR. Due to this fact it was originally not planned to address this objective. As there have been some questions regarding the objective in the questionnaire results are presented here.

In general, the participating controllers evaluated the effectivity of manual route modifications as mostly and rather ok.



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
The manual modification of routes was effective	7,1	28,6	28,6	14,3	21,4	0,0

Figure Appendix E-6: Controller Response to Routes' Relevance - Hamburg (in nominal situations)

The following results can be obtained

- The modification function itself was rated positive. The algorithm responded correctly with the requested routing updates. However; regarding the usability of the HMI areas for improvement have been identified.
- The interaction with the system requires more training and knowledge of the function. This is related to the time available for familiarization and the HMI status itself.
- The HMI of the CWP did not allow modifying the route after a given clearance (wrongly defined). Thus, the route modification capabilities were limited. Additionally, the nature of passive shadow-mode trials (and the issue with the wingspan of the Boeing 757-300 already described in chapter E3.4.1.a) led to more route modifications than expected in active shadow-mode trials or real operations. These issues negatively impacted the usability of manual route modification capabilities with real surveillance data.
- Route modification between tower and apron controller needs to be coordinated due to different areas of responsibility.
- Especially for arrivals the adaption of routes by the apron controller with the shadow mode setup was very difficult, as taxi distances and times are very short.

Based on the questionnaire item it can be concluded that the manual route modification functionality is POK.

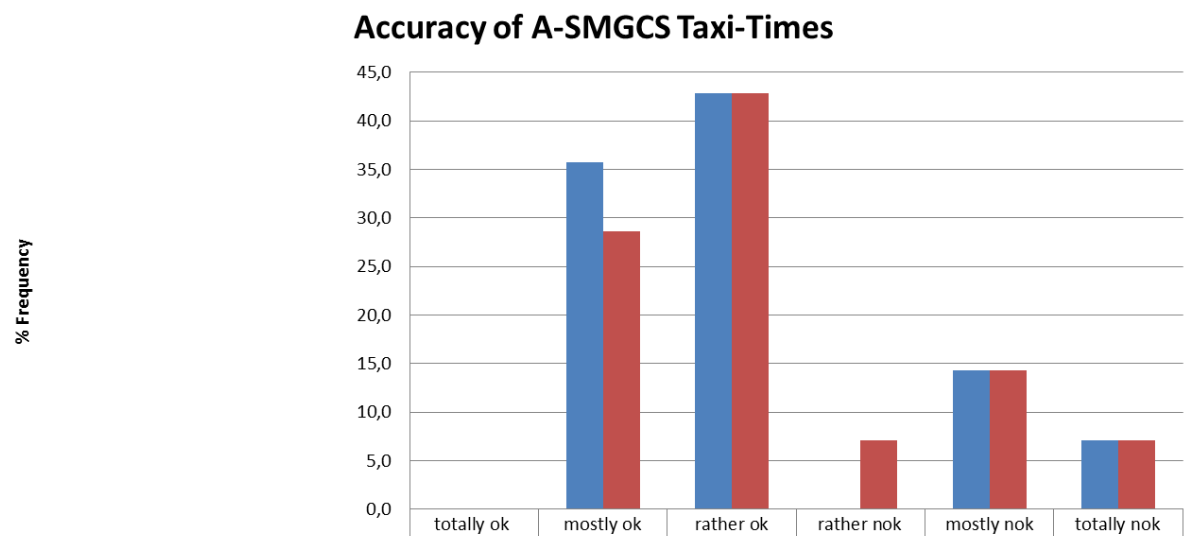
Improvements of the HMI, corrections in the implementation, when a route can be changed as well as training are related to the specific situation for the Hamburg Exercise.

In general it can be expected that the number of modification should be reduced without shadow mode operations.

E3.4.3 EX5-OBJ-VLD-28-003 Taxi Time Accuracy

E3.4.3.a EX5-CRT-VLD-28-003-001: Positive evaluation of the A-SMGCS taxi time with respect to the actual taxi time from off-block to runway holding point

The following Figure Appendix E-7 presents the feedback from the controllers regarding the accuracy of the taxi time:



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
The taxi times of aircraft appeared optimal to the best of my knowledge:	0,0	35,7	42,9	0,0	14,3	7,1
The planned taxi times of aircraft appeared accurate to the best of my knowledge	0,0	28,6	42,9	7,1	14,3	7,1

Figure Appendix E-7: Taxi Time Accuracy - Hamburg (in nominal situations)

The accuracy of A-SMGCS taxi times were considered as rather acceptable by the participants. However analysis of the recorded data and the observations and remarks regarding pushback procedures already described in chapter E3.4.1.a have to take into account for the assessment of the criterion. Measured taxi times have been compared to real taxi time processes.

The following assumptions during the data analysis have been made:

- For the real ground movement processes clearances and A-CDM milestones have been used. Recorded screen videos have been used to verify movements of the aircraft vs recorded timestamps.
- The Pushback procedure was defined from Off-Block to Taxi begin time.
- The Taxi procedure was defined from Taxi begin time to Actual Line Up.

Some of the movements where filtered out

- Movements with taxi times lower than 10 seconds, were the A-CDM time stamps may have been set incorrectly.
- Movements where the system prototype obviously miscalculated plans due to data or algorithm errors.

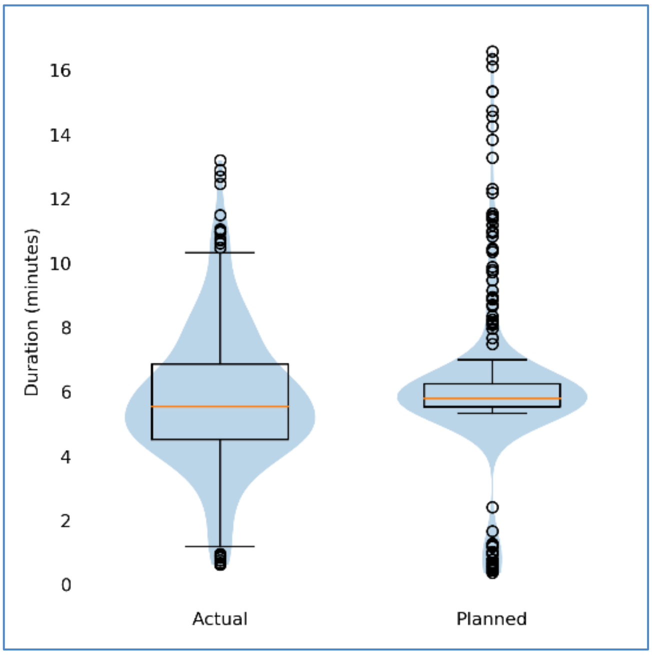


Figure Appendix E-8: Distribution of actual and planned duration from off-block to line-up for 403 departure flights.

While the average taxi times were close to the planned ones, the uncertainty cannot be sufficiently reflected in the prediction, as shown in Figure Appendix E-8. For solution #53 a high accuracy of taxi times is needed for every single flight, as even small variations in the taxi times may change the sequence towards the runway. The taxi time is not only dependent on the route taken, but it seems that there are various other influential factors.

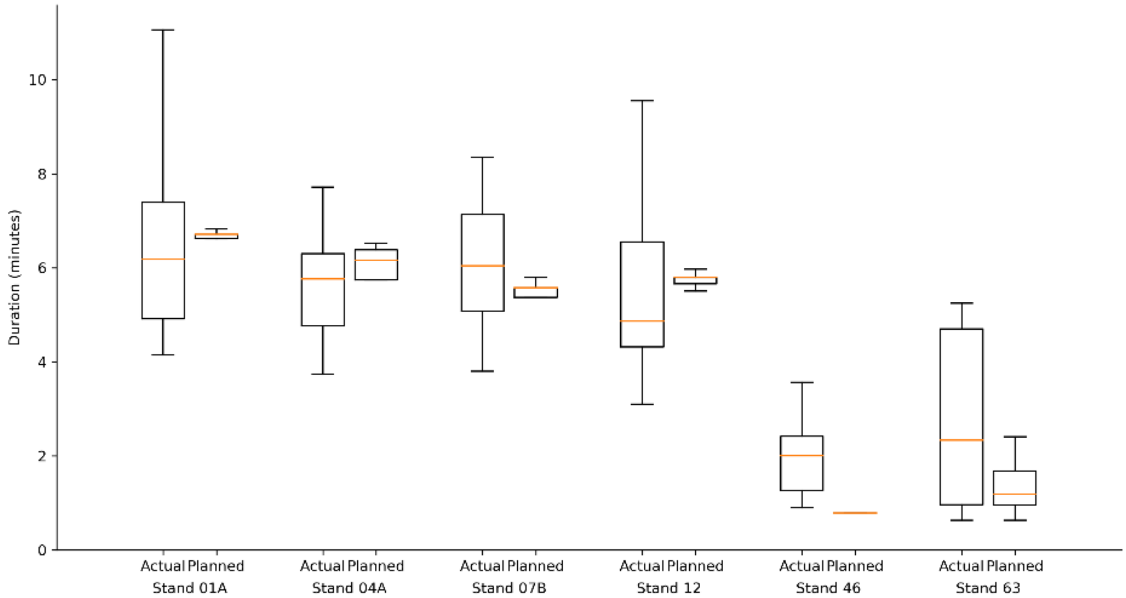


Figure Appendix E-9: Distribution of actual and planned duration from off-block to line-up for selected stands, 112 departure flights.

In Figure Appendix E-9 we have analysed selected stands that were utilized often such that we obtained a big enough sample. As all this traffic departed on Runway 33, the routes from the stands to the runway were usually the same. However, as the figure shows, there is a large variation per stand in actual taxi times. The route alone does therefore not explain well enough the variations in time. Figure Appendix E-10 shows the frequency, at which deviations of the predicted time from the actual taxi time occurred.

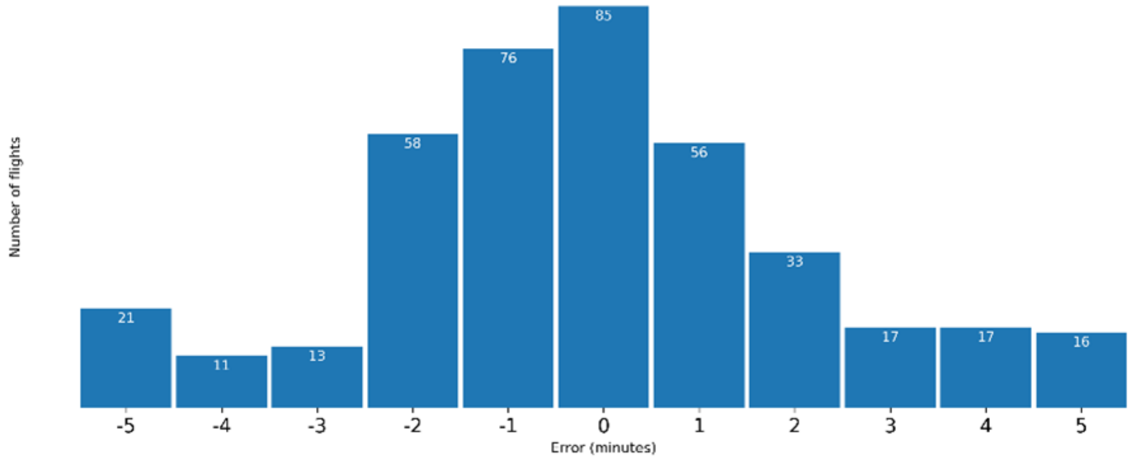


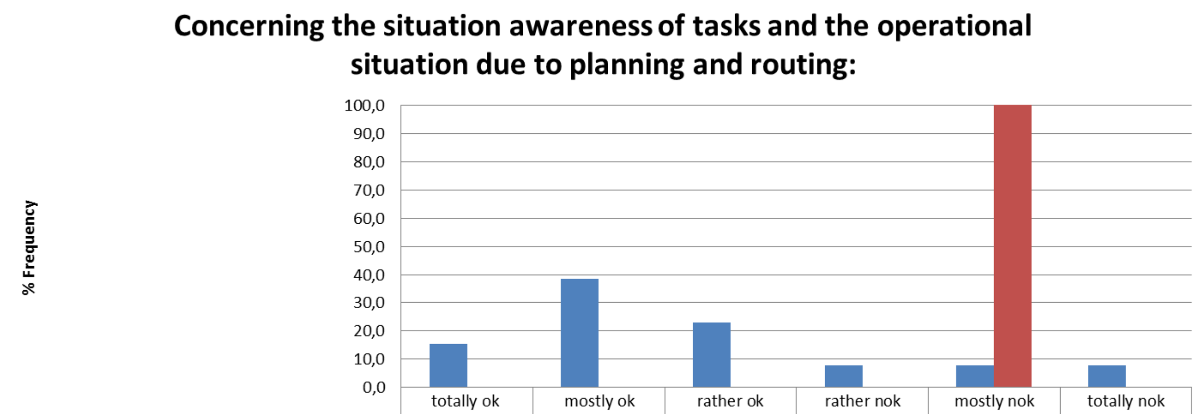
Figure Appendix E-10: Distribution of actual and planned duration from off-block to line-up for selected stands, 112 departure flights.

Out of a sample of 403 flights, 85 have been predicted within +/- 30 seconds of the actual taxi out time. Out of this sample, the prediction of the taxi time was off 1 minute and 58 seconds (mean absolute error), this is 34% of the average taxi time.

Therefore, the criterion EX5-CRT-VLD-28-003-001 is rated NOK.

E3.4.4 EX5-OBJ-VLD-28-005 Situational Awareness for routing and planning functions

E3.4.4.a EX5-CRT-VLD-28-005-001: Positive evaluation of the situational awareness of Ground Controllers due to the integration and operation of routing and planning functions



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
I (Apron Controller) have maintained a sufficient level of situation awareness	15,4	38,5	23,1	7,7	7,7	7,7
I (Tower/Ground Controller) have maintained a sufficient level of situation awareness	0,0	0,0	0,0	0,0	100,0	0,0

Figure Appendix E-11: Controller Responses to SA due to Routing Operations - Hamburg

Apron controller rated SA on an acceptable level. However there is a change in operations as the focus much more on the HMI then the outside view which distracts them partially from their tasks.

- The shadow-mode had influence here, as the controllers basically followed the decisions made by the active controller. The situation awareness was influenced by the fact, that controllers had their own planning and needed to adapt to the operational decisions.
- Apron controllers spent much more time interacting with the HMI than they would normally.do with their current systems.
- The adaption of the routings in case of changes on short notice (to align the system with the real situation) is too time consuming and retracts the controllers from their tasks. The used HMI had also limitations here.

However, the Apron controller agreed that they have maintained a sufficient level of situation awareness.

The tower controller rated the function as not ok as the distraction from the tasks was too significant.

This feedback helps to conclude that the criterion EX5-CRT-VLD-28-005-001 can be rated as POK.

E3.4.4.b EX5-CRT-VLD-28-005-002: Positive evaluation of the situational awareness of Runway controllers due to the A-SMGCS planning and routing functions

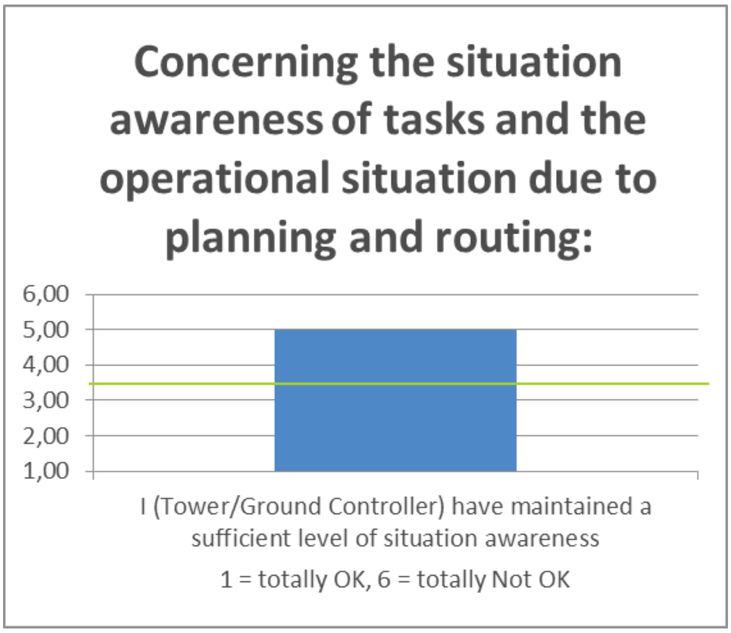


Figure Appendix E-12: Taxi Tower Controller Response to SA due to Routing Operations - Hamburg

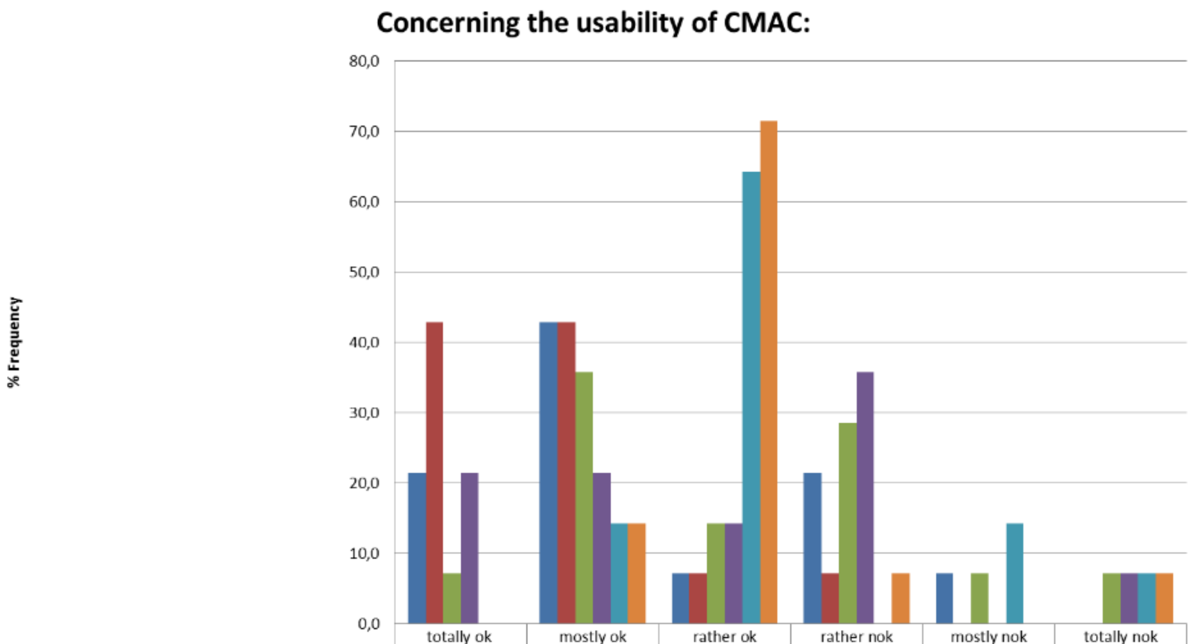
Only one tower controller took part in the demonstration, therefore no standard deviation is depicted in the figure above. The tower controller was mostly not ok with the statement "I have maintained a sufficient level of situation awareness". This may be due to the short familiarization and demonstration time (about 1 hour) he was able to use the system. Note that his evaluation is also depicted in Figure Appendix E-11 (the red bar).

As only one tower controller was asked, the answer to this question and the criterion EX5-CRT-VLD-28-005-002 cannot be assessed in a sound and proper way. To interpret answers to questionnaire items and draw validate conclusions, it is important to have sufficient answers from different participants. Answers from individual participants cannot be generalized to the population.

