# VALR-DAP-G-SNET-V3 Operational evaluation of enhanced STCA using DAP

| Document information | |
|---|---|
| Project Title | Evolution of Ground-Based Safety Nets |
| Project Number | 04.08.01 |
| Project Manager | DNSA |
| Deliverable Name | VALR-DAP-G-SNET-V3 Operational evaluation of enhanced STCA using DAP |
| Deliverable ID | D20 |
| Edition | 00.01.01 |
| Template Version | 03.00.00 |
| **Task contributors** | |
| ***ENAV,*** *DSNA* | |

*Please complete the advanced properties of the document*


***Abstract***

Deliverable D20 purpose is to provide the validation report related to EXE-VP-239, Step 1 V3 phase. The validation was conducted using the ENAV IBP located at the Experimental Centre in Rome. The exercise scenario was located in Milano ACC airspace. The exercise was focused on the use of existing Down linked Aircraft Parameters (DAP) within STCA and to assess the possible benefits. The exercise VP-239 was divided in two phases 239a and 239b in order to distinguish two different approaches represented by comparative exercise and Real Time. Furthermore, another validation activity was conducted in order to assess the non-nominal cases scenarios. The EXE-VP-239 simulation mainly investigates the following aspects:

- maintain or increase the genuine alert rate ,
- reduce the nuisance alert rate ,
- maintain or increase the alert warning time,
- increase the overall confidence of ATCOs in the use of STCA.

# Authoring & Approval

| Prepared By - *Authors of the document.* | | |
|---|---|---|
| Name &Company | Position & Title | Date |
| [redacted] ENAV | [redacted] | 16/10/2013 |
| [redacted] ENAV | | 08/11/2013 |
| [redacted] ENAV | | 09/12/2013 |
| [redacted] ENAV | | 09/12/2013 |
| [redacted] /ENAV | | 15/01/2014 |
| [redacted] /DSNA | | 17/02/2014 |
| [redacted] /ENAV | | 02/04/2014 |

| Reviewed By - *Reviewers internal to the project.* | | |
|---|---|---|
| Name & Company | Position & Title | Date |
| [redacted] /ENAV | [redacted] | 13/01/2014 |
| [redacted] /DSNA (Egis Avia) | | 28/01/2014 |
| [redacted] /DSNA | | 28/01/2014 |
| [redacted] /SELEX ES | | 05/02/2014 |
| [redacted] /EUROCONTROL | | 11/02/2014 |
| [redacted] /ENAV | | 19/02/2014 |
| [redacted] /SELEX ES | | 16/04/2014 |
| [redacted] /NATS | | 17/04/2014 |
| [redacted] /DSNA | | 24/04/2014 |
| [redacted] /INDRA | | 29/04/2014 |
| [redacted] EUROCONTROL | | 30/04/2014 |

| Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.* | | |
|---|---|---|
| Name & Company | Position & Title | Date |
| [redacted] /DFS | [redacted] | 28/02/2014 |
| [redacted] /SELEX ES | | 05/02/2014 |
| [redacted] /INDRA | | 29/04/2014 |

| Approved for submission to the SJU By - *Representatives of the company involved in the project.* | | |
|---|---|---|
| Name & Company | Position & Title | Date |
| [redacted] /SELEX ES | [redacted] | 16/04/2014 |
| [redacted] /ECTL | | 30/04/2014 |
| [redacted] /INDRA | | 08/05/2014 |
| [redacted] /NATS | | 08/05/2014 |
| [redacted] /DSNA | | 09/05/2014 |

| Rejected By - *Representatives of the company involved in the project.* | | |
|---|---|---|
| Name & Company | Position & Title | Date |
| <Name / Company> | <Position / Title> | <DD/MM/YYYY> |

| Rational for rejection |
| --- |
| None. |

# Document History

| Edition | Date | Status | Author | Justification |
| --- | --- | --- | --- | --- |
| 00.00.01 | 08/11/2013 | Draft | ENAV | Document creation |
| 00.00.02 | 09/11/2013 | Draft | ENAV | Added first Human Performance contribution |
| 00.00.03 | 09/11/2013 | Draft | ENAV | Added first Safety contribution |
| 00.00.04 | 13/01/2014 | Draft | ENAV | Added second Human Performance contribution |
| 00.00.05 | 16/01/2014 | Draft | ENAV | Added second Safety contribution |
| 00.00.06 | 17/01/2014 | Draft | ENAV | Document reviewed |
| 00.00.07 | 18/02/2014 | Revised Draft | DSNA | Added DSNA safety contribution |
| 00.00.08 | 19/02/2014 | Revised Draft | All | Document updated |
| 00.00.08 | 19/03/2014 | Revised Draft | ENAV | Added warning time section And document updated |
| 00.00.09 | 04/04/2014 | Final Draft | ENAV | Added Human Performance Assessment Report |
| 00.00.09 | 07/04/2014 | Final Draft | ENAV | Added EXE-04.08.01-VP239c analysis |
| 00.00.09 | 15/04/2014 | Final Draft | ENAV | Added a second contribution to the EXE-04.08.01-VP239c analysis |
| 00.01.00 | 12/05/2014 | Final | ENAV | Document updated and approved by 4.8.1 partners. |
| 00.01.01 | 21/07/2014 | Document Review | ENAV | Document reviewed after SJU assessment. |

# Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

# Table of Contents

# List of tables



# List of figures

# Executive summary

SESAR Project 4.8.1 deals with the evolution of ground-based Safety Nets. Deliverable D20 purpose is to provide the validation report related to EXE-VP-239. This exercise is involved in validation activity referred to Step 1- Time Based Operations - ATM Service Level 2 – within SESAR Joint Undertaking programme. It was conducted in V3 phase according to E-OCVM methodology. This exercise was conducted in Rome by ENAV in the experimental center with Milan en-route and TMA operational scenario. The exercise was focused on the use of existing Down linked Aircraft Parameters (DAP) within STCA and to assess the possible benefits. EXE-VP-239 will mainly investigate the following aspects:

- maintain or increase the genuine alert rate,
- reduce the nuisance alert rate,
- maintain or increase the alert warning time,
- increase the overall confidence of ATCOs in the use of STCA.

To achieve these objectives exercise VP-239 will be divided in two phases 239a and 239b in order to distinguish two different approaches represented by :

- Comparative evaluation of STCA alerting performances (with and without DAPs) through an iterative Experimental Sessions (two traffic samples will be used: TS1 and TS2) based on Mode S traffic samples properly adapted to address all the foreseen cases;
- Assessment of the enhanced STCA using DAPs through a small scale Real Time Simulation (RTS) aiming to evaluate the impact of the introduction of the enhanced STCA on ATCOs trust level and in the general to evaluate Human Performance aspects.

Another unplanned validation activity was conducted, VP-239c, in order to assess the functioning of the STCA prototype in non-nominal cases.

The validation activities will be conducted by means of a DAPs STCA prototype based on a multi-hypothesis algorithm developed by SELEX ES in the project 10.4.3.

After a quantitative analysis of the log files, the main results from the comparison between the STCA prototype using DAPs and the STCA baseline are listed below:

- A reduction of nuisance alerts: 17% for TS1 and 26% for TS2 (compared to the nuisance of STCA no DAP); 4% for TS1 and 5% for TS2 (compared to the total number of alerts)
- The alert rate of genuine conflicts is maintained
- An increased warning time
- A correct operative functioning even during non-nominal cases

Both SFL and TAR provide improvements in terms of STCA performances, although SFL contribution is more evident than the others particularly in en-route scenario.

# 1 Introduction

## 1.1 Purpose of the document

This document provides the validation report for project 04.08.01 and more specifically the validation of enhanced STCA using existing down-linked parameters related to the EXE-04.08.01-VP-239. In accordance to the validation plan D19-VALP-DAP-G-SNET-V3 "Validation Plan V3 for enhanced STCA using existing down-linked parameters" [18], it describes how the validation exercise was conducted and presents results of the validation exercise.

The validation activities within the EXE-04.08.01-VP-239 were executed by ENAV within the P04.08.01 'Evolution of Ground-Based Safety Nets', which is allocated to Step1 Operational Focus Area (OFA) 03.04.01 Enhanced Ground Based safety nets. The goal of the validation activities planned in the EXE-04.08.01-VP-239 is to evaluate the potential benefits derived from the use of existing DAPs available through Mode S Enhanced Surveillance (EHS) in the ground based safety nets, specifically focused on STCA.

The validation activities were conducted in the frame of Release 3.The validation was conducted using the ENAV IBP located at the Experimental Centre in Rome. ENAV reproduced an ad-hoc airspace configuration based on Milan ACC areas encompassing en-route and TMA operational sectors.

## 1.2 Intended readership

This document is intended for the members of 4.8.1 project "Evolution of ground-based safety nets" and 10.4.3 project "Safety nets adaptation to new modes of separation" for use in the planned validation activities related to the DAPs STCA prototype.

In addition, the audience of this document is:

- OFA 03.04.01 "Enhanced ground-based safety nets" ;
- P04.02 "Consolidation of operational concept definition and validation including operating mode and air-ground task sharing" (federating project), as OFA Coordinating Operational Federating Project;
- P16.6.1 "Safety support and coordination function";
- P16.6.5 "Human Performance support and coordination function".
- P05.02 "Consolidation of Operational Concept Definition and Validation"

## 1.3 Structure of the document

The document is structured in six sections, plus four appendices:

**Chapter 1:** Introduction -provides an explanation of the purpose and scope of this document.

**Chapter 2:** Context of the Validation - outlines the scope of the validation and references the Validation Plan / Strategy and concept related documents used.

**Chapter 3:** Conduct of Validation Exercises – description of the participants, platform, scenarios, scope and intended objectives of the exercise. This section focuses on validation exercise preparation and execution, including deviations from planned activities.

**Chapter 4:** Exercises Results – this section is divided per exercise and reported in Chapter 6.

**Chapter 5:** Conclusions and Recommendations – a summary of all key data, results and findings and how these extend into the feasibility for the practical implementation of STCA. This also includes recommendations for next steps and the potential impact areas of significant deviation from the expected validation trial/concept goals

**Chapter 6:** Exercises Results - feedback and observations from quantitative comparison, qualitative analysis and from questionnaires taken during the three different validation activities conducted. These results will be analysed, interpreted and summarised with respect to how they relate to the relevant KPAs.

**Appendix A** reports the Human Performance Assessment Report related to the Small Scale RTS.

**Appendix B** reports the System Under Test Requirements to provide the corrections asked by SJU assessment to VALP [18].

**Appendix C** reports the analysis conducted through a DSNA safety tool.

**Appendix D** reports the situation awareness analysis linked to the HMI prototype implementation.

## 1.4 Glossary of terms

| Term | Definition |
|---|---|
| **Genuine or necessary alerts** | Alert which is correctly generated according to the rule set and is considered operationally appropriate. |
| **Nuisance or unnecessary alerts** | Alert which is correctly generated according to the rule set but is considered operationally inappropriate. |
| **Look ahead time** | The number of seconds of the trajectory prediction computed by the Safety Net System |
| **SESAR Programme** | The programme which defines the Research and Development activities and Projects for the SJU. |
| **SJU Work Programme** | The programme which addresses all activities of the SESAR Joint Undertaking Agency. |

## 1.5 Acronyms and Terminology

| Term | Definition |
|---|---|
| **ACC** | Area Control Center |
| **ADD** | Aircraft Derived Data |
| **ANSPs** | Air Navigation Service Providers |
| **ATCOs** | Air Traffic Control Operators |
| **ATM** | Air Traffic Management |
| **BLN STCA** | Baseline Short Term Conflict Alert |
| **CFL** | Cleared Flight Level |
| **DAPs** | Down-Linked Aircraft Parameters |
| **DCT** | Direct Routing |

| Term | Definition |
|---|---|
| **DOD** | Detailed Operational Description |
| **E-ATMS** | European Air Traffic Management System |
| **E-OCVM** | European Operational Concept Validation Methodology |
| **EHS** | EnHanced (Mode S) Surveillance |
| **ER** | En-route |
| **FL** | Flight Level |
| **GND** | Ground |
| **G-SNETs** | Ground-based Safety NETs |
| **IBP** | Industry Based Platform |
| **IRS** | Interface Requirements Specification |
| **INTEROP** | Interoperability Requirements |
| **OFA** | Operational Focus Areas |
| **MWL** | Mental WorkLoad |
| **OFA** | Operational Focus Areas |
| **OI** | Operational Improvement |
| **OSED** | Operational Service and Environment Definition |
| **PI** | Performance Indicator |
| **RA** | Roll Angle |
| **RTS** | Real-Time Simulation |
| **RWY** | Runway |
| **SA** | Situation Awareness |
| **SESAR** | Single European Sky ATM Research Programme |
| **SJU** | SESAR Joint Undertaking (Agency of the European Commission) |
| **SFL** | Selected Flight Level |
| **SPR** | Safety and Performance Requirements |
| **STCA** | Short-Term Conflict Alert |
| **SUT** | System Under Test |

| Term | Definition |
|---|---|
| **TAD** | Technical Architecture Description |
| **TAR** | Track Angle Rate |
| **TAS** | True Air Speed |
| **TMA** | Terminal Control Area |
| **TS** | Technical Specification |
| **UNL** | Unlimited |
| **VALP** | Validation Plan |
| **VALR** | Validation Report |
| **VALS** | Validation Strategy |
| **VP** | Verification Plan |
| **VR** | Verification Report |
| **VS** | Verification Strategy |
| **XFL** | Exit Flight Level |

# 2 Context of the Validation

The validation activities described in this document follow the principles of European-Operational Concept Validation Methodology (E-OCVM).

Based on the outcomes of a series of (V2) validation exercises to assess feasibility, safety and performance benefits (and possible side-effects), as well as costs estimates performed in the V2 phase of 4.8.1 project, the exercises is a V3 maturity level.

The goal of the validation activities in the EXE-04.08.01-VP-239 is to evaluate the potential benefits derived from the use of existing DAPs available through Mode S Enhanced Surveillance (EHS) in the ground based safety nets, specifically focused on STCA.

In the context of the 10.4.3 project, SELEX ES developed an STCA prototype based on a multi-hypothesis algorithm and capable of using Mode S down-linked aircraft parameters (e.g. Selected Flight Level, Roll angle/Track angle rate) to improve trajectory predictions. The deliverable D11 of the 10.4.3 project[15] lists the system requirements that have been used to develop the prototype.

The validation was conducted using the ENAV IBP located at the Experimental Centre in Rome.

The validation is part of the Priority Business Need "Conflict Management and Automation". The Operational Sub-Package is SPC03.04 "Air safety nets" and the Operational Focus Area is OFA03.04.01 "Enhanced ground-based safety nets".

| Operational Package | Operational Sub-Package | Operational Focus Area | OIs | Initial Maturity level | Target Maturity level | | | Reused validation material from past R&D Initiatives |
|---|---|---|---|---|---|---|---|---|
| | | | | | V1 | V2 | V3 | |
| Priority Business Need "Conflict Management and Automation" | SPC03.04 "Air safety nets" | OFA03.04.01 "Enhanced ground-based safety nets" | CM-0807-A[1] STEP1<br><br>CM-0811[2] STEP1 | V2 | | | X | EXE-04.08.01-VP-140 |

**Table 1 Maturity levels table**

During the validation activities, the stakeholders' needs were defined and formalised as a set of requirements in 4.8.1-D17-OR-DAP-G-SNET-V2 "Preliminary operational requirements for the use of down-linked aircraft parameters in ground based safety nets" will be validated.

[1] *CM-0807-A Enhanced Ground-based Safety Nets using Mode S EHS data replaced IS-0302:Use of Aircraft Derived Data (ADD) to Enhance ATM Ground System Performance*

[2] *CM-0811: Enhanced STCA for TMA specific operations*

## 2.1 Concept Overview

The following table summarizes the main details of the exercise under the scope of this Validation Report.

| Validation Exercise ID and Title | EXE-04.8.01-VP-239 : Operational validation of an enhanced STCA using existing down-link parameters |
|---|---|
| **Leading organization** | ENAV S.p.A. |
| **Validation exercise objectives** | To evaluate the potential benefits deriving from the use of existing DAPs in STCA . |
| **Rationale** | STCA presents a high rate of nuisance alerts especially in specific context and conditions. Room for improvements are foreseen using DAPs and the potential enhancements result in a reduced nuisance alert rate while maintaining or increasing the genuine alert rate and increasing alert warning times. |
| **Supporting DOD / Operational Scenario / Use Case** | 04.02-D07-En Route Detailed Operational Description Step1/<br>OS-4-04-Safety nets in En Route |
| **OFA addressed** | 03.04.01 |
| **OI steps addressed** | CM-0807-A STEP 1[3]<br>CM-0811 STEP1 |
| **Enablers addressed** | ER APP ATC 14b |
| **Applicable Operational Context** | En-route and TMA sectors |
| **Expected results per KPA** | Safety: improvement of safety level through:<br>• Detect actual hazards earlier than otherwise<br>• Identify actual hazards that would otherwise not be detected<br>• Reduce the rate of false and/or nuisance alerts<br>Human Performance: no negative impacts are expected on ATCOs working methods.<br>No negative effect are expected in terms of mental workload and situation awareness (SA).<br>A positive impact is expected on ATCOs' level of confidence in the enhanced STCA |
| **Validation Technique** | Experimental Session and operational expert off-line analysis (Comparative approach)<br>RTS with Human Factor experts analysis (Evaluative approach) |
| **Dependent Validation Exercises** | None |

**Table 2: Concept Overview**

[3] This OI replaced the IS-0302

## 2.2 Summary of Validation Exercise

### 2.2.1 Summary of Expected Exercise outcomes

The purpose of the exercise is to validate the importance of the use of DAPs in the Ground Based Safety Nets, and for STCA in particular to increase the reliability and accuracy. This was carried out comparing the performances of the two STCA behaviours (baseline and DAPs STCA prototype).

The exercise VP239 was divided in two phases 239a and 239b in order to distinguish the two different approaches used during the validation.

During the comparative phase several scenarios was run on a demonstrator, without the interaction of ATCOs. The planned scenario will be executed in two different organizations: Baseline STCA and STCA+DAP. Operational experts will be involved as observers and system data-log will be recorded, to be analysed post-hoc.

The evaluative phase has the scope of validate in the controllers perspective, the acceptability of the STCA DAPS prototype performance/behaviour and its impact on ATCOs performance and level of confidence. Quantitative and qualitative data collected will be analysed post-hoc.

The expected benefits are to improve warning times, to decrease nuisance alerts rate and at least to maintain or increase the genuine alerts rate.

Another unplanned validation activities was conducted in order to assess the function of the STCA prototype in non-nominal cases.

The stakeholders concerned by the scope of the intended validation activities are as follows:

**Airspace users**

The Airspace Users are expecting an increase in flight safety thanks to effective ground-based SNETs, then the demonstration that the safety indicator is improved with respect to baseline.

**ANSPs**

ANSPs aim at improving the level of safety in their managed airspace through the deployment of efficient ground-based SNETs enhanced with the use of existing DAPs.

The scope is to validate operational concept, show improvement of safety indicator with respect to baseline.

The validation of an Enhanced STCA should demonstrate:

- The improvement of genuine STCA alerts (timeliness and/or relevance) for controllers
- The reduction of false and nuisance STCA alerts for controllers specifically in TMA;

**Ground industry**

It is essential for the Ground Industry to validate the operational acceptability of STCA prototypes, prerequisite for the industrialization, the certification then marketing and deployment.

### 2.2.2 Benefit mechanisms investigated

A summary of the validation benefits are listed in the following section.

The number of nuisance (i.e. undesirable or unnecessary) alerts is expected to be reduced when using DAPs, notably the Selected Flight Level (SFL) during encounter situations where two aircraft are expected to level-off 1,000 feet apart from each other.

In specific scenarios, the warning time of necessary (or desirable) alerts are expected to be increased, e.g. when using the SFL to anticipate a level-off at an occupied FL or an imminent departure from level flight towards another aircraft, or when using the roll angle/track angle rate to anticipate a conflicting turn manoeuvre of an aircraft towards another aircraft.

For maximum safety benefits (particularly when the aircraft derived data is not valid), the use of DAPs is expected to not degrade the number of necessary and desirable alerts.

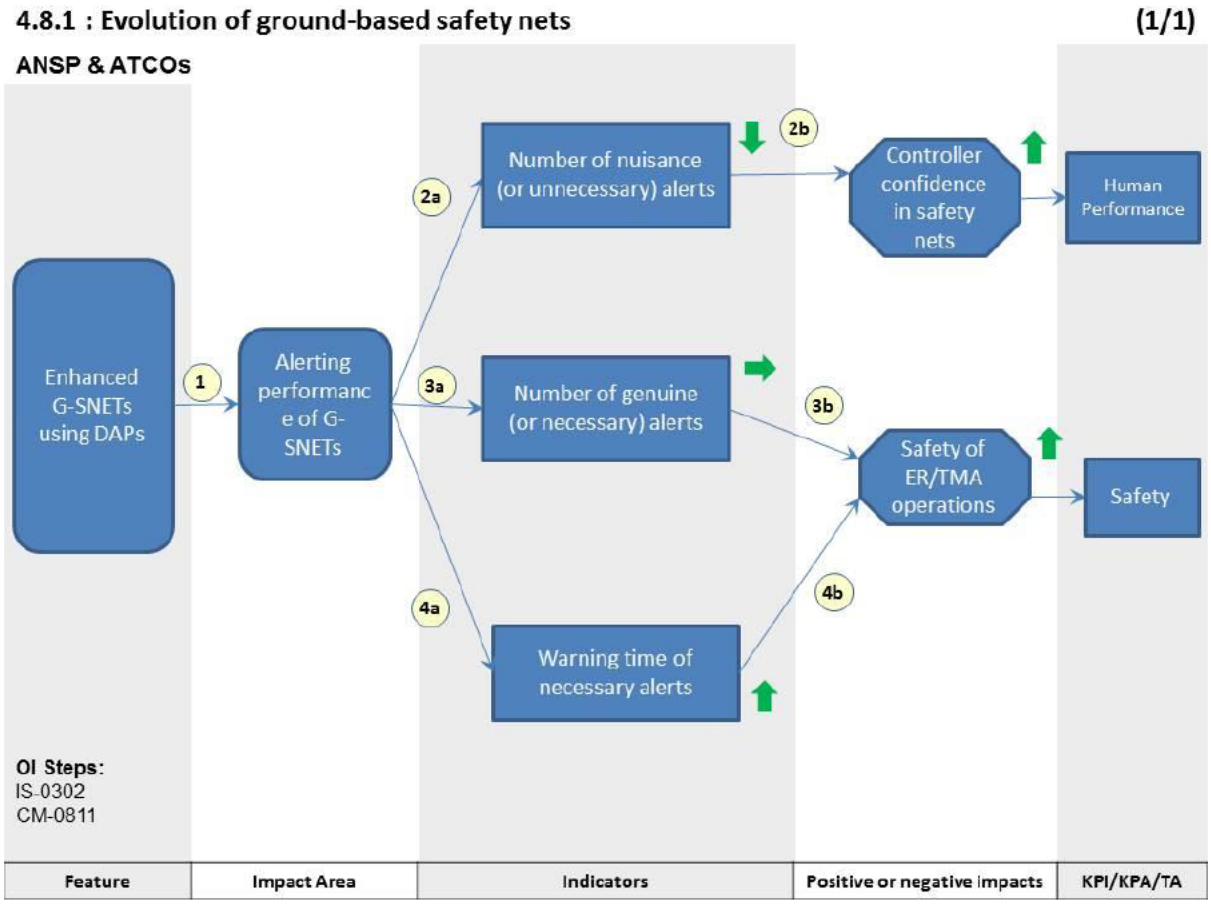


**Figure 1 Benefit Mechanisms**

*(1) Ground-based safety nets enhanced with DAPs will reduce risk of ATM induced accidents or incidents by increasing the effectiveness of the safety net. This benefit is expected to be achieved through an enhanced monitoring of the environment of operations with timely alerts of an increased risk of flight safety (both in en-route and TMA)*

*(2a) The system shall decrease the numbers of nuisance alerts*

*(2b) This will allow a greater ATCOs' trust in the STCA linked to the Human performance KPA*

*(3a) The system shall detect all the genuine alerts*

*(3b) This will allow to preserve the detection of genuine alerts, linked to the safety KPA*

*(4a) The system shall show the necessary alert earlier, through a higher warning time.*

*(4b) This will allow the ATCOs to have more time to assess the situation and to resolve the encounters, increasing the safety of the operations, linked to the safety KPA*

## 2.2.3 Summary of Validation Objectives and success criteria

It is expected that the use of DAPs (Downlink of Aircraft Parameters) allowed an improvements in terms of performances of the Ground Safety NETs.
This is one of the objectives of the project as indicated in the OSED document (see chapter 2)[16].
In particular, in the exercise 239, the main target is to evaluate the improvements of the STCA tool.

The validation followed two different and complementary approaches:

The Comparative approach has a selected number of micro-scenarios featured by Mode-S traffic samples by means of Experimental Sessions in which STCA was evaluated with and without the

DAPs support. The operational scenario tested was Milan ACC airspace, enclosing ER and TMA sectors. Datalog were recorded during the evaluation study. After this phase, an off-line analysis was conducted by ENAV operational experts. Results are expected to highlights the benefits provided by STCA with the DAPs support.

The Evaluative approach envisages a small scale RTS featured by the same operational scenario (Milano ACC enclosing en-route and TMA sectors). The aim of this phase is to collect operational feedback provided by ATCOs about the operational acceptability and potential impact on human performance of the introduction of STCA prototype using DAPs (DAPs STCA). Data collected (mainly qualitative) during the RTS were analysed by Human factors experts.

