Final Project Report

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Abstract

The purpose of P10.04.03 was to define system requirements derived from operational requirements and develop verified prototypes for Safety Nets in order to support operational validations performed by P04.08.01 (Enhanced Safety Nets for En-Route TMA operations), former P04.08.03 and Free Route Operational Focus Area (OFA).

All the validations supported by the project were focused on Short Term Conflict Alert (STCA) Safety Net and Resolution Advisories (RA) although the project has also worked on Approach Path Monitoring (APM), Area Proximity Warning (APW) and Minimum Safe Altitude Warning (MSAW) Safety Nets.

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Acronyms

Acronym	Definition
ACAS	Airborne Collision Avoidance System
ACC	Airspace Control Centre
ANSP	Air Navigation Service Provider
APM	Approach Path Monitoring
APW	Area Proximity Warning
ATM	Air Traffic Management
CWP	Control Working Position
DAP	Down-linked Aircraft Parameters
EHS	EnHanced Surveillance
EN	Enabler
HMI	Human Machine Interface
IBP	Industrial Based Platform
OFA	Operational Focus Area
PCP	Pilot Common Project
MSAW	Minimum Safe Altitude Warning
QNH	Sea Level Atmospheric Pressure
RADP	Resolution Advisory Downlink Parameters
RTS	Real Time Simulation
SFL	Selected Flight Level
SPIN SG	Safety nets: Planning Implementation & eNhancement Sub Group
STCA	Short Term Conflict Alert
TAR	Track Angle Rate
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level

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1 Project Overview

The project objective was to define system requirements for Safety Nets and later on develop, verify prototypes and integrate them on industrial based platforms (IBP) to support operational and integrated validations where Safety Nets capabilities were evaluated or needed.

The project focused on supporting validation exercises for Short Term Conflict Alert (STCA) and Resolution Advisories (RA).

The project also worked in Approach Path Monitoring (APM), Area Proximity Warning (APW) and Minimum Safe Altitude Warning (MSAW) Safety Nets defining system requirements and developing a prototype.

Finally, the project also supported an integrated Free Route validation exercise with an STCA prototype integrated in the platform used for that validation.

1.1 Project progress and contribution to the Master Plan

The work undertaken by the project was done through three phases using the same pattern in all of them. First of all, the project worked analysing the operational documentation in order to translate the operational requirements into system requirements. Based on the technical specification and the requested capabilities to support the validation exercises (from the validation plans), prototypes were developed. After the verification of the prototypes the support to the operational validation started. During this step technical support was essential to integrate the prototype into the industrial based platform used for the validation. After the validation exercise was finished and conclusions were ready, an update of the technical requirement was done.

During the first phase a STCA prototype was developed addressing the baseline operational requirements from EUROCONTROL SPIN SG included in the "consolidated baseline framework for Safety & Performance evaluation of STCA" developed by the P04.08.01 project and then addressing the technical specification to adapt STCA for Operation in TMA (APP ATC 136). This prototype supported a standalone V3 operational validation in constrained Terminal Manoeuvring Area (TMA) airspace. Since this validation was limited to fast-time simulation with off-line analysis by a single air traffic controller, HMI aspects were not addressed. A platform was used for performing this validation exercise with local ATM Lyon traffic.

During the second phase three prototypes were developed within the project:

- A first prototype was developed and verified addressing the system requirements defined for APM, APW and MSAW. The operational project (mirror of this technical project) finally decided not to perform a validation exercise to validate these types of safety nets, so this prototype didn't support any validation exercise.
- Another prototype was developed based on STCA for En-Route environment in order to support a V3 validation exercise. The objective of this exercise was to evaluate the potential benefits derived from the use of existing Down-linked Aircraft Parameters (DAPs) available through Mode S EnHanced Surveillance (EHS) in the ground based safety nets, specifically focused on STCA in En-Route ACC environment (Rome). Three sessions took place, two comparative sessions, addressing the nominal and non-nominal cases through the analysis of log files produced by the prototype, and one evaluative session, though interviews and questionnaires to the Controllers involved in the validation. The results of this Real Time Simulation (RTS) exercise using DAPs were compared with Milano ACC simulations performed on the same traffic samples not using DAPs.
- A third prototype was developed to support a V3 validation exercise in Langen (DFS) in order to evaluate the benefit to present controllers at the Controller Working Position the Resolution Advisory (RA) events and the time sequence analysis between STCA and RA events.

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Additional information was shown at the same time the RA occurred, for instance, information to identify a "climb RA", "descend RA" or "level off RA". A proposal was also made to pay attention to the RA like in the case of STCA warning when an RA alert is present.

During the third phase the second above mentioned prototype developed in the previous phase was updated to adapt it and integrate it in a Free Route environment into a V3 IBP. In this validation no new Safety Net requirement was validated as it was considered that the Safety Net prototype used didn't need further improvements to support free route operations.