The criterion EX5-CRT-VLD-28-005-002 is therefore N/A

E3.4.5 EX5-OBJ-VLD-28-009 Utility of CMAC functions

E3.4.5.a EX5-CRT-VLD-28-009-001: Positive evaluation of the utility of CMAC functions when real surveillance data is used



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
The readability of CMAC was effective	21,4	42,9	7,1	21,4	7,1	0,0
I could effectively understand the meaning of CMAC labels	42,9	42,9	7,1	7,1	0,0	0,0
Interactions with the CMAC alerts were effective	7,1	35,7	14,3	28,6	7,1	7,1
The route deviation alerts are useful	21,4	21,4	14,3	35,7	0,0	7,1
Compared to my normal operation shifts I need less time to monitor for conformance with the given clearances using the PJ28 solutions	0,0	14,3	64,3	0,0	14,3	7,1
Because of the PJ28 solutions the conformance monitoring is improved	0,0	14,3	71,4	7,1	0,0	7,1

Figure Appendix E-13: Usability of CMAC - Hamburg

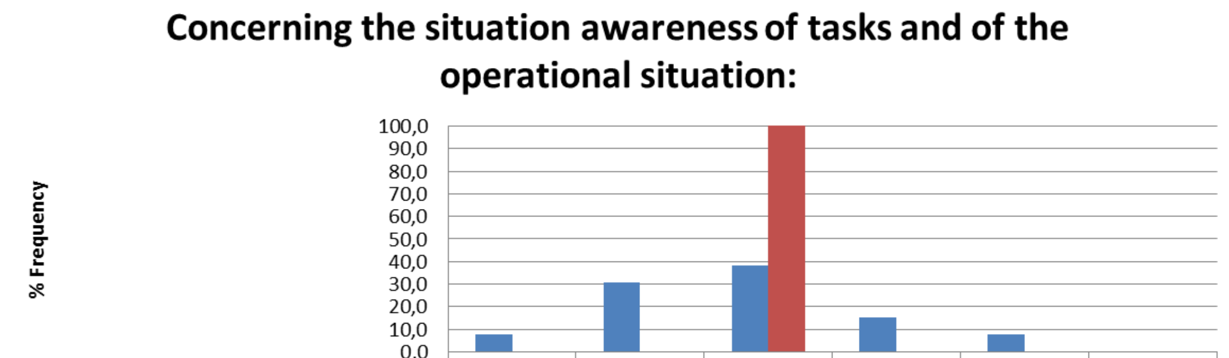
In general, the participants considered the usability of CMAC alerts as positive and there was slight agreement that the controller need less time for conformance monitoring with PJ28 solutions compared to their normal work and their conformance monitoring would improve.

- Route deviations have been triggered because of used pushback procedures that were not planned correctly by the algorithm. This happened, when aircraft have been pushed back into other taxi lanes and started their taxi procedure from there.
- Tuning of route deviation alert was very complex in hotspot areas, which lead to some delays in the alert display.
- The audio alarm was not implemented in the Demosystem, but was mentioned as maybe helpful by a controller.

Therefore, the criterion EX5-CRT-VLD-28-009-001 is POK.

E3.4.6 EX5-OBJ-VLD-28-015 CMAC controller situational awareness

E3.4.6.a EXE5-CRT-VLD-28-015-001: Positive evaluation that the situational awareness of Ground controllers due to the integration of CMAC is improved



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
I (Apron Controller) maintained an acceptable situation awareness during the management of CMAC	7,7	30,8	38,5	15,4	7,7	0,0
I (Tower/Ground Controller) maintained an acceptable situational awareness during the management of CMAC	0,0	0,0	100,0	0,0	0,0	0,0

Figure Appendix E-14: Ground Controller SA of CMAC - Hamburg

Note that in this Figure the Tower controller is also shown as red bar.

The necessity to check and update the system (clearances, routing, safety net) require mental resources more often than it would be expected in operational conditions (not passive shadow-mode). This was also expressed by the lack of time for GROUND controllers to observe real traffic through the window since their attention was tunnelled by the HMI. This was mentioned by the controllers. It is therefore assumed that the controllers had difficulties to differentiate between the special situation of passive shadow mode and the normal situation awareness they would have in real operations.

There are some shortcomings of the system in terms of handling alerts generated by the system. The used Touch Display and the size of the windows to handle alerts (acknowledge and clearing) was rated sometimes difficult and influenced the feedback.

Despite that, the Apron controller agreed that they have maintained a sufficient level of situation awareness due to the integration of CMAC alerts. This feedback helps to conclude that the criterion EX5-CRT-VLD-28-015-001 is POK.

E3.4.6.b EX5-CRT-VLD-28-015-002: Positive evaluation that the situational awareness of RUNWAY controller due to the integration of CMAC is improved

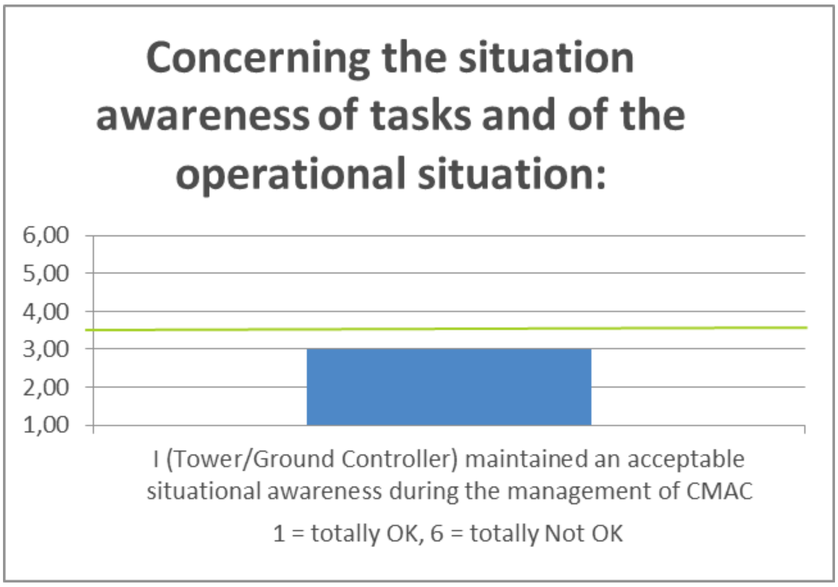


Figure Appendix E-15: Tower Controller SA of CMAC - Hamburg

Only one tower controller took part in the demonstration, therefore no standard deviation is depicted in the figure above. The tower controller was rather ok regarding the situational awareness due to CMAC alerts. This may be due to the short familiarization and demonstration time (about 1 hour) he was able to use the system. Note that the evaluation of the Tower controller is also shown in Figure Appendix E-14 of CRT-VLD-28-015-001.

As only one tower controller was asked, the answer to this question and the criterion EX5-CRT-VLD-28-015-002 cannot be assessed in a sound and proper way. To interpret answers to questionnaire items and draw validate conclusions, it is important to have sufficient answers from different participants. Answers from individual participants cannot be generalized to the population.

The criterion CRT-VLD-28-015-002 is therefore N/A

E3.4.7 EX5-OBJ-VLD-28-018 Utility of DMAN functions

E3.4.7.a EX5-CRT-VLD-28-018-001: Positive evaluation of the utility of the DMAN function supported by route planning

The DMAN supported by routing and planning functionalities were used to calculate TTOT and TSAT as well as the sequence at the runway based on the availability of taxi route.

Due to the fact that at Hamburg Airport a pre-departure sequencing is already implemented timings where available from the operational systems.

Despite the fact that the ground controller was not part of the demonstration exercise, each demonstration participant had the opportunity to compare the real pre-departure sequence with the VLD-system calculated sequence including updated timings. Therefore, each participant answered the following questionnaire after the hands-on session.

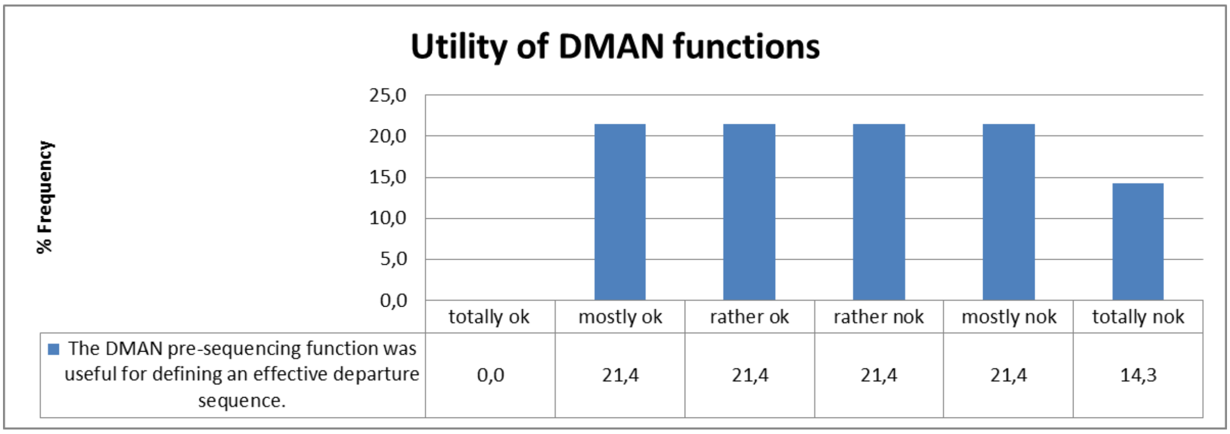


Figure Appendix E-16: Utility of DMAN functions - Hamburg

The following results have been obtained:

- TSATs of the PJ28 system have been updated according to the traffic situation and updated flight plan information, so the function itself worked based on available real data.
- Ground controller are not responsible for runway sequence planning, therefor take the given TSAT for their operation.
- During the runs traffic was not extremely high, so the timings where not critical and controller did not pay high attention to it.
- Due to shadow mode the VLD controller could not act to the proposed sequence and TSATs because the real controller operated based on the real system times.
- The controller used the various runway entries to have more flexibility on the runway sequence.

As the core of this criterion was not part of the tasks of the participating controllers, the utility of its functions could not be appropriately demonstrated.

The criterion CRT-VLD-28-018-001 is therefore N/A

E3.4.8 EX5-OBJ-VLD-28-021 Situational awareness DMAN (supported by route planning)

E3.4.8.a EX5-CRT-VLD-28-021-002: Positive evaluation that the situational awareness of GROUND controller due to DMAN function supported by route planning is improved

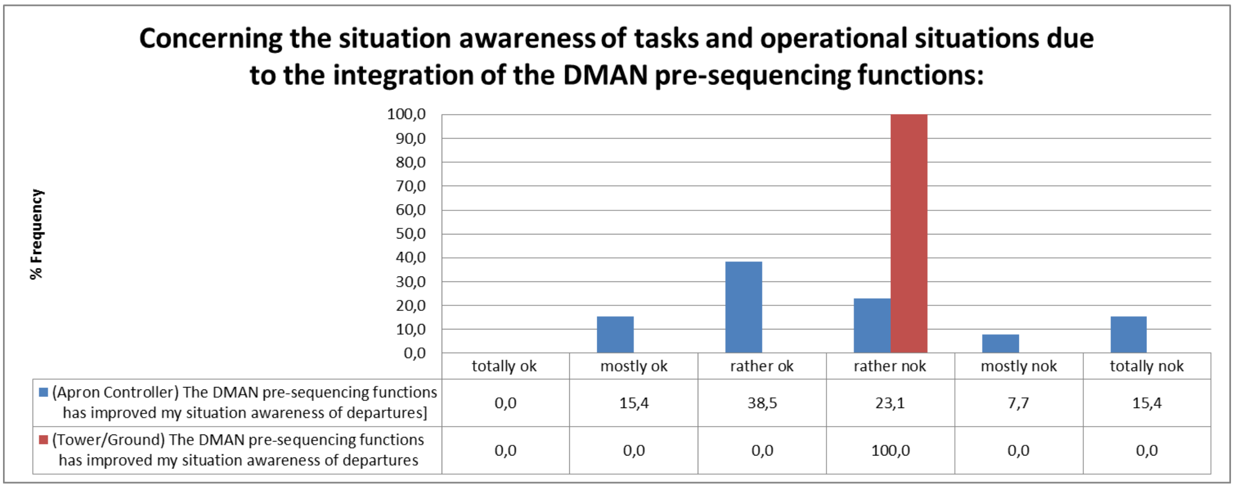


Figure Appendix E-17: SA due to DMAN integration Ground Controller- Hamburg

Note that in this Figure the Tower controller is also shown as red bar.

The Apron Controllers considered their situation awareness due to DMAN functions supported by route planning as acceptable. Neither an improvement nor deterioration has been noticed by the Apron Controllers. As they have the information already available by the operational A-CDM system including the pre-departure sequencer, no significant difference in the SA could be demonstrated.

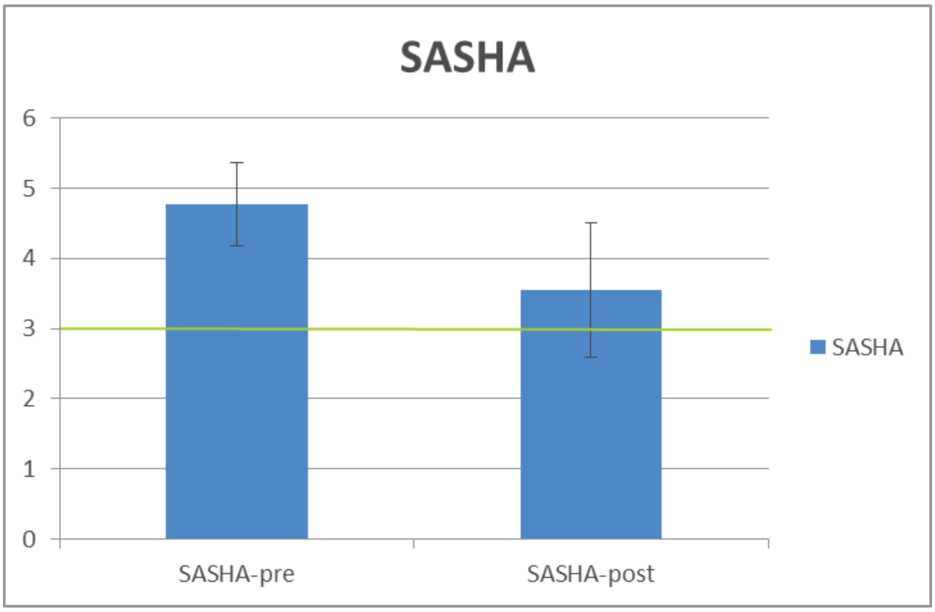


Figure Appendix E-18: SA due to DMAN integration Ground Controller SASHA questionnaire - Hamburg

The used scale for the questionnaire’s answers is as follows:

Scale	0	1	2	3	4	5	6
	never	seldom	sometimes	often	more often	very often	always

The Situation Awareness for SHAPE (SASHA) questionnaire provides an index of operators' situation awareness based on a seven point Likert scale ranging from 0 ("never") to 6 ("always"). The results obtained here are between 3,5 (post) and nearly 5 (pre), showing generally acceptable situation awareness. However, participants rated their situation awareness as better in a normal shift without the PJ28 solutions (SASHA-pre) compared to their rating while using the PJ28 solutions (SASHA-post). Despite the still positive values for the PJ28 solution, a decline in the ratings can be observed. This may be caused by the short time the participants had to familiarize themselves with the new controller working position and the new solutions. The short interaction time was mentioned multiple times in the debriefing and should be considered in future passive shadow-mode trials.

In addition the availability of the operational and the PJ28 values at the same time could be a factor for rating the solution system sometimes more demanding than in their normal shift

The criterion CRT-VLD-28-021-002 is therefore NOK

E3.4.8.b EX5-CRT-VLD-28-021-003: Positive evaluation that the situational awareness of RUNWAY controller due to DMAN function supported by route planning is improved

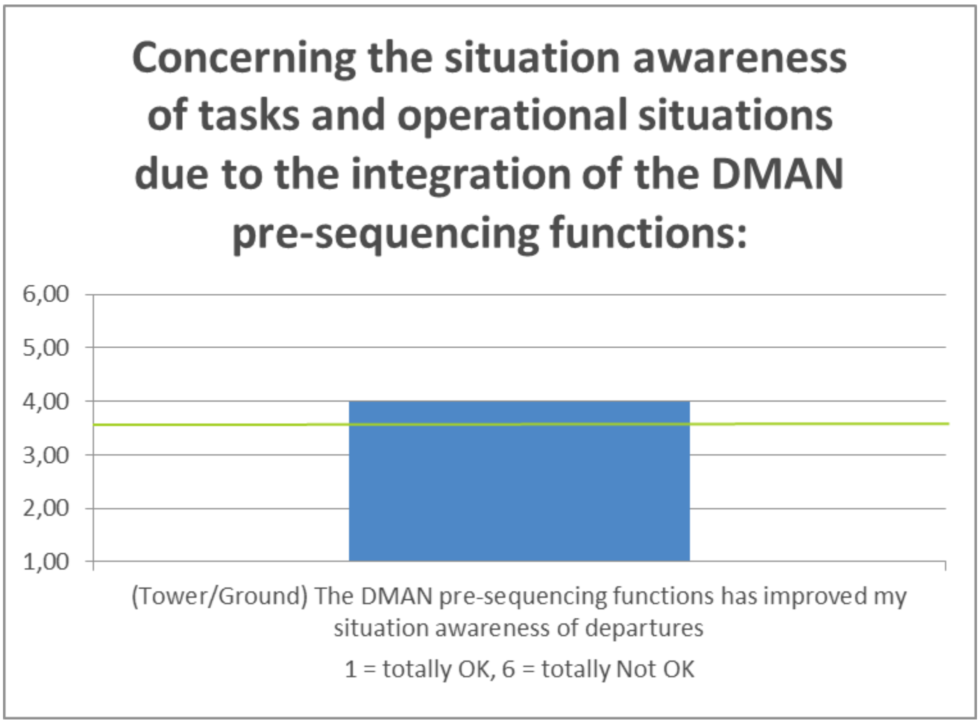


Figure Appendix E-19: SA due to DMAN integration – Tower Controller - Hamburg

Only one tower controller took part in the demonstration, therefore no standard deviation is depicted in the figure above. The tower controller was rather not ok regarding the situational awareness due to DMAN functions supported by route planning. Note that the evaluation of the Tower controller is also shown in Figure Appendix E-17 of CRT-VLD-28-021-002.

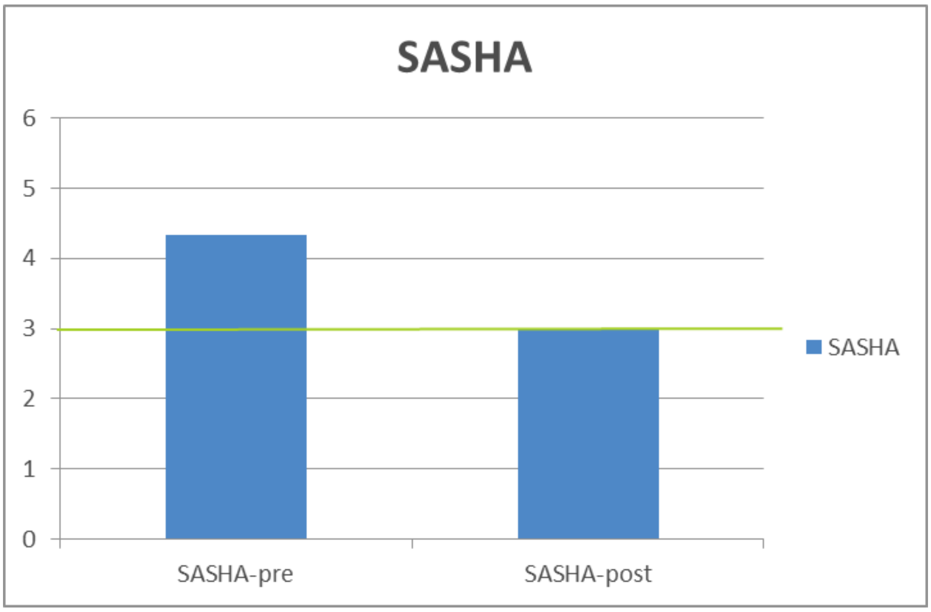


Figure Appendix E-20: SA due to DMAN integration Tower Controller SASHA questionnaire - Hamburg

The Situation Awareness for SHAPE (SASHA) questionnaire provides an index of operators' situation awareness based on a seven point Likert scale ranging from 0 ("never") to 6 ("always"). The results obtained here are between 3,0 (post) and 4,3 (pre), showing a medium to acceptable situation awareness. However, participants rated their situation awareness as better in a normal shift without the PJ28 solutions (SASHA-pre) compared to their rating while using the PJ28 solutions (SASHA-post).