The validation objectives are summarised as follow:

| Identifier | OBJ-04.08.01-VALP-0010.0055 |
|---|---|
| Objective | Validate the ability of DAPs STCA to detect and alert operationally relevant conflicts in TMA .and en-route airspace |

| Identifier | Success Criterion |
|---|---|
| CRT-04.08.01-VALP-0010.0005 | The alert rate for operationally relevant conflicts that occur inside the TMA and the en-route airspace is maintained or increased compared to baseline STCA. |
| CRT-04.08.01-VALP-0010.0012 | The STCA+DAPs prototype detects all the encounters in TMA and en-route airspace in non-nominal cases. |

| Identifier | OBJ-04.08.01-VALP-0010.0060 |
|---|---|
| Objective | Validate the rate of operationally irrelevant conflicts (nuisance) detected and alerted by DAPs STCA in TMA and en-route airspace. |

| Identifier | Success Criterion |
|---|---|
| CRT-04.08.01-VALP-0010.0006 | The nuisance alerts rate that occur inside the TMA and the en-route airspace is decreased compared to baseline STCA. |

| Identifier | OBJ-04.08.01-VALP-0010.0070 |
|---|---|
| Objective | Validate the warning time of operationally relevant conflicts detected and alerted by DAPs STCA in TMA and en-route airspace. |

| Identifier | Success Criterion |
|---|---|
| CRT-04.08.01-VALP-0010.0007 | The alert warning times that occur inside the en-route and the TMA airspace are maintained or increased compared to baseline STCA. |

| Identifier | OBJ-04.08.01-VALP-0010.0080 |
|---|---|
| Objective | To validate the acceptability from the controller perspective of the STCA DAPs performance/behaviour in the simulated operational environment. |

| Identifier | Success Criterion |
|---|---|
| CRT-04.08.01-VALP-0010.0008 | The performance/behaviour of STCA DAPs prototype is considered acceptable by ATCOs. |
| CRT-04.08.01-VALP-0010.0009 | The introduction of STCA DAPs does not negatively impact controller task load, that shall remain within acceptable levels. |

| Identifier | OBJ-04.08.01-VALP-0010.0090 |
|---|---|

| | |
|---|---|
| Objective | To evaluate the level of ATCOs confidence in DAPs STCA prototype in the simulated operational environment |

| Identifier | Success Criterion |
|---|---|
| CRT-04.08.01-VALP-0010.0010 | The level of confidence in using the STCA DAPs prototype is considered acceptable by ATCOs. |
| CRT-04.08.01-VALP-0010.0011 | The level of confidence in using the STCA DAPs prototype is considered acceptable in the different ATS areas. Particular benefit are expected in TMA. |

### 2.2.3.1 Choice of metrics and indicators

This section provides a list of KPAs and metrics adopted during the validation activities.

| KPA | Metrics/Indicators | Related Validation Objectives/Hypothesis |
|---|---|---|
| Safety | -Flights id (pair)<br>-STCA ON time<br>-STCA OFF time<br>-Aircrafts (horizontal) separation (NM) at STCA ON time<br>-Aircrafts (horizontal) separation (NM) at STCA OFF time<br>-Aircrafts Flight Level at STCA ON time<br>-Aircrafts Flight Level at STCA OFF time<br>-Aircrafts Climbing/Descending rate<br>-Aircrafts CFL at STCA ON time<br>-Aircrafts CFL at STCA OFF time | OBJ-04.08.01-VALP-0010.0055(↑) |
| | -Aircrafts SFL at STCA ON time<br>-Aircrafts SFL at STCA OFF time<br>-Aircrafts Roll Angle at STCA ON time<br>-Aircrafts Roll Angle at STCA OFF time<br>-Aircrafts Track Angle Rate at STCA ON time | OBJ-04.08.01-VALP-0010.0060 (↓) |
| | -Aircrafts Track Angle Rate at STCA OFF time<br>-Warning time | OBJ-04.07.07-VALP-0010.0070 (↑) |

**Table 3 Choice of metrics and indicators**

## 2.2.4 Summary of Validation Scenarios

The environment reproduced was Milan ACC.

The Validation Scenario was based on the simulation of two measured sectors of Milan ACC (namely SWS and ASW) plus one feeder sector defined as "external sector" as the whole validation scenario. These sectors was slightly modified in order to customize the traffic in the appropriate sectors dimension. In addition, also the Feeder sector is envisaged . The role of the feeder sector is to transfer the traffic into the measured sectors according the LoA and FLAS in Milan Area of Control. . In addition, the Scenario will include also 2 major airports LIML Linate and LIMC Malpensa airport.

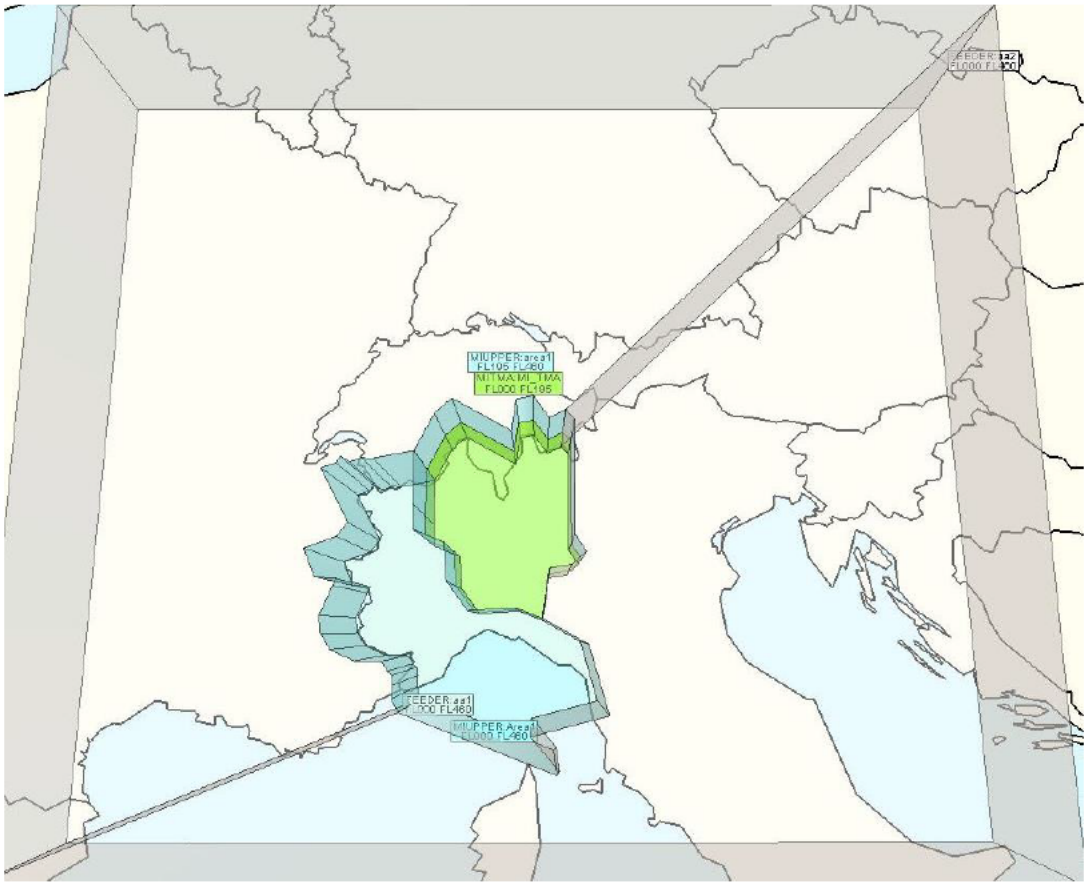

**Figure 2 Airspace layout**

During the scenario preparation, the dimension of these sectors was slightly modified in order to better accommodate the traffic and to create some conflicts in the interested area of simulation for both TMA and en-route phase of flight. The difference between the two environments is the different longitudinal separation adopted that is 5 NM in en-route and 3 NM in TMA.

The reference Scenario refers to the current Italy Airspace in Milano ACC enclosing ER and TMA sectors, with the implementation and application of the current STCA tool without the DAPs support "Baseline STCA".

The Solution Scenario simulated the same operational scenario, while the STCA was featured by DAPs "DAPs STCA".

### *EXE-04.08.01-VP-239a: comparative approach.*

During the comparative exercise several scenarios were run on a demonstrator, without the interaction of ATCOs. The planned scenario was executed in two different organization: Baseline

STCA and STCA+DAP. Operational experts were involved as observers and system data-log will be recorded, to be analysed post-hoc

| | |
|---|---|
| Identifier | SCN-04.08.01-VALP-0010.0001 |
| Scenario | This is a reference Scenario. It provides the use of baseline STCA in Milan en-route and TMA sectors with recorded controlled traffic. |

| | |
|---|---|
| Identifier | SCN-04.08.01-VALP-0010.0002 |
| Scenario | This is the solution Scenario. It provides the use of DAP STCA in Milan en-route and TMA sectors with recorded controlled traffic. |

### *EXE-04.08.01-VP-239b: evaluative approach.*

The purpose of the following exercise phase was to validate from the controllers perspective the acceptability of the STCA DAPs prototype performance/behaviour and its impact on ATCOs performance and level of confidence. Quantitative and qualitative data collected were analysed post-hoc.

| | |
|---|---|
| Identifier | SCN-04.08.01-VALP-0010.0003 |
| Scenario | Use baseline STCA at Milan en-route and TMA sectors with live controlled traffic (Pseudo Pilots) |

| | |
|---|---|
| Identifier | SCN-04.08.01-VALP-0010.0004 |
| Scenario | Use DAP STCA in Milan en-route and TMA sectors with live controlled traffic (Pseudo Pilots) |

### *EXE-04.08.01-VP-239c: non-nominal cases.*

| | |
|---|---|
| Identifier | SCN-04.08.01-VALP-0010.0006 |
| Scenario | Use STCA+DAPs in Milan en-route and TMA sectors with live controlled traffic (Pseudo Pilots) in non-nominal cases |
| Status | <In Progress> |

## 2.2.5 Summary of Assumptions

This section provides an overview of the validation assumptions applicable to the validation exercises.

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-001 | No change to the role of ground-based safety nets | Procedures in place | Ground-based safety nets will continue to assist air traffic controllers as last ATC safety barriers against collision risks/hazards of aircraft with other aircraft, airspace, terrain, etc. | When envisaging using Down-linked Aircraft Parameters, it is essential to clarify their expected role that needs to be complementary to the role dedicated to other Conflict Detection/Resolution tools or monitoring aids, In order to do that, STCA needs to be an independent safety barrier in case of conflict not detected by the others tools. | All phases in flight (en-route, TMA) | Safety | 04.08.01 Initial OSED: 4.8.1-D17-OR-DAP-G-SNET-V2-Ed 1.1 | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-002 | Milano ACC - TMA sectorization | Airspace layout | The scenario airspace is Milano ACC.<br>The TMA portion of airspace will be divided in the following sectors:<br>ADE<br>LAR<br>ANE<br>ANW<br>ASW<br>MAR<br>During the exercise, the sector selected is ASW. The vertical limits are GND/FL195. | Before starting the exercise, it's important to define in a unique way, the sectors in which it will be executed. Sectors are selected in order to build a more specific view and to limit the range of airspace to be monitored. | TMA phase of flight. | Safety | VP-239 Operational Leader | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-003 | Milano ACC - en-route sectorization | Airspace layout | The scenario airspace is Milano ACC.<br>The en-route portion of airspace will be divided in the following sectors:<br>SWN<br>SWS<br>CEN<br>During the exercise, the sector selected is SWS. The vertical limits are FL 195/UNL and GND/UNL.. | Before starting the exercise, it's important to define in a unique way, the sectors in which it will be executed. Sectors are selected in order to build a more specific view and to limit the range of airspace to be monitored. | En-route phase of flight. | Safety | VP-239 Operational Leader | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-004 | Milano Malpensa Airport (LIMC) and Milano Linate Airport (LIML) | Airport characteristics | For the arrival/departure phases of flight, Milano Malpensa (LIMC) and Milano Linate (LIML) Airports have been identified.<br>The Milano Malpensa Airport is one of the most important Italian airports. It has two parallel runways: 17/35R and 17/35L.<br>Milano Malpensa is Milan's intercontinental airport with its wide range of domestic, international and intercontinental flights.<br>The Milano Linate Airport (LIML) is one of the three major airports of Milan, Italy.<br>Due to its closer proximity to Milan, it is mainly used for domestic and short-haul international flights.<br>It has two runways: one for the commercial aviation 18/36 and the other one for the general aviation. | The reference airports chosen for the validation are Milano Malpensa and Milano Linate.<br>This will provide the exercise with a differentiated and representative type of traffic patterns. | TMA phase | Safety | VP239 Operational Leader | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-005 | Ad-Hoc patterns for the comparative approach of VP-239. | Traffic characteristics | Specific encounters will be reproduced to create the conflicts scenarios in overfly, departure, arrival, climbing and descending phase of flight. | For the comparative evaluation of STCA alerting performances (with and without DAPs), the target is to create a well-defined type and planned conflicts. | All phases in flight (En-route, TMA) | Safety | WP3, ENAV VP-239 team | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-006 | Traffic patterns for the human performance approach of VP-239. | Traffic characteristics | Simulated traffic on a daily base related to summer weekday operations shall reproduce a whole operational working context. In particular, the days selected are Friday the 13th and Friday the 20th July 2012. | In the second phase of the exercise, another approach will be used that will provide an operational assessment of the enhanced STCA in ATCOs confidence level and taking into account Human Performance aspects. | All phases in flight (en-route, TMA) | Safety | WP3, ENAV VP-239 team | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-007 | Aircraft EHS capability | Traffic characteristics | In our case, we simulate all the traffic and so we decided to have all aircrafts equipped and the availability and accuracy of concerned DAPs is 100%. | The scope of the validation is to obtain possible operational benefits coming from the use of DAPs into the STCA algorithm and not to check the availability and accuracy of DAPs. The operational benefits are increasing the warning time, not degrading the genuine alert and decreasing the nuisance alert. In this context, we didn't take into account the non-nominal events and we used the availability and accuracy of DAPs at 100%.<br><br>An assessment of the availability and accuracy is reported in the 4.8.1-D12-VR-Feasibility-DAP- G-SNET-V2 deliverable. | All phases in flight (En-route, TMA) | Safety | 4.8.1 previous related activities:<br>4.8.1-D12-VR-Feasibility-DAP-G-SNET-V2<br>4.8.1-D13-VR-Benefits-DAP-STCA-V2<br>4.8.1-D14-VR-Benefits-DAP-G-SNET-V2 | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-008 | Simulated surveillance data type : Mode-S EHS | Ground Tools Technology | The STCA prototype is based on a multi-hypothesis algorithm and capable of using Mode-S EHS downlinked aircraft parameters (e.g. Selected Flight Level, Roll angle/Track angle rate). | The objective of the two different exercises is to evaluate the potential benefits derived from the use of existing DAPs available through Mode-S Enhanced Surveillance (EHS) in the ground based safety nets, specifically focused on STCA. | All phases in flight (en-route, TMA) | Safety | VP 239 ENAV team | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-009 | Display CFL and SFL data into the track label | Ground Tools Technology | Dedicated ground HMI for the Controller Working Position to display on track label of CFL and SFL. | DAPs on track label will improve the OPL and ATCOs situational awareness during the conflicts analysis. | All phases in flight (en-route, TMA) | Safety | VP-239 Operational Leader. | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-010 | Ground Tools Technology | DAPs minimum set for STCA prototype. | The expected DAPs minimum set is represented by SFL, Roll Angle/Track Angle Rate. | The providing of DAPs minimum set to the STCA prototype is foreseen to address the validation scenarios and to achieve the validation objectives. | All phases in flight (en-route, TMA) | Safety | 4.8.1 previous related activities:<br>4.8.1-D11-VP-DAP-G-SNET-V2 Feasibility & Options<br>4.8.1 V3 exercise VP140 (Release1) | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-0011 | HP indicator | Human Performance | Qualitative and quantitate HP indicators and metrics will be collected during the measured run | Metrics and indicators are assumed to be directly related to human performance | All phases in flight and all sectors (en-route, TMA) | Human Performance | ENAV HF/HP Expert | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

| Identifier | Title | Type of Assumption | Description | Justification | Flight Phase | KPA Impacted | Source | Value(s) | Owner | Impact on Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| ASS-04.08.01-VP239-S1-0012 | Initial training | Human Performance | ATCOs will be provided by appropriate training and information related to the STCA DAPs. | An initial training session is foreseen for ATCOs to familiarize with the enhanced STCA functionality. | All phases in flight and all sectors (en-route, TMA) | Human Performance | ENAV HF/HP Expert | None | 04.08.01 | High |

**Table 4 Validation Assumptions**

## 2.2.6 Choice of methods and techniques

The following table shows the methods and techniques used during the experiment to obtain metrics and indicators.

| Supported Metric / Indicator | Platform / Tool | Method or Technique |
|---|---|---|
| STCA alerts (per sector and scenario: with or without DAP) | IBP/10.4.3 prototype, data log recording. | Ad-hoc experimental Sessions based on Mode S traffic samples properly adapted to address all the foreseen cases and data log Post-Processing analysis |
| Number of nuisance (per sector and scenario: with or without DAP) | IBP/10.4.3 prototype, data log recording | Ad-hoc experimental Sessions based on Mode S traffic samples properly adapted to address all the foreseen cases and data log Post-Processing analysis |
| ATCOs tactical orders | IBP/10.4.3 prototype, data log recording. | Tactical orders ( i.e. DCT, CFL, XFL) |
| ATCOs Workload | IBP/10.4.3 prototype, data log recording. | ATCOs mental workload (NASA-TLX) |
| ATCOs Trust | IBP/10.4.3 prototype, data log recording. | ATCOs situation awareness(SHASA) |
| Traffic management patterns | IBP/10.4.3 prototype, data log recording | Planned and Flown Trajectory, TAS, AFL, RWY |

**Table 5: Methods and Techniques**

## 2.2.7 Validation Exercises List and dependencies

There was only one standalone validation exercise planned and executed, EXE-04.08.01-VP-239.

The Validation exercise VP239 is related to the V2 maturity activities that are explained in the validation plan 4.8.1-D11-VP-DAP-G-SNET-V2 "Validation Plan (V2) for Enhanced Ground-based Safety Nets using Existing Down-link Parameters"[9]. From this, five Validation Reports were produced for specific investigated areas. In particular, the 4.8.1-D12-VR-Feasibility-DAP-G-SNET-V2[10]evaluates the feasibility and options for the use of existing down-linked aircraft parameters within ground-based safety nets; the deliverable4.8.1-D13-VR-Benefits-DAP-STCA-V2 [11]and 4.8.1-D14-VR-Benefits-DAP-G-SNET-V2[12], evaluates the safety and performance benefits of using existing down-linked aircraft parameters; the 4.8.1-D15-SAR-Safety-DAP-G-SNET-V2[13] provides assurance elements for the safe use of existing down-linked aircraft parameters in ground-based safety nets – based on safety hazard analysis and the 4.8.1-D16-VR-Costs-DAP-G-SNET-V2[14] provides a cost estimates for the use of downlinked aircraft parameters in ground-based safety nets

A preliminary activity of V3 maturity has been conducted in Release 1. The validation plan is 4.8.1-D04-VP-TMA-STCA-V3 "Final validation plan (V3) for enhanced Short Term Conflict Alert (STCA) for Terminal control area (TMA) specific operations"[7] and the associated final Validation Report is 4.8.1-D05-VR-TMA-STCA-V3 "Operational evaluation of industrial Short Term Conflict Alert (STCA) prototype for Terminal control area (TMA) specific operations" [8].

The following figure shows the activities conducted within the 4.8.1 Project, related to this exercise.

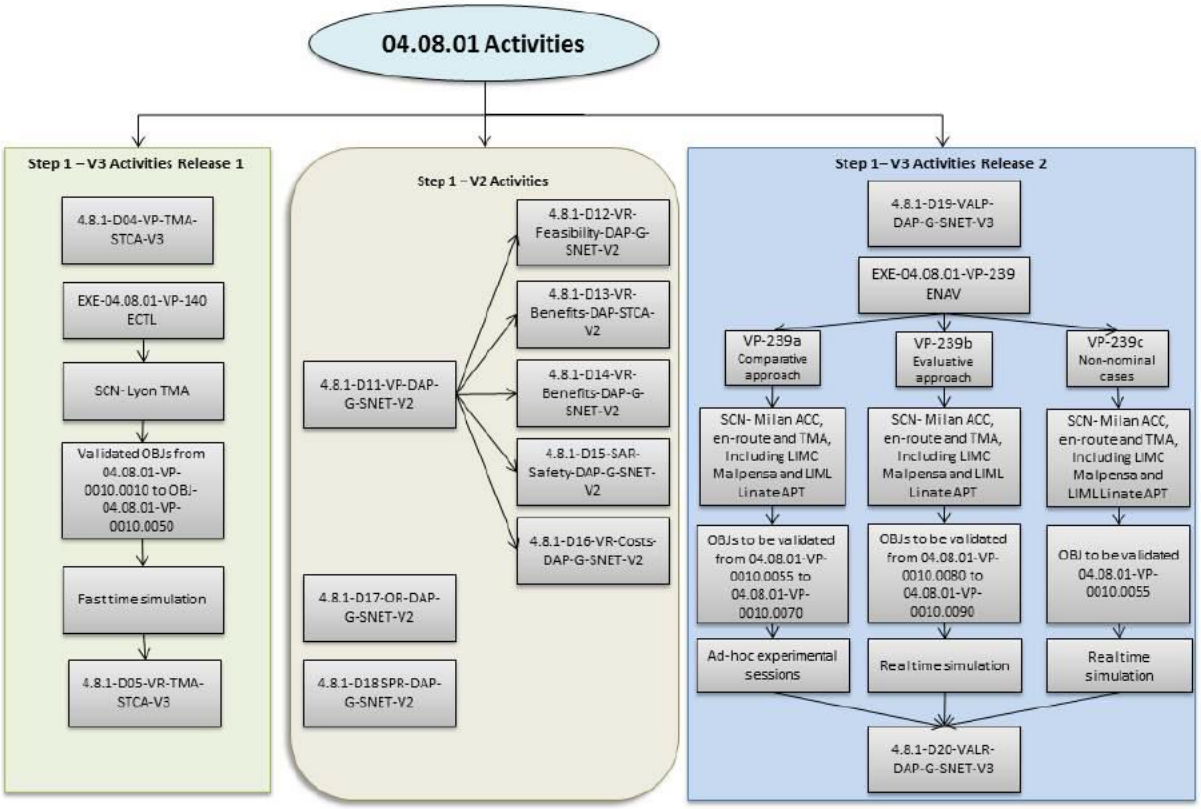


**Figure 3 04.08.01 Activities**

# 3 Conduct of Validation Exercises

## 3.1 Exercises Preparation

The preparation of VP-239 required the involvement and the cooperation of different actors with specific skills, roles, responsibilities and tasks.
The following table summarises the activities carried out by the different actors during the preparation phase. Actors are indicated by their role, not by personal name.

| ACTOR | ACTIVITIES |
|---|---|
| Exercise Manager | • Manages the preparation process in order to ensure the execution of the exercise in line with objectives and timeline |
| Exercise Technical Coordinator | • Sets the Technical platform according to project requirements<br>• Organises regular Technical and Operational Tests, according to the project schedule. |
| Exercise Operational Leader | • Supports the definition of the operational scenario applied<br>• Contributes to the definition of ATCOs' working methods and operational procedures<br>• Supports the definition and evaluation of the traffic samples<br>• Coordinates with the ACCs the ATCOs' availability during tests and exercise<br>• Manages the training preparation |
| Scenario Preparer | • Prepares the operational scenarios for the exercise<br>• Prepares the traffic samples for tests, training and exercise<br>• Implements non nominal events in the traffic samples if needed |
| Human Factors Analyst | • Contributes to define the organisations applied<br>• Contributes to select the data collection methods applied<br>• Prepares data collection materials (observation grids, scripts for debriefings, questionnaires)<br>• Contributes to define the recording specifications<br>• Defines non nominal events to be introduced in the traffic samples, if needed<br>• Defines experimental design and agenda of the exercise<br>• Defines the ATCOs seating plan according to the experimental design |

**Table 6: Preparation Activities**

### 3.1.1 STCA settings

During the exercise EXE-VP-239 execution the following parameters have been used.

| STCA Settings | STCA+DAPs | STCA |
|---|---|---|
| Look-ahead time in linear extrapolation | 120 sec | 120 sec |
| Look-ahead time in maneuver extrapolation | 120 sec | - |
| Warning time in linear extrapolation | 80 sec | 80 sec |
| Warning time in maneuver extrapolation | 100 sec | - |
| Imminent time | 40 sec | 120 sec |
| Separation threshold horizontal convergent aircraft in linear extrapolation | 5 NM FL195-410<br>3 NM FL000-195 | 5 NM FL195-410<br>3 NM FL000-195 |
| Separation threshold horizontal divergent aircraft in linear extrapolation | 4.98438 NM FL195-410<br>2.9 NM FL000-195 | 4.98438 NM FL195-410<br>2.9 NM FL000-195 |
| Separation threshold vertical | 900 Ft RVSM<br>1900 Ft NON RVSM | 900 Ft RVSM<br>1900 Ft NON RVSM |
| Separation threshold horizontal convergent aircraft in maneuver extrapolation | 5 NM FL195-410<br>3 NM FL000-195 | 5 NM FL195-410<br>3 NM FL000-195 |
| Separation threshold horizontal divergent aircraft in maneuver extrapolation | 4.98438 NM FL195-410<br>2.9 NM FL000-195 | 4.98438 NM FL195-410<br>2.9 NM FL000-195 |
| Number of alarms detection | 3 (12 s) | 3 (12 s) |
| Consecutive detection number to confirm the alarm | 2 (8 s) | 2 (8 s) |
| Confirm number to delete the alarm | 2 (8 s) | 2 (8 s) |

**Figure 4 STCA settings in the two different configuration: solution and reference.**

The first two rows refers to the forward time that the system uses in the trajectory extrapolation. They are the same during the linear and the maneuver trajectory.

The warning time is different in linear with respect to the maneuver extrapolation, in particular the warning time in maneuver is bigger than the warning time in linear extrapolation.