With the system requirements and the prototypes developed the project contributed to increase the level of maturity of the following Enablers included in DataSet15 [31]:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
APP ATC 136	Adapt STCA for Operation in TMA	The project contributed with the support of a validation exercise by providing fully verified prototypes and platforms and by the definition of technical requirements related to the enabler.	TRL4	TRL6
ER APP ATC 14	Enhance Short Term Conflict Alert (STCA) to use Downlinked Aircraft Parameters	The project contributed with the support of a validation exercise by providing fully verified prototypes and platforms and by the definition of technical requirements related to the enabler.	TRL2	TRL6
ER APP ATC 68	Enable Controller workstation to indicate when an aircraft systems indicates an RA occurrence	The project contributed with the support of a validation exercise by providing fully verified prototypes and platforms and by the definition of technical requirements related to the enabler.	TRL2	TRL6

Project P10.04.03 developing the above ENs contributed to the following SESAR Solutions:

- SESAR Solution #60: Enhanced Short Term Conflict Alert for Terminal Manoeuvring Areas
- SESAR Solution #69: Enhanced Short Term Conflict Alert using Mode S EHS data
- SESAR Solution #58: Display and use of ACAS resolution advisory information on the controller working position.
- SESAR Solution #32: Free Route through the use of Direct Routing for flights both in cruise and vertically evolving for cross ACC borders and in high & very high complexity environments.
- SESAR Solution #33: Free Route through Free Routing for Flights both in cruise and vertically evolving within low to medium complexity environments
- SESAR Solution #100: ACAS Ground Monitoring and Presentation System

1.2 Project achievements

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The project achievements were focused mainly in STCA developments.

The first prototype developed by the project was related to STCA for TMA, specifically evaluated in a constrained TMA environment. Real surveillance tracks from an operational STCA were used to feed the prototype and used to establish its STCA alert set. Corresponding operational STCA alerts were used as a baseline for comparison. Alerts from the prototype were compared encounter by encounter with corresponding alerts recorded in the baseline system. Both sets of alerts were classified by a single air traffic controller. The prototype as well as the baseline system implemented STCA based on multi-hypothesis algorithm.

It is important to note that human factors and local circumstances have a significant influence on determining what constitutes an operationally relevant conflict to be alerted by STCA and an effective minimum of nuisance/false alerts. The STCA definitely needed to be tuned to the operational preferences of the ANSP implementing it and to the local airspace configuration.

The second prototype developed by the project was related to STCA using the Down-linked Aircraft Parameters (Selected Altitude, Roll Angle, Track Angle Rate and True Air Speed). The validation, aimed at demonstrating the benefits of the use of DAPs in STCA function, was held as real time simulation considering ACC sectorization with recorded live traffic samples, performing a comparison between the results obtained by the prototype configured with and without the use of DAPs.

The comparative sessions outcomes showed that the use of DAPs in the STCA prototype determined a reduction of the number unnecessary alarms, an increase of the number of genuine alarms and of warning time with respect to the run not using DAPs. The non-nominal cases session demonstrated coherence with the one referring to nominal ones.

The evaluative session obtained the same results in terms of nuisance alerts reduction also receiving a positive feedback from the Controllers in terms of decrease of mental workload and stress, increase of confidence and trust.

The third prototype implemented the presentation on the Controller Working Position (CWP) the RA events generated by Airborne Collision Avoidance System (ACAS) on the line 0 as a chain of characters. Controllers are currently not aware of on-going RA events except if the pilots are reporting this event. Therefore clearances or instructions opposite to the RA can occur. This can be both, confusing for the pilots because they have to follow the RA events, and also the controllers because they may be surprised by unexpected actions of the pilots (during the actual RA event) due to the RA event.

Finally, the project provided a Safety Nets prototype to support a Free Route integrated validation exercise. This validation contributed to Pilot Common Project (PCP) AF#3 related to Free Routing but unfortunately the results of this exercise were not concluded at the time of writing this document.

1.3 Project Deliverables

The following table presents the relevant deliverables that have been produced by the project.

Reference	Title	Description
D32	Final Technical Specifications for Safety Nets	This document is the Final Technical Specification for Safety Nets for SESAR1. This document is an incremental update from the previous technical specifications performed in P10.04.03. It includes system requirements mainly for STCA safety net and RA down-linked parameters. It also includes system requirements for APW, MSAW and APM.

1.4 Contribution to Standardisation

No standardisation activities were performed within the scope of the project. Nevertheless the material produced (i.e. the technical specification) can be used as technical input to support any.

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1.5 Project Conclusion and Recommendations

This project, as a technical project, developed system requirements and prototypes taking into account operational needs to support the delivery of the ATM Master Plan.

In the context of this project the results were for Safety Nets, and more precisely for STCA and RA. For the other Safety Nets (APW, APM and MSAW) technical requirements were produced based on operational needs and implemented in a verified prototype, but any operational validation couldn't be performed in the scope of SESAR Programme for these other Safety Nets.

On STCA results it was proved, from a TMA point of view, that developed capabilities were considered clear advantages compared with the baseline, particularly in terms of false alerts.

On the other hand, from an En-Route point of view it was proved that the enhancement of STCA using DAPs such as Selected Flight Level (SFL) and Track Angle Rate (TAR) provide important quality improvements in the STCA tool allowing a significant reduction of nuisance alerts and as a consequence a significant reduction of ATCOs' workload. Indeed, the major benefits were obtained with the use of SFL.

Regarding RA results, the display of the RAs on the CWP brought a wide acceptance by the ATCOs although there wasn't conclusion regarding the best operational procedure, the safety contribution nor the final HMI.

Recommendations are mainly on the evolution of STCAs. STCAs could be adapted to future operations taking into account the new techniques of airspace design, traffic patterns, trajectories characteristics and separation minima.

On the other hand, Safety Nets could take advantage of the use of SWIM available additional information updating en-route and Approach area safety-net functionality to accept additional aircraft provided information and to implement additional rules for its use to provide additional conflict warnings and to reduce false conflict warnings.

Moreover, the compatibility between Ground and Airborne Safety Nets as well as the compatibility between STCA and ACAS could be improved. There is a need for better procedures in order to avoid inconsistent collision detection and solution and minimising negative operational interactions between ACAS and STCA.

Finally, it would be also beneficial to extend exercises to validate improvements on APW, APM and MSAW Safety Nets

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