This may be due to the short familiarization and demonstration time (about 1 hour) he was able to use the system. Additionally, the same reasoning as for EX5-CRT-VLD-28-018-001 can be applied here.

As only one tower controller was asked, the answer to this question and the criterion EX5-CRT-VLD-28-021-003 cannot be assessed in a sound and proper way. To interpret answers to questionnaire items and draw validate conclusions, it is important to have sufficient answers from different participants. Answers from individual participants cannot be generalized to the population.

The criterion CRT-VLD-28-021-003 is therefore N/A

E3.4.9 EX5-OBJ-VLD-28-022 Integration of routing and planning functions, airport Safety Nets and DMAN functions

E3.4.9.a EX5-CRT-VLD-28-022-001: Positive evaluation of the integration of routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning

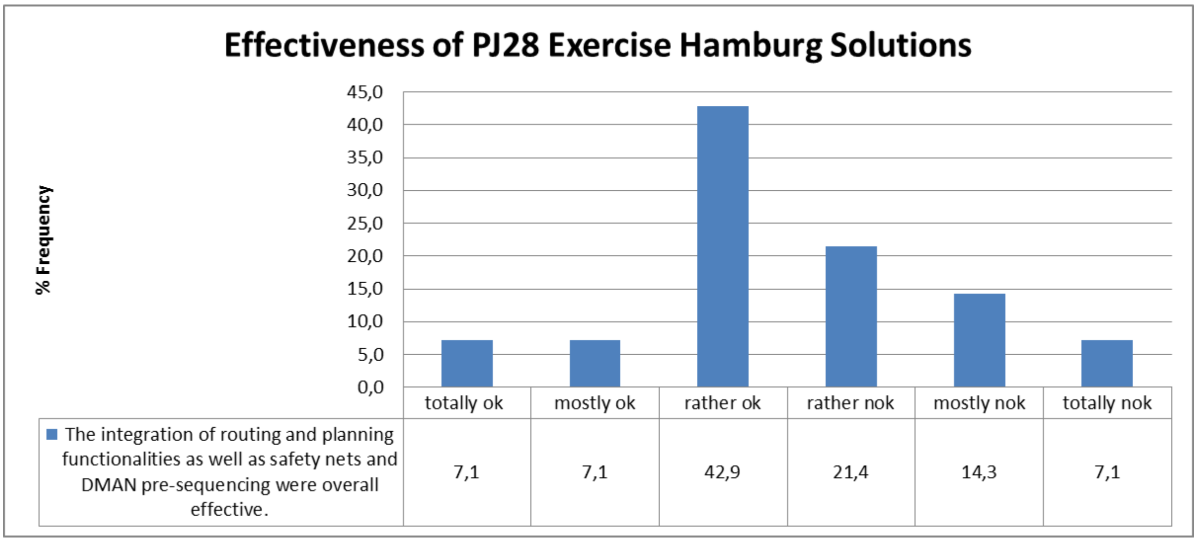


Figure Appendix E-21: Effectiveness of PJ28 solutions - Hamburg

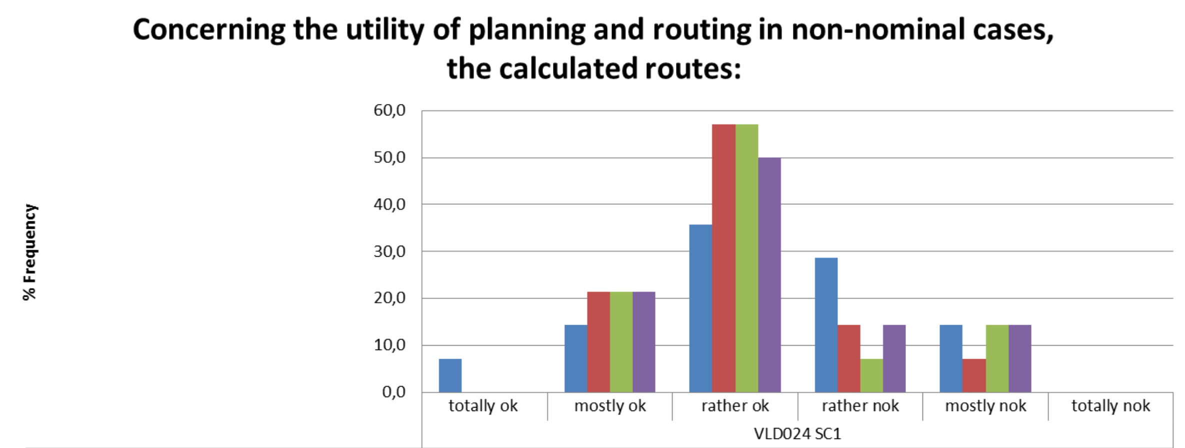
- The participants considered the effectiveness of the PJ28 Exercise Hamburg Solutions as neutral to rather ok.
- While Routing and planning as well as safety net functions have been rated POK, the DMAN functions could not be demonstrated.
- The HMI had an impact on the functions, as some fields were rated too small for the touch interaction.
- The solutions could not be tested in a wide variety. Feedback was given, that the solutions needed to be tested and evaluated in high traffic situations.
- Typical operations like flexible pushback procedures need to be implemented.

Therefore, criterion EX5-CRT-VLD-28-022-001 is POK.

E3.4.10 EX5-OBJ-VLD-28-024 Routing and Planning Function non-nominal

E3.4.10.a EX5-CRT-VLD-28-024-001: Positive evaluation of the calculated routes conforming to operational needs/rules for managing surface operations in case of specific events (e.g. taxiway closure)

Non-nominal conditions were induced by the VLD technical team during the VLD in order to demonstrate the capabilities in non-nominal conditions (e.g. taxiway closure).



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
Conformed to the operational constraints at Hamburg	7,1	14,3	35,7	28,6	14,3	0,0
Were representative of the usually given routes at Hamburg	0,0	21,4	57,1	14,3	7,1	0,0
Conformed to operational needs at Hamburg	0,0	21,4	57,1	7,1	14,3	0,0
Conformed to operational rules at Hamburg	0,0	21,4	50,0	14,3	14,3	0,0

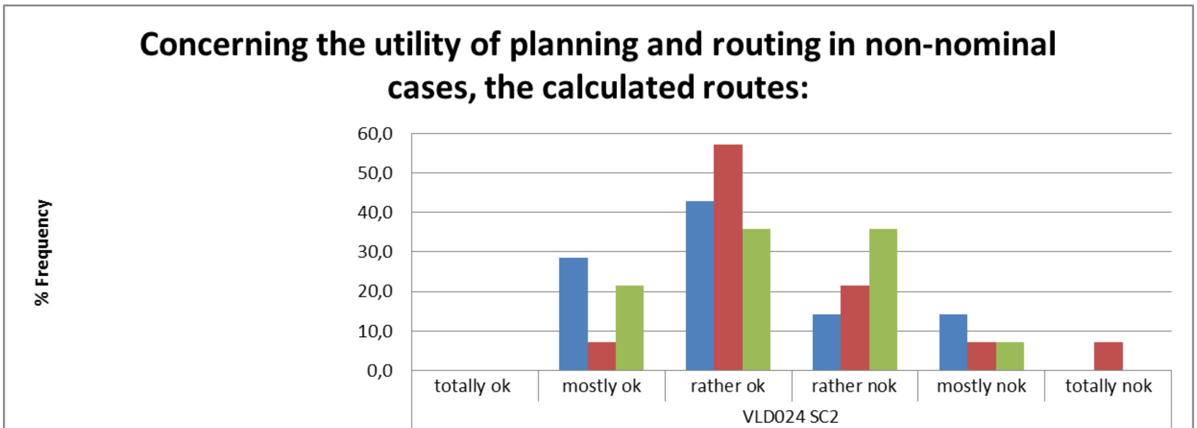
Figure Appendix E-22: Utility of planning and routing in non-nominal cases - Hamburg

The controllers considered the utility of the calculated routes in non-nominal cases as rather ok for all four items.

- The system reacted quickly and correct in the given situation
- To give a more significant answer other non-nominal situations and the system reaction should be demonstrated (no detailed feedback which situation should be covered)
- The traffic load was low, so it could not be assessed whether the system is still capable to handle more complex situations

Therefore, the criterion EX5-CRT-VLD-28-024-001 is POK.

E3.4.10.b EX5-CRT-VLD-28-024-002: Positive evaluation of the calculated routes' relevance in case of specific events (e.g. taxiway closure)



	totally ok	mostly ok	rather ok	rather nok	mostly nok	totally nok
Are relevant (e.g. regarding time horizon, correct start and end point,...)	0,0	28,6	42,9	14,3	14,3	0,0
Helped me to adhere to the pre-departure sequence	0,0	7,1	57,1	21,4	7,1	7,1
Are efficient	0,0	21,4	35,7	35,7	7,1	0,0

Figure Appendix E-23: Utility of planning and routing route relevance in non-nominal cases - Hamburg

The majority of controllers considered the utility of the calculated routes in non-nominal cases as relevant and efficient.

Therefore, the criterion EX5-CRT-VLD-28-024-002 is POK.

E3.5 Unexpected Behaviours/Results

No specific unexpected behaviour was encountered.

E3.6 Confidence in the Demonstration Results

E3.6.1 Level of significance/limitations of Demonstration Exercise Results

Availability of staff

Only one tower controller took part in the exercise. There was a risk from the beginning on the availability but despite a lot of effort to cover it, only one controller could be scheduled. The original plan to cover both positions with dedicated Controllers for the exercise runs could not be achieved. If no tower controller was available technical expert with operational knowledge acted as a tower controller. Therefore, tower controller specific question have to be interpreted with caution. To interpret answers to questionnaire items and draw validate conclusions, it is important to have sufficient answers from different participants. Answers from individual participants cannot be generalized to the population.

Shadow Mode

There is a clear impact from the shadow mode setup. As controllers acted based on the real instructions on the operational controller, very often additional workload was induced. Especially on route planning, where controller changed the route more often to comply with the real outside situation. It can be expected, that this would be limited if they are in charge and prepare and work on their own planning. This has to be kept in mind, especially by interpreting the results of workload and situation awareness related questions.

In addition the DMAN functionalities are affected, as the calculations by the PJ28 system have not been taken into account.

HMI

The used HMI was adapted to operate the solutions provided by SINTEF. It was not validated as a controller working position and had limitations on features and usability. This needs to be taken into account in terms of usability, workload and situation awareness feedback.

Process coverage

There are limitations with regard to the coverage of non-nominal situations and other operations at the airport

- No coverage of Towing operations: There are towing operations that influenced the routing and planning. This was not demonstrated in the Exercises
- Some manoeuvres, like Go-around, aborted take-off or return to stand have not been demonstrated during the exercise.
- Pushback Process: The process was implemented as a standard process with one Pushback end point on the airport Layout. The high number of different procedures used by the Hamburg controllers could not be implemented. These procedures are not published and have a high variation

Traffic situation

The available time slots for the exercise runs had to be adapted to the availability of controllers. Despite carefully balancing the exercise schedule prior to the demonstration to ensure that as many different traffic situations as possible could be observed over the exercise week, some very high traffic situations could not be covered. To give a full feedback on the solutions controllers would have needed to test it in these situations. The answers of controllers are therefore based on their experience in that specific situation with that traffic load. Their feedback therefore reflects only a limited set of traffic situations and may not be generalised to other traffic situations.

Airport Layout

Hamburg Airport has a layout with very short taxi distances and only a limited number of options. Very short reaction times, when aircraft enter the apron.

E3.6.2 Quality of Demonstration Exercise Results

This section describes all issues concerning the quality of the results achieved in the Demonstration Exercise #01. In that regard quality could refer to both the accuracy of results and the confidence in the results, which might be influenced by decisions, constraints, and assumptions made at exercise level.

As is the case with all demonstration exercises, only a very limited set of exercises could be performed, due to the limited duration of demonstration trial days and the availability of the supporting demonstration platform. This results in a limited set of observable traffic situations. Regarding the quality of the results it can therefore be stated that the results are based on realistic demonstrations on a (passive-shadow mode) live system in a real airport environment with very experienced participants and hence the results can be considered to be of high quality from an operational point of view. However, only a limited set of non-nominal conditions and a limited set of traffic situations could be observed by each participant and therefore the results cannot easily be generalized.

E3.6.3 Significance of Demonstration Exercises Results

As only one tower controller took part in the exercise criteria related to the RWY position cannot be assessed in a sound and proper way. To interpret answers to questionnaire items and draw validate conclusions, it is important to have sufficient answers from different participants. Answers from individual participants cannot be generalized to the population.

For the Apron Controller part 13 different controllers took part, so conclusions can be drawn and descriptive statistics have been performed. However it has to be stated, that for inferential statistics and deriving significant results a much larger number of controllers would be necessary. As only a limited number of controllers are available in general for Hamburg airport, the 14 participants are nevertheless representative.

8 sessions have been conducted of the period of one week with typical traffic. From an operational viewpoint, the exercise is representative in terms of traffic situations in the observed time frame.

8 sessions have been conducted of the period of one week with typical traffic.

- Sessions have been conducted during the same periods at the days. 4 Sessions in the morning and 4 sessions in the afternoon. Therefore the results are comparable between the days, but traffic situations outside these time windows (morning departure peaks, evening arrival peaks) have been not part of the exercise.
- All types and sizes of traffic has been taken into account, including private jets, airline operated aircraft (small, medium, heavy), business aircraft all operating under IFR conditions. The variety of aircraft encountered ensures that the results were not biased towards a single type of aircraft.

E4 Conclusions

This section discusses and summarises the results of individual SESAR solutions under consideration for the Hamburg exercise.

Concerning Solution #22 – Automated Assistance to Controller for Surface Movement Planning and Routing the following.

Controllers evaluated the Routing and Planning function neutral; however, the answers showed high variability. Discussions taking place in the route workshop, the results from this workshop, and feedback during the exercise supported the ambivalence.

- We found that the notion of the efficient (or optimal) route is misleading because it omits the complexity of defining the criteria in what regards optimality should be achieved. On the quite constricted apron of Hamburg airport, we observed that controllers often preferred different routes to the proposed ones because they offered increased flexibility in reacting to uncertainty. Furthermore, flexibility and conflict resolution has been also achieved by varying the timing, utilizing custom push-back procedures, and choosing one of several feasible runway entry points, these were decisions that were not made by the system prototype during the demonstration.
- However, the results indicate that in non-nominal conditions the routing and planning function was evaluated more positive. In this situation this function supported the controllers with relevant and efficient routes.
- Due to the close-to-real nature of the demonstration, the system was confronted with situations that have not been experienced in earlier trials, induced by a frequently changing airport layout and aircraft types currently not registered in the used aircraft performance data base. This sometimes resulted in routes not conforming to the rules at Hamburg airport.
- The runways in Hamburg offered the opportunity to choose different runway entries for increased flexibility in sequencing the departures. There was no logic included that would automatically determine the runway entry. Thus, the routes needed to be adapted and led to increased workload.
- There are no defined standard routes. Even there are some best practices almost all controllers operated slightly differently – this is reflected by the high variation in the answers to the questionnaires and in the workshops
- Due to the layout and limited routing options, the routing and planning function might not be relevant as a separate function for the specific case in Hamburg and will likely not bring significant benefits.
- Handover between Tower and Apron is done by dedicated Handover Points which have been taken as constraints for the calculations. In some situations there is short voice coordination if a deviation from this standard procedure is possible or not. Adaption of the Handover Point was then inserted into the system –sometimes delayed or not updated which caused incorrect planning.

Due to the layout and limited routing options, the routing and planning function might not be relevant as a separate function for the specific case in Hamburg and will likely not bring significant benefits. However, the discussion of the three demonstrated solutions needs to be understood in a more holistic perspective. Solution #22 is a prerequisite for solutions #53, #02 and other solutions that have been not under investigation in this exercise. Therefore, the results cannot be viewed isolated.

As long as managing the taxi routes is in the controller's responsibility, in our view a well-working routing and planning function needs to be a combination of automatic route calculation that can cover the basic load and an easy, quick, and flexible possibility for the controller to adapt routes to her or his need

Concerning solution *#53 – Pre-departure sequencing supported by route planning*.

As in this exercise no ground controllers were involved, we were not able to demonstrate the utility of the solution. However, the participants (Apron and Tower Controller) had the opportunity to compare the real pre-departure sequence with the PJ28 prototype. The feedback was mixed, but in average neutral rating which can be related to the already available information.

The expected benefit, by replacing the variable taxi time matrices by taxi times calculated by the routing and planning function could not be demonstrated. The calculated taxi times differed from the real taxi times. The solution is based on the availability of accurate taxi times which could not be proven during the trials at Hamburg.

It could be observed, that taxi times are not only dependent on aircraft type and airport layout (straight segments, turns), but also on company procedures, traffic situation, pilots behaviour (experience, airport knowledge). These factors are very hard to be covered in algorithms and system parameter values.

Pushback procedures (including taxi preparation) are an essential part of the taxi time. It was discovered that there is a high variability also in these procedures, hardly to be implemented into algorithm parameters.

Concerning *Solution #02 – Airport safety nets*

For the Hamburg Exercise only the conformance monitoring as part of the Safety Nets has been addressed.. According to their feedback, they maintained an acceptable situational awareness during the management of CMAC.

However, during the implementation of this solution we experienced issues with the quality of the surveillance data in some areas, such that triggering the alarms based only on the raw data was not feasible. We developed therefore algorithms that considered additional information such as the airport network, or information from the Stand Entry Guidance system. That can increase confidence over time as new measurements come in. As the positional data contained noise, the system needs sometimes several measurements to increase the confidence that a deviation has happened. Inaccurate data either leads to false alarms or a late triggering of the alarm, depending on the confidence threshold set for triggering the alarm.

E5 Recommendations

E5.1 Recommendations for industrialization and deployment

General recommendations applicable to all solutions

(EX5-RECOM-VLD-28-001) Implement a master data management strategy for airport related data like airport layout, stands and operational constraints.

Recommendations applicable to Solution #02 – Airport Safety Nets for Controllers

(EX5-RECOM-VLD-28-002) Consider increasing the accuracy of positional data: Because positional data always includes some noise, the system needs sometimes several measurements to increase the confidence that a deviation has happened. In some areas we experienced a very low accuracy of positional data. Inaccurate data either leads to false alarms or a late triggering of the alarm, depending on the confidence threshold set for triggering an alarm. In order to prevent false, nuisance, or late alerts, the accuracy of positional data needs to be increased.

(EX5-RECOM-VLD-28-003) Integrate data from different sources with varying availability and accuracy. Combination and cross-verification from multiple sources can increase the confidence level. For the "no push back approval" alert, for example, we combined both the high accuracy data from the Stand Entry Guidance System, if available, with lower accuracy surveillance data.

Recommendations applicable to Solution #22 – Automated Assistance to Controller for Surface Movement Planning and Routing

(EX5-RECOM-VLD-28-004) Revisit objective for calculating routes. The route minimizing taxi time is often not the best route. Flexibility and management of uncertainty should play a role in route selection and is a much more complex topic than initially thought.

(EX5-RECOM-VLD-28-005) Include routes aircraft towing from one stand to another (without callsign).

(EX5-RECOM-VLD-28-006) Include all relevant information from the operational database to construct routes. In Exercise #05, for example, the handover points between apron and ground controller are input by the controller as of today. They needed to be included into the route. In a further step, Solution #22 may provide this handover point automatically.