Warning and imminent time are associated to the alarm state of the STCA (see par. Appendix D).

The separation thresholds in the case of horizontal convergent aircraft in linear extrapolation and manoeuvre extrapolation is 5 NM for FL195-410 and 3NM FL000-195.The separation thresholds in

the case of horizontal divergent aircraft in linear extrapolation and manoeuvre extrapolation is 4.98438 NM for FL195-410 and 2.9 NM FL000-195.

The vertical separation was set to 900 feet for RVSM approved flights and 1900 feet for NON RVSM approved ones. The number of alarms detections needed to issue an alert was set to 3 of which 2 must be consecutive. The number of consecutive missing detections of an existing alarm before its deletion was set to 2.

## 3.2 Exercises Execution

The exercise VP239 was divided in three phases 239a, 239b and 239c in order to distinguish the different analysis carried on during the validation. The classification of the conflicts was conducted by operational experts.

The first two validation activities were planned , later on another validation activity was conducted in order to evaluate the operation of the prototype STCA in non-nominal situations. The exercises were executed with the subsequent schedule:

| Exercise ID | Exercise Title | Actual Exercise execution start date | Actual Exercise execution end date | Actual Exercise start analysis date | Actual Exercise end date |
|---|---|---|---|---|---|
| EXE-VP-239a | Operational validation of an enhanced STCA using existing down-link parameters | 07/10/2013 | 08/10/2013 | 21/10/2013 | 31/01/2014 |
| EXE-VP-239b | Operational validation of an enhanced STCA using existing down-link parameters | 14/10/2013 | 16/10/2013 | 21/10/2013 | 31/01/2014 |
| EXE-VP-239c | Operational validation of an enhanced STCA using existing down-link parameters | 27/03/2014 | 27/03/2014 | 31/03/2014 | 18/04/2014 |

**Table 7: Exercises execution/analysis dates**

EXE-VP-239a was carried out comparing the performances of the two STCA behaviours (baseline and DAPs STCA prototype). During the comparative exercise several scenarios was run on a demonstrator, without the interaction of ATCOs. The planned scenario was executed in two different organization Baseline STCA and STCA+DAP as described in the agenda below. Operational experts were involved as observers and system data-log was recorded, to be analysed post-hoc.

| | P04.08.01: RTS EXE-VP-239a V3 (R3) | | | |
|---|---|---|---|---|
| | 07/10/2013 | 08/10/2013 | 09/10/2013 | |
| 09.00 - 09.15 | Welcome and validation activities introduction | STCA + SFL (Solution Scenario) TS1 | Spare | 09.00 - 09.15 |
| 09.15 - 09.30 | | | | 09.15 - 09.30 |
| 09.30 - 09.45 | | | | 09.30 - 09.45 |
| 09.45 - 10.00 | | | | 09.45 - 10.00 |
| 10.00 - 10.15 | | Debriefing | *coffee break* | 10.00 - 10.15 |
| 10.15 - 10.30 | | | Debriefing | 10.15 - 10.30 |
| 10.30 - 10.45 | STCA (Reference Scenario) TS1 | *coffee break* | | 10.30 - 10.45 |
| 10.45 - 11.00 | | STCA + SFL (Solution Scenario) TS2 | Spare | 10.45 - 11.00 |
| 11.00 - 11.15 | | | | 11.00 - 11.15 |
| 11.15 - 11.30 | | | | 11.15 - 11.30 |
| 11.30 - 11.45 | *coffee break* | | | 11.30 - 11.45 |
| 11.45 - 12.00 | Debriefing | | | 11.45 - 12.00 |
| 12.00 - 12.15 | | Debriefing | Debriefing | 12.00 - 12.15 |
| 12.15 - 12.30 | | | | 12.15 - 12.30 |
| 12.30 - 12.45 | STCA + DAP (Solution Scenario) TS1 | lunch break | lunch break | 12.30 - 12.45 |
| 12.45 - 13.00 | | | | 12.45 - 13.00 |
| 13.00 - 13.15 | | | | 13.00 - 13.15 |
| 13.15 - 13.30 | | | | 13.15 - 13.30 |
| 13.30 - 13.45 | lunch break | STCA + Track angle rate (Solution Scenario) TS1 | Spare | 13.30 - 13.45 |
| 13.45 - 14.00 | | | | 13.45 - 14.00 |
| 14.00 - 14.15 | | | | 14.00 - 14.15 |
| 14.15 - 14.30 | | | | 14.15 - 14.30 |
| 14.30 - 14.45 | STCA (Reference Scenario) TS2 | Debriefing | Debriefing | 14.30 - 14.45 |
| 14.45 - 15.00 | | | | 14.45 - 15.00 |
| 15.00 - 15.15 | | | | 15.00 - 15.15 |
| 15.15 - 15.30 | | *coffee break* | *coffee break* | 15.15 - 15.30 |
| 15.30 - 15.45 | Debriefing | STCA + Track angle rate (Solution Scenario) TS2 | Spare | 15.30 - 15.45 |
| 15.45 - 16.00 | | | | 15.45 - 16.00 |
| 16.00 - 16.15 | | | | 16.00 - 16.15 |
| 16.15 - 16.30 | *coffee break* | | | 16.15 - 16.30 |
| 16.30 - 16.45 | STCA + DAP (Solution Scenario) TS2 | Final Debriefing | Final Debriefing | 16.30 - 16.45 |
| 16.45 - 17.00 | | | | 16.45 - 17.00 |
| 17.00 - 17.15 | | | | |
| 17.15 - 17.30 | | | | |
| 17.30 - 17.45 | Final Debriefing | | | |
| 17.45 - 18.00 | | | | |

**Figure 5: EXE-VP-239a Agenda**

EXE-VP-239b purpose is to validate from the controllers perspective the acceptability of the STCA DAPS prototype performance/behaviour and its impact on ATCOs performance and level of confidence. These aspects were validated through a Real Time Simulation taking into account the following agenda:

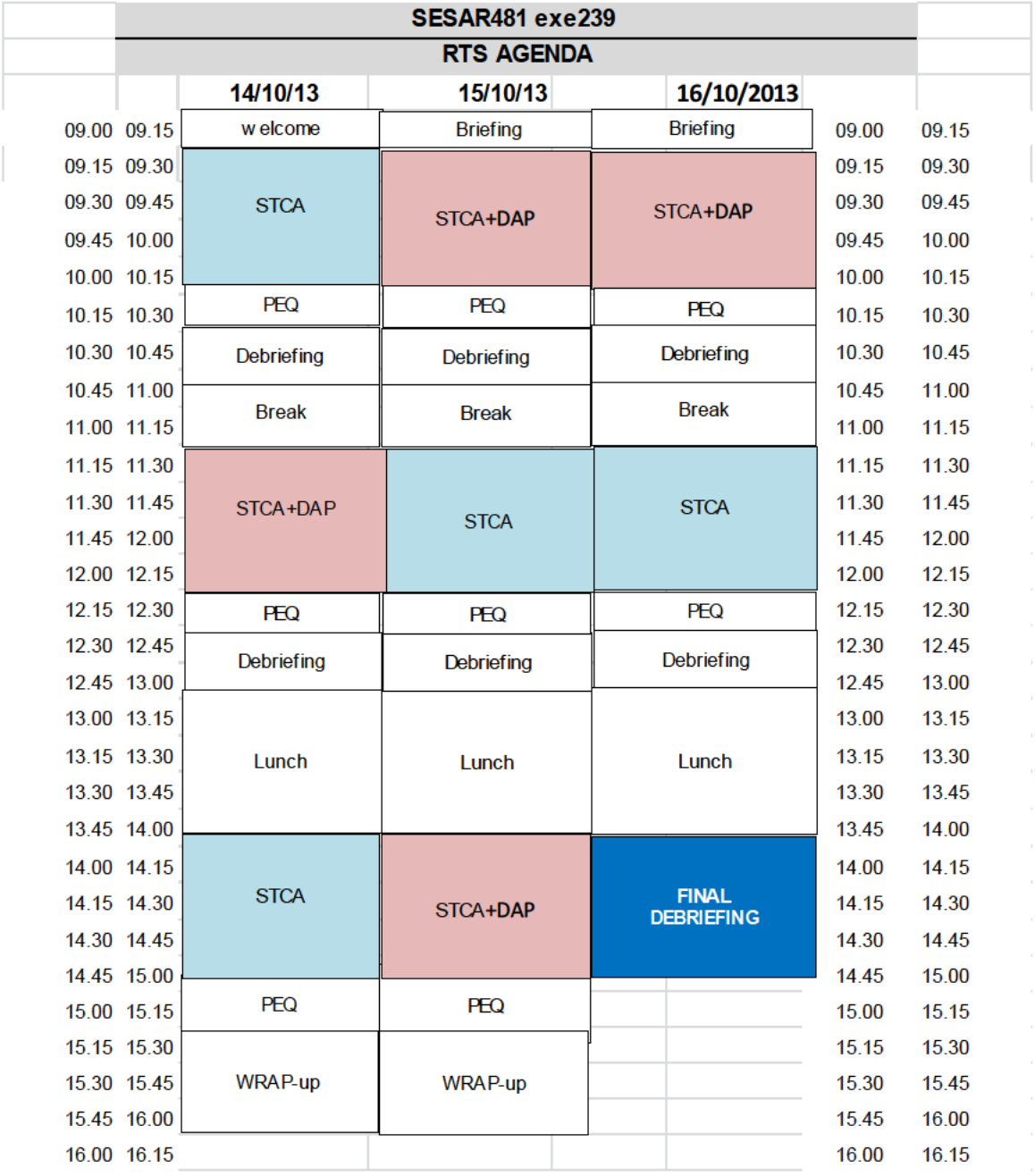


**Figure 6: EXE-VP-239b Agenda**

During each simulation day, the measured exercises were rotated according to the schedule presented above, balancing the solution and the reference scenario: Reference scenario STCA (STCA) and solution scenario STCA+DAPs (STCA+DAPs).Each scenario was run twice under two different traffic sample, namely sTS1 and TS2. Total number of measured run was 8.
Each exercise was followed by a Post Exercises Questionnaire (PEQ) enclosing two different instrument: the NASA-TLX questionnaire for the assessment of the ATCOs perceived mental workload and the SATI questionnaire for ATCOs trust evaluation.
Moreover, each run was followed by a dedicated debriefing.

Each exercise was observed by HF experts.
Before starting the RTS and at the end of the RTS activities ATCOs were required to fill a custom questionnaire called TEQ (trust evaluation questionnaire) aiming to collect ATCOs feedback about the comparison b/w the actual STCA currently in use in Milan ACC and the STCA+DAP tested during the RTS.

On the last RTS day, ATCOs participated to the final debriefing.

For the EXE-VP-239c, which was unplanned according to the para. 3.3.2, the purpose is to validate the correct operation of the STCA+DAPs prototype during non-nominal situations. During the validation activities, we designed ad-hoc encounters, following some predefined events. These aspects were validated through a Real Time Simulation taking into account the following agenda:

| | **P04.08.01: EXE-VP-239c V3 (R3)**<br>**27/03/2014** |
|---|---|
| 09.00 - 09.15 | Welcome and Validation Activities |
| 09.30 - 09.45 | |
| 09.45 - 10.00 | |
| 10.00 - 10.15 | **STCA + DAPs (Solution Scenario)**<br>**TS3 non-nominal cases: Incorrect MCP/FCU Selected Altitude** |
| 10.15 - 10.30 | |
| 10.30 - 10.45 | |
| 10.45 - 11.00 | |
| 11.00 - 11.15 | *coffee break* |
| 11.15 - 11.30 | |
| 11.30 - 11.45 | **STCA + DAPs (Solution Scenario)**<br>**TS3 non-nominal cases: no Mode-S capable** |
| 11.45 - 12.00 | |
| 12.00 - 12.15 | |
| 12.15 - 12.30 | |
| 12.30 - 12.45 | *lunch break* |
| 12.45 - 13.00 | |
| 13.00 - 13.15 | |
| 13.15 - 13.30 | |
| 13.30 - 13.45 | **STCA + DAPs (Solution Scenario)**<br>**TS3 non-nominal cases: corrupted SFL** |
| 13.45 - 14.00 | |
| 14.00 - 14.15 | |
| 14.15 - 14.30 | |
| 14.30 - 14.45 | *coffee break* |
| 14.45 - 15.00 | |
| 15.00 - 15.15 | Spare |
| 15.15 - 15.30 | |
| 15.30 - 15.45 | |
| 15.45 - 16.00 | |
| 16.00 - 16.15 | Final debriefing |
| 16.15 - 16.30 | |
| 16.30 - 16.45 | |
| 16.45 - 17.00 | |

**Figure 7 EXE-04.08.01-VP239c Agenda**

## 3.3 Deviations from the planned activities

### 3.3.1 Deviations with respect to the Validation Strategy

No deviations have been found.

### 3.3.2 Deviations with respect to the Validation Plan

The following deviations from the planned activities occurred.

The exercise was conducted during two weeks and not in one, as reported in the VALP [18].

During the first week, on the 7th, 8th and 9th of October 2013, we performed the comparative approach and during the second week, on the 14th, 15th and 16th of October 2013, we performed the evaluative approach. This allows us to have more time to deal with possible problems.

Agenda run updated: during the first RTS day the run STCA+DAP TS1 and the run STCA TS1 were swapped. In the following days, the exercises execution followed the planned agenda.

It was decided to address ATCOs situation awareness by collecting qualitative feedback and debriefing sessions instead to require ATCOs to fill an additional questionnaire.

The DAP implemented in the STCA version under test were SFL and track angle rate. The support provided by the use of roll angle was considered overlapping the use of track angle rate. In fact, the STCA prototype use the Roll Angle and the True Air Speed to calculate the Track Angle Rate, if the latter isn't provided

Then the project team decided to use only SFL and track angle during the whole exercise. These features were evaluated during the 239a phase both in the same run and separately in a dedicated run, while were tested working together during the 239b phase.

After the first two parts of the validation exercise (VP-239a and VP-239b), we decided to perform another validation activity to be compliant to the SESAR JU procedures in order to proceed to V4 maturity. During this new activity, we planned some encounters in order to assess the correct STCA+DAPs prototype operation during non-nominal cases scenario REF.

The experimental conditions performed during this simulation were:

- Incorrect MCP/FCU Selected Altitude: the pilot performed a wrong manoeuvre without following the clearance of the ATCO.
- Corrupted SFL:, the SFL data arrives corrupted during the exchange of the information in the downlink from the aircraft, for example due to a transmission error in receiving the data.
- No Mode-S capable: one of, or both, the aircraft involved in the encounter were no Mode-S equipped.

We added the success criterion CRT-04.08.01-VALP-0010.0010 to the validation objective OBJ-04.08.01-VALP-0010.0055. We added a dedicated section in the document in which we describes the validation activities, see para. 6.3.

The final version of the document D18 "VALR-DAP-G-SNET-V3 Operational evaluation of enhanced STCA using DAP" has been completed on 21st February 2013 while the TS (D11 VALR-DAP-G-SNET-V3 Operational evaluation of enhanced STCA using DAP produced by the System Project (10.4.3) were issued before, on 5th October 2012.

The final version of the D19 VALP, which final version was issued on 10th June 2013, takes into account the D18 while the prototype (and the TS) have been developed before the D18 so the SPR is not taken into account. The TS are updated with a refinement document (D20) produced by 10.4.3 within which are included the outputs of the 4.8.1-D20 VALR- DAP-GSNET V3.

# 4 Exercises Results

This section provide an overall summary of the validation activities in para. 6.1, 6.2 and 6.3.

## 4.1 Summary of Exercises Results

The validation activities conducted were divided in three phases, respecting the different approaches used:

- The comparative approach, EXE-VP-239a
- The evaluative approach, EXE-VP-239b
- The non-nominal cases study, EXE-VP-239c.

The obtained results are listed below.

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| EXE-VP-239a | OBJ-04.08.01-VALP-0010.0055 | STCA using DAPs in TMA .and in en-route | CRT-04.08.01-VALP-0010.0005 | The alert rate for operationally relevant conflicts that occur inside the TMA and the en-route airspace is maintained or increased compared to baseline STCA. | The analysis of the alarms LOG have shown that the alert rate of the relevant conflicts was maintained , and in some cases increased, with the use of DAP | OK |
| EXE-VP-239a | OBJ-04.08.01-VALP-0010.0060 | Nuisance alerts of STCA using DAPs in TMA and en-route | CRT-04.08.01-VALP-0010.0006 | The nuisance alerts rate that occur inside the TMA and the en-route airspace is decreased compared to baseline STCA. | The analysis of the alarms LOG have shown a reduction of the nuisance alarms by a percentage of 17% for TS1 and 26% for TS2 with the use of DAP (compared | OK |

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| | | | | | to the nuisance of STCA no DAP); 4% for TS1 and 5% for TS2 (compared to the total number of alerts). | |
| EXE-VP-239a | OBJ-04.08.01-VALP-0010.0070 | Warning time of STCA using DAPs in TMA and en-route | CRT-04.08.01-VALP-0010.0007 | The alert warning times that occur inside the en-route and the TMA airspace are maintained or increased compared to baseline STCA. | There are evidences of improvements in the alert warning time inside the en route and TMA airspace | Ok |
| EXE-VP-239b | OBJ-04.08.01-VALP-0010.0080 | Acceptability of STCA DAPs performance | CRT-04.08.01-VALP-0010.0008 | The performance/behaviour of STCA DAPs prototype is considered acceptable by ATCOs. | Controllers report a positive feedback concerning the acceptability of the use of STCA+DAP. Operational benefits related to significant reduction (compare to the current STCA) of nuisance alerts were identified | OK |
| | | | CRT-04.08.01-VALP-0010.0009 | The introduction of STCA DAPs does not negatively impact | ATCOs perceived as less demanding | OK |

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| | | | | controller task load, that shall remain within acceptable levels. | working with the STCA with DAP support then using the current STCA version. | |
| EXE-VP-239b | OBJ-04.08.01-VALP-0010.0090 | Confidence assessment | CRT-04.08.01-VALP-0010.0010 | The level of confidence in using the STCA DAPs prototype is considered acceptable by ATCOs | ATCOs report significant higher trust values with DAP support compared to the current STCA version | OK |
| | | | CRT-04.08.01-VALP-0010.0011 | The level of confidence in using the STCA DAPs prototype is considered acceptable in the different ATS areas. Particular benefit are expected in TMA | The use of STCA+DAP is globally rated quite high in both sectors under test, however a more significant effect is recorded in the en-route sector. | OK |
| EXE-VP-239c | OBJ-04.08.01-VALP-0010.0055 | STCA using DAPs in TMA .and in en-route | CRT-04.08.01-VALP-0010.0010 | The STCA+DAPs prototype detects all the encounters in TMA and en-route airspace in non-nominal cases. | The Log files analysis demonstrate the coherence in the alarm detection also in the non-nominal | OK |

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| | | | | | cases. | |

**Table 8 Summary of Validation Exercises Results**

### 4.1.1 Results on concept clarification

Results arisen from this validation activities do not impact the STCA concept itself. The results provide further support to the acceptability of the STCA concept enhanced through the use of downlinked aircraft parameters DAPs.

### 4.1.2 Results per KPA

The major results assessed during the validation were a reduced number of nuisance alerts, the number of genuine alerts was equally to the reference (at least) and an increased warning time. The ATCo perceived less mental workload as well as an increased trust in the prototype. The benefits were mainly due to the use of the selected flight level. The major benefits due to the downlink of DAPs were obtained in en-route phase. Furthermore, the technical analysis carried on during non-nominal cases simulation, showed the coherent functioning of the STCA+DAPs prototype.

For the detailed analysis and for further details see para. 6.1.3.1.2, 6.2.3.1.2 and 6.3.3.1.2.

### 4.1.3 Results impacting regulation and standardisation initiatives

The concept under validation related to STCA+DAPs, at this stage, has not impact on current Regulation and Standardisation activities..

## 4.2 Analysis of Exercises Results

### 4.2.1 Unexpected Behaviours/Results

See para. 6.1.3.2.1, 6.2.3.2.1 and 6.3.3.2.1.

## 4.3 Confidence in Results of Validation Exercises

The exercise results are based on a number of realistic simulated run, that enabled the comparative and the evaluative approach of the STCA alerting performance with and without the use of DAPs. This simulation covered a wide range of possible STCA implementations based on different scenarios.

### 4.3.1 Quality of Validation Exercises Results

Accuracy of the results and confidence in the results is ensured by the realism of the simulations conducted in the exercise. Thanks to the use of real data in the simulation scenario a level of realism is obtained.

### 4.3.2 Significance of Validation Exercises Results

The realism and amount of situations covered by the simulation runs ensure operational significance of the exercise results..

# 5 Conclusions and recommendations

This section reports the overall conclusions and recommendations summary of the Validation Activities conducted.

Refer to sections 6.1.4, 6.2.4 and 6.3.4 for further details.

As indicated in the template, this section won't be filled. The exercise conclusions and recommendations will be explained in sections 6.1.4, 6.2.4 and 6.3.4.

## 5.1 Conclusions

In the following paragraph are reported the general conclusions deducted by the three validation activities. The main and significant conclusions are listed below:

- Decreased number of nuisance alarms
- Increased warning time (or at least equal)
- Detection of all the genuine alarms
- Coherent operational functioning also in non-nominal cases
- Decrease of ATCOs'mental workload
- Increase in ATCOs'confidence and trust
- Drastic reduction of perceived stress
- Less demanding working
- No need to double check the alarms
- ATCOs allocate easier their attention resources to their primary task (maintain a safe separation)

All the objectives has been verified with success. Major evidences are reported in en-route sector. Major improvements are linked to the SFL (Selected Flight Level) availability. The STCA prototype showed problems below the height of 3000 ft ( radar minima).

All the required objectives have been verified and the V3 maturity is fully achieved.

So the prototype is ready for the V4 pre-implementation phase.

## 5.2 Recommendations

The recommendation issued during the validation activities are as follows:

- a better tune of the tool parameters under a certain altitude (e.g. 3000ft radar minima) in order to avoid the nuisances occurring between aircraft still on the ground and aircraft just departed
- for a future development of STCA, the selected heading and the cleared heading could be used for a better turn identification.
- it is recommended to develop a more standardized working methods (such as sequencing traffic) in order to facilitate a reliable behaviour of the STCA+ DAP.
- it is suggested to implement specific filters/volumes in the terminal area with a differentiated STCA tuning.
- it is recommended to improve the STCA+DAP HMI
- it is recommended to execute further studies on other non- nominal situations.

# 6 Validation Exercises reports

## 6.1 Validation Exercise EXE-04.08.01-VP-239a Report (Operational validation of an enhanced STCA using existing down-link parameters)

This section illustrates the findings of the comparative phase of the exercise

### 6.1.1 Exercise Scope

The Comparative approach has a selected number of micro-scenarios featured by Mode-S traffic samples by means of Experimental Sessions in which STCA was evaluated with and without the DAPs support. The operational scenario tested was the Milan ACC, enclosing ER and TMA sectors. Datalog were recorded during the evaluation study. After this phase, an off-line analysis was conducted by ENAV operational experts. Results are expected to highlights the benefits provided by STCA with the DAPs support.

### 6.1.2 Conduct of Validation Exercise

#### 6.1.2.1 Exercise Preparation

See para. 3.1.

#### 6.1.2.2 Exercise execution

See para. 3.2.

#### 6.1.2.3 Deviation from the planned activities

See para. 3.3.

### 6.1.3 Exercise Results

#### 6.1.3.1 Summary of Exercise Results

The results of the EXE-VP-239a are summarised in Table 9. It shows the summary of results compared to the success criteria identified within the Validation Plan per validation objective. The analysis covers all the Validation Objectives embedded in the Validation Exercise as for the corresponding Validation Plan.

The results were assessed against the success criteria and it is indicated if the Validation objective analysis status is OK or NOK:

- OK: Validation objective achieves the expectations (exercise results achieve success criteria)
- NOK: Validation objective does not achieve the expectations (exercise results do not achieve success criteria).

In the table have only been reported a summary of the exercises results, therefore for more details please refer to next section.

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| EXE-VP-239a | OBJ-04.08.01-VALP-0010.0055 | STCA using DAPs in TMA .and in en-route | CRT-04.08.01-VALP-0010.0005 | The alert rate for operationally relevant conflicts that occur inside the TMA and the en-route airspace is maintained or increased compared to baseline STCA. | The analysis of the alarms LOG have shown that the alert rate of the relevant conflicts was maintained , and in some cases increased, with the use of DAP | OK |
| EXE-VP-239a | OBJ-04.08.01-VALP-0010.0060 | Nuisance alerts of STCA using DAPs in TMA and en-route | CRT-04.08.01-VALP-0010.0006 | The nuisance alerts rate that occur inside the TMA and the en-route airspace is decreased compared to baseline STCA. | The analysis of the alarms LOG have shown a reduction of the nuisance alarms by a percentage of 17% for TS1 and 26% for TS2 with the use of DAP (compared to the nuisance of STCA no DAP); 4% for TS1 and 5% for TS2 (compared to the total number of alerts). | OK |
| EXE-VP-239a | OBJ-04.08.01-VALP- | Warning time of STCA using | CRT-04.08.01-VALP- | The alert warning times that occur inside the en- | There are evidences of | Ok |

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| | 0010.0070 | DAPs in TMA and en-route | 0010.0007 | route and the TMA airspace are maintained or increased compared to baseline STCA. | improvements in the alert warning time inside the en route and TMA airspace | |

**Table 9: Summary of Validation Exercises Results**

#### 6.1.3.1.1 Results on concept clarification

Results arisen from this validation activity do not impact the STCA concept itself. The results provide further support to the acceptability of the STCA concept. Moreover, the evaluation executed reports detailed feedback on the benefits and the potential advantages in detecting loss of separation minima linked to the implementation of STCA supported by the DAP in the simulated environment.

#### 6.1.3.1.2 Results per KPA

**Safety KPA**

The test has proved an increased efficiency and work capability of the controllers employed for the two exercise phases. It mainly increased their confidence with the system and improved their concentration on real traffic conflicts.
The analysis the team has conducted mainly consisted in comparing the alarms the system detected in the present configuration of Milan ACC with those detected by the new STCA in order to find out a sensible reduction of the nuisance or false alarm of the tool.
We defined “necessary alarms” the alert which is correctly generated according to the rule set and is considered operationally appropriate; when the alert is correctly generated according to the rule set but is considered operationally inappropriate,Furthermore, we defined “anomalies” as alarms not operatively significant in the RTS (and that cannot be considered as non-nominal events), i.e. missed level track for an aircraft; alarms linked to aircrafts still on the ground or alarms raised at the end of the simulation run that don’t have a term.The team involved in the testing phase began by identifying pairs of airplanes in conflict that appeared in the alarm log produced by the system. They then analysed in which area the conflict took place (area control or TMA) and consequently highlighted whether the conflict resulted in an infringement of minimum separation with respect to the minimum separation parameters according to Milan ACC’s flight region area.
Please find below some examples so as to gain a clearer understanding of the analysis carried out without including all the less relevant data.

| CONFLICT TIME | CALLSIGN TRACK 1 | CALLSIGN TRACK 2 | SEPARATION | LEVEL TRACK 1 | LEVEL TRACK 2 |
|---|---|---|---|---|---|
| 10:17:34 | EZY2938 | SWR1621 | 3NM/1000ft | 23 | 34 |

**Table 10 - Conflict between EZY2938 and SWR1621**

As seen in Table 10, the team extracted the conflict between the two airplanes - EZY2938 and SWR1621 - from the log at the minute 10:17:34. The conflict took place as the first airplane was flying through altitude 2300ft and the second at an altitude of 3400ft. From these indications it can be seen that the conflict took place in Milan TMA, which is an airspace where the minimum horizontal separation allowed is 3NM and minimum vertical separation is 1000ft.

| ALARM STATUS | CONFLICT TIME | CALLSIGN TRACK 1 | CALLSIGN TRACK 2 | Heading (°) | Heading(°) | LATERAL DISTANCE (NM) | VERTICAL DISTANCE (ft) | NECESSARY ALARM |
|---|---|---|---|---|---|---|---|---|
| FRST | 10:17:34 | EZY2938 | SWR1621 | 347 | 190 | 3.08 | 800 | not necessary |
| UPDT | 10:17:35 | EZY2938 | SWR1621 | 347 | 190 | 3.06 | 700 | not necessary |
| UPDT | 10:17:37 | EZY2938 | SWR1621 | 347 | 190 | 3.03 | 700 | not necessary |
| UPDT | 10:17:42 | EZY2938 | SWR1621 | 347 | 190 | 3.02 | 600 | not necessary |
| UPDT | 10:18:14 | EZY2938 | SWR1621 | 347 | 190 | 3.02 | 500 | not necessary |
| UPDT | 10:17:42 | EZY2938 | SWR1621 | 347 | 190 | 3.02 | 500 | not necessary |
| TERM | 10:17:46 | EZY2938 | SWR1621 | 347 | 190 | 3.03 | 400 | not necessary |

**Table 11 - STCA analysis for EZY2938 and SWR1621 aircraft**

Table 10 continues the analysis of this specific example and it follows how the alarm status progresses from the start time (first row – 'frst') to the successive updates (rows 'updt') and finally arriving at the last row ('term'). The alarm status in this table shows that the minimum separation between the two airplanes was never less than the minimum separation in Milan TMA required by Milan ACC (minimum horizontal separation allowed is 3NM and minimum vertical separation is 1000ft). So the testing team considered this alarm as not necessary, that is a nuisance.

| CONFLICT TIME | CALLSIGN TRACK 1 | CALLSIGN TRACK 2 | SEPARATION | LEVEL TRACK 1 | LEVEL TRACK 2 |
|---|---|---|---|---|---|
| 10:42:24 | BAW3120 | EZY2904 | 7.45NM/1100ft | 142 | 130 |

**Table 12 Conflict between BAW3120 and EZY2904**

| ALARM STATUS | CONFLICT TIME | CALLSIGN TRACK 1 | CALLSIGN TRACK 2 | Heading (°) | Heading (°) | LATERAL DISTANCE (NM) | VERTICAL DISTANCE (ft) | NECESSARY ALARM |
|---|---|---|---|---|---|---|---|---|
| FRST | 10:42:24 | BAW3120 | EZY2904 | 197 | 87 | 8.58 | 1500 | not necessary |
| UPDT | 10:42:24 | BAW3120 | EZY2904 | 197 | 87 | 8.02 | 1300 | not necessary |
| UPDT | 10:42:24 | BAW3120 | EZY2904 | 197 | 87 | 7.45 | 1100 | not necessary |
| UPDT | 10:42:25 | BAW3120 | EZY2904 | 197 | 87 | 6.92 | 1000 | not necessary |
| TERM | 10:41:58 | BAW3120 | EZY2904 | 197 | 87 | 6.36 | 1000 | not necessary |

**Table 13 - Conflict between BAW3120 and EZY2904**

In Table 13, the analysis shows a common nuisance case produced by the existing system in Milan ACC. On the other hand, the new tool never produced any such case, under any circumstances, throughout the testing phase.
The alarm was produced between tracks BAW3120 and EZY2904 (as seen in Table 12) whose vertical separation reduced from 1500ft to 1000ft (within the regulated limit of separation). This alarm never occurred in the test results from the new STCA tool. Therefore when the pilot selects the correct level as communicated by the air traffic controller's clearance the system manages to ensure that the two airplanes in question never come into conflict and no false alarms are produced. As a result, the air traffic controller is not distracted by these false problems and can dedicate attention to other matters. Vertical nuisances, as those in Table 13, were eliminated completely (100%).
The number of alarms the system detected divided between the two different runs are listed below:

**Exercise TS1:**

The new STCA detected 46 alarms: 19 of those came out to be necessary while 19 of those came out to be not necessary. 8 alarms resulted to be anomalies.

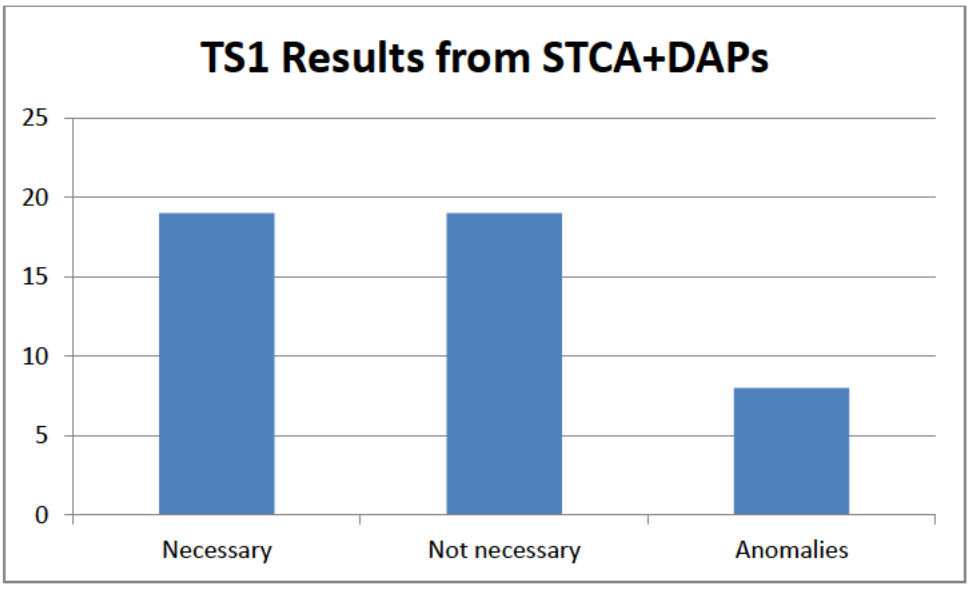


**Figure 8 - TS1 Results from STCA+DAPs**

The system set using parameters similar to current STCA working at Milan ACC detected 50 alarms. 17 of those came out to be necessary while 23 of those came out to be not necessary and 10 anomalies.

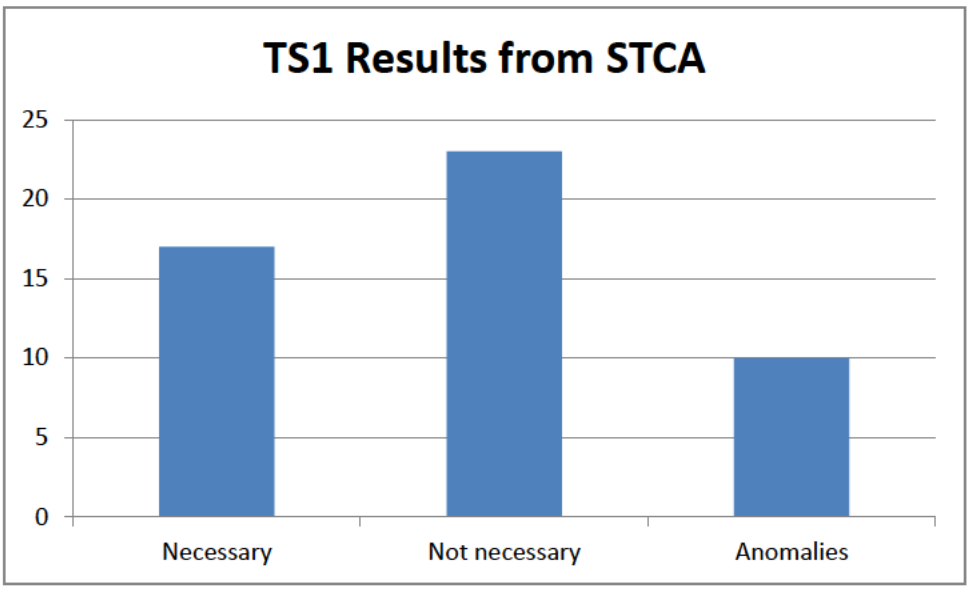


**Figure 9 - TS1 Results from STCA**

Comparing the number of nuisance alarms found in the STCA+DAPs prototype with the STCA baseline, we can see that the number of STCA+DAPs alarms is lower by a percentage of 17%.

**Absolute percentage**

Below we reported the percentages referred to the total numbers of alerts raised during the simulation in the TS1 scenario.

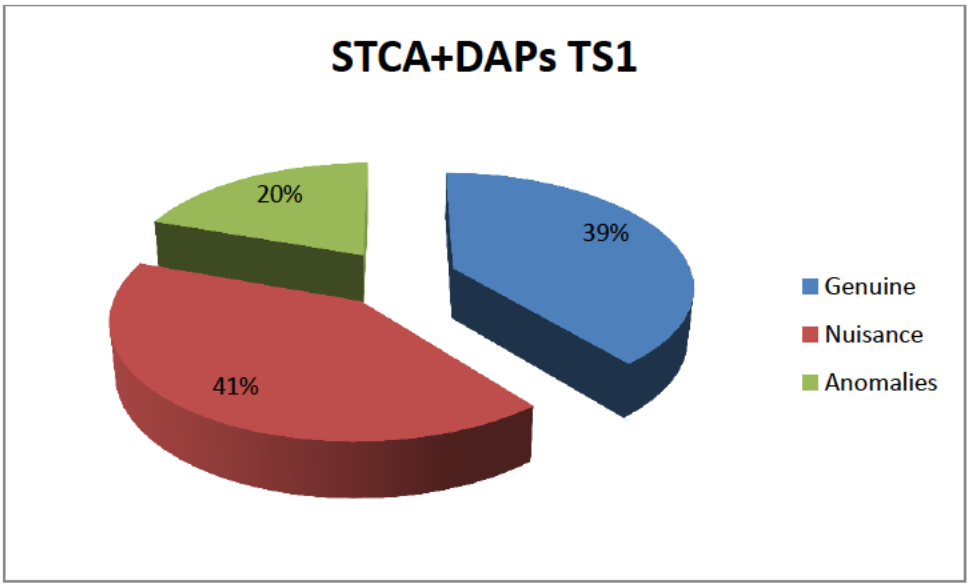


**Figure 10 Percentage per type of alert STCA+DAPs.**

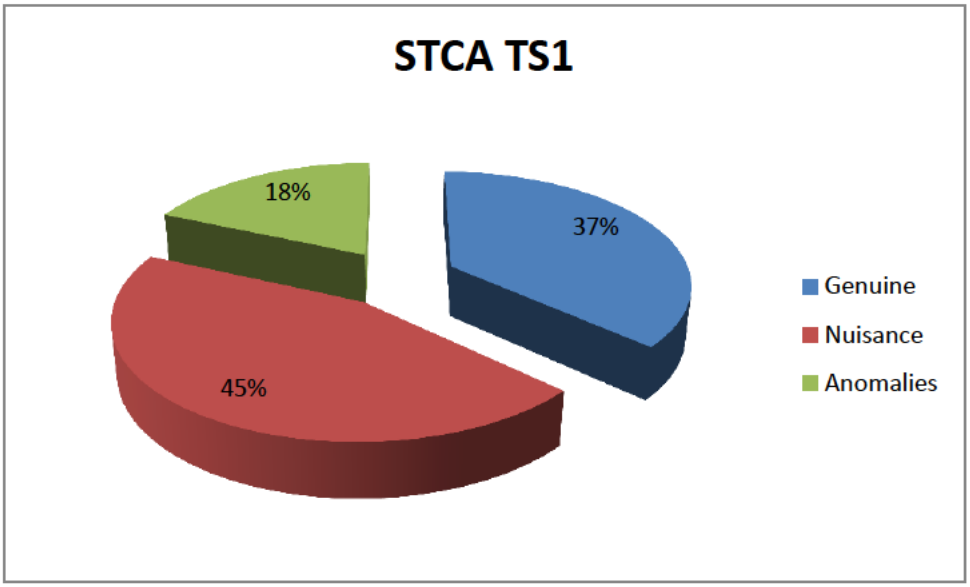


**Figure 11 Percentage per type of alert STCA+DAPs.**

**Exercise TS2:**

The new STCA detected 33 alarms. 7 of those came out to be necessary while 20 of those came out to be not necessary. While 6 alarms resulted to be anomalies.

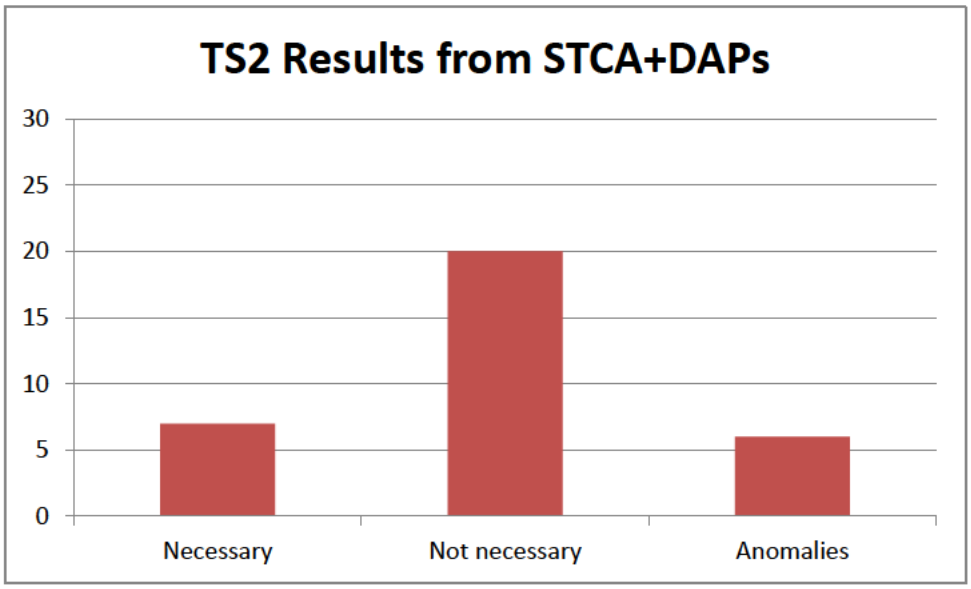


**Figure 12 – TS2 Results from STCA+DAPs**

The system set using parameters similar to current STCA working at Milan ACC detected 42 alarms. 7 of those came out to be necessary while 27 of those came out to be not necessary. While 8 alarms resulted to be anomalies.

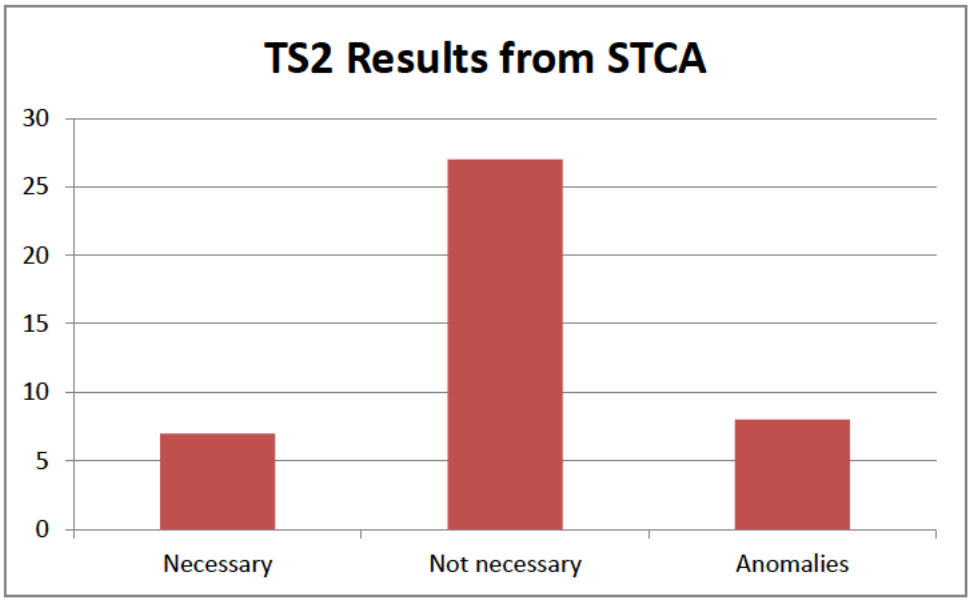


**Figure 13 – TS2 Results from STCA**

Comparing the number of nuisance alarms for the STCA+DAPs with the STCA baseline, we can see that the number of STCA+DAPs alarms is lower by a percentage of 26%.

**Absolute percentage**

Below, we reported the percentages referred to the total numbers of alerts raised during the simulation in the TS2 scenario.

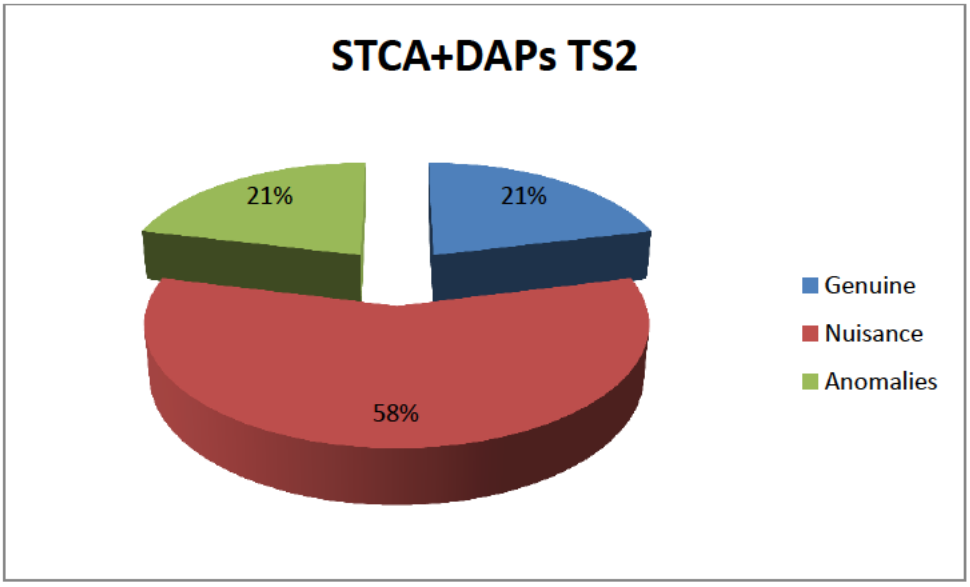


**Figure 14 Percentage per type of alert, STCA+DAPs.**

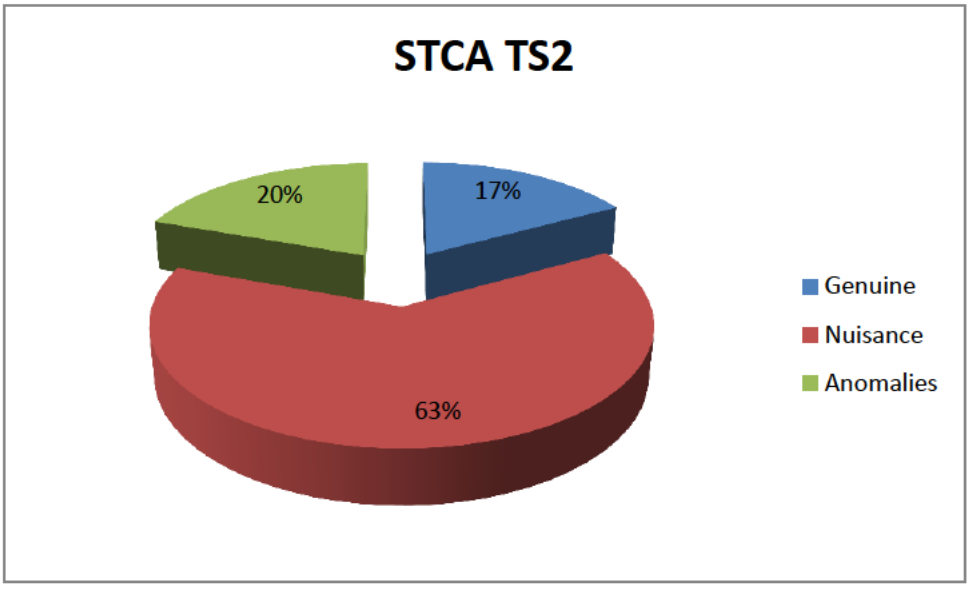


***Figure 15 Percentage per type of alert, STCA.***

For the warning time the following considerations were deducted.
The Table 14 show the warning time found during the TS1 traffic configuration for the genuine alerts.

| TS1 | | | |
|---|---|---|---|
| WARNING TIME | | ENCOUNTER | Δ time (s) |
| STCA BASELINE | STCA DAPs | | |
| 00:00:48 | 00:00:48 | SWR1621-EZY2938 | 00:00:00 |
| 00:00:36 | 00:00:40 | AMC629-AZA1746 | 00:00:04 |
| 00:01:08 | 00:00:44 | ITL401-SMX5047 | 00:00:24 |
| 00:00:07 | 00:00:41 | BAW811-BAW5739 | 00:00:34 |
| 00:01:13 | 00:01:16 | AZA8801-AZA9501 | 00:00:03 |
| 00:00:16 | 00:00:16 | AZA801-AFR378 | 00:00:00 |
| 00:00:40 | 00:01:24 | SWR443-AFR2036 | 00:00:44 |
| 00:00:16 | 00:00:20 | SWR443-AFR2036 | 00:00:04 |
| 00:01:08 | 00:01:12 | DLH331-AZA9501 | 00:00:04 |
| 00:00:16 | 00:00:08 | AZA9501-EZY2904 | 00:00:08 |
| 00:02:11 | 00:00:44 | LBY863-DLH312 | 00:01:27 |
| 00:00:06 | 00:00:20 | NOS743-ADH1012 | 00:00:14 |
| 00:00:52 | 00:00:52 | EZY4677-AZA8801 | 00:00:00 |
| 00:00:48 | 00:00:40 | LBY863-DLH312 | 00:00:08 |
| 00:00:00 | 00:00:00 | NOS743-ADH1012 | 00:00:00 |
| 00:00:08 | 00:00:08 | AZA9501-EZY2904 | 00:00:00 |
| 00:01:06 | 00:00:27 | TAR2272-OMA154 | 00:00:39 |

**Table 14 Warning time TS1**

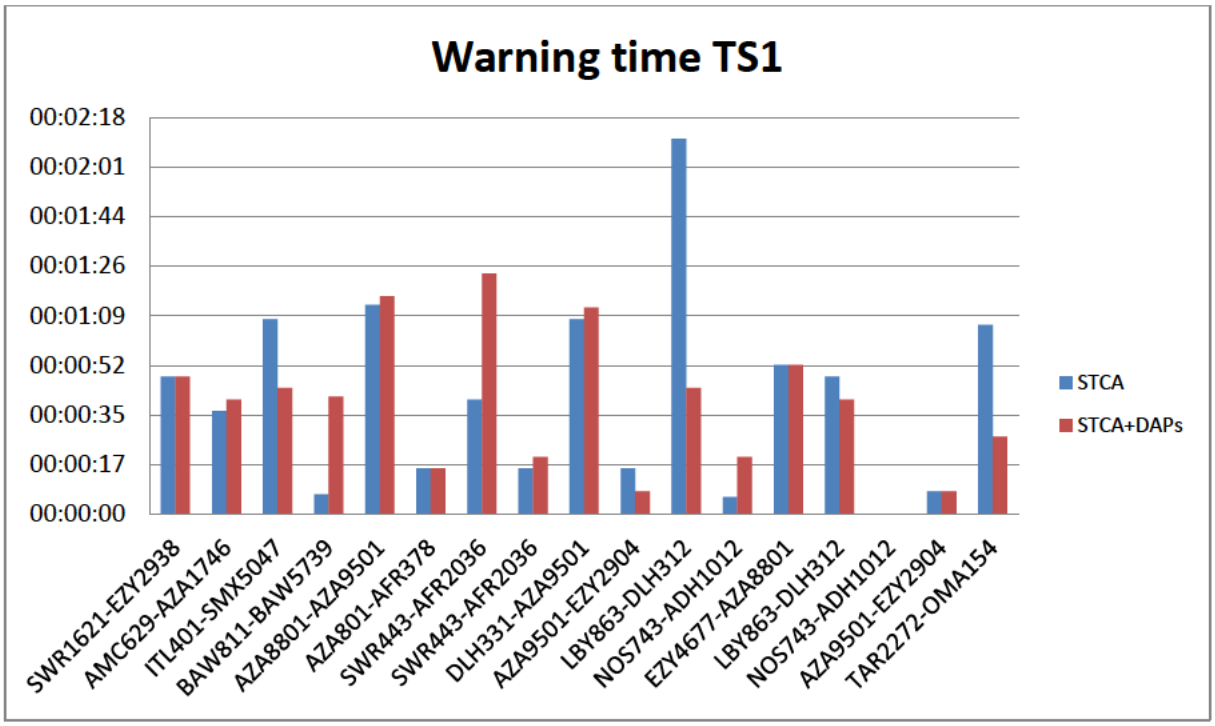


**Figure 16 Warning time comparisons for TS1 configuration**

As shown in the Figure 16, the warning time is generally greater for the STCA+DAPs than in the STCA baseline. In Table 14, in light green the delta time for encounters with STCA+DAPs warning time greater than the STCA baseline and in light red the delta time for encounter with STCA+DAPs warning time lower than the STCA baseline.