(EX5-RECOM-VLD-28-007) Ensure operational data accuracy. For the routing data accuracy from the operational database is crucial. This includes departure/arrival stand/runway, or hand-over points between tower and ground controllers, that have been used as information to construct routes.

(EX5-RECOM-VLD-28-008) Provide functionality for runway entry selection. If multiple runway entries are available, there should either an easy way to manually choose it for an aircraft. Optionally, an algorithm can support in making this decision.

(EX5-RECOM-VLD-28-009) Adapt the route according to the actual runway exit. For arriving aircraft, a good estimation should provide the likely runway exit for plan stability. However, the route should be automatically adjusted, when the aircraft has exited.

Recommendations applicable to Solution #53 – Pre-Departure Sequencing supported by Route Planning

Referring to the Solution #53 we want to highlight the fact that the estimated outbound taxi time is used inconsistently today, as it may include the time waiting for line-up. Solution #53 requires an accurate estimation of the expected taxi period from off-block to take-off with no buffer or delay. In the OSED, the term EXOP is proposed.

We issue the following recommendations originating from the exercise:

(EX5-RECOM-VLD-28-010) Reduce process uncertainty. We see more potential in this solution when the uncertainty connected to the involved processes (start-up, pushback, taxi) are reduced. This includes reduced window for target start-up approval (today +/- 5 minutes), and reduction of variability of taxi times by considering the implementation of Solution #47 – Guidance Assistance through Airfield Ground Lighting.

E5.2 Recommendations on regulation and standardisation initiatives

(EX5-RECOM-VLD-28-011) A central, machine-readable aircraft performance database should be established that provides the necessary data for operational constraints for taxiing. This database must provide wingspan and outer main gear wheel span and should also provide other relevant performance data as, for example, the aeroplane reference field length or wake turbulence category.

Appendix F Safety Assessment Report (SAR)

F1 Executive Summary SAR

This Safety Report includes all safety assessment activities that were developed in the PJ28 Safety Report. It evaluates the implementation of the safety activities that were set in order to guarantee a safe implementation of the demonstration without any interactions with the operational environment. The report presents the assurance that the Safety Requirements for the Very Large Demonstration are complete, correct and realistic.

F2 Introduction

F2.1 Purpose of the Safety Report

This Safety Assessment Report (SAR) is part of the Demo Report of PJ28. It evaluates the safety aspects of the exercises developed in the Safety Plan (SAP).

Safety actions have been developed in the SAP which is part of the Demo Plan. In this document, the implemented safety activities are described.

F2.2 Structure of the Safety Report

The structure of the Safety Report is as follows.

- Section 1 consists of the Executive Summary.
- Section 2 is the Introduction which includes the purpose of the SAR and its scope.
- Section 3 describes the Safety Criterion as well as the safety activities that have been implemented in order to guarantee a safe exercise implementation.

F3 Safety Activities

F3.1 Scope

In this section, the Safety Criterion (SAC) developed in the Safety Assessment Plan (SAP) and its corresponding Safety Objective (SO) as well as Safety Requirements (SR) are described.

Afterward, the achievability of the safety activities will be described. In accordance with the Safety Assessment Report (SOURCE), this section is split up in two parts. The first part consists of the general safety activities for all exercises including both external and internal safety activities. The second part describes platform related safety activities.

F3.2 Safety Criteria

The Safety Criterion, Safety Objective and Safety Requirements for the VLD are listed in the table below.

SAC	Definition	SO	Definition	SR	Definition
SAC	The operational environment will not be affected during the exercises	SO	The operational environment is shielded from the demonstration platform during the duration of the exercise	SR #1	The demonstration platform shall be implemented with a unidirectional data transmission
				SR#2	There shall be no communication between the exercise participants and the actual pilots

Table Appendix F-1: Safety Criteria

F3.3 Achievability of the Safety Criterion

F3.3.1 General Safety Activities

F3.3.1.a External Safety Activities

External safety activities include actions regarding the environment outside the demonstration platform. They shall ensure that the exercise has no direct influence on the airport operations. The external safety activities for this VLD have been:

- No test-vehicles that could have had an impact on the airport's operations were involved in the exercises. There have been no direct interactions between the demonstration and the operational environment.
- The operational staff has been informed about the exercise in advance. This action ensured the awareness about the demonstration amongst the staff.

F3.3.1.b Internal Safety Activities

Internal safety activities are provided in order to guarantee a smooth implementation of the exercise. It had to be ensured that there will be no disturbance with the operational environment during the exercise. The according internal safety activities for this VLD have been:

- An electronic access control and an additional control via the validation team to the demonstration platform have been provided. This way, any disturbance from people not participating in the exercise has been prevented.
- The validation team was responsible for the safe implementation during the demonstration. The participants were briefed before the observation by the validation team.

F3.3.2 Platform Related Safety Activities

In this section, implemented safety activities regarding communication and system interfaces that could allow the controller to interact with the operational environment are described as well as actions taken in order to prevent unintentional interactions.

All airport exercises have been performed under passive shadow mode. Systems were fed with real data from the operational systems via unidirectional data transmission. Relevant data for the implementation of the exercise were available whereas actions taken by the exercise participants during the exercise were not transmitted. This ensured that the operational environment was not affected and hence, there was no influence on the operations by the exercise.

In the following, the safety activities taken for each exercise will be described.

F3.3.2.a Demonstration Exercise #1 – Demo Nice LFMN

The experimental protocol used for the demonstration was not a live-trial as defined in the POC/VLD Risk Assessment Guide (cf. h2020-guide-execution-vld-sesar-ju_en.pdf). The approach was a shadow-mode demonstration and as such, risks were limited to a local usage of the platform and its location.

3.3.2.1.1 Arguments

- As a means of reducing the risks of reduced staffing and fatigue:
  - Participants were hired on a voluntary basis through a call for participation months in advance of the exercise,
  - Controller participants attended the exercise outside of their operational roster and ensured that sufficient resting time was available to them,
- Demonstration participants were not allowed to activate the PTT button on walkies, used for listening in on real-time traffic, and the instructions were repeated during training and before each run. There were no further means of transmitting over radio or other links to parties outside of the demonstration room (including pedals, PTT microphones, headsets, etc),
- Hands-on training runs were executed before the start of the demonstration runs as a means of consolidating the theoretical training information and reducing any erroneous utilisation of the platform,
- Alerts sounding in the demonstration room were out of earshot of anyone outside the room,
- An independent 3G network was used for the purpose of questionnaire and general internet access from the demonstration room,
- As a proof of concept, certain alerts were triggered willingly by controllers by deviating from nominal clearances. Such alerts and clearances had no impact on the real traffic given the shadow-mode protocol in place,
- Concerning data management:
  - Recording of the live traffic did not include radio communications,
  - Participants consented formally to their participation before the exercise and were free to leave at any time, according to the following ethical documents: “Participant Information Sheet” and “Participant Consent Forms”,
  - All anonymised data was managed under the responsibility of the DPO (Data Protection Officer) communicated in the “Participant Information Sheet”.

F3.3.2.b Demonstration Exercise #2 – Onboard Traffic Alerts

The Demonstration Exercise #2 – Onboard Traffic Alerts includes onboard part consisting of ADS-B data collection during normal operation flights. AUs participating on the ADS-B data collection are responsible for following all rules and legislation relevant for ADS-B data collection. Obtaining of operational approval is part of AUs scope of work and is covered by the subcontract agreements with all participating Airspace Users.

F3.3.2.c Demonstration Exercise #3 – Demo Budapest LHBP

The demonstration platform was installed in the contingency tower at Budapest. It is located at HungaroControl's headquarter, providing full duplication of the operational tower completed with a visualization system (visual reproduction of the "out of the window" aerodrome view).

Besides its use for contingency situations, the contingency facility is currently used by HungaroControl for temporary live operation. Every Tower ATCO is trained and licensed for the remote operation.

All the extra features of the contingency system were switched off, such as zoomed cameras or label information, which allowed the creation of an out of the window view in real time, using the same ATC systems and working method as in the Tower.

During the demonstration, the contingency tower was only used for contingency (there was no any other planned activity), with the possibility to transit from demonstration system to contingency system within 2 hours. Transition time was defined by HungaroControl based on their experience from several trials were made in the past years and it was tested during the dry run week, before the VLD was taken place.

There was no need to use the room for contingency purpose in the time period of the preparation and the exercise.

The demonstration platform that was used is InNOVA and it was replacing the existing NOVA9000 system in the contingency tower. The platform was connected to the operational surveillance and flight plan data streams. To ensure that there should be no influence on the live operation, every communication between the demonstration platform and the operational interfaces were strictly limited to one way only. Therefore controllers were allowed to manipulate the demonstration platform in full range, including giving clearances, modifying flight plan data or, to trigger special events (e.g. alerts).

The radio communication system was used in "listen only" mode and the controllers were not allowed to use microphone or headset during the demonstration.

The controllers had access to all the necessary information. Passive shadow mode ensured that there was no influence on the live operation.

F3.3.2.d Demonstration Exercise #4 – Manual Taxi Routing

This exercise did not take place.

F3.3.2.e Demonstration Exercise #5 – Demo Hamburg EDDH

The demonstration platform used for Exercise #5 is the Airport Research & Innovation Facility Hamburg (ARIF). The ARIF is a room cooperatively operated by DFS Deutsche Flugsicherung, German Aerospace Center (DLR e.V., Institute of Flight Guidance) and Hamburg Airport (FHG). It is located at the Hamburg Airport providing a view over the apron.

Since the ARIF is also used as a contingency room in case of an emergency by the Air Traffic Controllers, all systems necessary to perform their work appropriately must be available. Therefore, these systems are connected to the operational data stream. All systems that allow a direct communication with operational staff have not been used throughout the entire exercise implementation. They have been manipulated so that it was impossible for the exercise participants to intervene with the operations. Systems regarding communication equipment as well as information displays and interfaces have been manipulated.

As communication equipment, the radio communication system (both for Tower and Apron Controllers) has been manipulated by removing the microphones.

The flight strips display is an interactive interface that allows the controller to enter clearances by using a special pen on the touch display. In order to prevent any interaction with this system, the pen has been removed so that no input has been possible.

Inputs to the Hamburg Airport's HAM SuITe which acts as a flight information display can be done by using keypad and mouse. Both the keypad and mouse have been removed throughout the exercise implementation so that no interference with the system was possible.

The Stand and Gate Manager displays the current stand and gate positions of aircraft. Inputs can be done my using keypad and mouse. Both the keypad and mouse have been removed throughout the exercise implementation so that no interference with the system was possible.

The systems under test have been fed with real data from the AODB (Airport Operation Data Base) via unidirectional data transmission. This way, the exercise participants had no possibility to intervene with the operational environment when using the systems under test.

During the exercise, there has been no emergency and therefore, the ARIF has not been used as a contingency room.

Appendix G Security Assessment Report (SecAR)

Based on the information from the security task force, there are no cyber-security requirements from the SESAR programme on the VLD projects. VLDs run in an operational environment, and need to comply with the cyber-security requirements from the operational stakeholders in which the VLD takes place, usually to be coordinated with the cyber-security manager of these stakeholders. This coordination has taken place on the Exercise level.

Appendix H Human Performance Assessment Report (HPAR)

H1 Executive Summary HPAR

This annex describes the result of the activities conducted to date according to the Human Performance assessment process to derive the Human Performance Plan for the solution #2, #22, and #53 as demonstrated in the very large-scale demonstration in PJ28.

The HP Guidance V1-V3 was used as a basis for structuring the current document. As a means of avoiding confusion concerning the step names as applicable to a VLD, the following steps were elicited:

It corresponds to the completion of the third step of the Human Performance assessment process, as well as an added step for collating finding and concluding on the demonstration exercise, namely:

- Step 3 – Improve and Demonstrate the Concept, and
- Step 4 – Collate findings & conclude on the Demonstration.

It is noted that Step 4 concludes on the findings but not on a transition to the next V-Phase, given the PJ28 Demonstration being a V3+ exercise, beyond the scope of the HP Assessment Process.

It is also noted that Steps 1 and 2 have been completed and reported in the HPAP and its associated HPLog (see, HPAP).

H2 Introduction

H2.1 Purpose of the HPAR

This annex provides the Human Performance Assessment Report for SESAR PJ28 VLD. It describes the results of HP Assessment exercises defined in the HPAP and provides a set of relevant conclusions, requirements and recommendations.

H2.2 Scope of the HPAR

This section describes the result of the activities conducted according to the HP Assessment Process to derive the Human Performance Plan for PJ28 "Integrated Airport Operations". The overall aim of this HP assessment is to demonstrate the introduction of the Operational Improvement (OI) steps linked to the solution "Integrated Airport Operations" which covers SESAR1 Solutions #22, Solution #02 (part of the OFA04.02- Airport Safety Nets) and Solution #53 (part of the OFA 04.01.01 - Integrated Arrival/Departure Management at Airports):

- AO-0104-A: Airport Safety Nets for Controllers in Step 1
- AO-0205: Automated Assistance to Controller for Surface Movement Planning and Routing
- TS-0202: Pre-Departure Sequencing supported by Route Planning

H2.3 Structure of the HPAR

The structure of the document follows the template and guidelines provided by PJ19, and the chapters describe the content proposed there.

The HP Report includes:

- The Step 3 of the Human Performance Assessment: Improve and Demonstrate the Concept,
- The Step 4 of the Human Performance Assessment: Collate Findings and Conclude on the Demonstration.

Note: when the information already exists in a SESAR document or in the HP Log, the HP Report will refer to it.

H3 The Human Performance Assessment Process: Objective and Approach

The purpose of the HP assessment process described is to ensure that HP aspects related to SESAR2020 technical and operational developments are systematically identified and managed.

The SESAR HP assessment process uses an 'argument' and 'evidence' approach. A HP argument is a 'HP claim that needs to be proven'. The aim of the HP assessment is to provide the necessary 'evidence' to show that the HP arguments impacted have been considered and satisfied by the HP assessment process. This includes the identification of HP requirements and recommendations to support the design and development of the concept.

The HP assessment process is a four-step process. Figure Appendix H-1 provides an overview of these four steps with the tasks to be carried out and the two main outputs (i.e. HP plan and HP assessment report in addition, a HP Log is maintained throughout the lifecycle of the Solution in which all the data/ information obtained from all HP activities conducted as part of the HP assessment is documented. This HP Log is a living document and is updated and/or added to as the Solution progresses.

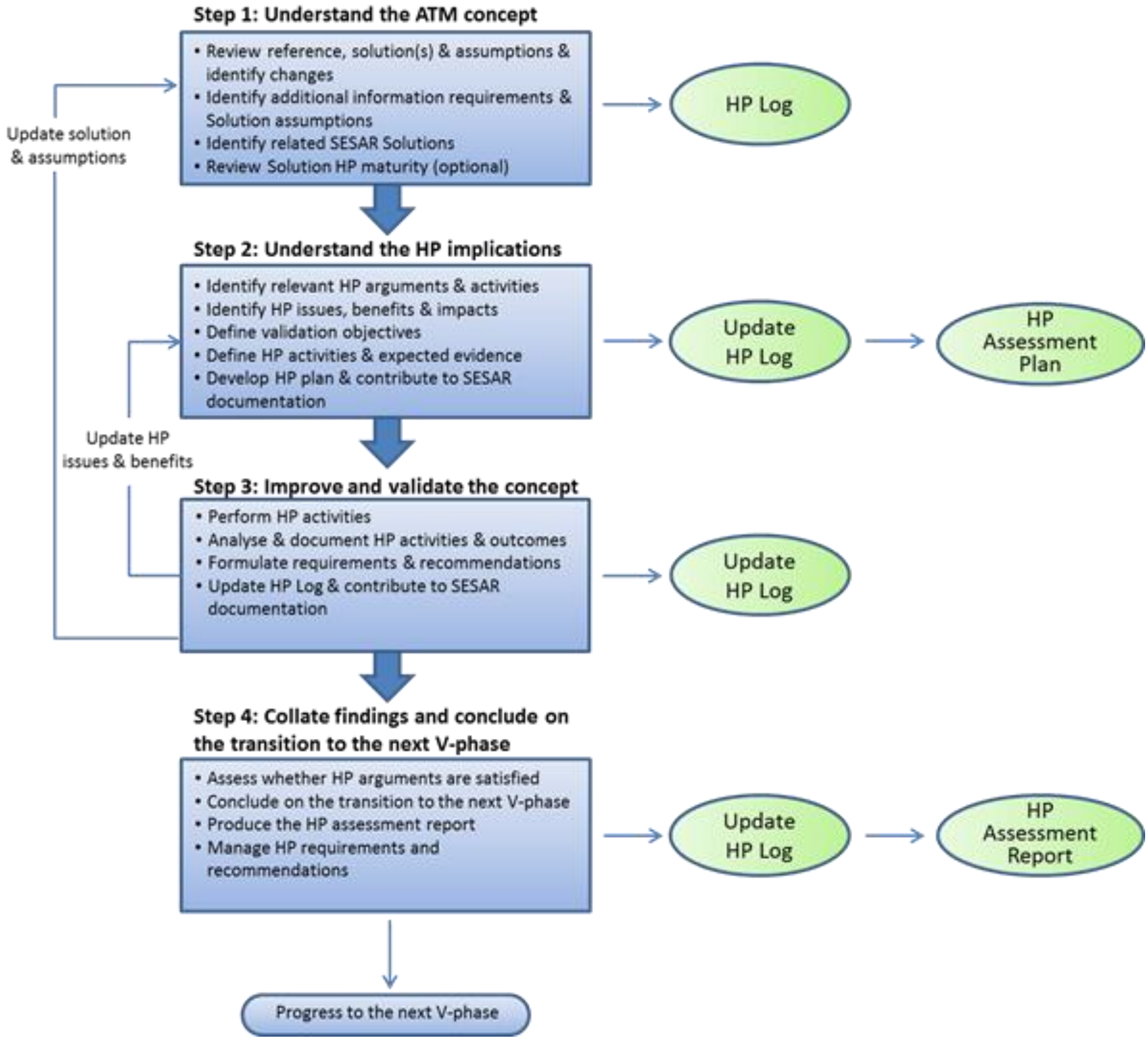


Figure Appendix H-1: Steps of the HP assessment process

It is to be noted that Step 3 and 4 of the model in Figure 1 have been adapted to the particularities of the VLD as such:

- The Step 3: Improve and Demonstrate the Concept,
- The Step 4: Collate Findings and Conclude on the Demonstration.

H4 Human Performance Assessment

H4.1 Step 1 Understand the ATM concept

H4.1.1 Description of reference scenario

The main actors impacted by the solutions demonstrated in PJ28 are the Tower Controllers.

A detailed description of reference scenarios for mid-size and large airports can be found in the PJ28 DEMOPLAN ([34]), Chapter 6.1.4.1, 6.3.4.1 and 6.5.4.1.

H4.1.2 Description of solution scenario

The main actors impacted by IAO are the Tower Controllers, namely ground controllers.

A detailed description of solution scenarios for integrated airport operations (IAO) for mid-size and large airports can be found in the PJ28 DEMOPLAN ([34]), Chapter 6.1.4.2, 6.3.4.2 and 6.5.4.2.