For the cases where the STCA+DAPs warning time is lower in Table 14, we are under the 3000 ft. In particular, the encounter are: the two alarms linked to AZA9501-EZY2904, the two alarms linked to LBY863-DLH312 and TAR2272-OMA154.

In the first LBY863-DLH312 encounter, the Roll Angle contribution in the STCA+DAPs configuration, allowed the safety nets to identify the LBY863 turn, causing the switch off of the alarm. Then the alarm raised again as soon as the roll angle allows the safety net to identify the final turn during the approaching path. Each of the aircraft were cleared to the localizer at 3000 ft.

Instead, for the first NOS743-ADH1012 encounter, where the trajectories are slowly convergent, the STCA+DAPs configuration is better thanks to the roll angle contribution. In fact, it helps in detecting previously the ADH1012 turn.
The TAR2272-OMA154 encounter identifies two aircraft that fly at 3000 ft directed to the localizer.

The Table 15 show the warning time found during the TS2 traffic configuration for the genuine alerts.

| TS2 | | | |
|---|---|---|---|
| WARNING | | ENCOUNTER | Δ time (s) |
| STCA BASELINE | STCA DAPs | | |
| 00:00:00 | 00:00:04 | ADH804-AZA1746 | 00:00:04 |
| 00:00:24 | 00:00:28 | DLH331-BAW5739 | 00:00:04 |
| 00:01:01 | 00:01:16 | SWR443-AFR2036 | 00:00:15 |
| 00:01:00 | 00:01:20 | SWR443-AFR2036 | 00:00:20 |
| 00:00:01 | 00:00:04 | EZY686-DLH312 | 00:00:03 |
| 00:00:04 | 00:00:27 | AMC629-EZY686 | 00:00:23 |
| 00:00:43 | 00:00:48 | EZY4677-WZZ221 | 00:00:05 |

**Table 15 Warning time TS2**

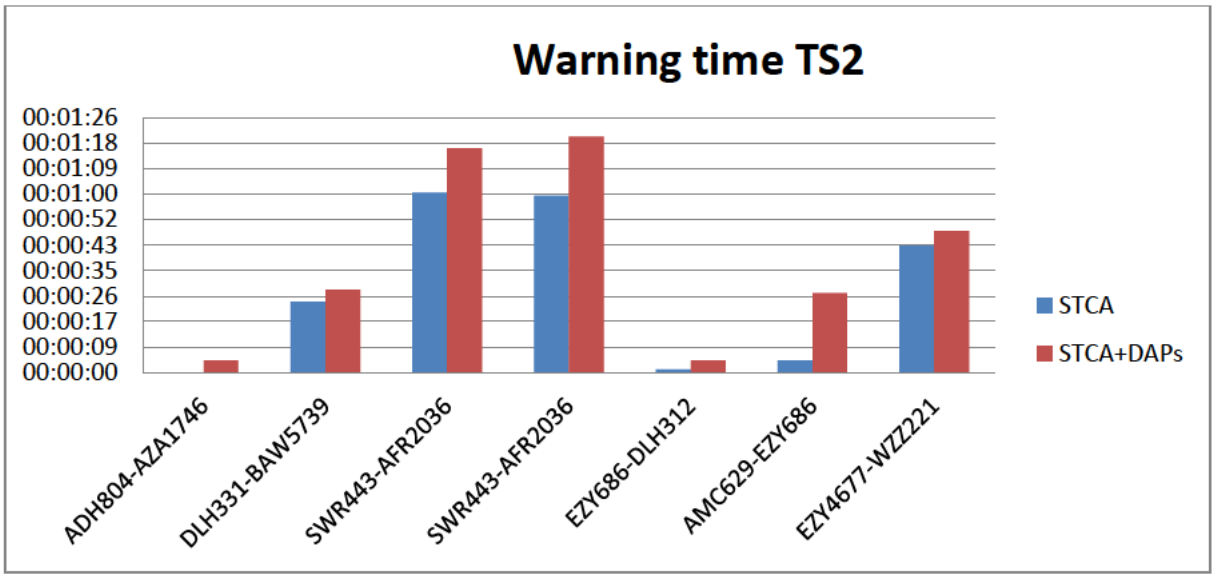


**Figure 17 Warning time comparisons for TS2 configuration**

Also in this traffic scenario, the warning time is better in the STCA+DAPs than in the STCA baseline configuration. In Table 15, in light green the delta time for encounters with STCA+DAPs warning time greater than the STCA baseline and in light red the delta time for encounter with STCA+DAPs warning time lower than the STCA baseline.

In the EZY686-DLH312 encounter, the STCA+DAPs raised an alarm as soon as the pilot selected the flight level (FL 170) cleared by the ATCO.

#### 6.1.3.1.3 Results impacting regulation and standardisation initiatives

The concept under validation related to STCA+DAPs, at this stage, has not impact on current Regulation and Standardisation activities.

### 6.1.3.2 Analysis of Exercise Results

#### 6.1.3.2.1 Unexpected Behaviours/Results

The tool needs a more accurate tune on traffic conflicts between aircrafts on the ground with aircrafts just departed. The log of the alarms shows few unexpected level anomalies and the cause might be found in random errors in inserting level data by the pseudo-pilots or by the computer itself, as sometimes the data flow of the aircrafts level seems to unexpectedly interrupt and, as a result, the level data gets 0 which create a false alarm.

### 6.1.3.3 Confidence in Results of Validation Exercise

The exercise results are based on a number of realistic simulated run, that enabled the comparative and the evaluative approach of the STCA alerting performance with and without the use of DAPs. This simulation covered a wide range of possible STCA implementations based on different scenarios.

#### 6.1.3.3.1 Quality of Validation Exercise Results

Accuracy of the results and confidence in the results is ensured by the realism of the simulations conducted in the exercise. This realism is obtained due to the approach followed to build the simulations scenarios, which rely use of real data.

#### 6.1.3.3.2 Significance of Validation Exercise Results

The realism and amount of situations covered by the simulation runs ensure operational significance of the exercise results.

## 6.1.4 Conclusions and recommendations

### 6.1.4.1 Conclusions

The outcome of the two tests has proven a relevant reduction of the nuisance of the STCA tool.
The number of alarms the system detected divided between the two different runs are listed below:
TS1: 46 alarms detected by the new STCA compared with 50 by the current STCA working at Milan ACC; and 19 unnecessary alarms compared with the 23 unnecessary alarms (by unnecessary alarm we refer to nuisance that is the flight that would never lose their minimum separation), with a resulting decrease of about 17%.
TS2: 33 alarms detected by the new STCA compared with 42 by the current STCA working at Milan ACC; and 20 not necessary alarms compared with the 27 unnecessary alarms, with a resulting decrease of about 26%.
Referring to the absolute percentage, we obtained a decrease of 4% in TS1 and 5% in TS2.
So the average of the nuisances has proved to be reduced by the use of this new tool and as a result both the human performance and the safety have been improved as stated by the feedback received by the controllers employed.
In conclusion we consider the target of the test carried out as fulfilled.
In particular, the number of nuisance alerts is decreased with a consequent gain in the confidence of the ATCOs regarding the tool and an increase in terms of safety.
In TS1, the STCA+DAPs configuration detected two more genuine alarms with respect to the STCA baseline. In TS2, the number of the genuine alarms remains the same.

The warning time is greater or at least the same.

#### 6.1.4.2 Recommendations

We recommend a better tune of the tool in order to filter the traffic below a certain altitude (it has been suggested an altitude filter of 3000ft). This would avoid the nuisance occurring between aircrafts still on the ground with aircrafts just departed and also nuisance between traffic flying the last segment of the approach path where relevant changes of heading make unpredictable for the system to detect a real traffic conflict.
We suggest to not use the STCA under the 3000 ft, or in the final approach path.

## 6.2 Validation Exercise EXE-04.08.01-VP-239b Report (Operational validation of an enhanced STCA using existing down-link parameters)

This section illustrates the findings of the evaluative phase of the exercise.

### 6.2.1 Exercise Scope

The Evaluative approach foresees a small scale RTS featured by the same operational scenario (Milano ACC enclosing en-route and TMA sectors). The aim of this phase is to collect operational feedback provided by ATCOs about the operational acceptability and potential impact on human performance of the introduction of STCA prototype using DAPs (DAPs STCA). Data collected (mainly qualitative) during the RTS will be analysed by Human factors experts.

### 6.2.2 Conduct of Validation Exercise

#### 6.2.2.1 Exercise Preparation

See para. 3.1.

#### 6.2.2.2 Exercise execution

See para. 3.2.

#### 6.2.2.3 Deviation from the planned activities

See para. 3.3.

### 6.2.3 Exercise Results

#### 6.2.3.1 Summary of Exercise Results

The results of the EXE-VP-239b are summarised in **Table 16**. It shows the summary of results compared to the success criteria identified within the Validation Plan per validation objective. The analysis covers all the Validation Objectives embedded in the Validation Exercise as for the corresponding Validation Plan.

The results were assessed against the success criteria and it is indicated if the Validation objective analysis status is OK or NOK:

- OK: Validation objective achieves the expectations (exercise results achieve success criteria)
- NOK: Validation objective does not achieve the expectations (exercise results do not achieve success criteria).

In the table have only been reported a summary of the exercises results, therefore for more details please refer to next section.

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| EXE-VP-239b | OBJ-04.08.01-VALP-0010.0080 | Acceptability of STCA DAPs performance | CRT-04.08.01-VALP-0010.0008 | The performance/behaviour of STCA DAPs prototype is considered acceptable by ATCOs. | Controllers report a positive feedback concerning the acceptability of the use of STCA+DAP.<br><br>Operational benefits related to significant reduction (compare to the current STCA) of nuisance alerts were identified | OK |
| | | | CRT-04.08.01-VALP-0010.0009 | The introduction of STCA DAPs does not negatively impact controller task load, that shall remain within acceptable levels. | ATCOs perceived as less demanding working with the STCA with DAP support then using the current STCA version. | OK |
| EXE-VP-239b | OBJ-04.08.01-VALP-0010.0090 | Confidence assessment | CRT-04.08.01-VALP-0010.0010 | The level of confidence in using the STCA DAPs prototype is considered acceptable by ATCOs | ATCOs report significant higher trust values with DAP support compared to the current STCA version | OK |
| | | | CRT-04.08.01- | The level of confidence in | The use of STCA+DA | OK |

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| | | | VALP-0010.0011 | using the STCA DAPs prototype is considered acceptable in the different ATS areas. Particular benefit are expected in TMA | P is globally rated quite high in both sectors under test, however a more significant effect is recorded in the en-route sector. | |

**Table 16: Summary of Validation Exercises Results**

#### 6.2.3.1.1 Results on concept clarification

See para.6.1.3.1.1.

#### 6.2.3.1.2 Results per KPA

**Human performance analysis.**

| | Metrics/Indicators | Related Validation Objectives/Hypothesis |
|---|---|---|
| **Human Performance** | Mental Workload (NASA-TLX questionnaire)<br><br>Debriefing<br>Over-the-shoulder observations<br>System data log (tactical instruction, communications air-ground; coordination intersectors; Aircraft flown trajectory) , | OBJ-04.08.01-VALP-0010.0080(↑) |

| | Metrics/Indicators | Related Validation Objectives/Hypothesis |
|---|---|---|
| **Human Performance** | Mental Workload (NASA-TLX questionnaire)<br><br>Debriefing<br>Over-the-shoulder observations<br>System data log (tactical instruction, communications air-ground; coordination intersectors; Aircraft flown trajectory) , | OBJ-04.08.01-VALP-0010.0080(↑) |
| | Debriefing<br>Over-the-shoulder observations<br>Trust questionnaire (SATI) | OBJ-04.07.07-VALP-0010.0090 (↑) |

**Table 17 Human Performance metrics choice**

The ATCO acceptability and the impact on operator performance (ATCO' MWL) related to the introduction of STCA DAP tool were evaluated (in the 239a exercise phase) using qualitative data, integrating ATCOs 'feedback and expert observations with results from subjective questionnaires addressing mental workload and trust concepts.
The two versions of STCA with and without the DAP support were compared during the RTS activities.
Two different traffic samples were took into account, namely TS1 and TS2.
After each measured run, ATCOs were required to fill NASA-TLX questionnaire (addressing mental workload evaluation) and SATI questionnaire (addressing trust/confidence ). Successively they participated to guided debriefing .

Results of this evaluation phase are presented in the following section.

**OBJ-04.08.01-VALP-0010.0080**
**To validate the acceptability from the controller perspective of the STCA DAPs performance/behaviour in the simulated operational environment.**

- CRT-04.08.01-VALP-0010.0008: The performance/behaviour of STCA DAPs prototype is considered acceptable by ATCOs

- CRT-04.08.01-VALP-0010.0009: The introduction of STCA DAPs does not negatively impact controller task load, that shall remain within acceptable levels.

Global acceptability can be considered a key pre-requisite for the effective usage of any new system, concept or procedure. It is also strongly linked to the controllers' perception of workload and level of confidence in the automation support (this latter aspect will be discussed in the following para).

Globally, controllers report a positive feedback concerning the acceptability of the use of STCA+DAP. They highlighted operational benefits related to significant reduction of nuisance alerts. (compared to the current STCA).
This effect was particularly evident in the simulated en-route sector (SWS sector). While in the terminal area (ASW sector) this positive impact was perceived as less evident.

Even if during the RTS evaluation was not planned specific runs to investigate potential differences in the support provided by the two DAP under test, ATCOs stated that the SFL provided the more effective (and operationally relevant) contribution in the reduction of no operationally-relevant alerts. The positive impact of the use of track angle rate was more complex to be highlighted during the controller tasks in a RTS.

From ATCOs perspective the main benefits provided by the significant reduction of nuisance alerts using STCA+DAP is led to a drastic reduction of perceived mental workload and the related "perceived stress" as they literally report . Moreover ATCOs report that some specific feature of the STCA+DAP HMI have had an impact on their awareness of the potential loss of separation (details are reported in the HMI section)

In order to assess this aspect a dedicated questionnaire was planned. ATCOs were required to fill the NASA-TLX at the end of each measured run in all the experimental organizations (STCA and STCA +DAP). The questionnaires were randomly presented on a digital support (tablet device).

The graph below reports the NASA-TLX average scores recorded for each experimental organization. Results suggest as ATCOs perceived as less demanding working in a traffic sample featured by STCA with DAP support then using the current STCA version.

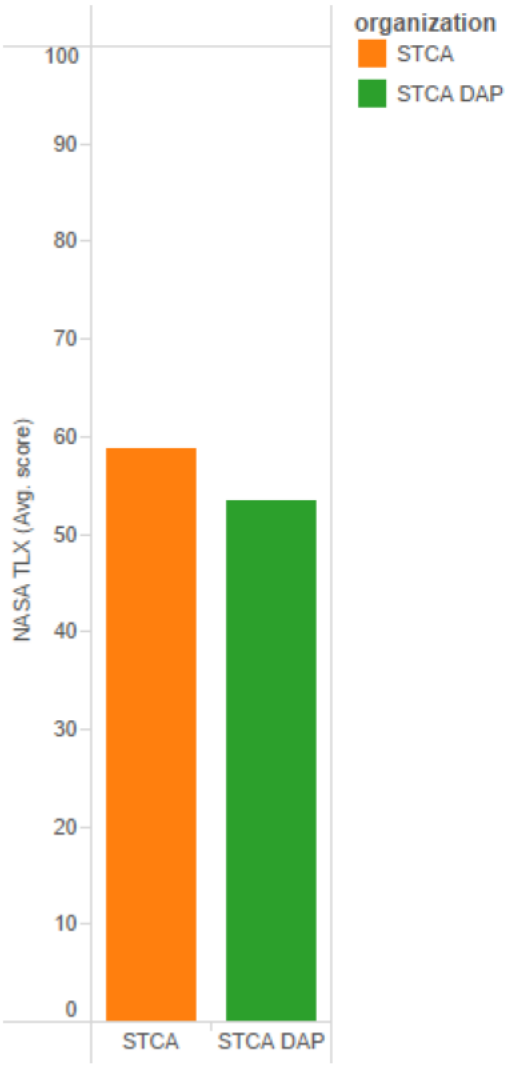


**Figure 18 NASA-TLX scores per organization**[4]

Controllers were asked to qualitatively estimate the rate of operational-relevant alerts issued by the two STCA under test in the two experimental organizations. They report unanimously that the DAP support provide a large benefits in terms of reduction of nuisance. The warnings provided by the STCA+DAP are evaluated as operationally relevant in almost 100% of the case. As a consequence, this effect allows ATCOs to build a good level of confidence in the tool support (as confirmed by the results from the SATI questionnaire) reflected also by a decrease of perceived mental workload.

Data about the alerts issued by both STCA and STCA DAP version were also recorded during the real time simulation. Integrating the qualitative findings with the analysis of these data can help - from one side- to corroborate qualitative findings and -from the other- to better interpret raw numbers.

[4] In this graph a lower score represents a lower perceived mental workload

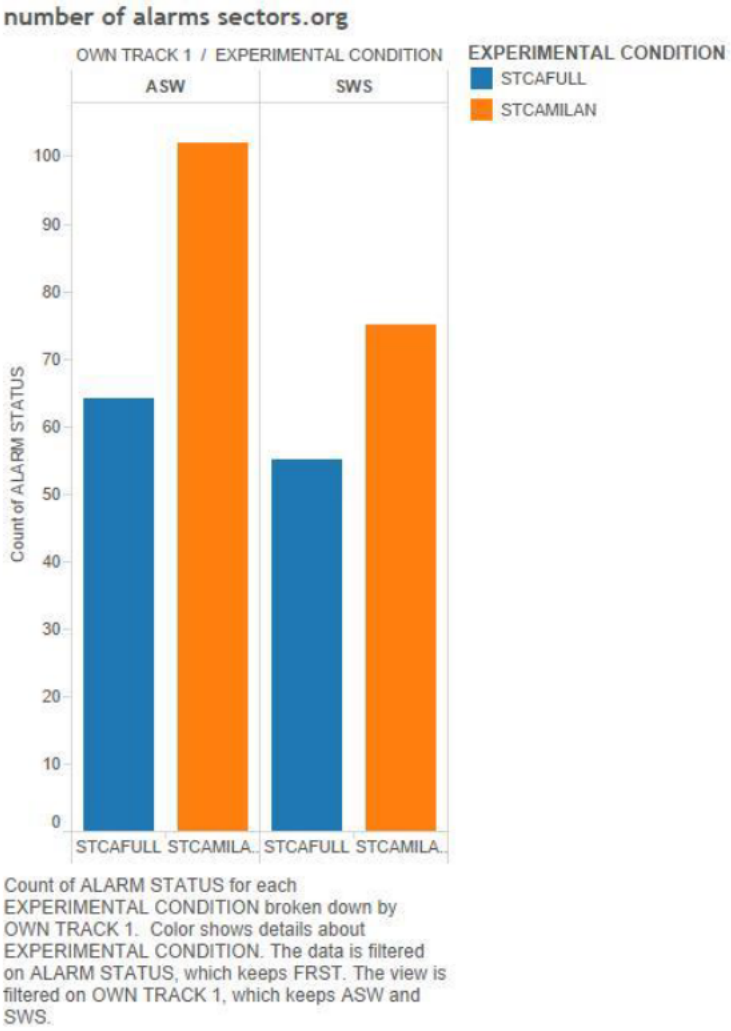


**Figure 19 – Number of alerts broken down by sector and experimental condition**

The above Figure 19 shows the number of alerts raised during the whole real time simulation, collapsing data from TS1 and TS2by the STCA currently implemented in Milan (STCA Milan) and the STCA implementing the DAP support (STCA full) in the two measured sectors.
A sensible reduction in the raised alerts is shown when the STCA with the DAP support was used. As mentioned before -in the qualitative findings discussion- controllers reported an overall reduction in the perceived workload for the STCA DAP condition and they linked this effect to the significant reduction of nuisance produced by the advanced STCA version used in that condition. This information, together with the Figure 19data, seems to suggest than the observed reduction in the number of alerts it is indeed a reduction in terms of nuisance. At the same time it is possible to suppose that alerts issued in the STCA-DAP condition were mostly operationally relevant.
Effects of the suggested nuisance reduction, seems to provide a different impact on the two sectors. Even if the trend in terms of MWL decrease is consistent with the nuisance reduction the perceived workload presents a more consistent decrease in the en-route sector, while the number of alerts reduction is shown to be more relevant in the ASW sector (see Figure 23).
Although there is no clear evidence that links this aspect to a precise reason, a series of hypothesis can be derived from these results:

- Nuisance reduction simply is more “significant” in the en-route sectors from debriefing ATCOs report as STCA DAP benefits were mostly linked to the SFL feature while was more difficult to appreciate for the Track Angle Rate (indeed this feature was expected to be more useful in the ASW sector).

- Benefits have been perceived in a less clear way by the ASW sector because ATCOs were less familiar in using this tool in ASW sector, in the current operations.

- Benefits of the STCA DAP were mitigated by some minor issues. Those issues were indeed reported during the debriefings. As mentioned, HMI clutter was realized as a problem specially in the ASW sector

Results about the number of alerts have also been broken down by the two traffic samples used during the simulation (TS1 and TS2). This view is shown in the Figure 20.The bars highlight how in the "TS1" scenario most of the alerts have been presented in the ASW sector. This might have contributed to the perceived workload on that simulated sector. On the other hand SWS sector shows a more regular pattern with similar reduction rates between the two experimental conditions.

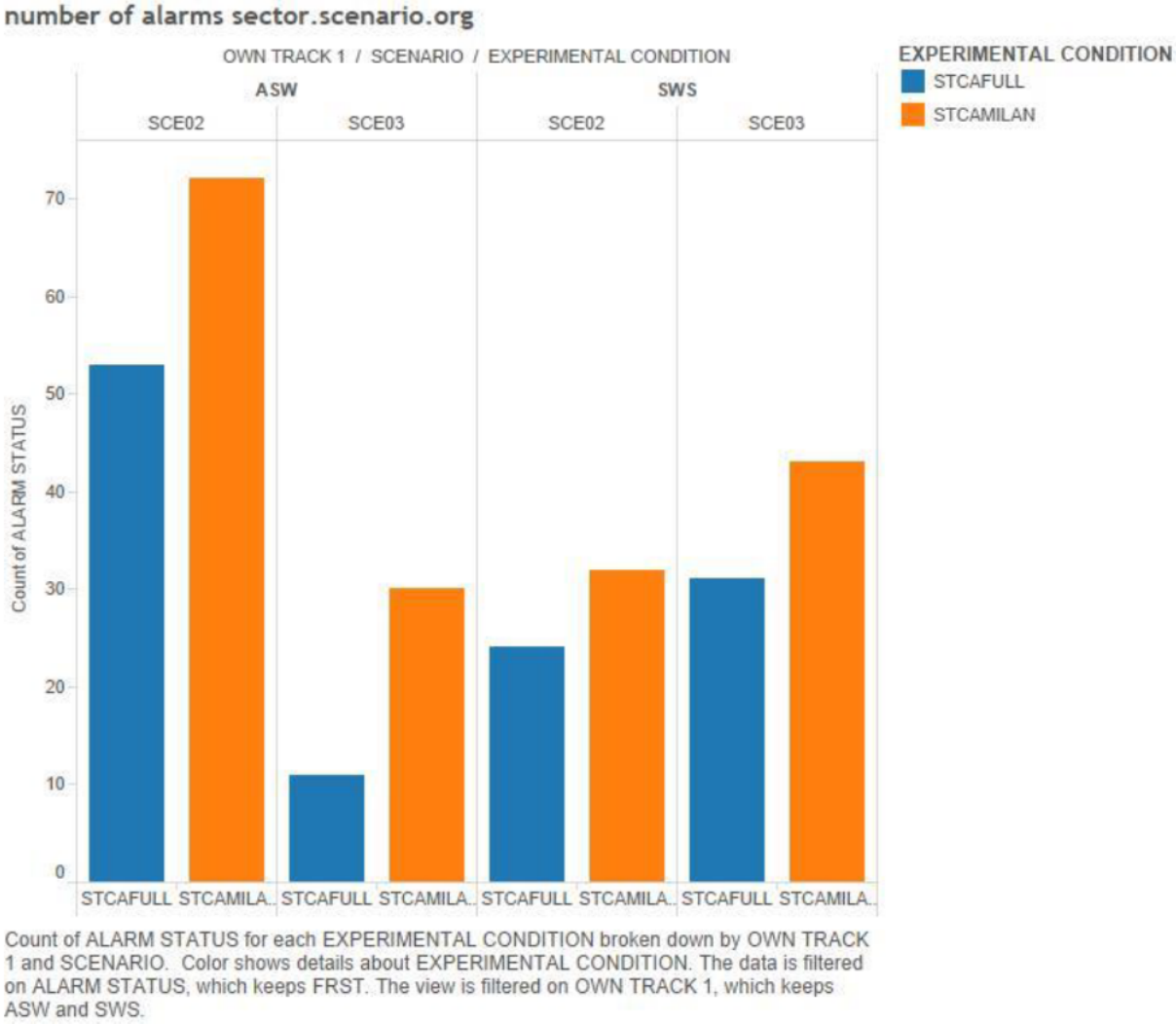


**Figure 20 - Number of alerts broken down by sector and scenario**

NASA-TLX questionnaire allows to break up the perceived mental workload into six subscales or factors providing a more detailed analysis of this multidimensional construct.
Figure 21 provides a scores analysis taking into account the NASA-TLX factors identifying their differentiated contribution to the results.
It is interesting to note the differences between STCA and STCA +DAP considering the perceived mental demand and effort required to ATCOs working using STCA with and without DAP support. ATCOs report to invest less mental and perceptual activity working in STCA+DAP environment (see mental demand factor). And generally, they report the need to engage less mental e physical resources working with STCA +DAP compared the current STCA (see effort factor).
Coherently, they report a lower level of frustration, suggesting that they felt more secure in performing their tasks working, using STCA+DAP.

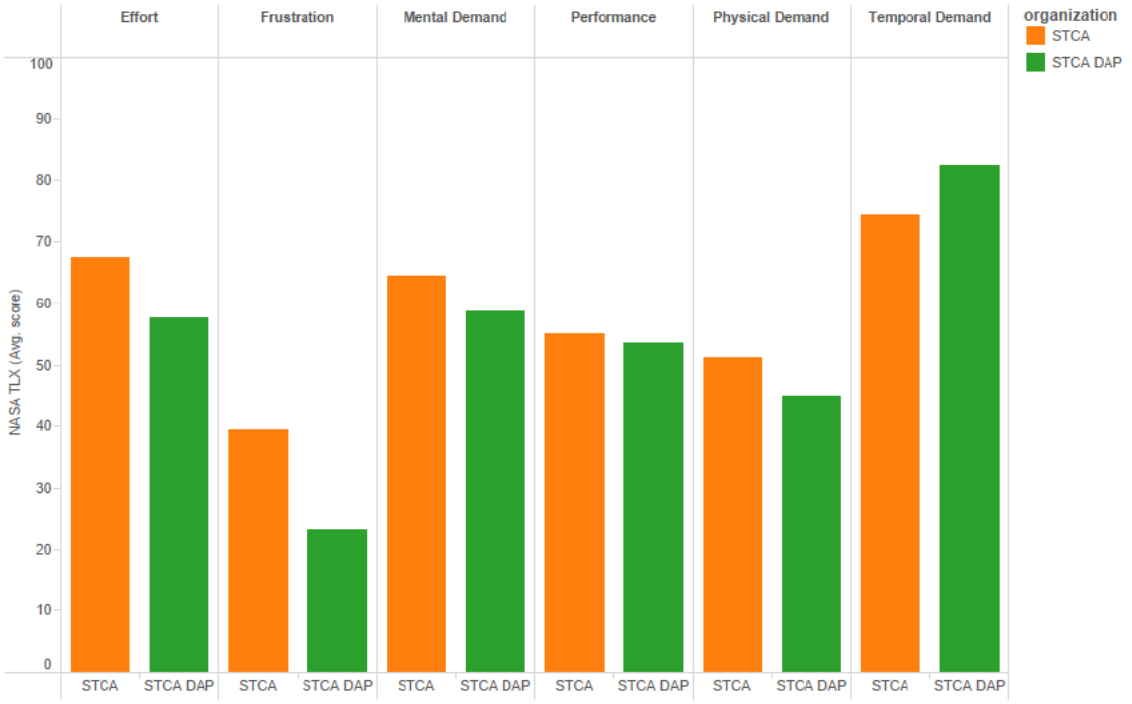


**Figure 21 NASA-tlx scores per factors**[5]

Finally, the value recorded for the temporal demand factor is less clear. ATCOs report to felt more time pressure and more frantic working rate with STCA+DAP compared to the current STCA.
Analyzing the same pool of data taking into account the simulated sectors (Figure 22) , it was found that the main contribution to this result was provided by the ATCOs working in the ASW sector, which report higher value in this factors compared to SWS.
This finding could be related to the nature itself of the terminal area, that usually require a more frantic work-flow.
Feedback from debriefing suggests that this effect can be also partially attribute to the impact of the STCA HMI on controllers activities.
ATCOs reported often in the discussions, that the actual HMI implementation was not suitable for their needs. Particularly, they highlighted that the impact was more critical in the terminal area, where the traffic is usually more "thick" and the HMI features, such as the color coding of the STCA status , the sign "STCA" in line0 and the STCA window , significantly contribute to clutter the radar screen. It is possible to suppose that this aspects could have had an impact on ATCOs workload in term of perceived temporal pressure.

[5] In this graph a lower score represents a lower perceived mental workload

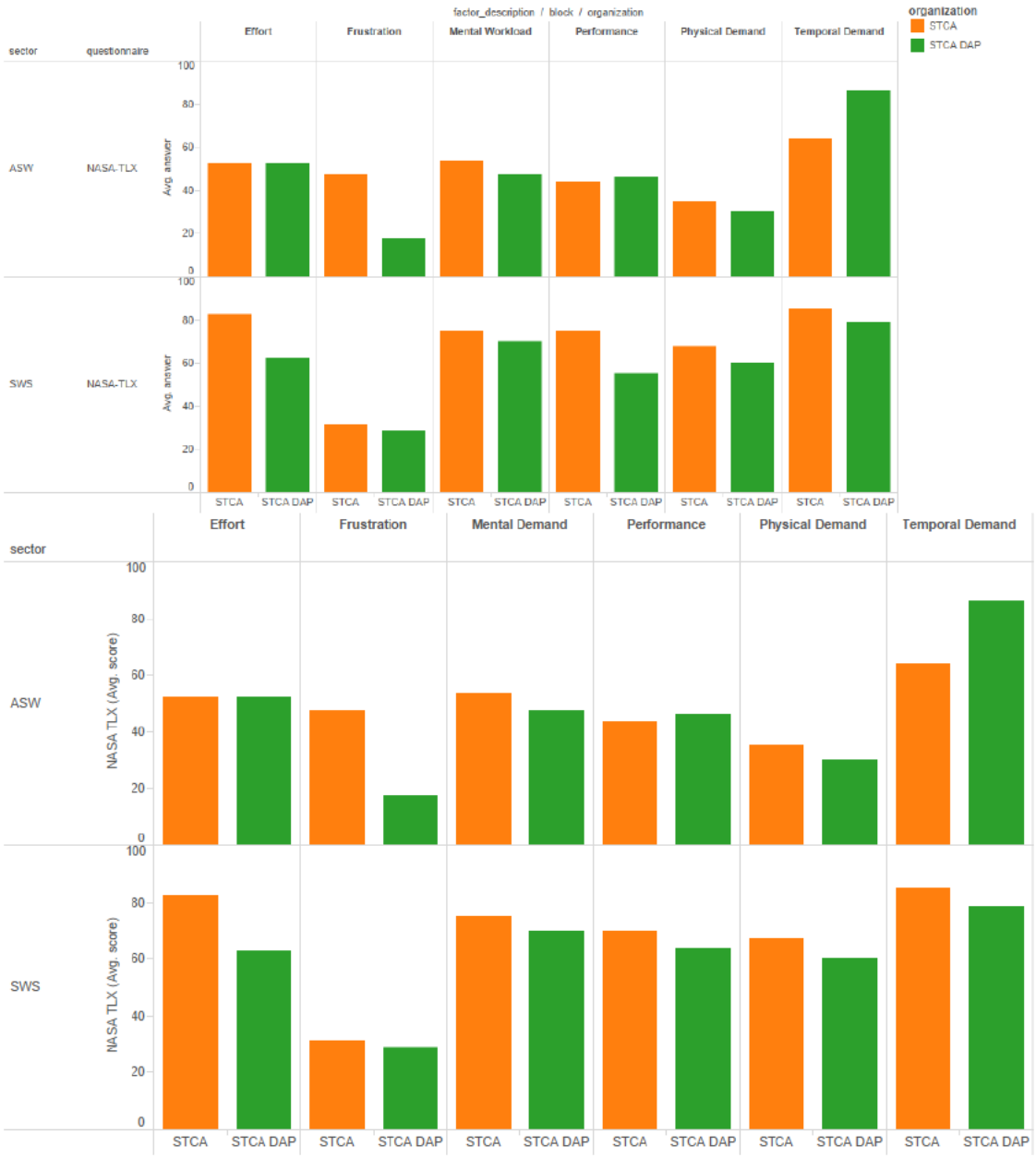


**Figure 22 NASA-tlx scores per sectors**[6]

The global reduction of perceived mental workload working with STCA+DAP is an encouraging result. Some operative aspects seem to be positively impacted by this result.
ATCOs highlighted that this aspect is potentially linked to a strong reduction of "context traffic information" that are usually issued in airspace such as in Milan, featured by number of climbs and descends traffics.
This effect is expected to have a very positive impact on the air/ground communications, realising the r/t channel and allowing a more effective use of the frequency.

The drastic decrease of the nuisance alert working with STCA+DAP compared to the current STCA seems to contribute also to expedite the management of the traffic in case of loss of separation.

[6] In this graph a lower score represents a lower perceived mental workload

Results seem to suggest that with the STCA+DAP support controllers' attentional resources can be easily allocated to their primary task (maintain a safe separation) instead to verify if the warning is operational relevant.
Indeed, controllers report that, in case of STCA warning, they do not need to double check the alarm in order to verify if it is a nuisance or not. They can concentrate their effort in the "conflict resolution" task, allowing the aircraft to maintain the separation minima. This effect is, of course, amplified once the controller perceives as reliable the STCA implemented.

Analysing the NASA-TLX scores per sectors (see Figure 23) , it is possible to highlight as in the SWS the controllers spend more effort working with STCA instead to STCA +DAP. This effect is less pronounced in the ASW sector, but still appreciable.
Contrasting globally the perceived workload reported in the two simulated areas, ATCOs report as more demanding work in the SWS sector compared to the ASW.

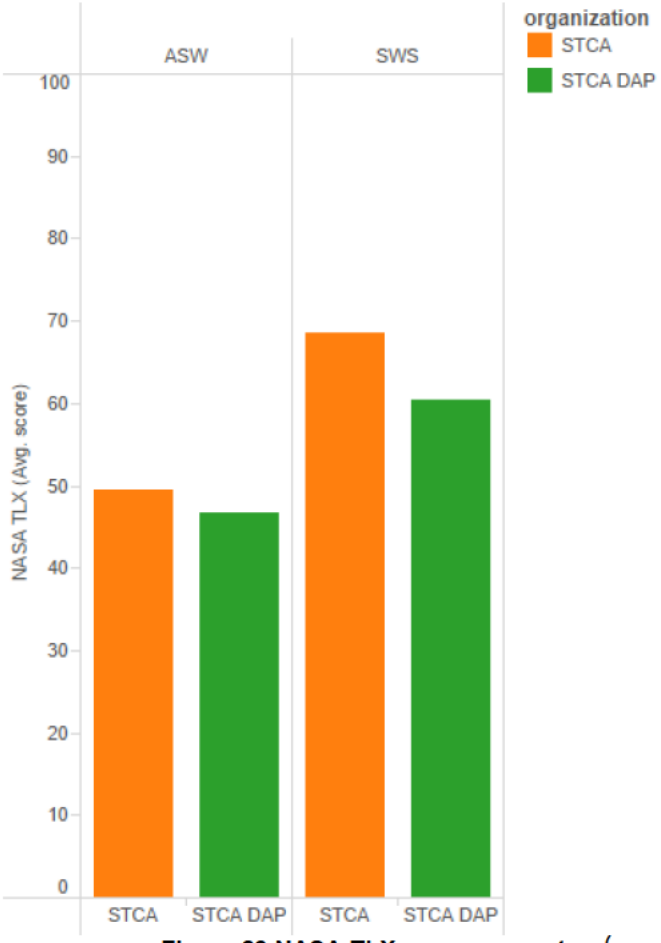


**Figure 23 NASA-TLX score per sectors**[7]

Even if the perceived mental workload is lower in the ASW sector, ATCOs report unanimously that the positive impact of STCA+DAP was less evident in this area compared to the en-route sector.

ATCOs suggest that this is partially due to the nature itself of the terminal area that requires frantic work-flow and to manage traffic mainly on the horizontal plane. In this case the impact of the track angle DAP can be theoretically more relevant compare to the SFL. Unfortunately, the support of the track angle rate is much more less "detectable" during a simulated run, compared to the SFL.
Additionally, ATCOs stated also that in the ASW sector the STCA HMI was perceived as much more cluttering compared to the SWS area.

[7] In this graph a lower score represents a lower perceived mental workload

Compared to the current operation in Milan area, where the STCA support is planned to terminate at 6000ft, controllers unanimously appreciated the possibility to have the STCA+DAP support until 3000ft (minima radar). ATCOs report that this setting, experienced during the RTS, can be effective in decreasing the nuisance in this area providing them significant support in the identification of loss of separation minima.

ATCOs identify some factors that may contribute to improve the positive impact of the use of STCA+DAP in the simulated environment:

1. More standardized working methods (such as sequencing traffic) should facilitate a reliable behaviour of the STCA, minimizing the nuisances.

2. Implement specific filters/volumes in the terminal area with a differentiated STCA tuning (e.g. according to the type of traffics or tasks of that area ).

3. Differentiated tuning of the track-angle rate according to the terminal and en-route area.

4. Warning time set with a differentiated tuning according to the airspace area.
   During the RTS this parameter was rated as sufficient to avoid incident ,but sometimes not enough to avoid the loss of separation minima. Controllers, highlighted as with specific traffic geometry and collision angles the warning time may potentially be different. For example, in case of opposite traffics in en route area ATCOs would need more time and then more evident heading to resume the safe separation. In this case a warning time rate at 120 sec. could be acceptable, while with a conflict geometry with a collision angle of 45° the warning time may be sufficient set at 80 sec.

5. Improve the STCA+DAP HMI. Controllers found the HMI implemented for STCA+DAP not fully suitable for their need. During the debriefing they reported some suggestions and feedback to improve the STCA+DAP HMI. (see details in the session above)

**OBJ-04.08.01-VALP-0010.0090**

**To evaluate the level of ATCOs confidence in DAPs STCA prototype in the simulated operational environment**

CRT-04.08.01-VALP-0010.0010:The level of confidence in using the STCA DAPs prototype is considered acceptable by ATCOs .

CRT-04.08.01-VALP-0010.0011: The level of confidence in using the STCA DAPs prototype is considered acceptable in the different ATS areas. Particular benefit are expected in TMA.

A good level of trust and confidence in the system is a key issue working in complex environment featured by automation support. In this case, is expected that a good level of reliability of the STCA +DAP under evaluation should allow controllers to allocate attention to concurrent tasks because they rely on the automation to correctly alert them of any impending hazard (then effectively balance also their mental workload). If the automation fails to announce a problem in the form of nuisance or miss, the controller should become less reliant and pay closer attention to the raw data (e.g., radar display), resulting in better detection performance and avoiding loss of separation minima. Of course, he will also sped more effort and attentional resources in check the reliability of the support tool, increasing its mental workload.
In order to assess the perceived level of trust/confidence in the STCA+DAP under test a dedicated questionnaire was planned.
SATI (SHAPE Automation Trust Index) questionnaire is designed to assess the level of trust in the system. In this questionnaire, trust is described as the extent to which a user is willing to act on the basis of external information, recommendations, actions and decisions of another person, a

computer-based tool or a decision aid. In this study, controllers were asked to refer to the implementation of the STCA, with and without the DAP support (according to the run rotation).
ATCOs were required to fill the SATI at the end of each measured run in all the experimental organizations (STCA and STCA +DAP). The questionnaires were randomly presented on a digital support (tablet device).

The graph below report the SATI average scores recorded for each experimental organization. Results shown as ATCOs report significant higher trust values with DAP support compared to the current STCA version.

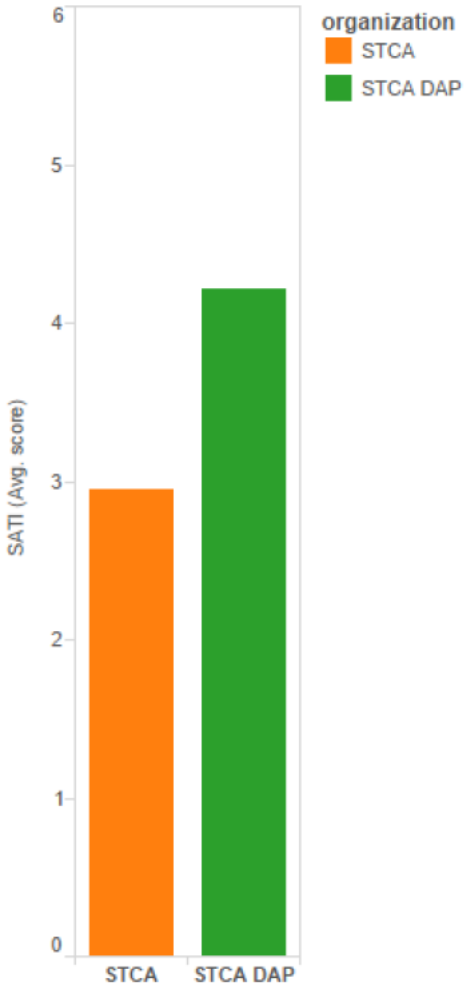


**Figure 24 SATI scores per Organization**[8]

Breaking-up the same set of data according to the SATI factors is possible to observe as this effect is strongly evident in all the component that allow to better details the trust construct. The smaller difference is recorded referring to the factor "understanding" where is supposed to negatively impact the STCA HMI, which was critically rated by ATCOs

[8] In this graph a higher score represents a higher trust

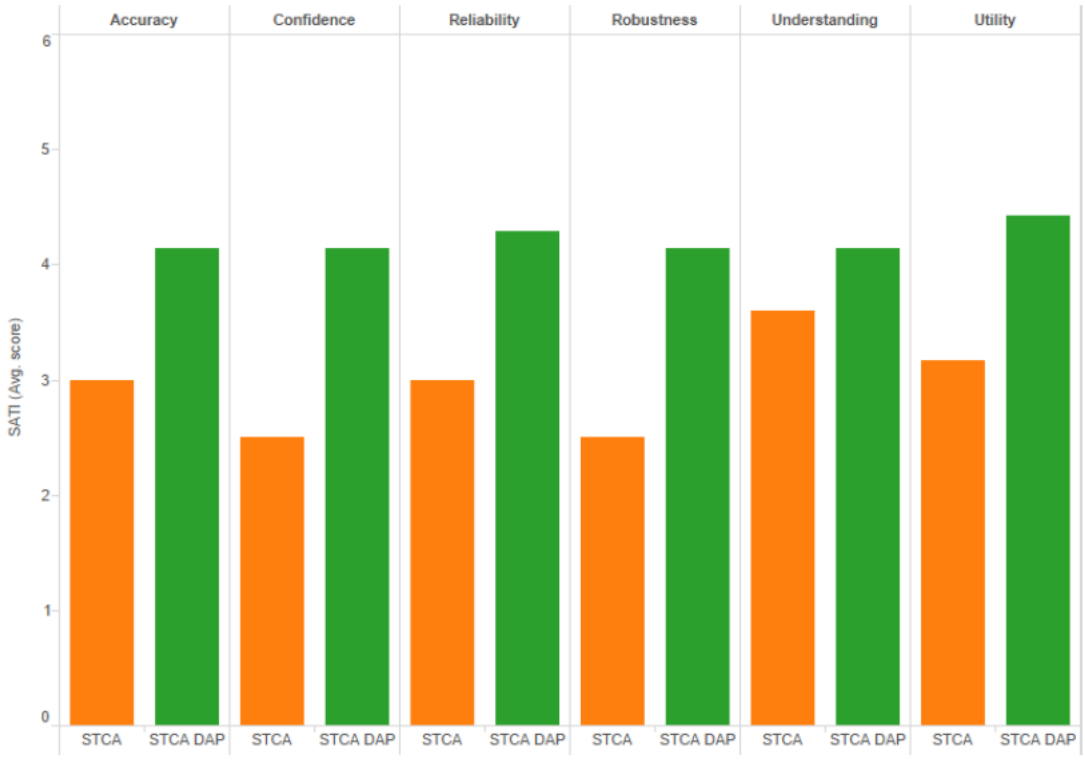


**Figure 25 SATI scores per factors**[9]

The graph in Figure 26 shows a good picture of the ATCOs feedback in terms of confidence in the current and in the DAP version of the STCA. The current STCA is rated quite low in the ASW sector, in which its tuning is still a critical issue, while is rated higher in the SWS sector. The STCA+DAP support is rated by controller significantly higher in the terminal area compared to the STCA without DAP. This effect is replicated also in the SWS sector, where- however- the difference with the current STCA is less evident. The use of STCA+DAP is globally rated quite high in both sectors under test, however a more significant effect is recorded in the en-route sector.

[9] In this graph a higher score represents a higher trust

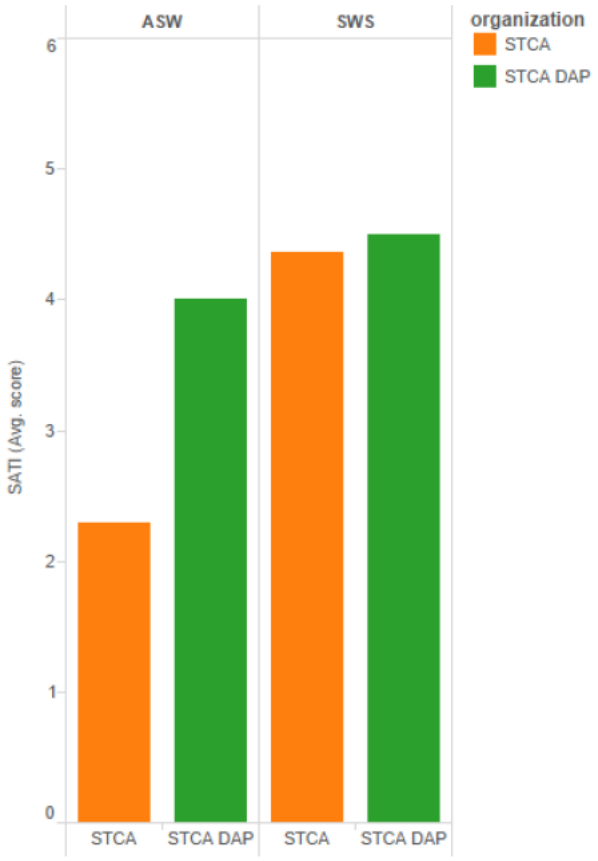


**Figure 26 SATI scores per Sectors**[10]

The "building" of the trust construct was analysed investigating the trend across the run during the RTS days. The graph in Figure 27 shows as the trend of the level of trust reported by controllers is largely different comparing STCA and STCA+DAP.

[10] In this graph a higher score represents a higher trust

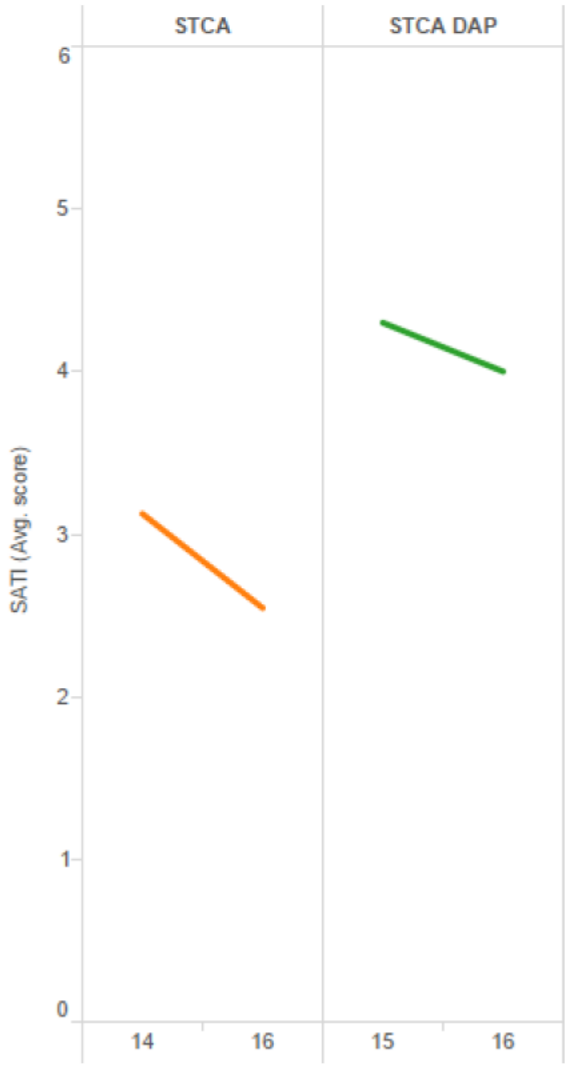


**Figure 27 SATI scores trend per RTS days**

The STCA was rated lower since the beginning of the evaluation and a descending trend was recorded in the following runs. On the contrary the STCA+DAP was rated higher and shows only a slight decrement in the following runs.

Even if the number of runs taking into account in this analysis are quite limited this result provides a good indication of the positive feedback recorded.

In order to collect the overall impression of the level of trust perceived by ATCOs before and after the experience with the STCA+DAP support a custom and no-standardized questionnaire has been defined and administered according to the before/ after procedure.

The first training day, before to familiarize with the STCA+DAP and with the platform in general ATCOs were required to fill the TEQ (Trust Evaluation Questionnaire) taking into account their working experience with the current STCA, as implemented in Milan area. After the RTS, the same questionnaire were administer to the controllers. This time, they were required to taking into account their RTS experience with the STCA+DAP.