H4.1.3 Reference and Proposed Scenarios Comparison

Reference and Proposed Scenarios comparison		
Element	**Reference ATM Scenario**	**Proposed ATM Scenario**
Route generation	Currently, the routing of mobiles is decided by the Tower Ground Controller.	Planned routing of mobiles will be proposed to controllers by the system; they will have the possibility to use this proposal or to modify the route.
Safety nets	Alerts available in some airports are limited to Runway Incursion Monitoring System and Area Intrusion Monitoring (RIMS & AIM).	In addition to RIMS & AIM: • with predictive CATC mode, controllers can anticipate conflicting clearances. • With the alert CATC mode, controllers are aware of conflicted clearances. CMAC alerts indicate hazardous situations to the controllers (e.g. High-Speed Alert).
Route generation integrated with safety nets	Currently, the routing of mobiles is decided by the Ground Controller. Alerts available in some airports is limited to Runway Incursion Monitoring and Area Intrusion Monitoring (RIM & AIM) and are thus independent from the “manual” route generation	Taxi routes are planned to consider specific constraints, in order to avoid potential hazardous situations. This will reduce the occurrence of safety nets alert related to 'Taxiway Type’, ‘Taxiway Closed’ and ‘Runway closed’ because taxi routes are planned to consider these constraints. All CATC and CMAC are available. It should be noted that the A-SMGCS Routing & Planning function allows controllers to override airport constraints. This possibility can trigger safety nets alerts; for example, if the controller can give a closed taxiway as clearance, an alert will occur when the aircraft will reach this taxiway.
Route provision	Currently, the routing of mobiles is given by R/T.	In the solution scenario, controllers still give routing clearances to mobiles by R/T.

Reference and Proposed Scenarios comparison		
Element	**Reference ATM Scenario**	**Proposed ATM Scenario**
		Additionally, detailed taxi instructions are known to the system via automatically generated routes, complemented by ATCO input (who thus must inform both the pilot AND the system). With alerts: The integration of the route provision (clearance issued by controller) with safety nets will enable the detection of hazardous situations such as aircraft deviating from the assigned and cleared route (Route Deviation).
System input	Depending on the airport, ATCOs work with paper or electronic strips. The ATCOs usually do not record the detailed taxi (i.e. the complete taxi route) instructions on the paper flight strips. It should be noted that the duty to fill out papers strip depends on the airport and/or kind of clearances. With electronic flight strips, only the type of clearance (e.g. push back, start-up, taxi) is put into the system and not the detailed taxi route.	In case the taxi route proposed by the system is not appropriate, the ATCO will have to update it via his/her CWP. With CMAC alerts: In order to benefit CMAC alerts, the ATCO will have to maintain in accordance the detailed route in the ATC system with the clearances given to mobiles. With CATC alerts: Concerning towers still using paper-strips, controllers will have to update the system with clearances given over R/T instead of noting them down on the paper strips.
Link of routing information with other systems	Route information is not known to the system.	The planned and cleared routes being input in the system will allow for: • detection of CMAC and CATC; • increased predictability of taxi times which will link to the A-CDM process for sequencing departures and providing more accurate arrival estimates
Controller's workload w.r.t. required system input	The Ground Controller can be one of the busiest positions in a tower and generally the ATCO will not record a modification of the route on the paper or Electronic Flight Strips. It could be noted that this remark is also applicable to the Apron manager (APN) when the position exists (e.g. Charles-de-Gaulle airport).	The planned route will be automatically calculated by the route server. The Tower Ground Controller's workload might be increased in case he/she has to modify it for any reason, or maintained to current levels, in the usual case where the route generated automatically matches the controller's needs. With alerts: Once clearances are entered into the

Reference and Proposed Scenarios comparison		
Element	**Reference ATM Scenario**	**Proposed ATM Scenario**
		system, it enables the detection of potential CATC and CMAC alerts (CMAC alerts[8] indicate hazardous situations to the controllers (e.g. High-Speed Alert). Without CATC and CMAC some situations could increase controllers' workload. The verification of the route and input of taxi instructions into the system might slightly increase controllers' workload but on the other hand it should enable to avoid critical situations and give better situational awareness.
Support to controllers' situational awareness	There is no planned route today. Only the Tower Ground Controller knows the route he/she will give after the aircraft starts up or lands, even if that route is highly predictable as usual or standard paths are generally given. Any change from the standard scheme will require coordination between all impacted controllers, thus sharing the critical information.	The planned and cleared routes can be accessed by all controllers so that they share the same information and have an increased awareness of the movements on the aerodrome surface. With alerts: CMAC and CATC will support the Controllers in detecting potentially dangerous situations and thus increase their situational awareness. Globally, the time spent to update the system might have a negative impact on situation awareness if it impinges upon the time spent for outside visual scan and traffic situation monitoring. On the contrary, the possibility to visualize the planned and cleared route should increase situational awareness. In the same way, alerts should also increase the situational awareness.
Solution 53	The Clearance Delivery Controller provides start-up approval based on the Target Start-Up Approval Time (TSAT)	TSAT is given as in reference. Taxi Times are now calculated based on the route planning function instead of static times.
	The Tower Ground Controller and Tower Runway Controllers are not provided with any sequence information.	The Tower Runway Controller will be provided with a TTOT. This is only used as a information. Controller can use the sequence but does not have to adhere.

Table Appendix H-1: Comparison of Reference and Proposed Scenarios

[8] Cf. Table 3-5 for list of CMAC and CATC alerts and details on individual alerts

H4.1.4 Consolidated list of assumptions

The assumptions are identical to those identified for the demonstration in chapter 6.3.5 of the DEMOPLAN ([34]).

H4.1.5 List of related SESAR Solutions to be considered in the HP assessment

These solutions directly influence HP for IAO:

- #2 Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances
- #22 Automated assistance to controllers for surface movement planning and routing
- #53 Pre-departure sequencing supported by route planning

H4.1.6 HP maturity of the Solution

Solution #2 and #22, and #53 were assessed V3 mature.

Identified open issues were taken from the solution packages provided by SJU.

H4.1.7 Identification of the nature of the change

HP argument branch	Change & affected actors
1. Roles & Responsibilities	
1.1 Roles & Responsibilities	No change identified.
1.2 Operating Methods	Solution 02: Roles and responsibilities of the concerned actors (ATCO and vehicle driver), with regards to providing Air Traffic Services, will not change. Solution 22: ATCOs must update the system with clearances given by voice to the aircraft. Solution 53: The system calculates a new TSAT for each aircraft and the controller must inform pilots about changed TSATs.
1.3 Tasks	Solution 02: ATCOs are assisted by solution #2 by automated alerts indicating potentially critical situations. Solution 22: ATCOs are assisted in their planning tasks by solution #22; thus, they should consider input of planning assistance tools (Tower Controller) ATCOs may modify the routes in the system if necessary. ATCOs must update the system with clearances given by voice to the aircraft. Solution 53: ATCOs are assisted in their planning tasks by solution #53 by providing TSAT based on calculated of taxi out time.
2. Human & System	
2.1 Allocation of tasks (human & System)	Solution 02: The detection of CATC is a safety net for the controller. The detection will be performed by the ATC system based on the availability of data such as clearances given, holding points assigned and surveillance information. It essential that controllers make timely inputs into the system. Nevertheless, the ATCO remains responsible of safety

	in his AOR, and still must be vigilant in all cases, the new system being only there to help him detect potential hazards. Solution 22: The routing and planning function automatically provides routing options thus increases the level of automation of the current existing task of route allocation. First, an initial planned route is proposed by the system to the Apron Manager and the Tower Ground Controller. Therefore, controllers must spend less time identifying closed taxiway or aircraft and taxiways types. Secondly, the Apron Manager and the Tower Ground Controller will build the aircraft route, accept or modify the planned route, by automation support provided by the routing function. Route management constitutes a change in the allocation of tasks and would require HP assessment contribution. Solution 53: Pre-departure sequence provides TSAT based on calculated of taxi out time as a supporting tool for ATCOs.
2.2 Performance of Technical System	Solution 02: The real surveillance data should allow an accurate localisation of mobiles on the airport to allow the proper functioning regarding the detection of CATC and CMAC. Solution 22: The routing function shall propose suitable routes according to the airport situation and/or current configuration. Solution 53: It should provide a stable pre- departure sequence.
2.3 Human – Machine Interface	Solution 02: The information displayed on the HMI shall enable controllers to immediately detect alerts, identify involved mobiles and understand why an alert is triggered. The HMI should also enable ATCOs to easily turn off the alert audio warning. Solution 22: The HMI will display, and allow distinguishing, the planned taxi route and the cleared and pending portion of the routes. The HMI should facilitate route management. System update is a critical issue related to alert functions (e.g. conformance monitoring). There should be no discrepancy between the voice instruction and the route displayed on the HMI. Solution 53: Information concerning TSAT is displayed on the HMI.
3. Teams & Communication	
3.1 Team composition	No change identified.
3.2 Allocation of tasks	Solution 02 and 22: No changes to the allocation of tasks between ATCOs are foreseen. Solution 53: (Pre-sequencing of flights) might change task allocation between different ATCO working positions, but these aspects are not fundamental to the scope of demonstration in IAO.
3.3 Communication	Solution 2: Alerts systems might require communications with other team members. Solution 22 and Solution 53: Additional information might be

	transferred between ATCOs and pilots, thus coordination between ground and cockpit might be affected.
4. HP related transition factors	
4.1 Acceptance & Job satisfaction	Solution 02, Solution 22, Solution 53: ATCOs should accept new solutions; acceptance is influenced by system design, reliability, and stability for solution 2, 22 and 53.
4.2 Competence Requirements	Solution 22: Training on the tools HMI and operating methods is likely to be required. The new tools will require dedicated training, especially to 1) the input taxi route changes into the ATC system in a timely manner. Solution 02: The new tools will require dedicated training, especially to respond to alerts in an appropriate and timely manner.
4.3 Staffing Requirements & Staffing levels	No change identified.

Table Appendix H-2: Description of the change

H4.2 Step 2 Understand the HP implications

H4.2.1 Identification of relevant arguments, HP issues & benefits and HP activities

Arg.	Issue ID	HP issue / Benefit	HP/Demo. Obj. ID	HP demonstration objective	recommended activity/ies
1.2.1: Operating methods (procedures) cover operation in normal operating conditions.	HP-ARG-PJ28-1.2-02	Working procedures for the Tower controllers are adapted to ensure that detailed taxi clearances given to aircraft and vehicles are input in the system by the Tower controllers.	OBJ-VLD-28-001, OBJ-VLD-28-002, OBJ-VLD-28-004	Operating methods can be followed in an accurate, efficient and timely manner.	Passive shadow mode trials
1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).	HP-ARG-PJ28-1.3-01	The automatically proposed sequence could change working style of ATCOs as they start to work to primarily follow the proposed pre-departure sequence rather than their own estimated sequence.	HP-OBJ-PJ28-1.3-01	To find evidence that the working style of ATCOs using information about proposed sequence is appropriate for actual traffic situation.	Task analysis and workshops in preparation of the exercise (e.g. working methods workshops)
1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).	HP-ARG-PJ28-1.3-02	ATCOs need to provide input of cleared routes and any route modifications to the automated system in a timely and efficient manner	HP-OBJ-PJ28-1.3-02	To generate evidence that aggregated results concerning technical system performance are rated as a "timely and efficient" manner of system input.	"post-hoc workshop" (PHW) to the demonstration based on results from section 2 to 3 Working methods workshops leading to the exercise

2.1: Allocation of tasks (between the human and the machine) - Are there any changes to the allocation of tasks between the human and the machine?	HP-ARG-PJ28-2.1-01	Task allocation between human and system is affected by Sol #22. The automated system calculates the planned taxi route. This task is no longer conducted by the ATCO, also under real traffic data, although a verification and modification if necessary, is performed.	OBJ-VLD-28-005	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is acceptable. Performance could be degraded because of the "ironies of automation" where inadequate task allocation leads to out-of-the-loop phenomena. Out of the loop is best addressed by assessing situational awareness.	Passive shadow mode trials SASHA SART China Lakes SA Rating
2.2: Performance of the technical systems - Are there any changes to technical systems and/or their performance?	HP-ARG-PJ28-2.2-01	Solutions (technical systems) are expected to perform in the expected manner to increase ATCOs /Crews situational awareness and to reduce ATCOs /Crews workload. Expected performance of the solutions is: Sol #02: proper functioning regarding the detection of CATC and CMAC Sol #22: propose suitable routes according to the airport situation	OBJ-VLD-28-004	Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable.	Passive shadow mode trials SASHA SART China Lakes SA Rating assess workload of human operators during demonstration AIM, NASA-TLX, ISA
			OBJ-VLD-28-005	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.	

		and/or current configuration Sol #53: a stable pre- departure sequence.	OBJ-VLD-28-013	Demonstrate that the controller workload incurred due to integration of CMAC is acceptable	
			OBJ-VLD-28-014	Demonstrate that the controller workload incurred due to integration of CATC is acceptable.	
			OBJ-VLD-28-015	Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC	
			OBJ-VLD-28-016	Demonstrate whether the Situational Awareness of controllers is improved with the integration of CATC.	
			OBJ-VLD-28-020	Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable.	
			OBJ-VLD-28-021	Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved	
2.2: Performance of the	HP-ARG-PJ28-	Effectiveness and performance of the	OBJ-VLD-28-022	Demonstrate the	Passive shadow mode trials

technical systems - Are there any changes to technical systems and/or their performance?	2.2-03	solutions under real traffic data		effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	
2.3: Human-machine interface - Are there any changes to the Human-Machine Interface? E.g. in terms of the information displayed? Input devices? design of displays/output devices? Alarms and alerts presented to human actors?	HP-ARG-PJ28-2.3-01	The Human-Machine-Interface design must be usable and efficient to use. Insufficient usability might lead to increased workload and increased time to provide necessary input.	OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.	Passive shadow mode trials measure usability: ISO-NORM Questionnaire for usability System Usability Scale (SUS) Semi-structured Questionnaires Semi-structured interviews System Log Analysis (frequency counts)
			OBJ-VLD-28-008	Demonstrate the usability of CATC function.	
			OBJ-VLD-28-010	Demonstrate the usability of CMAC functions.	
			OBJ-VLD-28-019	Demonstrate the usability of DMAN functions supported by route planning.	
	HP-ARG-PJ28-2.3-02	Nuisance and false alerts should be reduced by improved input device and automated alerts (CMAC / CATC)	OBJ-VLD-28-006	Demonstrate the utility of CATC alerts functions.	Passive shadow mode trials Alert Integration workshops leading to the exercise
			OBJ-VLD-28-007	Demonstrate the utility of CATC functions in predictive mode.	
			OBJ-VLD-28-009	Demonstrate the utility of CMAC functions	

			OBJ-VLD-28-018	Demonstrate the utility of DMAN functions supported by route planning.	
			OBJ-VLD-28-024	Demonstrate utility of routing and planning functions in non-nominal conditions.	
3.2: Allocation of tasks (between human actors) - Are there any changes to the allocation of tasks between human actors?	HP-ARG-PJ28-3.2-01	Generate evidence that pre-departure sequencing does not impact negatively task allocation between actors.	HP-OBJ-PJ28-3.2-001	To generate evidence on impact of pre-departure-sequencing on task allocation and communication of ATCO.	task distribution of ATCOs not assessed in demonstration proposed activity Task Analysis in preparation phase of the demonstration
4.1.2: Acceptance and job satisfaction - Are there any potential impacts on acceptability and/or Job satisfaction?	HP-ARG-PJ28-4.1-01	ATCOs should accept new solutions; acceptance is influenced by system design, reliability of planning, stability of planning. System performance will influence acceptance, can be used to explain degraded acceptance.	OBJ-VLD-28-001	Demonstrate utility of routing and planning functions.	Assess acceptance by combining results of 2.2 and 2.3 and comments from debriefing → tailormade debriefing questionnaire & semi-structured guided interview
			OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.	
			OBJ-VLD-28-003	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.	
			OBJ-VLD-28-024	Demonstrate utility of routing and planning functions in non-	

				nominal conditions.	
4.2: Competence requirements - Are there any impacts on competence requirements e.g. affecting training?	HP-ARG-PJ28-4.2-01	Routing system with high usability and utility might reduce required training times	HP-OBJ-PJ28-4.2-01	To generate evidence by aggregating results of exercises regarding usability and utility of the SUT of IAO have potential to reduce required training times.	Working methods workshops leading to the exercise Introductory training session to the exercise "post-hoc workshop" (PHW) to the demonstration based on results from section 2 to 3

Table Appendix H-3: HP Arguments, related HP issues and benefits, and proposed HP activity

H4.2.2 Description of HP activities conducted

The HP concerns are mainly covered by the VLD exercises, i.e. the operational passive shadow mode demonstration trials. Two additional activities were identified to gather evidence on human performance issues not covered within the exercise. Two workshops also mitigate the missing baseline.

HP activity	By when
Demonstrations (shadow-mode trial), as executed at the time of writing.	EXE LFMN: 04/2019 EXE LHBP: 04/2019 EXE EDDH: 03/2019
Post-Hoc Stakeholder Workshop (priority 2)	Post-execution phase of demonstrations after 04/2019
A-Priori Stakeholder Workshop (priority 3)	Preparatory phase of demonstration EXE LFMN: before 04/2019 EXE LHBP: before 04/2019 EXE EDDH: before 03/2019

Table Appendix H-4: Table of HP activities and their priority

Activity 1.	Passive shadow mode trials
Description	Passive shadow mode trials as planned in the DEMOP
Arguments & issues to be addressed	Arguments and issues relating to Human & System (Change indication 2.1 Allocation of tasks between human and the machine, 2.2 Performance of technical systems and 2.3 Human machine interface) are addressed within the planned shadow mode trials.
HP OBJECTIVES	HP-ARG-PJ28-2.1-01 HP-ARG-PJ28-2.2-01 HP-ARG-PJ28-2.2-02 HP-ARG-PJ28-2.2-03 HP-ARG-PJ28-2.3-01 HP-ARG-PJ28-2.3-02 HP-ARG-PJ28-4.1-01
Required Evidence	Appropriate and sufficient evidence is collected that: • the task allocation between human and machine is appropriate and supports human performance • the transition from automatic to manual mode (and vice-versa) is properly supported • the workload induced by automation level is acceptable

	• the human actors can acquire an adequate mental model of the machine and it functions • the level of trust in automated functions is adequate. • the timeliness of information is adequate for carrying out the task • the accuracy of information is adequate for carrying out the task. • the user information requirements are satisfied • the design of input and output devices is compliant with HF Principles and the workstation adhere to ergonomic principles • that alarms and alerts have been developed according to HF principles • the user interface design reduces human error potential and support situation awareness as far as possible • the user interface design supports team situational awareness
Tool selected out of the HP repository	operational trials in passive shadow mode
Planning and Approach	The plan for the shadow mode trials is detailed in the DEMOPLAN
resources	As detailed in the DEMOPLAN
timeline	As detailed in the DEMOPLAN

Table Appendix H-5: Description of Activity 1- Passive shadow mode trials

Activity 2.	**Post-Hoc Stakeholder Workshop**
Description	The Post-Hoc Workshop is conducted AFTER completing the demonstrations and summarizes findings and results of the exercises in order to derive evidence on issues which cannot directly be assessed during the exercises and which should be asses relative to existing standards.
Arguments & issues to be addressed	Arguments and issues relating to Roles & Responsibilities – Changes to tasks (change indication 1.3) and HP related transition factors - competence requirements (change indication 4.2) are addressed within post-hoc stakeholder workshops. The rational is that the assessment of these issues should use combined results and knowledge gathered within the shadow mode trials.
HP OBJECTIVES	HP-ARG-PJ28-1.3-02 HP-ARG-PJ28-4.2-01
Required Evidence	Consolidation of exercise results to asses if tasks are achieved effectively. Appropriate and sufficient evidence is collected that the operating methods: • cover normal, abnormal and degraded operating conditions • are clear and consistent • can be followed in an accurate, efficient and timely manner • with limited error rate • with acceptable workload, situational awareness and task demands • the changes in role and responsibilities are acceptable • the impact of changes on job satisfaction has been considered.