The graph below reports the average values recorded in the two sessions, before referring to the current STCA and after referring to the STCA+DAP. Results report a slightly difference in terms of trust, showing as the STCA+DAP was rated higher compared the STCA. This result even if reports a quite small difference between the two tool versions under test, however provides additional support

to the previous finding. This can also suggests that this effect is strong enough to be detected also with a no-standard questionnaire.

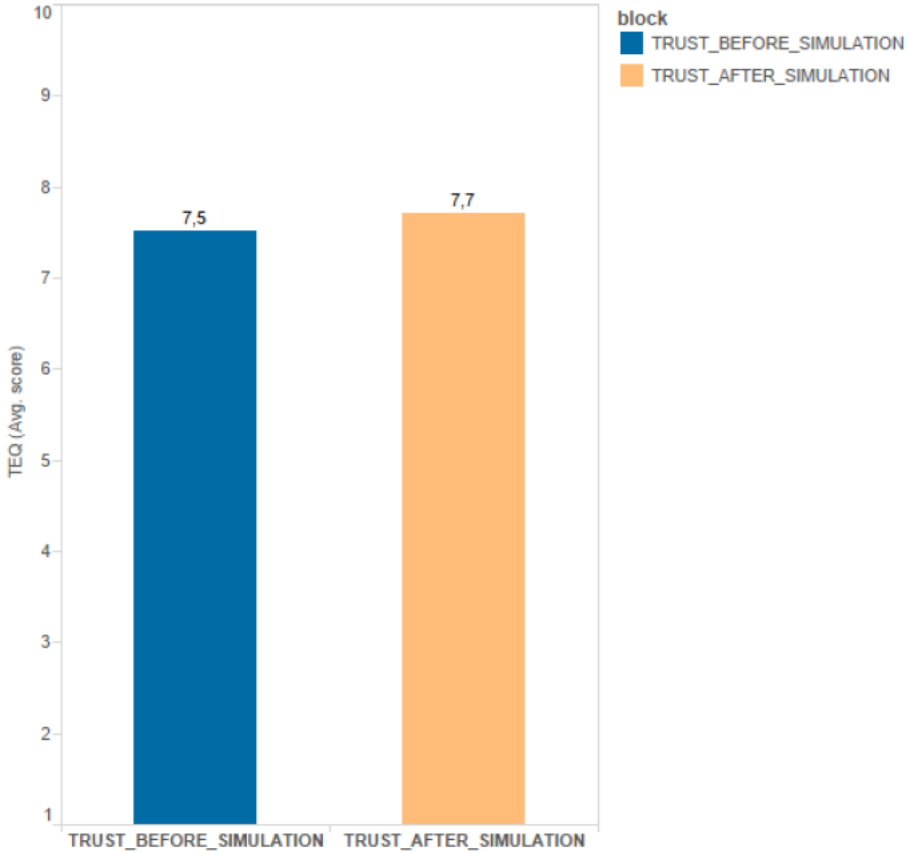


**Figure 28 TEQ scores before/after**[11]

#### 6.2.3.1.3 Results impacting regulation and standardisation initiatives

See para. 6.1.3.1.3.

### 6.2.3.2 Analysis of Exercise Results

#### 6.2.3.2.1 Unexpected Behaviours/Results

No unexpected behaviours impacting on the human performance assessment has been recorded during the RTS.

### 6.2.3.3 Confidence in Results of Validation Exercise

See para. 6.1.3.3.

#### 6.2.3.3.1 Quality of Validation Exercise Results

[11] In this graph a higher score represents a higher trust

See para. 6.1.3.3.1.

#### 6.2.3.3.2 Significance of Validation Exercise Results

See para. 6.1.3.3.2.

## 6.2.4 Conclusions and recommendations

### 6.2.4.1 Conclusions

Globally, controllers report a positive feedback concerning the acceptability of the use of STCA+DAP. They highlighted operational benefits related to significant reduction of nuisance alerts, compared to the current STCA.
This effect was particularly evident in the simulated en-route sector (SWS sector). While in the terminal area (ASW sector) this positive impact was perceived as less evident, but still present.

Controllers unanimously appreciated the possibility to have the STCA+DAP support until 3000 ft (minima radar). ATCOs report that this setting, experienced during the RTS, can be effective in decreasing the nuisance in the terminal area providing them significant support in the identification of loss of separation minima.

ATCOs feedback collected during debriefing are corroborated by a quantitative log analysis, showing a sensible reduction in the raised alerts when the STCA with the DAP support was used.
From debriefing, ATCOs report a qualitative evaluation of the differentiated but positive impact of the two DAP features under evaluation.
SFL provided the more effective (and operationally relevant) contribution in the reduction of no operationally-relevant alerts. The positive impact of the use of track angle rate was rated more complex to be highlighted during the controller tasks in a RTS.

From ATCOs perspective the main benefits provided by the significant reduction of nuisance alerts using STCA+DAP is led to a drastic reduction of perceived mental workload and the related “perceived stress” as they literally report.
Results from NASA-TLX suggest as ATCOs perceived as less demanding working in a traffic sample featured by STCA with DAP support then using the current STCA version. Moreover, the decrease of nuisances using STCA+DAP support controllers to easily allocate their attentional resources to their primary task (maintain a safe separation) instead to verify if the warning is operationally relevant. Significantly, ATCOs report that, in case of STCA+ DAP warning, they do not need to double check the alarm in order to verify if it is a nuisance or not.

The positive impact of STCA+DAP on ATCOs mental workload is mirrored in the increase of the level of ATCOs confidence and trust in using this tool’ version compare the current one. Results from SATI questionnaire shown as ATCOs report significant higher trust values with DAP support compared to the current STCA version.

The “building” of the trust construct was analysed investigating the trend across the measured run during the RTS days. Results shown that the trend of the STCA+DAP was rated higher compared to the STCA Milan from the beginning, showing only a slight decrement.

Finally, the impact of the STCA +DAP HMI’ implementation on the ATCOs interaction situation awareness was evaluated. ATCOs appreciated some feature (such as the SFL and the ASPA link) and identified some critical features (such as the STCA status and the STCA window). Recommendations are reported in the following section.

### 6.2.4.2 Recommendations

Results from the human performance evaluation allow to derive the following recommendations:

REC. 1.In the simulated environment, a more standardized working methods (such as sequencing traffic) should facilitated a reliable behaviour of the STCA+ DAP, further minimizing the nuisances.

REC. 2 In order to maximize the benefit in the simulated Milan area -enclosing en-route and approach sectors- it is suggested to implement specific filters/volumes in the terminal area with a differentiated STCA tuning (e.g. according to the type of traffics or tasks of that area ).

REC. 3.it is suggested to implement a differentiated tuning of the track-angle rate according to the terminal and en-route area.

REC.4. It is suggested to implement a warning time set with a differentiated tuning according to the airspace area.

REC. 5.It is recommended to improve the STCA+DAP HMI. Some aspects were rated as critical:

a) The STCA window should be optimized in terms of info provided and in order to not clutter the radar screen.
b) The three STCA status, identified by a colour-coding sign, was considered a misleading feature. ATCOs prefer to have a single status STCA coloured in red.
c) The STCA sign in the line0 was considered unanimously critical, because misleading (can be mixed up with the call sing). ATCOs suggest to highlights the a/c label at the STCA warning.

# 6.3 Validation Exercise EXE-04.08.01-VP-239c Report (Operational validation of an enhanced STCA using existing down-link parameters)

## 6.3.1 Exercise Scope

The scope of this analysis is to assess the correct operation of the STCA prototype using DAPs during non-nominal cases. In particular, we designed some ad-hoc encounters and we studied the coherence of alarms raised in the following in the following configurations:

- An incorrect MCP/FCU Selected Altitude configuration, where we supposed that the pilot performed a coherent read-back, but executed a wrong manoeuvre.
- A corrupted SFL configuration, where we supposed that downlinked SFL is incorrect, due to transmission or receiving errors.
- A no mode-S capable configuration, in which we supposed that one or two of the aircraft wasn't Mode-S capable.

After this phase, an off-line analysis will be conducted by ENAV operational experts. Through the log files we reconstructed the dynamic of the encounters, combining the orders given by the ATCOs with the action executed by the pilot.

## 6.3.2 Conduct of Validation Exercise

### 6.3.2.1 Exercise Preparation

See para. 3.1.

.

### 6.3.2.2 Exercise execution

See para. 3.2.

The events created for the RTS simulation were listed below.

All the events (excepted the 1.3) will be assessed for flight level above and below FL195 in order to address the validation objective for airspaces with a different separation minima (above FL195 is 3NM; above FL195 is 5 NM).
EVENTS:

1. The aircraft are flying opposite routes. The line segments are the flight levels (FL).

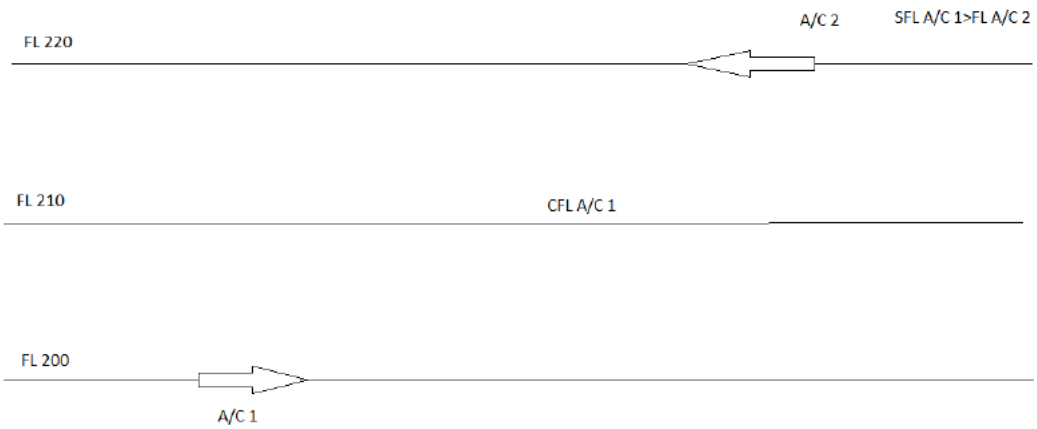


**Figure 29 Event 1**

Example: A/C 1 FL 200, A/C 2 FL 220.
A/C 1 is cleared to FL 210 and in the case of incorrect MCP/FCU Selected Altitude, it selected a FL higher than the A/C2 FL

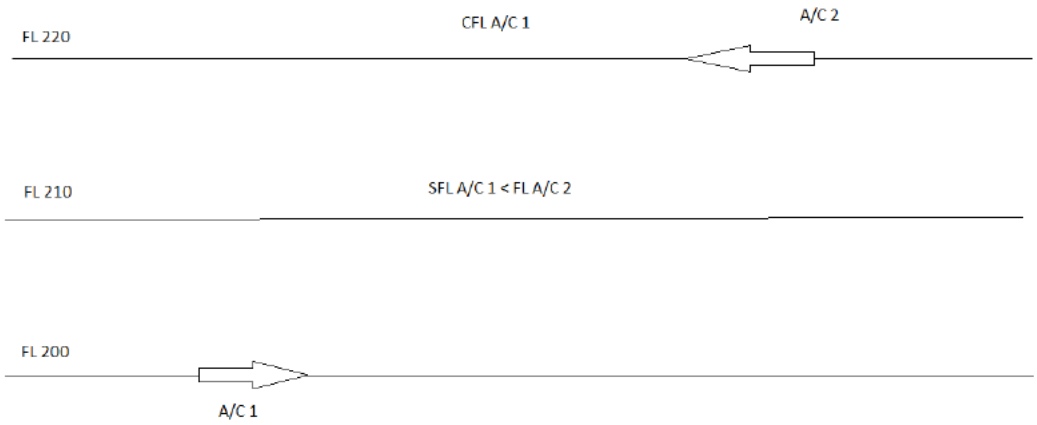


**Figure 30 Event 1.2**

Example: A/C 1 FL 200, A/C 2 FL 220.
A/C 1 is cleared to FL 220 and in the case of incorrect MCP/FCU Selected Altitude, it selected a FL lower than A/C2 FL.

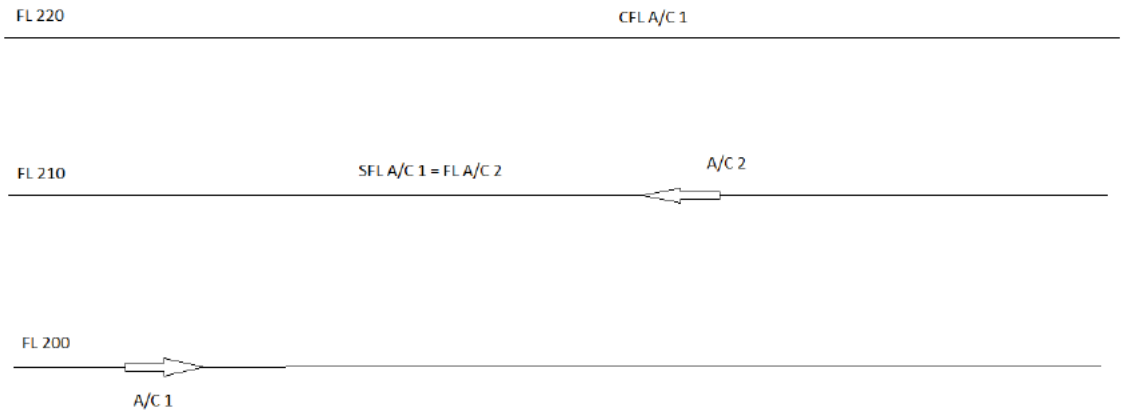


**Figure 31 Event 1.3**

Example: A/C 1 FL 200, A/C 2 FL 210.
A/C 1 is cleared to FL 220 and in the case of incorrect MCP/FCU Selected Altitude, it selected a FL equal to A/C2 FL.

2. The aircraft are flying opposite routes. The line segments are the flight levels (FL).

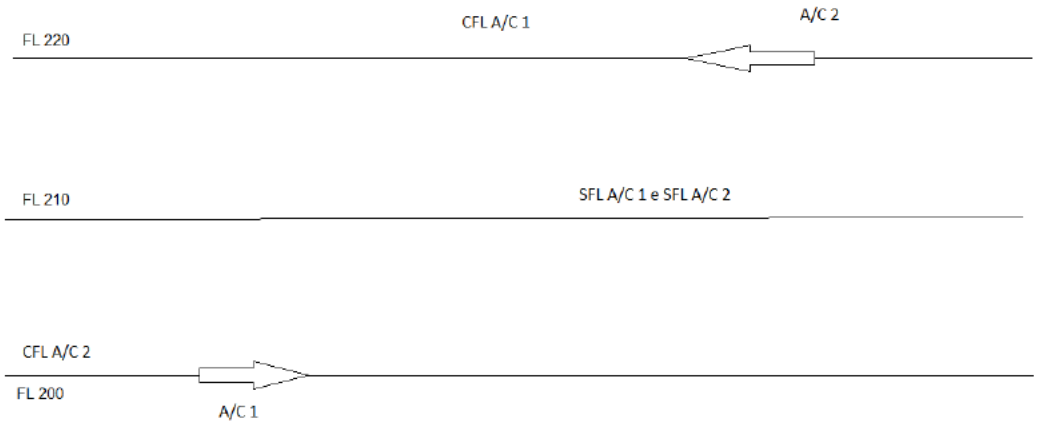


**Figure 32 Event 2**

Example: A/C 1 FL 200, A/C 2 FL 220.
A/C 1 is cleared to FL 220 and A/C 2 is cleared to FL 200 and in the case of incorrect MCP/FCU Selected Altitude, both the A/C selected the same intermediate FL equal to 210.

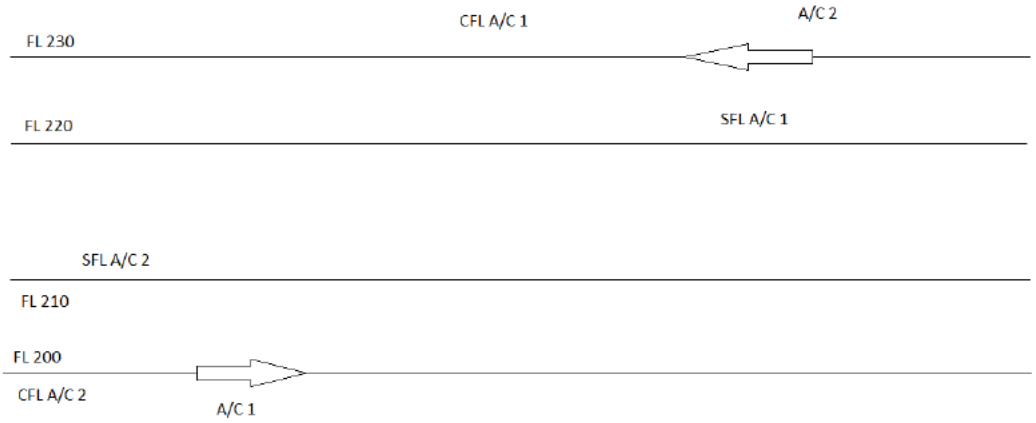


**Figure 33 Event 2.1**

Example: A/C 1 FL 200, A/C 2 FL 230.
A/C 1 is cleared to FL 230 and A/C 2 is cleared to FL 200 and in the case of incorrect MCP/FCU Selected Altitude, the A/C1 selected FL 220 and the A/C2 selected FL 210.

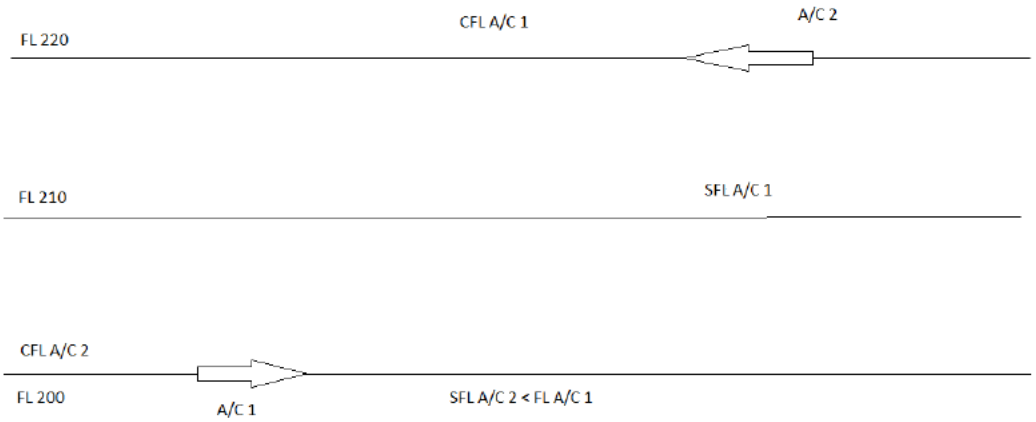


**Figure 34 Event 2.2**

Example: A/C 1 FL 200, A/C 2 FL 220.
A/C 1 is cleared to FL 220 e A/C 2 is cleared to FL 200 and in the case of incorrect MCP/FCU Selected Altitude, the A/C1 selected FL 210 and the A/C2 selected a FL lower than A/C1 FL.

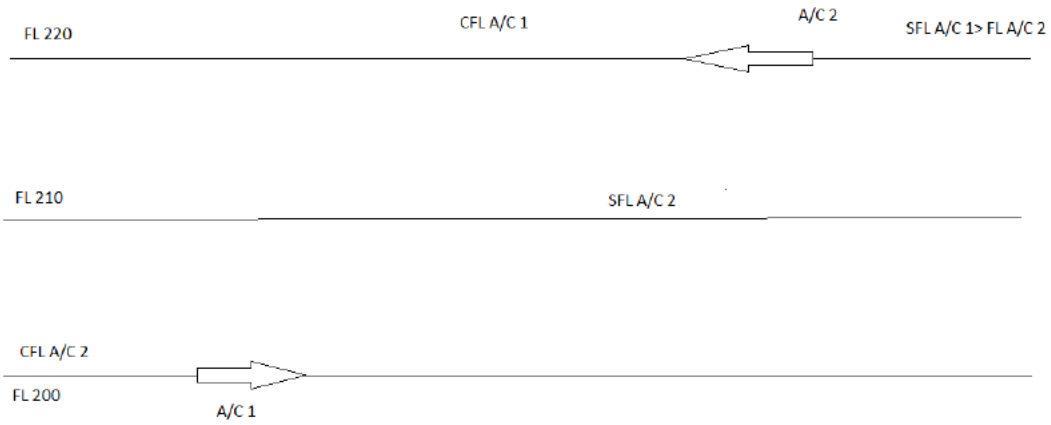


**Figure 35 Event 2.3**

Example: A/C 1 FL 200, A/C 2 FL 220.
A/C 1, is cleared to FL 220 and A/C 2 is cleared to FL 200 and in the case of incorrect MCP/FCU Selected Altitude, the A/C1 selected FL higher than A/C2 FL and the A/C2 selected a FL 210.

The cases presented above are referred only in the case of incorrect MCP/FCU Selected Altitude, just to give an example.

In the other cases, the SFL imputed by the pilot was changed in accordance with the expected results.

#### 6.3.2.3 Deviation from the planned activities

This exercise was unplanned in the VALP D19 [18].

See para. 3.3 for more details.

### 6.3.3 Exercise Results

#### 6.3.3.1 Summary of Exercise Results

The results of the EXE-VP-239c are summarised in

Table 18. It shows the summary of results compared to the success criteria identified within the Validation Plan per validation objective. The analysis covers all the Validation Objectives embedded in the Validation Exercise.

The results were assessed against the success criteria and it is indicated if the Validation objective analysis status is OK or NOK:

- OK: Validation objective achieves the expectations (exercise results achieve success criteria)
- NOK: Validation objective does not achieve the expectations (exercise results do not achieve success criteria).

In the table have only been reported a summary of the exercises results, therefore for more details please refer to next section.

| Exercise ID | Validation Objective ID | Validation Objective Title | Success Criterion ID | Success Criterion | Exercise Results | Validation Objective Status |
|---|---|---|---|---|---|---|
| EXE-VP-239c | OBJ-04.08.01-VALP-0010.0055 | STCA using DAPs in TMA .and in en-route | CRT-04.08.01-VALP-0010.0010 | The STCA+DAPs prototype detects all the encounters in TMA and en-route airspace in non-nominal cases. | The Log files analysis demonstrates the coherence in the alarm detection also in the non-nominal cases. | OK |

**Table 18 Summary of Validation Exercises Results**

#### 6.3.3.1.1 Results on concept clarification

Results arisen from this validation activity do not impact the STCA concept itself. The results provide further support to the maturity of the STCA+DAPs prototype and strengthen the operative robustness of the prototype demonstrating the continuum functioning of STCA+DAPs even in non-nominal cases.

#### 6.3.3.1.2 Results per KPA

### Safety KPA

The validation conducted influenced only the Safety KPA. The log analysis is reported below. We assessed the alarm status of STCA+DAPs prototype and checked this with every single event we created. We wanted to prove that, even in this degraded mode, the STCA raised an alarm coherent with what we expected. In case this isn't verified, we tried to identify the reason explaining why that happened. We referred to 'necessary' alarms to the ones that really have a loss of separation, "not necessary" alarms to the ones that don't have a loss of separation and "not detected" alarms to the ones that haven't to be raised by the STCA prototype.

### Incorrect MCP/FCU Selected Altitude

The following table reports the results for the first type of non-nominal cases created. In the column "Type of STCA DAPs alarm" are reported the type of alarms detected by the STCA prototype and in the column "Expected Result" the expected results. As we can see, the alarms are coherent in all the events created.

| | | | Incorrect MCP/FCU Selected Altitude | |
|---|---|---|---|---|
| Event | A/C 1 | A/C 2 | Expected Result | Type of STCA DAPs alarm |
| 1 | AFR1012 | AZA1011 | Necessary | Necessary |
| 1A | AZA932 | AZA911 | Necessary | Necessary |
| 1.2 | RYR1022 | EZY1021 | Not detected | Not detected |
| 1.2A | RYR276 | EZY011 | Not detected | Not detected |
| 1.3 | ALS1032 | DLA1031 | Necessary | Necessary |
| 2 | FNX042 | AXV041 | Necessary | Necessary |
| 2A | HTO337 | LEA133 | Necessary | Necessary |
| 2.1 | AZA801 | AFR378 | Necessary | Necessary |
| 2.1A | AFR666 | AZA732 | Necessary | Necessary |
| 2.2 | VLG112 | VLG8710 | Necessary | Necessary |
| 2.2A | VLG902 | SWR465 | Necessary | Necessary |
| 2.3 | SWS3110 | KLM414 | Necessary | Necessary |
| 2.3A | SWR865 | DAH432 | Necessary | Necessary |

**Table 19 Alarm analysis incorrect MCP/FCU Selected Altitude scenario**

### Corrupted SFL

The following table reports the results for the second type of non-nominal cases created. In the column "Type of STCA DAPs alarm" are reported the type of alarms detected by the STCA prototype and in the column "Expected Result" the expected results. As we can see the alarms are coherent in all the events created, except for the encounter 2.3 and 2.3A, in which we missed the correct timing for the SFL input because of the real time simulation nature of the validation activity.

| | | | Corrupted SFL | |
|---|---|---|---|---|
| Event | A/C 1 | A/C 2 | Expected Result | Type of STCA DAPs alarm |
| 1 | AFR1012 | AZA1011 | Not detected | Not Necessary |
| 1A | AZA932 | AZA911 | Not detected | Not Necessary |
| 1.2 | RYR1022 | EZY1021 | Not detected | Not Necessary |
| 1.2A | RYR276 | EZY011 | Not detected | Not Necessary |
| 1.3 | ALS1032 | DLA1031 | Necessary | Necessary |
| 2 | FNX042 | AXV041 | Necessary | Necessary |
| 2A | HTO337 | LEA133 | Necessary | Necessary |
| 2.1 | AZA801 | AFR378 | Necessary | Necessary |
| 2.1A | AFR666 | AZA732 | Necessary | Necessary |
| 2.2 | VLG112 | VLG8710 | Necessary | Necessary |
| 2.2A | VLG902 | SWR465 | Necessary | Necessary |
| 2.3 | SWS3110 | KLM414 | Necessary | Not Necessary |
| 2.3A | SWR865 | DAH432 | Necessary | Not Necessary |

**Table 20 Alarm analysis Corrupted SFL scenario**

Further, we can note that when we expected a "not detected" result and instead the prototype detected a not necessary alarm this is linked to the nature of the scenario.