	• knowledge, skill and experience requirements for human actors have been identified • the impact on operator licensing have been identified • the potential interferences between existing and new knowledge and skills have been identified.
Tool selected out of the HP repository	Stakeholder Workshop
Planning and Approach	after 05/2019 in a F2F meeting at Hamburg, Budapest or Nice When suitable, this workshop can be conducted within a telephone conference. Quantitative results of all three demonstrations need to be available. The HP specialists provide a first interpretation of these results. The results are presented. Their meaning / interpretation with regards to changes to tasks and transition factors are discussed between operational experts, HP specialist, and demonstration leads afterwards. The outcome of this activity is evidence, whether tasks change and if these changes should lead to adapted training, selection and/or certification.
resources	HP specialist 5 days for preparation HP specialist 1 day 3 operational experts (which participated in the exercise) 1 day Demonstration Exercise Leads 1 day Training and Licensing Expert 1 day
timeline	after the last exercise is conducted and data need for overall assessment of acceptance is evaluated

Table Appendix H-6: Description of Activity 2- Post-Hoc stakeholder Workshop

Activity 3.	Task Analysis
Description	The task analysis is conducted BEFORE the demonstrations within the preparation phase and addresses issues which are not fundamental to the solutions demonstrated but might impact human performance within the exercise. Pre-Departure sequencing is introduced through solution #53. Initially the project planned to integrate Solution #14 into the demonstration. Due to insufficient maturity, functionality of solution #14 was covered by solution #53. Therefore, within the human performance assessment preparation issues were identified which should be closed before conducting the exercises. Inter-operability is another issue which should be clarified before the demonstration.
Arguments & issues to be addressed	Arguments and issues relating to Roles & Responsibilities – Operating methods and Changes to tasks (change indication 1.2 & 1.3), as well as communication between human actors (change indication 3.3) are addressed within a task analysis
HP OBJECTIVES	HP-ARG-PJ28-1.2-01 HP-ARG-PJ28-1.3-01

	HP-ARG-PJ28-1.2-02 HP-ARG-PJ28-3.2-01 HP-ARG-PJ28-3.3-01
Required Evidence	Appropriate and sufficient evidence is collected that: • the changes to the task allocation among human actors do not lead to adverse effects • the proposed task allocation between human actors is supported by the technical system • the intra and inter-team communication support the information requirements of team members • the changes in communication means and modalities are identified and acceptable • the (expected) communication load is acceptable in all operating conditions
Tool selected out of the HP repository	Task Analysis
Planning and Approach	Information exchange and communication is identified for working positions of the exercise. Additional communication and tasks DURING the shadow mode trials introduced by solution #53 is highlighted. The HP experts decide if changes to task allocation, communication and team work might influence evidence gathered during shadow mode trials. These findings are harmonized within the HP team. In case influence is expected, this influence should be assessed during the passive shadow mode trials.
resources	HP specialist two days
timeline	conducted during preparation phase of exercise

Table Appendix H-7: Description of Activity 3- Task Analysis

H4.3 Step 3 Improve and validate the concept

Please refer to H6 for the recommendations register.

Please refer to H7 for the requirements register.

H4.4 Collate findings & conclude on demonstration

H4.4.1 Summary of HP activities results & recommendations / requirements

Table Appendix H-8 provides a summary of the HP argument and related issues / benefits along with the HP activities conducted during the VLD.

Arg.	Issue ID	HP issue / Benefit	HP/Demo. Obj. ID	HP demonstration objective	Actual evidence	Recom.	Req.
1.2.1: Operating methods (procedures) cover operation in normal operating conditions.	HP-ARG-PJ28-1.2-02	Working procedures for the Tower controllers are adapted to ensure that detailed taxi clearances given to aircraft and vehicles are input in the system by the Tower controllers.	OBJ-VLD-28-001, OBJ-VLD-28-002, OBJ-VLD-28-004	Operating methods can be followed in an accurate, efficient and timely manner.	Reported as part of Demonstration Report chapter 4.2.1 – 4.2.3	Reported as part of Demonstration Report chapter 5	Not applicable
1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).	HP-ARG-PJ28-1.3-01	The automatically proposed sequence could change working style of ATCOs as they start to work to primarily follow the proposed pre-departure sequence rather than their own estimated sequence.	HP-OBJ-PJ28-1.3-01	To find evidence that the working style of ATCOs using information about proposed sequence is appropriate for actual traffic situation.	The proposed pre-departure sequence could not be sufficiently demonstrated in the exercises. Either, real tower controllers were lacking an operational DMAN, thus impacting the baseline. Another reason was that most participants in this exercise were ground controllers, the departure sequence was not their main task. The utility of its function could not appropriately be demonstrated.	Reported as part of Demonstration Report chapter 5.1	Not applicable
1.3: Human actors can achieve their	HP-ARG-	ATCOs need to provide input of cleared routes	HP-OBJ-PJ28-1.3-02	To generate evidence that aggregated results	Reported as part of Demonstration Report	Reported as part of	Not applicable

tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).	PJ28-1.3-02	and any route modifications to the automated system in a timely and efficient manner		concerning technical system performance are rated as a "timely and efficient" manner of system input.	chapter 4.2.2 and 4.2.24	Demonstration Report Requirements chapter 5.1	
2.1: Allocation of tasks (between the human and the machine) - Are there any changes to the allocation of tasks between the human and the machine?	HP-ARG-PJ28-2.1-01	Task allocation between human and system is affected by Sol #22. The automated system calculates the planned taxi route. This task is no longer conducted by the ATCO, also under real traffic data, although a verification and modification if necessary, is performed.	OBJ-VLD-28-005	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is acceptable. Performance could be degraded as a consequence of the "ironies of automation" where inadequate task allocation leads to out-of-the-loop phenomena. Out of the loop is best addressed by assessing situational awareness.	Reported as part of Demonstration Report chapter 4.2.5	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable
2.2: Performance of the technical systems - Are there any changes to technical systems and/or their	HP-ARG-PJ28-2.2-01	Solutions (technical systems) are expected to perform in the expected manner to increase ATCOs /Crews situational awareness	OBJ-VLD-28-004	Demonstrate that the controller workload incurred by the integration and operation of routing and planning functions is acceptable.	Reported as part of Demonstration Report chapter 4.2.4, 4.2.5, 4.2.13, 4.2.14, 4.2.15, 4.2.16, 4.2.20, 4.2.20	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable

performance?		and to reduce ATCOs /Crews workload. Expected performance of the solutions is: Sol #2: proper functioning regarding the detection of CATC and CMAC Sol #22: propose suitable routes according to the airport situation and/or current configuration Sol #53: a stable pre-departure sequence.	OBJ-VLD-28-005	Demonstrate that the situational awareness incurred by the integration and operation of routing and planning functions is improved.				
			OBJ-VLD-28-013	Demonstrate that the controller workload incurred due to integration of CMAC is acceptable				
			OBJ-VLD-28-014	Demonstrate that the controller workload incurred due to integration of CATC is acceptable.				
			OBJ-VLD-28-015	Demonstrate that the Situational Awareness of controllers is improved with the integration of CMAC				
			OBJ-VLD-28-016	Demonstrate whether the Situational Awareness of controllers is improved with the integration of CATC.				

			OBJ-VLD-28-020	Demonstrate that the controller workload incurred due to DMAN supported by route planning is acceptable.			
			OBJ-VLD-28-021	Demonstrate that the controllers' situational awareness due to DMAN supported by route planning is improved			
2.2: Performance of the technical systems - Are there any changes to technical systems and/or their performance?	HP-ARG-PJ28-2.2-03	Effectiveness and performance of the solutions under real traffic data	OBJ-VLD-28-022	Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.	Reported as part of Demonstration Report chapter 4.2.22	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable
2.3: Human-machine interface - Are there any changes to the Human-Machine Interface? E.g. in terms of the information displayed? Input	HP-ARG-PJ28-2.3-01	The Human-Machine-Interface design must be usable and efficient to use. Insufficient usability might lead to increased workload and increased time to provide necessary input.	OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.	Reported as part of Demonstration Report chapter 4.2.2, 4.2.6, 4.2.8, 4.2.17, 4.2.19	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable
			OBJ-VLD-28-006	Demonstrate the usability of CATC function.			
			OBJ-VLD-28-008	Demonstrate the usability of CMAC functions.			

devices? design of displays/output devices? Alarms and alerts presented to human actors?			OBJ-VLD-28-017	Demonstrate the effectiveness of integrating RMCA with CATC and CMAC functions			
			OBJ-VLD-28-019	Demonstrate the usability of DMAN functions supported by route planning.			
	HP-ARG-PJ28-2.3-02	Nuisance and false alerts should be reduced by improved input device and automated alerts (CMAC / CATC)	OBJ-VLD-28-006	Demonstrate the utility of CATC alerts functions.	Reported as part of Demonstration Report chapter 4.2.6, 4.2.7, 4.2.8, 4.2.22	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable
			OBJ-VLD-28-007	Demonstrate the utility of CATC functions in predictive mode.			
			OBJ-VLD-28-008	Demonstrate the utility of CMAC functions			
			OBJ-VLD-28-022	Demonstrate the utility of DMAN functions supported by route planning.			
3.2: Allocation of tasks (between human actors) - Are there any changes to the allocation of tasks between human actors?	HP-ARG-PJ28-3.2-01	Generate evidence that pre-departure sequencing does not impact negatively task allocation between actors.	HP-OBJ-PJ28-3.2-001	To generate evidence on impact of pre-departure-sequencing on task allocation and communication of ATCO.	The Apron Controllers considered their situation awareness due to DMAN functions supported by route planning as acceptable. Neither an improvement nor deterioration has been	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable

					noticed by the Apron Controllers.		
4.1.2: Acceptance and job satisfaction - Are there any potential impacts on acceptability and/or Job satisfaction?	HP-ARG-PJ28-4.1-01	ATCOs should accept new solutions; acceptance is influenced by system design, reliability of planning, stability of planning. System performance will influence acceptance, can be used to explain degraded acceptance.	OBJ-VLD-28-001	Demonstrate utility of routing and planning functions.	Reported as part of Demonstration Report chapter 4.2.1, 4.2.2, 4.2.3, 4.2.22	Reported as part of Demonstration Report Requirements chapter 5.1	Not applicable
			OBJ-VLD-28-002	Demonstrate the utility and usability of route modification capabilities.			
			OBJ-VLD-28-003	Demonstrate the accuracy of A-SMGCS taxi-time from off-block to runway holding point.			
			OBJ-VLD-28-022	Demonstrate the effectiveness of integrating routing and planning functions, airport Safety Nets for controllers and DMAN functions supported by route planning.			
4.2: Competence requirements - Are there any impacts on competence requirements e.g.	HP-ARG-PJ28-4.2-01	Routing system with high usability and utility might reduce required training times	HP-OBJ-PJ28-4.2-01	To generate evidence by aggregating results of exercises regarding usability and utility of the SUT of IAO have potential	The usability of the routing and route modification functions was sufficiently effective as to allow basic routing interactions to be	EX1-RECOM-VLD-28-009 EX1-RECOM-VLD-28-010 (EX5-RECOM-	EX1-REQ-VLD-28-001 EX1-REQ-VLD-28-

affecting training?				to reduce required training times.	performed by controllers following a few hours training. However, the training requirements for manual route modifications more demanding. Further, in one exercise, the workload of controllers during training was positively correlated with their age and experience.	VLD-28-012) (EX5-RECOM-VLD-28-013)	002 EX1-REQ-VLD-28-003 EX1-REQ-VLD-28-004

Table Appendix H-8: Summary of the HP results and recommendations/ requirements for each identified issue & related argument

H5 Additional HP activities conducted

H5.1 Task Analysis

This activity is mainly proposed to gather evidence on HP Objectives "HP-ARG-PJ28-1.3-01" – "The automatically proposed sequence could change working style of ATCOs as they start to work to primarily follow the proposed sequence rather than the actual traffic situation". In this chapter of the task analysis results are documented.

Information exchange and communication is identified for relevant working positions of the exercise, namely ground and runway controller and clearance delivery. Additional communication and tasks DURING the shadow mode trials introduced by solution #53 is highlighted. The HP experts decide if changes to task allocation, communication and team work might influence evidence gathered during shadow mode trials. In case influence is expected, this influence should be assessed during the passive shadow mode trials.

Reference Scenario

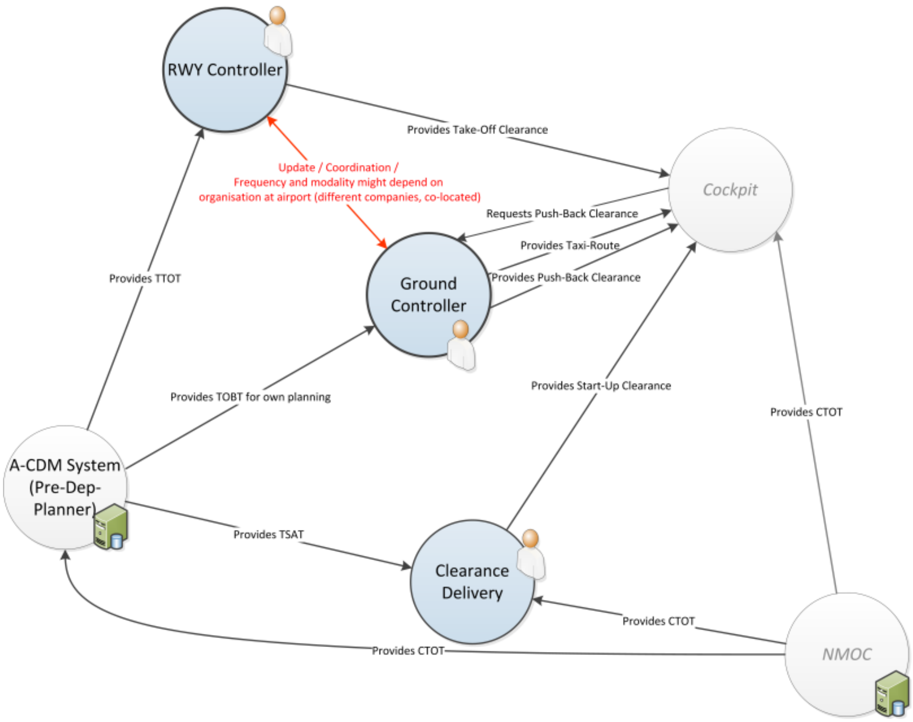


Figure Appendix H-2: Information flow between Ground Controller and other working positions in the reference scenario

First, the working procedures of Ground Control position with regard to planned sequence and ACDM is described. The main features are given in Table Appendix H-9. An overview on information flows between the working positions is given in Figure Appendix H-2. It becomes clear that the ground controller does not actively try to follow a certain sequence. When the a/c got the start-up clearance, push-back and taxi clearances are delivered and the Ground Controller follows his/her goals to ensure a safe, orderly and expeditious flow on apron and taxi-ways. The final conclusion is that in the reference scenario, the departure sequence of any ACDM process is operationalized by Clearance Delivery position.

Area of Responsibility	executes taxiing of a/c to RWY or dedicated point on airport
Task Goals	executes task in a 1) safe, 2) orderly and 3) expeditious manner
Responsibilities and Impact on sequence	takes over responsibility for a/c when a/c requests push-back or taxi (≈ actual start-up time) is informed about ACDM milestones

Table Appendix H-9: Overview on Tasks and Goals for Ground Control WP

Solution Scenario

First, assumptions on human-automation interaction are given, which were used for the analysis.

Human and Automated System should work as a team. But Human Operator is legally responsible for all decisions. Human Operator must supervise the plans conducted by the Automated System. Thus – human operator must understand plan and goals of the automated system. Principles of human-centred automation must be met. Team members must share a common goal. Team members must have shared mental models (of the problem). If automated system considers sequence for planning, ground controller must do so as well.

The expected flow of information with a focus on the Ground Controller position is shown Figure Appendix H-3

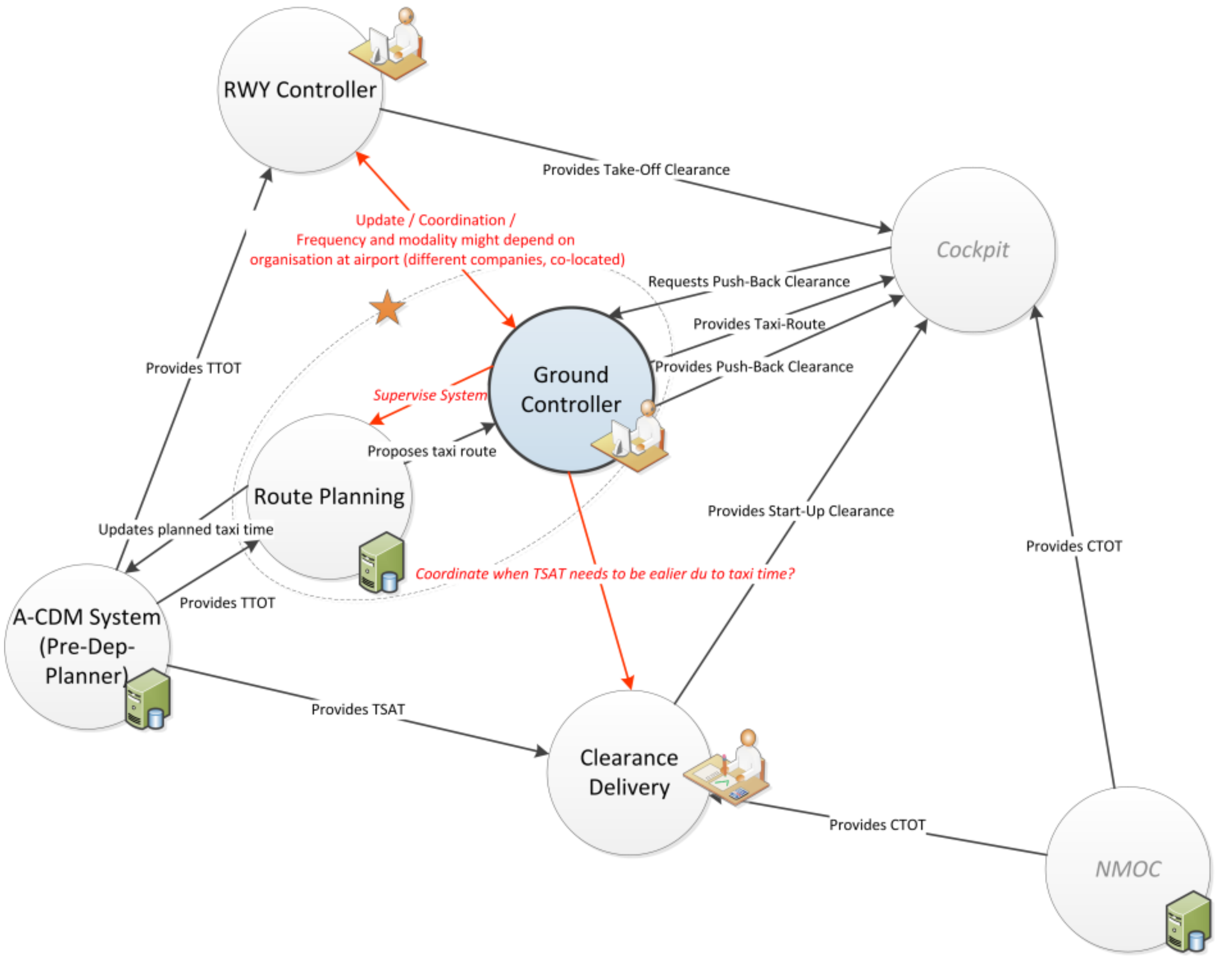


Figure Appendix H-3: Information flow in solution scenario.

Within the solution scenario, Ground Controller has same responsibilities and is supported by route planning system. The route planning systems adapts taxi times to TTOT to meet the sequence which is defined within or through ACDM processes.

Based on this analysis, the following changes on working procedures are expected:

- Ground Controller needs to check planning of route planning system to ensure safe, orderly and expeditious operations that comply with TTOT.
- For checking planning of route planning system controller needs to take TTOT into account.

Conclusion and Recommendations

Based on this analysis, conclusions were drawn:

- BUD airport: No major change in working procedures is expected, impact can be expected in extra workload of the ATCOs.
- HAM airport: Potential issues will be addressed through tailor-made questions during the debriefing of the passive shadow mode trials.

- NICE airport: At Nice, a number of tests have been done to verify TSAT proposals from DMAN.

Controllers should rate the workload they experienced during the exercises due to check conformance of planned taxi times with TTOT after running an exercise.

H5.2 Detailed Workload Analysis for EX5

Descriptive data of the workload assessment with NASA-TLX show that PJ28 solutions are judged to have a marginal impact on workload, the score is slightly lower by 2 points of the scale. Standard deviation of the measured data is rather high. Therefore, the sample of 14 controllers was grouped by a median split conducted by the age of controllers. Median age of the sample was 35 years. Descriptive data was calculated for the two groups of rather young (38.5 years and younger) and rather old controllers (older than 38.5 years).

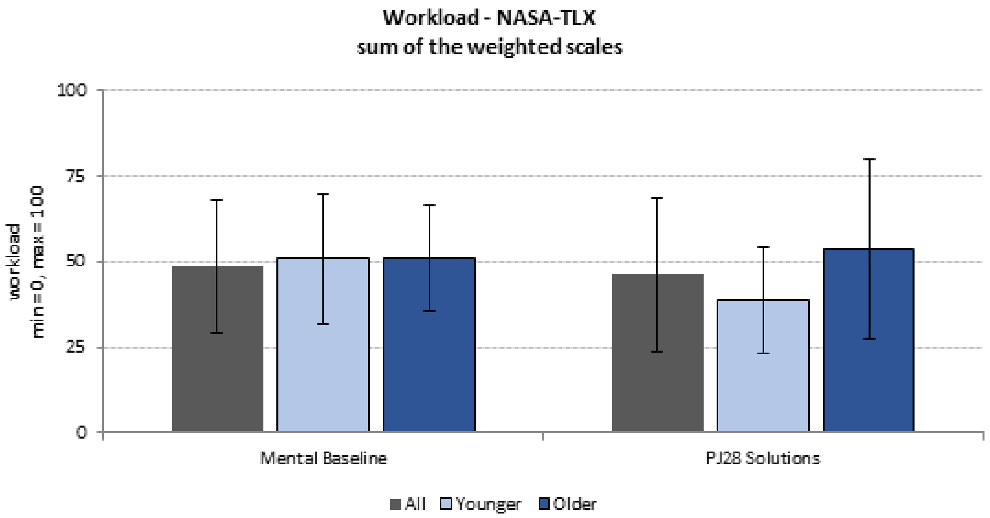


Figure Appendix H-4: Plot of experienced workload in the mental baseline and with PJ 28 solutions

	All *(N = 14)*		Younger *(N = 7)*		Older *(N = 7)*	
	mean	sd	mean	sd	mean	sd
Mental Baseline	50.9	*17.4*	50.9	*20.4*	50.9	*15.5*
PJ28 Solutions	46.4	*22.6*	38.9	*16.8*	53.8	*26.3*

Table Appendix H-10: Descriptive Data of NASA-TLX Scores

Descriptive data shows that younger controllers tend to rate that PJ28 solutions will lead to less workload. Older controllers are less homogenous in their rating (have a higher standard deviation) but tend to rate that workload will slightly increase by PJ28 solutions.

Analysis of task load dimensions

Further exploratory analysis of the NASA-TLX scales was conducted to understand why the impact of PJ28 might be different for the two groups. First, both groups were compared regarding the weight they gave to the six workload dimensions.

Achieving the expected performance, combined with temporal and mental demand of the task are the top three dimensions of experienced workload for air traffic control at airport Hamburg. Especially, workload is less influenced by frustration and physical demands of the task. For younger controllers, temporal demands of the task and achieving performance are the main dimensions of workload. Mental demand is rated lower. In contrast, older controllers rate mental demands of the task as main contributing dimension and on average 1.5 points higher on the scale, compared to younger controllers. Achieving the required performance and meeting the temporal demands of the task is contributing less to workload experienced by older controllers.

The influence of PJ28 solutions on experienced workload was assessed by comparing mean ratings of the mental baseline with mean ratings of the shadow mode tests. The results are visualized in Figure Appendix H-5. The six dimensions are ordered by their scoring on the subscales for the mental baseline. Mental demand, temporal demand and performance are the top three contributors to workload, followed by effort frustration and physical demands. The scores are weighted according to the groups weighting profiles.

Dimension	Rank All			Rank Younger			Rank Older		
		MW	SD		MW	SD		MW	SD
Performance	1	3.71	1.33	1	4.14	0.90	2 ↓	3.29	1.60
Temporal Demand	2	3.64	0.93	1 ↑	4.14	0.69	3 ↓	3.14	0.90
Mental Demand	3	3.50	1.09	3	2.71	0.76	1 ↑	4.29	0.76
Effort	4	2.50	0.94	4	2.29	0.95	4	2.71	0.95
Frustration	5	1.07	1.38	5	1.14	1.86	5	1.00	0.82
Physical Demand	6	0.57	0.65	6	0.57	0.53	6	0.57	0.79

Regarding all controllers, descriptive data shows that PJ28 solutions had a neglectable effect on perceived overall workload but on the contribution of the different dimensions. Whilst PJ28 solutions led to decreased mental and temporal demand, workload induced by accomplishing the performance increased.

Furthermore, the effect of PJ28 solutions differed for younger and older controllers. Younger controllers rated PJ28 solutions as leading overall to less workload, with a reduction of temporal demand and performance by 4 points on the 20 point scale (reduction of 20 %).

Older controllers perceived PJ28 solutions as leading to slightly higher overall workload. Especially, the workload induced by accomplishing the required performance was rated as nearly 50 % higher. This change equalizes the effect of PJ28 solutions on mental demand (on average 20% lower rating) and temporal demand.

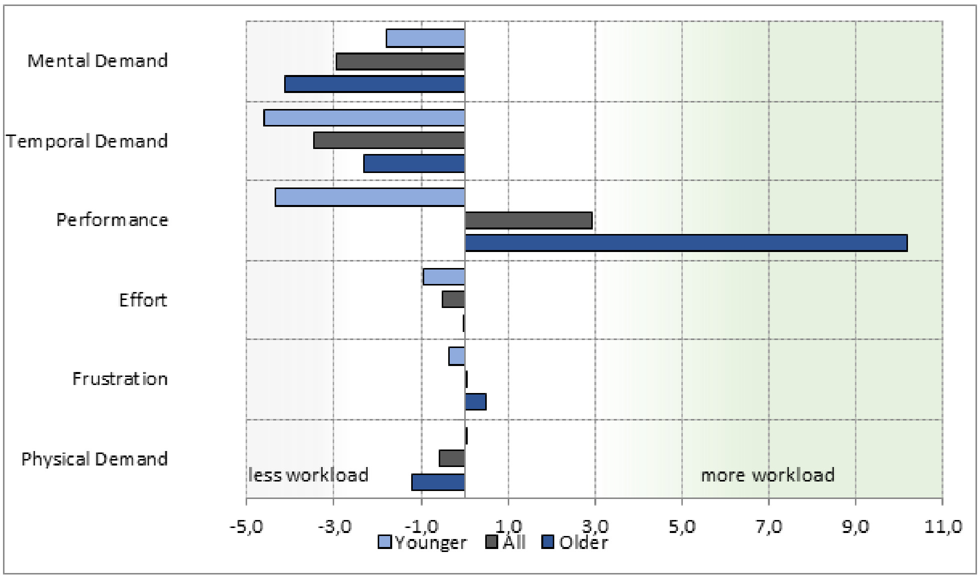


Figure Appendix H-5: Comparison of effect of PJ28 solutions on workload for the younger and older ATCOs

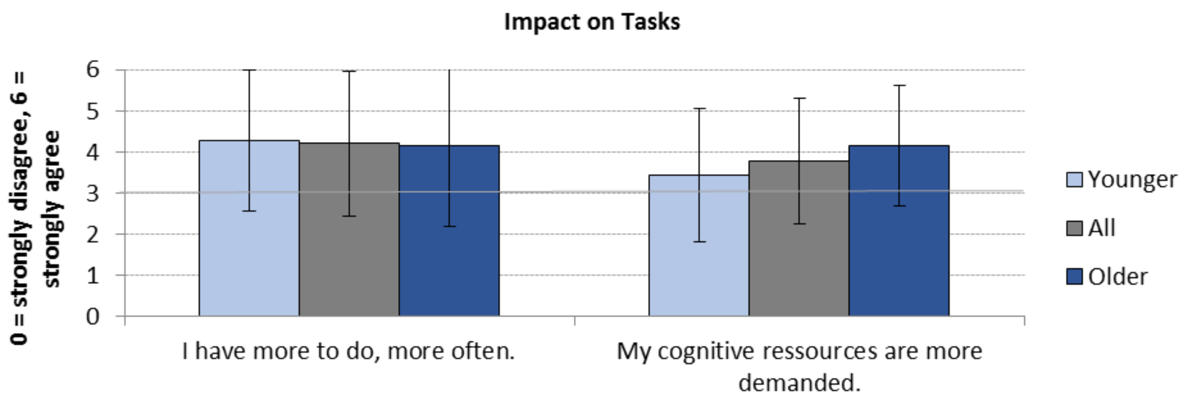
Impact of Automation on perceived demands of younger and older controllers

Controllers were asked to rate the statement "Because of the SESAR PJ28 solutions my working procedures will change" on a 5-point Likert-Scale where 0 resembles "strongly disagree" and 4 "strongly agree". The overall agreement with statement on average is 2.5 (sd = 1.16), meaning a neutral position. The rating of younger controllers is 2.86 (sd = 0.9), of older controllers it is 2.14 (sd = 1.35). Controllers tend to be neutral to agree to this statement, whilst younger controllers agree more with this statement.

When controllers see a change in working procedures these changes are rated on average as being neutral (score = 2.2, sd = 1.1). Nevertheless, looking at the frequencies (table below) the sample is heterogeneous whether these impacts are regarded positive or negative. More older controllers do think that PJ28 solutions do not impact their working procedures. Younger controllers see an impact but are not all convinced that changes will have a positive impact for them.

	All (n = 9)	Younger (n = 6)	Older (n = 3)
++	0	0	0
+	3	1	2
+/-	2	2	0
-	3	3	0
--	1	0	1
no impact	**5**	1	**4**

Table Appendix H-11: Impact on working procedures and evaluation of impact (positive vs. negative)



Overall impact of PJ28 solutions on Controllers tasks. A task analysis was conducted to identify subtasks of controllers. Controllers rated the impact of PJ28 solutions on these subtasks with a 5-point Likerat Scale where 0 means “no impact” and 4 “high impact”. A value of 2 on this scale indicates tasks which are moderately impacted by PJ28 solutions, values over 2.0 resemble a higher impact. In Figure Appendix H-6, the tasks with the five highest impacts are marked. The two higher-level tasks “manage systems” and “double-checking information” were mainly impacted by PJ28 solutions.

Changes to tasks of controllers are further visualized in Figure Appendix H-6 and differentiated for younger and older controllers. Tasks, for which impact was rated to be higher than 2.0 (A moderate impact), were considered and highlighted. A moderate or lower impact was rated for tasks related to “Giving Instructions” and “Coordination”. Younger and older Controllers rate impact of tasks on double-checking and managing systems similar. Impact on issuing clearances and coordination with other operators is rated differently by younger and older Controllers. Especially older Controllers tend to see a higher impact of PJ28 solutions on issuing and checking routes given to the cockpit.

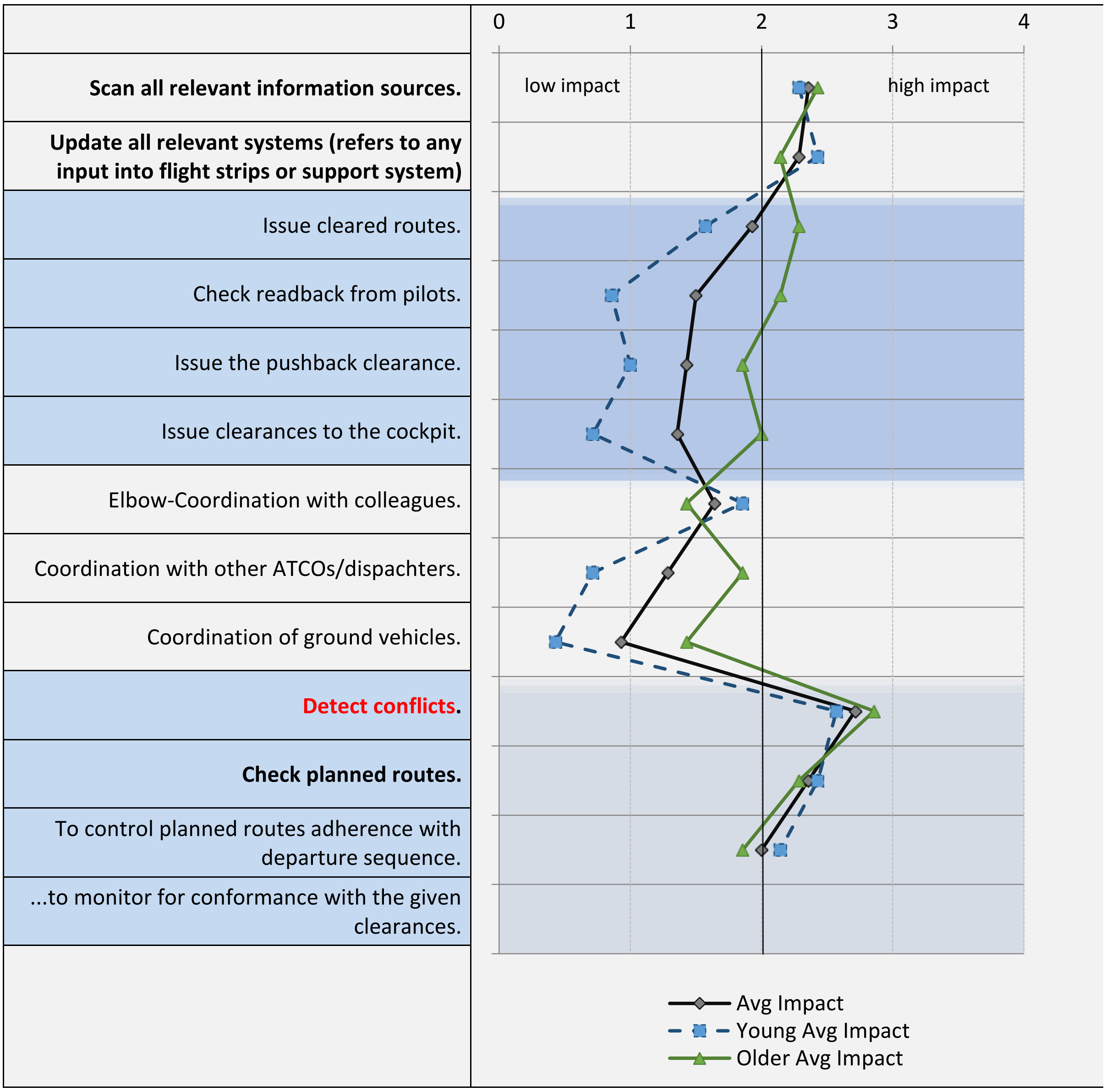


Figure Appendix H-6: Detailed impact of PJ28 on subtasks

Nature of the impact:

Comparing the ratings for time needed and having available, it becomes clear that these different ratings cannot be explained by perceived time available and time needed for these tasks, because both groups rate these scales quite similar. The impact of PJ28 solutions on time needed for subtasks is visualized in Figure Appendix H-7. Only for the task “detecting conflicts” the two groups differ. Basically, younger Controllers rate PJ28 solutions as leading to less time needed to detect conflicts whilst older Controllers tend to rate that PJ28 solutions require more time to detect conflicts.

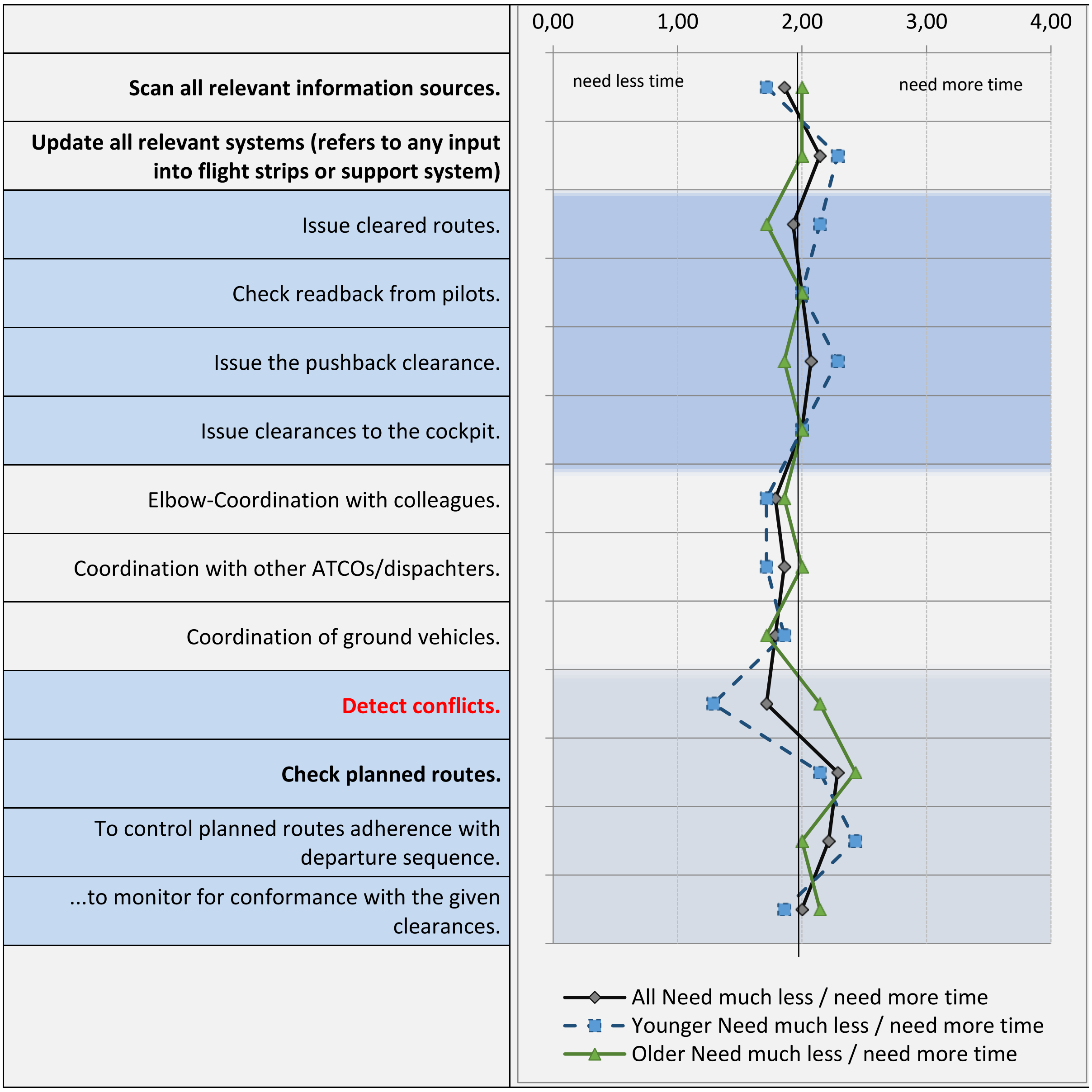


Figure Appendix H-7: Impact of PJ28 on time needed for subtasks

H6 HP Recommendations Register

Ref.	Type of recom.	Recommendation description		Recommendation follow-up					
		Recommendation	Rationale	Assessment source + Reference report if available	Scope (Air, Air/Ground, Ground)	Concept/ solution involved	Recom. status	Rationale in case of rejection	Comments
EX1-RECOM-VLD-28-009.	Human Performance	Improve the acquired training minima for baseline proficiency.	Although the SUT comprises high usability and utility standards, training time is highly dependent on controllers' ability to operate the baseline system in an effective way.	HP-OBJ-PJ28-4.2-01	Ground	Routing	Open		
EX1-RECOM-VLD-28-010.	Human Performance	Apply case scenarios to route modification modalities.	While the different modes of route modification are understood, controllers tend towards only one mode, regardless of the operational issue being managed.	HP-OBJ-PJ28-4.2-01	Ground	Routing	Open		

(EX5-RECOM-VLD-28-012)	Human Performance	Develop training to enable controllers to make use system according their individual needs.	Automated route generation has different effect on controllers workload, depending on age and experience.	HP-OBJ-PJ28-4.2-01	Ground	Routing	Open		
(EX5-RECOM-VLD-28-013)	Human Performance	Enable experienced operators to make use of an automated system, e.g. teach the automation.	To keep the human in the loop and support the strengths of human decision making, design of automation should support different working styles.	HP-ARG-PJ28-4.2-01	Ground	Routing	Open		

Table Appendix H-12: HP recommendations

H7 HP Requirements Register

Ref.	Type of requirement	Requirement description				Requirement status			
		Requirement	Rationale	Assessment source + Reference report if available	Scope (Air, Air/Ground, Ground)	Concept/ solution involved	Req. status	Rationale in case of rejection	Comments
EX1-REQ-VLD-28-001	Human Performance	An operational level of Baseline expertise should be ensured as a requisite for SUT training.	Although the SUT comprises high usability and utility standards, training time is highly dependent on controllers' ability to operate the baseline system in an effective way.	HP-OBJ-PJ28-4.2-01	Ground	Routing	Open		
EX1-REQ-VLD-28-002	Human Performance	Manual route modification and shortcuts training should be iterated throughout the training.	While the different modes of route modification are understood, controllers tend towards only one mode, regardless of the operational issue being managed.	HP-OBJ-PJ28-4.2-01	Ground	Routing	Open		
EX5-REQ-VLD-28-001	Human Performance	Provide different working modes to cover personal preferences and experiences	To keep the human in the loop and support the strengths of human decision making, design of automation should support different working styles.	HP-OBJ-PJ28-4.2-01	Ground	Routing	Open		

Table Appendix H-13: HP Requirements

Appendix I VLD progress towards TRL-7

The following section describes the results from the maturity assessment.

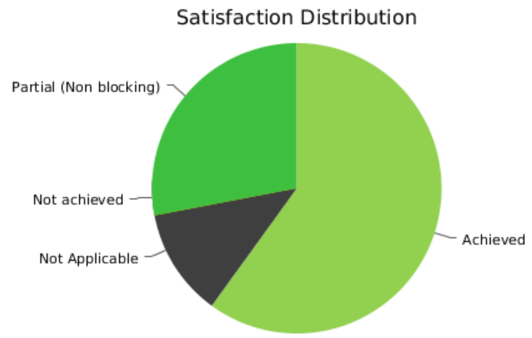


Figure Appendix I-1: Satisfaction Distribution

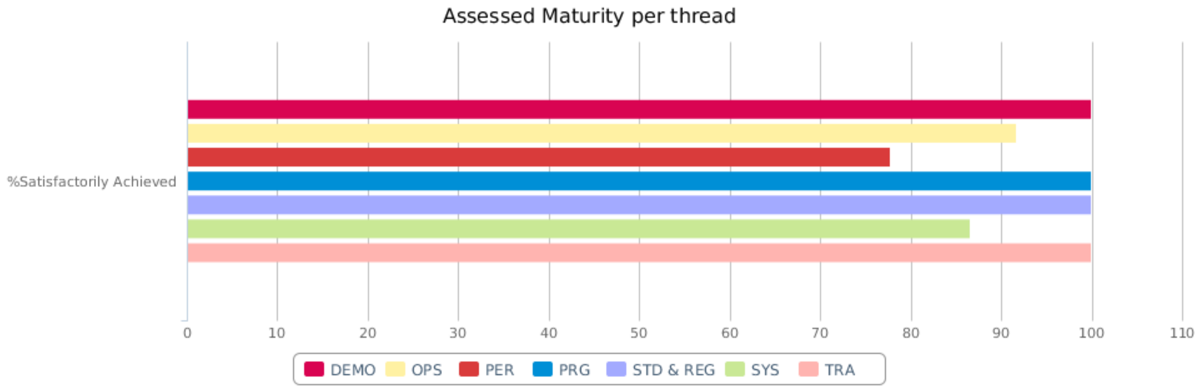
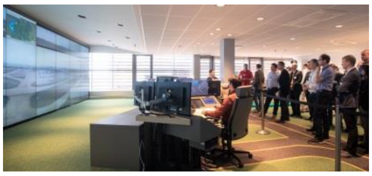


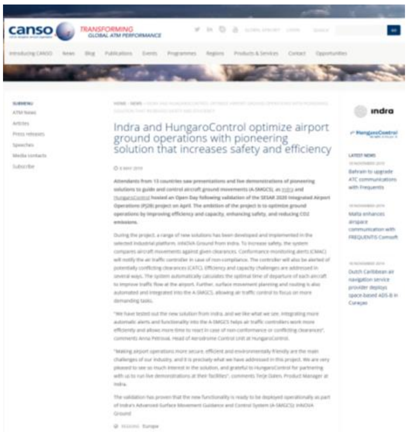
Figure Appendix I-2: Assessed Maturity per thread

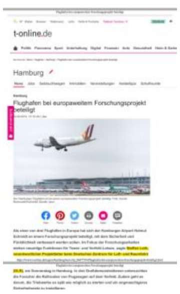
Appendix J Communication Material / Records

Communi-cation channel	Communication Media	Date	Copy / Link / Screenshot
Websites			
Project website	IAO website prepared with news blog and updates on project activities	since 2017	https://www.iao-project.eu/ 
SESAR project website	SESAR IAO project website	since 2017	
Company Websites	ANS CR participation overview of SESAR Programme		http://www.rlp.cz/en/company/press/Pages/SESAR-Programme.aspx
	DLR Institute of Flight Guidance: project presentation	since 2017	https://www.dlr.de/fl/en/desktopdefault.aspx/tabid-1149/1737_read-51079/ 
	Indra Press release	06/05/2019	

Videos			
Project Videos	Summary / overall video presented at IAO Open Day and available on SESAR Youtube Channel	19/09/2019	https://www.youtube.com/watch?v=AdApR8WCVdw 
	Videos about Hamburg, trials, presented at IAO Open Day	19/09/2019	
	Videos about Nice trials, presented at IAO Open Day	19/09/2019	
	Videos about Budapest trials, presented at IAO Open Day	19/09/2019	
External Videos and Radio Reports	Sat1 regional TV channel report about Open Days at Hamburg Airport (in German)	19/09/2019	
	NDR90.3 (Radio) Hamburg-am-Mittag (in German)	19/09/2019	https://player.vimeo.com/video/361077678
Demonstration events	Open Day at Hamburg Airport	19/09/2019	
	Budapest Remote Tower Facility of HungaroControl	11/04/2019	

Publications			
IAO Publications	Article in ACI EUROPE Airport Business	2019	
	Project Flyer 2018	2018	
	Project Flyer 2019	2019	
SESAR Publications	SESAR JU news	20/09/2019	Real-time planning for the airports – European research for more punctual and efficient airport operations https://www.sesarju.eu/news/real-time-planning-airports-european-research-more-punctual-and-efficient-airport-operations
	SESAR JU Twitter	19/09/2019	https://twitter.com/SESAR_JU/status/1174673751847387136 7 Tweets: Seeing is believing! Great to welcome #airports, #airlines & #ANSPs to see first hand 👓 #SESAR tech trialed in real ops in the very large-scale demo on Integrated Airport Operations

External Publications	CANSO.org: Indra and HungaroControl optimize airport ground operations with pioneering solution that increases safety and efficiency	08/05/2019	https://www.canso.org/indra-and-hungarocontrol-optimize-airport-ground-operations-pioneering-solution-increases-safety-and 
	Janesairport360.com	08/05/2019	HungaroControl validates InNOVA Ground technology
	Spacedaily.com: European research for more punctual and efficient airport operations	24/09/2019	http://www.spacedaily.com/reports/European_research_for_more_punctual_and_efficient_airport_operations_999.html 
	aiportzentrale.de	21/09/2019	http://www.airportzentrale.de/dlr-forschung-echtzeit-planung-fuer-das-vorfeld/60753/ as copy of DLR press release
	Altländer Tageblatt (in German): Hamburger Flughafen bei europaweitem Forschungsprojekt beteiligt	20/09/2019	https://app.bluereport.net/clips/938358168.pdf?reader_token=5904709561302e737e0d895b10a03758&inline=true  Altländer Tageblatt vom 20.09.2019 STADER BUXTEHUDER ALTLÄNDER TAGEBLATT Ressort: Hamburg Mediengattung: Tageszeitung Auflage: 1.534 (gedruckt) 1.526 (verkauft) 1.560 (verbreitet) Reichweite: 5.187 AVE (Print): 102 EUR (ungewichtet) **Hamburger Flughafen bei europaweitem Forschungsprojekt beteiligt** Als einer von drei Flughäfen in Europa hat sich der Hamburger Airport Helmut Schmidt an einem Forschungsprojekt beteiligt, mit dem Sicherheit und Pünktlichkeit verbessert werden sollen. Im Fokus der Forschungsarbeiten stehen neuartige Funktionen für Tower- und Vorfeld-Lotsen, sagte Steffen Loth, verantwortlicher Projektleiter beim Deutschen Zentrum für Luft- und Raumfahrt (DLR), am Donnerstag in Hamburg. In drei Großdemonstrationen untersuchten die Forscher die Rollrouten von Flugzeugen auf dem Vorfeld. Zudem geht es darum, die Triebwerke so spät wie möglich zu starten und ein engmaschigeres Sicherheitsnetz zu installieren. Neben Hamburg sind auch die Flughäfen in Nizza und Budapest an dem Projekt „Integrated Airport Operations" (IAO) im Rahmen des europäischen Forschungs- und Innovationsprogramms SESAR beteiligt. Die genaue Auswertung der Versuche und die abschließende Bewertung werden für Anfang 2020 erwartet. Foto Scholz/dpa Fotograf: htf Wörter: 127 Urheberinformation: (c) Zeitungsverlag Krause GmbH & Co. KG © 2019 PMG Presse-Monitor GmbH
	Aller Zeitung (in German): Flughafen forscht für Sicherheit	20/09/2019	https://app.bluereport.net/clips/938358162.pdf?reader_token=5904709561302e737e0d895b10a03758&inline=true  Aller-Zeitung vom 20.09.2019 Aller-Zeitung Seite: 7 Ressort: Niedersachsen & Der Norden Mediengattung: Tageszeitung Auflage: 14.680 (gedruckt) 14.630 (verkauft) 15.160 (verbreitet) Reichweite: 0,035 (in Mio.) AVE (Print): 216 EUR (ungewichtet) **Flughafen forscht für Sicherheit** Als einer von drei Flughäfen in Europa hat sich der Hamburger Airport Helmut Schmidt an einem Forschungsprojekt beteiligt, mit dem Sicherheit und Pünktlichkeit verbessert werden sollen. Im Fokus stehen neuartige Funktionen für Tower- und Vorfeldlotsen, sagte Steffen Loth, verantwortlicher Projektleiter beim Deutschen Zentrum für Luft- und Raumfahrt, am Donnerstag in Hamburg. In drei Großdemonstrationen untersuchten die Forscher die Rollrouten von Flugzeugen auf dem Vorfeld. Zudem geht es darum, die Triebwerke so spät wie möglich zu starten und ein engmaschigeres Sicherheitsnetz zu installieren. Wörter: 82 Ort: Hamburg © 2019 PMG Presse-Monitor GmbH

	Barmstedter Zeitung (in German): Flughafen forscht für Pünktlichkeit, Verspätungen am Gepäckband	20/09/2019	 Barmstedter Zeitung vom 20.09.2019 Barmstedter Zeitung **Seite:** UENI 11 **Reichweite:** 4.973 **Mediengattung:** Tageszeitung **AVE (Print):** 511 EUR (ungewichtet) **Auflage:** 1.828 (gedruckt) 1.581 (verkauft) 1.611 (verbreitet) **Flughafen forscht für Pünktlichkeit, Verspätungen am Gepäckband** **Hamburg** Als einer von drei Flughäfen in Europa hat sich der Hamburger Airport an einem Forschungsprojekt beteiligt, mit dem Sicherheit und Pünktlichkeit verbessert werden sollen. Im Fokus der Forschungsarbeiten stehen neuartige Funktionen für Tower- und Vorfeld-Lotsen, sagte gestern Steffen Loth, verantwortlicher Projektleiter beim Deutschen Zentrum für Luft- und Raumfahrt (DLR). Neben Hamburg sind auch die Flughäfen in Nizza und Budapest beteiligt. **Langes Warten auf den Koffer** Währenddessen landeten Fluggäste am Mittwochabend in Hamburg mal wieder auf dem Boden der Tatsachen: Die Passagiere eines Fluges, der am Abend verspätet aus Korfu landete, mussten sich in Geduld üben. Mehr als eine Stunde nach Landung dauerte es, bis die ersten Koffer über das Laufband liefen. „Ich kenne keinen Flughafen, bei dem die Gepäckabfertigung immer wieder so schlecht organisiert ist", ärgerte sich ein Fluggast. Auf Nachfrage sagte eine Sprecherin des Flughafens, es habe sich dabei um einen „Ausreißer" an diesem Abend gehandelt. Durch mehrere Flugverspätungen tagsüber hätte schon mehrfach Personal bei der Gepäckabfertigung umgeschichtet und zusätzlich eingesetzt werden müssen. Dies habe am Ende des Tages einen personellen Engpass verursacht. „Wir streben aber an, dass die Koffer immer 30 Minuten nach Landung auf dem Band liegen". Tatsächlich aber hat es in der Vergangenheit regelmäßig Probleme mit der Gepäckabfertigung gegeben. Erst am letzten August–Wochenende war es zu Verzögerungen am Gepäckband aufgrund „der wetterbedingten Hitze und einer erhöhten Anzahl an krankheitsbedingten Personalausfällen" gekommen, wie der Airport damals auf Twitter mitteilte. In Spitzenzeiten könne es zu Wartezeiten von einer Stunde oder länger kommen. „Wir bitten unsere Passagiere um Verständnis und Geduld", hieß es. Geduld war auch gefordert, als Urlauber, ausgerechnet am letzten Ferientag, wegen einer technischen Störung der Gepäckanlage bis zu zwei Stunden auf ihre Koffer warten mussten. An Deutschlands fünftgrößtem Flughafen werden am Tag 30 000 Koffer, Taschen und andere Stücke bewegt. *bgl/lno* **Wörter:** 296 © 2019 PMG Presse-Monitor GmbH
	szh.de (in German): Flughafen bei europaweitem Forschungsprojekt beteiligt	20/09/2019	
	aerosieger.de (in German): Praxistest für Lotsen: Flugzeuge auf Vorfeld optimiert	19/09/2019	https://www.aerosieger.de/news/13332/praxistest-fuer-lotsen-flugzeuge-auf-vorfeld-optimiert.html/ 
	airliners.de (in German): Flughafen Hamburg und DLR testen digital optimierten Roll-Betrieb	19/09/2019	
	t-online.de / DPA (in German): Flughafen bei europaweitem Forschungsprojekt beteiligt	19/09/2019	

	RTL.de (in German): Flughafen bei europaweitem Forschungsprojekt beteiligt	19/09/2019	 Flughafen bei europaweitem Forschungsprojekt beteiligt
	Süddeutsche Zeitung (in German): Flughafen bei europaweitem Forschungsprojekt beteiligt	19/09/2019	https://www.sueddeutsche.de/wirtschaft/luftverkehr-hamburg-flughafen-bei-europaweitem-forschungsprojekt-beteiligt-dpa.urn-newsml-dpa-com-20090101-190919-99-943123  Süddeutsche Zeitung Flughafen bei europaweitem Forschungsprojekt beteiligt
	ntv.de (in German): Flughafen bei europaweitem Forschungsprojekt beteiligt	19/09/2019	https://www.n-tv.de/regionales/hamburg-und-schleswig-holstein/Flughafen-bei-europaweitem-Forschungsprojekt-beteiligt-article21282943.html 
	Flughafen Hamburg Twitter (in German): Das @DLR_de stellt heute am @HamburgAirport das EU-Forschungsprojekt "Integrated Airport Operations" vor.	19/09/2019	https://twitter.com/HAM_Presse/status/1174593005887610880
Partner Publications	SURVEILLANCE FUTURE FUNCTIONS SESAR OPEN DAYS (Airbus PJ03B05 validation demonstration)	11/2018	PJ.01-07 / PJ03B-05 / PJ11-A3 / PJ28 
	ANS CR Internal electronic newsletter UPRO, "Progression within grant projects"	02/2019	
	ANS CR Internal company Newsletter STRIP 2017, "Involvement of ANS CR in SESAR projects"	2017	

	DLR Jahresrückblick 2017 (in German)	12/2017	
	DLR Jahresrückblick 2018 (in German)	12/2018	
	DLR FL newsletter Flugspur (in German): Erste IAO-Installationen am Flughafen Hamburg	I/2018	
	DLR Jahresrückblick 2019 (in German)	12/2019	
	DLR FL newsletter Flugspur (in German): Großdemonstrationen am Flughafen Hamburg	I/2019	
	DLR FL newsletter Flugspur (in German): announcement of IAO Open Days at Hamburg Airport	II/2019	
	DLR FL newsletter Flugspur (in German): Integrated Airport Operations in Hamburg	III/2019	
	DLR Press Release: European research for more punctual and efficient airport operations	19/09/2019	https://www.dlr.de/content/de/artikel/news/2019/03/20190919_europaeische-forschung-fuer-puenktlichere-abfluege.html
	DLR Twitter tweet about IAO Demo Day Hamburg	20/09/2019	https://twitter.com/DLR_de/status/1175367819950743552

	HungaroControl	04/2019	Information about open day Budapest on LinkedIn and Facebook
	HungaroControl	11/04/2019	https://en.hungarocontrol.hu/press-room/news/SESAR%20PJ28 
	Indra	05/2019	press release shared in social media channels, both Indra corporate and Indra Navia channels, on LinkedIn and Facebook
Presentations at relevant ATM stakeholder forums, SESAR demonstration events or seminars	DLR: S2020 PJ28 - Integrated Airport Operations (VLD) Overview	19/09/2019	
	DLR: Human Performance Assessment	19/09/2019	
	DSNA: Demonstration at Nice Airport	19/09/2019	
	Indra: Overview of demonstrations at Budapest Airport	19/09/2019	

	Sintef: Solutions implementation and integration in Hamburg	19/09/2019	
	HungaroControl	11/04/2019	Presentation at open day in Budapest
	Indra	11/04/2019	Presentation at open day in Budapest
	DLR: WAC 2018 Madrid	07/03/2018	https://www.iao-project.eu/wp/wp-content/uploads/2018/04/IAO_at_WAC2018_WalkingTour.pdf 
	ANS CR: XIV. ANNUAL MEETINGS OF AIR CARRIERS AND AVIATION COMMUNITY, Prague, Czech Republic	26/10/2016	Information on the involvement of ANS CR in the SESAR program
Company internal presentations	ANS CR: Annual General Meeting of ANS Plannig and Development Division (section SRPI)	03/04/2018	The current activities of ANS CR within SESAR program
	ANS CR: Annual General Meeting of ANS CR Strategy and Management Support Department	02/08/2018	Involvement of ANS CR in SESAR projects
	ANS CR: Internal meeting with Marketing Department	30/08/2018	The current activities of ANS CR within SESAR program
	ANS CR: Annual General Meeting of Division of ANS Plannig and Development	26/11/2018	Involvement of ANS CR in SESAR projects
	ANS CR: Internal Information Sharing Meetings	30/11/2018	PJ28 was presented on Workshop to ANS CR ATM experts / ATCO
	ANS CR: Management board meeting	05/02/2019	Progression within grant projects

Table Appendix J-1: Communication Material / Records