In fact, for example taking into account the encounter between RYR1022 and EZY1021, the aircraft RYR1022 selected a FL210, but the data processed by the STCA prototype -in the Table 21 this data is called SEL TRACK 1- was FL220 (due to the corruption in the transmission chain). So the alarm was raised and switched off as soon as the aircraft RYR1022 levelled off at FL210, in particular at the second scan of the level 210.

| EXERCISE TIME | ALARM STATUS | CALLSIGN TRACK 1 | CALLSIGN TRACK 2 | LEVEL TRACK 1 | SEL TRACK 1 | LEVEL TRACK 2 | SEL TRACK 2 |
|---|---|---|---|---|---|---|---|
| 10:12:59 | FRST | RYR1022 | EZY1021 | 204 | 220 | 220 | 220 |
| 10:13:03 | UPDT | RYR1022 | EZY1021 | 205 | 220 | 220 | 220 |
| 10:13:07 | UPDT | RYR1022 | EZY1021 | 207 | 220 | 220 | 220 |
| 10:13:11 | UPDT | RYR1022 | EZY1021 | 209 | 220 | 220 | 220 |
| 10:13:15 | UPDT | RYR1022 | EZY1021 | 210 | 220 | 220 | 220 |
| 10:13:19 | TERM | RYR1022 | EZY1021 | 210 | 220 | 220 | 220 |

**Table 21 Alarm between RYR1022 and EZY1022**

### No Mode-S capable

The following table reports the results for the third type of non-nominal cases created. In the column "Type of STCA DAPs alarm" are reported the type of alarms detected by the STCA prototype and in the column "Expected Result" the corrected results. As we can see, the alarms are coherent in all the events created, except for the encounter between the SWR865 and DAH432, in which we missed the correct timing for the SFL input because of the real time simulation nature of the validation activities.

| | | | No Mode-S | |
|---|---|---|---|---|
| Event | A/C 1 | A/C 2 | Expected Result | Type of STCA DAPs alarm |
| 1 | AFR1012 | AZA1011 | Necessary | Necessary |
| 1A | AZA932 | AZA911 | Necessary | Necessary |
| 1.2 | RYR1022 | EZY1021 | Not detected | Not detected |
| 1.2A | RYR276 | EZY011 | Not detected | Not detected |
| 1.3 | ALS1032 | DLA1031 | Necessary | Necessary |
| 2 | FNX042 | AXV041 | Necessary | Necessary |
| 2A | HTO337 | LEA133 | Necessary | Necessary |
| 2.1 | AZA801 | AFR378 | Necessary | Necessary |
| 2.1A | AFR666 | AZA732 | Necessary | Necessary |
| 2.2 | VLG112 | VLG8710 | Necessary | Necessary |
| 2.2A | VLG902 | SWR465 | Necessary | Necessary |
| 2.3 | SWS3110 | KLM414 | Necessary | Necessary |
| 2.3A | SWR865 | DAH432 | Necessary | Not Necessary |

**Table 22 No Mode-S scenario**

#### 6.3.3.1.2.1 Example of encounter

The following photos show an example of encounter, recreated during the simulation. In this encounter the two aircraft were in a configuration according to the event 2.2 in Figure 34.

In an ideal reference scenario, where the pilot execute the correct manoeuvre selecting the cleared level, the dynamic of traffic sees the two aircraft flying opposite routes with a difference in height of 2000 ft. The first aircraft, SWR465, is flying at a level of 190 and is authorized to descent to 170. The second aircraft is flying at FL170 and is authorized to climb to 190.


**Figure 36 STCA alarm: incorrect MCP/FCU Selected Altitude**

The Figure 36 is a screenshot of what happen during the simulation of the first scenario, in which we planned that the pilot selected an incorrect MCP/FCU Selected Altitude In this case, the pilot executed a right read-back to the ATCO, but he didn't follow the ATCO clearance, selecting the wrong flight level. The alarm is raised as we can see in the image. In this case, both the aircraft selected an incorrect MCP/FCU Selected Altitude: SWR465 SFL160 and VLG902 180.

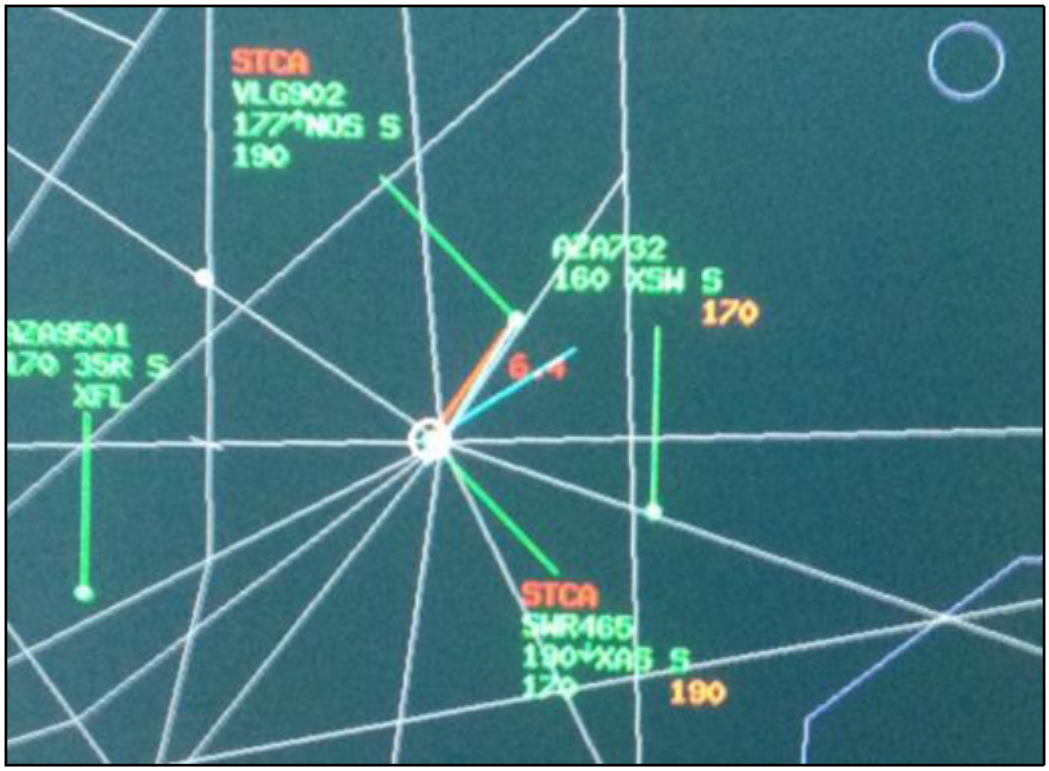


**Figure 37 STCA alarm: corrupted SFL**

The Figure 37 is a screenshot of what happen during the simulation in the second scenario, in which we planned that, due to a transmission error, the prototype processed a SFL different from the one selected by the pilot. The alarm is raised as we can see in the image. In this case, STCA prototype processed an incorrect MCP/FCU Selected Altitude: SWR465 SFL160, instead of 170 and VLG902 SFL190, instead of 180.


**Figure 38 STCA alarm: no Mode-S**

The Figure 38 is a screenshot of what happen during the simulation in the third scenario, in which we planned that one of the aircraft, or both of the aircraft, didn't have a Mode-S transponder capability. The alarm is raised as we can see in the image. In this case, the aircraft SWR465 SFL160, was mode-S capable and VLG902 wasn't mode-S capable.

#### 6.3.3.1.3 Results impacting regulation and standardisation initiatives

The concept under validation related to STCA+DAPs, at this stage, has not impact on current Regulation and Standardisation activities.

### 6.3.3.2 Analysis of Exercise Results

#### 6.3.3.2.1 Unexpected Behaviours/Results

N/A.

### 6.3.3.3 Confidence in Results of Validation Exercise

#### 6.3.3.3.1 Quality of Validation Exercise Results

See para. 6.1.3.3.1

#### 6.3.3.3.2 Significance of Validation Exercise Results

See para. 6.1.3.3.2.

## 6.3.4 Conclusions and recommendations

### 6.3.4.1 Conclusions

The exe VP239c has been executed in order to add a technical verification of the STCA+DAP Prototype in some specific non-nominal cases. The aim is to produce a more complete analysis within the Validation activity. The evidences raised during the real time simulation and after the data analysis, highlighted a coherence between the alarms expected to be raised within a "nominal" situation and the alarms raised in the non-nominal cases investigated. In some cases, already specified in paragraph 6.3.3.1.2, the incoherence was due to incorrect timing in the input of the pilots. For the non-nominal cases identified and investigated, the results are satisfactory and the new Validation Objective (ad-hoc) was successfully achieved.

### 6.3.4.2 Recommendations

The analysis of the non-nominal cases can be improved and continued with other encounters to be investigated in other validation activities. Anyway, an effective operative recommendation is to execute future validation activities, that imply the use of airborne data, with a tighter sharing of the progresses and the issues with the WP working on Airborne systems.

# 7 References

## 7.1 Applicable Documents

**[1]** Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

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

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

**[4]** European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

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

## 7.2 Reference Documents

**[6]** ATM Master Plan
https://www.atmmasterplan.eu

**[7]** 4.8.1-D04-VP-TMA-STCA-V3 “Final validation plan (V3) for enhanced Short Term Conflict Alert (STCA) for Terminal control area (TMA) specific operations”

**[8]** 4.8.1-D05-VR-TMA-STCA-V3 “Operational evaluation of industrial Short Term Conflict Alert (STCA) prototype for Terminal control area (TMA) specific operations

**[9]** 4.8.1-D11-VP-DAP-G-SNET-V2 “Validation Plan (V2) for Enhanced Ground-based Safety Nets using Existing Down-link Parameters”

**[10]** 4.8.1-D12-VR-Feasibility-DAP-G-SNET-V2 “Feasibility and Options for Use of Existing Downlinked Parameters in Ground-based Safety Nets”

**[11]** 4.8.1-D13-VR-Benefits-DAP-STCA-V2 “Evaluation of safety and performance benefits from the use of existing down-linked parameters in STCA”

**[12]** 4.8.1-D14-VR-Benefits-DAP-Other-G-SNET-V2 “Evaluation of safety benefits from the use of Existing Downlinked Parameters in Ground-based Safety Nets (other than STCA)”

**[13]** 4.8.1-D15-SAR-Safety-DAP-G-SNET-V2 “VALR-DAP-G-SNET-V3 Operational evaluation of enhanced STCA using DAP”

**[14]** 4.8.1-D16-VR-Costs-DAP-G-SNET-V2 “VALR-DAP-G-SNET-V3 Operational evaluation of enhanced STCA using DAP

**[15]** 10 04 03-D11-Preliminary Definition Report for Phase 2 (Enhance Safety Nets)-00 00 10

**[16]** 4.8.1-D17-OR-DAP-G-SNET-V2 “Preliminary operational requirements for the use of down-linked aircraft parameters in ground based safety nets”

**[17]** 4.8.1-D18-SPR-DAP-GSNET-V2 "Preliminary safety and performance requirements for the use of down-linked aircraft parameters in ground based safety nets (Step1)", Ed 1.0

**[18]** 4.8.1-D19-VALP-DAP-G-SNET-V3 “Validation Plan V3 for enhanced STCA using existing down-linked parameters”

# Appendix A KPA Templates

The Human Performance Assessment Report is attached in this section.

4 8
1-Vp239-HP_Assessm

# Appendix B SUT Requirements

According to the need to correct some SUT requirements fields in the Validation Plan4.8.1-D19-VALP-DAP-G-SNET-V3[18], as suggested by the SESAR JU, in the following section it's provided the SUT Requirements in which we did the corrections as required ("Rationale" and "Satisfies" fields).

The code used to identify the validation requirements is as follows:

- REQ-Project No–VALP-Deliverable No-Sequence number

| Identifier | REQ-04.08.01-VALP-0019.0010 |
|---|---|
| Requirement | The IBP shall generate simulated System Track data having contributions from SSR and Mode-S sensors including DAPs (Selected Altitude, Roll Angle and Track Angle Rate). |

| Identifier | REQ-04.08.01-VALP-0019.0020 |
|---|---|
| Requirement | The IBP generated simulated System Tracks data shall include specific targets to test STCA functionality, controlled by Pseudo-pilots, and background traffic. |

| Identifier | REQ-04.08.01-VALP-0019.0030 |
|---|---|
| Requirement | The IBP shall generate simulated System Tracks either in TMA or en-route areas. |

| Identifier | REQ-04.08.01-VALP-0019.0040 |
|---|---|
| Requirement | The IBP shall allow to exclude sending of DAPs parameters selectively (e.g. set to invalid Roll Angle) |

| Identifier | REQ-04.08.01-VALP-0019.0050 |
|---|---|
| Requirement | The IBP shall allow to record and playback the exercise runs in order to analyse possible changes to apply for the subsequent runs. |

| Identifier | REQ-04.08.01-VALP-0019.0060 |
|---|---|
| Requirement | The IBP shall allow to store the following types of data into log files for analysis purposes:<br>-Flights id (pair)<br>-STCA ON time<br>-STCA OFF time<br>-Aircrafts separation at STCA ON time<br>-Aircrafts separation at STCA OFF time<br>-Aircrafts Flight Level at STCA ON time<br>-Aircrafts Flight Level at STCA OFF time<br>-Aircrafts Climbing/Descending rate<br>-Aircrafts CFL at STCA ON time<br>-Aircrafts CFL at STCA OFF time |

| | |
|---|---|
| | -Aircrafts SFL at STCA ON time<br>-Aircrafts SFL at STCA OFF time<br>-Aircrafts Roll Angle at STCA ON time<br>-Aircrafts Roll Angle at STCA OFF time<br>-Aircrafts Track Angle Rate at STCA ON time<br>-Aircrafts Track Angle Rate at STCA OFF time |

| | |
|---|---|
| Identifier | REQ-04.08.01-VALP-0019.0070 |
| Requirement | The Safety Nets software used in the validation platform shall allow to configure the STCA function by means of the same parameters used for the operational Milan STCA. |

| | |
|---|---|
| Identifier | REQ-04.08.01-VALP-0019.0080 |
| Requirement | The IBP platform shall allow to tune STCA function configuration parameters in order to consider the test environment. |

# Appendix C Safety Analysis using a DSNA tool

An additional analysis has been carried out, with the help of a dedicated software. In summary, this software extrapolates different "what if" scenarios, starting at the time where STCA alarms have started. Here, two scenarios have been retained. The first scenario reproduces the extrapolation that an air traffic controller would do, meaning that if an aircraft is cleared at a given flight level, the air traffic controller expects that the flight will level off at that level. Similarly, in horizontal, if an aircraft follows a flight plan route, the air traffic controller expects that the aircraft will follow his flight plan route. As an illustration, Figure 39 shows an "air traffic controller" extrapolation of two aircraft trajectories, both in horizontal and in vertical. The real trajectories are shown in thick green and blue, and the extrapolated ones are shown in thin red and blue. Here, both the extrapolated and the real trajectories are merged, except for the green horizontal one, where, immediately after the alarm, the air traffic controller executes a turn on the aircraft. The extrapolated scenario is made at the time when the alarm was issued, and represents the "extrapolated future" at that time. Since the aircraft was on its flight plan route, the extrapolated future consists in following the flight plan route (as depicted in the thin red line in the top window of Figure 39).
The second scenario implemented by the software is a straight line scenario, meaning that the aircraft follows its route in straight line, both horizontally and vertically. For the same aircraft pair and the same STCA alarm shown in Figure 39, this straight line scenario is illustrated inFigure 40.
The operational situation illustrated in Figure 39 and Figure 40 corresponds to a *vertical nuisance alarm*, in the sense that the two aircraft were not supposed to cross vertically (we see on Figure 39that the descending aircraft was going to level off at FL330, 1000 ft above the other one). However, the STCA alarm was caused by a straight line extrapolation, which made the two aircraft pass below separation both in horizontal and in vertical.
So, by comparing between the two extrapolated scenarios, it becomes possible to extract nuisance alarms corresponding to a given operational criterion. Here, in order to evaluate the new STCA, two operational criteria have been retained, one for the SFL enhancement, and one for the cross track angle enhancement.
For the SFL enhancement, the vertical criterion is similar to the case illustrated in Figure 39 and Figure 40: ATCO extrapolation vertically separated, STCA extrapolation vertically intersecting. This operational configuration is the one where the SFL enhancement should result in a reduction of nuisance alarms

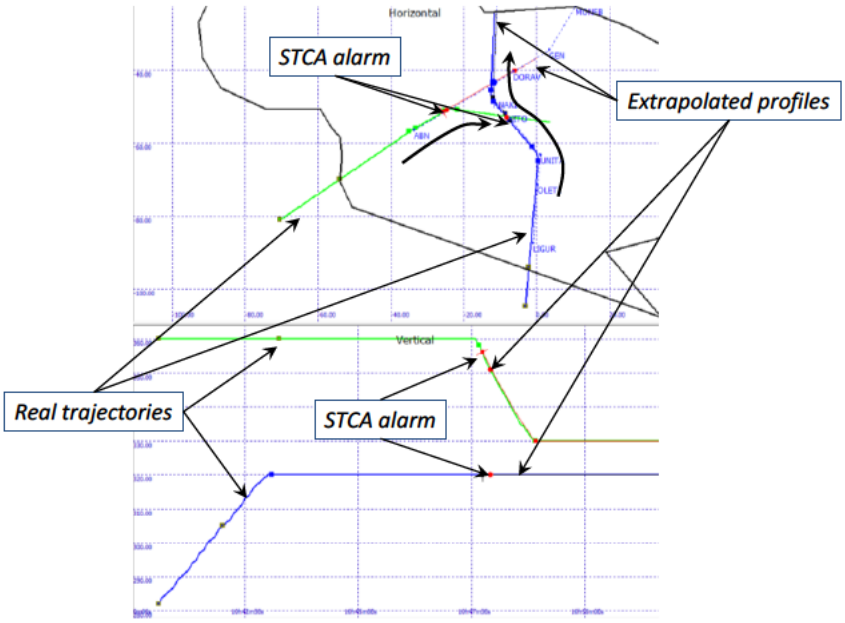


**Figure 39-Extrapolated "air traffic controller" scenario**

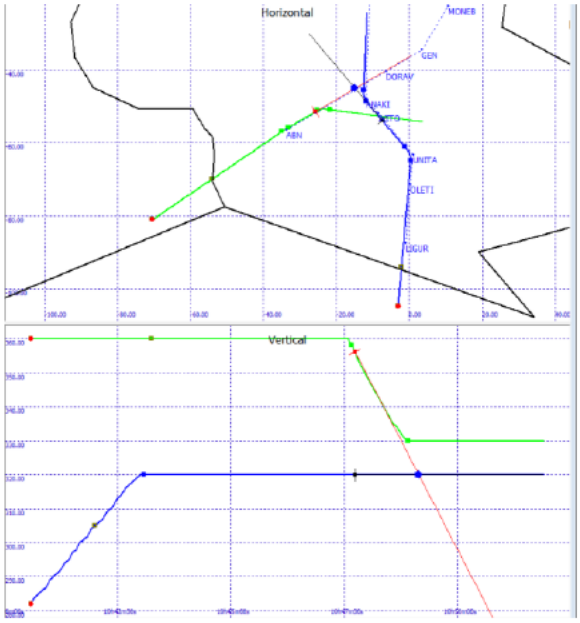


**Figure 40- Extrapolated "straight line" scenario**

For the cross track angle enhancement, the horizontal criterion corresponds to encounters which "seem to pass horizontally below separation" if each trajectory was extrapolated in straight line, but which passed horizontally above the separation in reality. This criterion is voluntarily loose, in order to have "as many operational situations as possible" to evaluate. An example of this criterion is illustrated in Figure 41, where the two aircraft "seem to pass" horizontally at 3.8Nm (if we extrapolate in straight line from the time when the STCA alarm was issued), but in reality the two aircraft passed by horizontally at 7.2Nm.
An exhaustive search for the horizontal criterion has given very scarce results: only two situations for all the exercises, one in TS2/BASELINE and one in TS3/BASELINE. We conclude that this operational situation has not been implemented in the experimentation VP239.

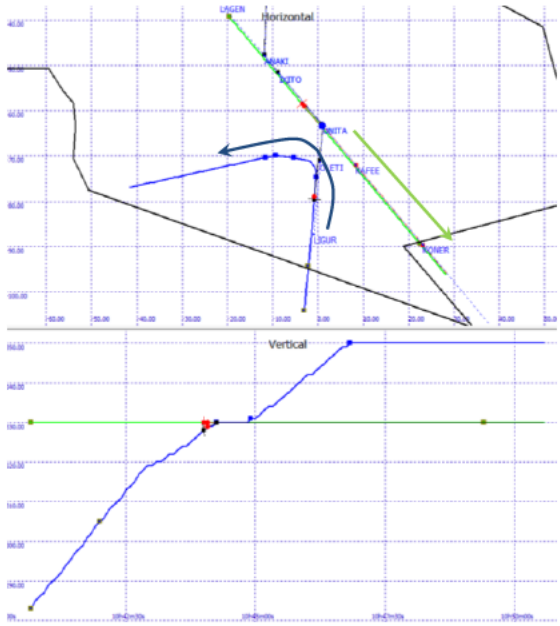


**Figure 41- Illustration of the horizontal criterion**

On the other hand, an exhaustive search for the vertical criterion has been more fruitful. We recall that this criterion can be seen intuitively as vertical nuisance alarms, which should be corrected by the SFL enhancement.
The horizontal and vertical criteria introduced before are not exhaustive for defining nuisance alarms. A final criterion is the "risk of passing below the separation". Alarms which have no risk of passing below separation are obviously nuisance alarms.
We notice that the vertical criterion captures such alarms, since, for those alarms, the aircraft have been cleared with at least 1000ft vertical separation, so that (provided the pilots follow ATCO instructions), there should not be any risk of loss of separation.
We now investigate the case of alarms for which the two aircraft were planned to lose vertical separation at the time of the alarm. Since the value of the separation depends on the flight level (3Nm below FL195, and 5Nm above), we have distinguished these two cases. For the two cases, we have represented, for each alarm, the minimal horizontal distance when the aircraft have lost vertical separation, and we have made that computation:

1) For the real trajectories;
2) For the "air traffic controller" extrapolation.

The reason why we have considered these two cases is that, it is possible that the air traffic controller modifies the trajectory of one of the aircraft after the alarm, and we want to detect such cases. A way of detecting these cases is to see mismatches between the two previous quantities 1) and 2), since 1) applies to the real trajectory, and 2) applies to the extrapolated trajectory at the time of the alarm, then if the controller modifies one trajectory after the alarm these two quantities should differ.

Figure 42 illustrates such a case, where the air traffic controller instructs one aircraft to turn immediately after the STCA alarm, causing the minimal horizontal distance without vertical separation to be of 0.7 Nm. If this minimal distance was computed based on the air traffic controller extrapolation, it would be of 6.8Nm.

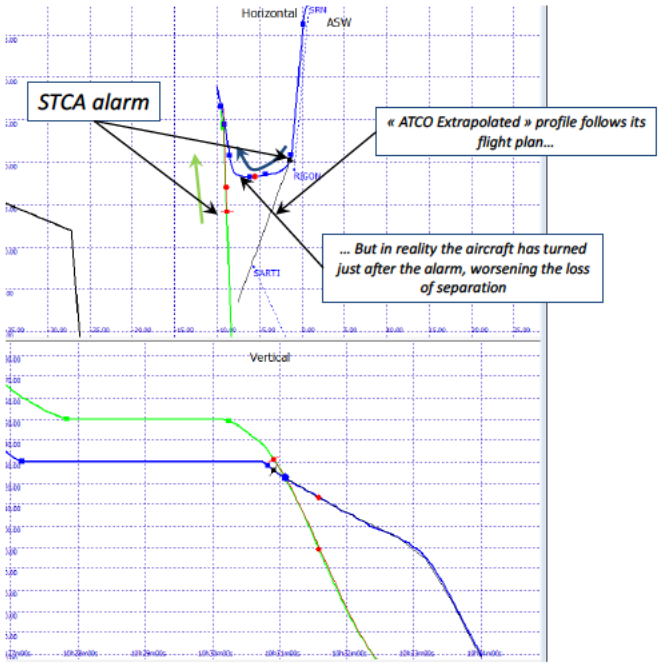


**Figure 42- Illustration of an alarm where the controller "worsens the situation"**

# Appendix D STCA HMI impact on ATCOs interaction and situation awareness

The impact of the STCA +DAP HMI' implementation on the ATCOs interaction and its impact on their situation awareness was observed and evaluated during the RTS. From debriefing , ATCOs feedback was collected in order to provide input to further optimize the STCA HMI supported by DAP. Hereafter are reported a brief description of the STCA+ DAP HMI as implemented during the RTS, in order to facilitate the understanding of the feedback and suggestions collected across the debriefing sessions.
Even if ATCOs do not report any significant differences in terms of general impact of their perceived situation awareness between the two version of STCA under test, however they highlighted as some HMI features have had an impact on their awareness of the STCA warning.

Pairs of a/c involved in a STCA event were linked by a red segment (see Figure 43) featured by a distance between them (in NM). ATCOs unanimously appreciated this feature, that supports them in a quick visual identification of a/c involved in the loss of separation.

The label implemented allows also the display of SFL. This feature made possible to check the input CFL against the down-linked SFL and indicates any inconsistency to the controller.
This function was appreciate by controllers, improving their awareness of a potentially hazardous situation arising, if the aircraft were not to adhere to the cleared level.

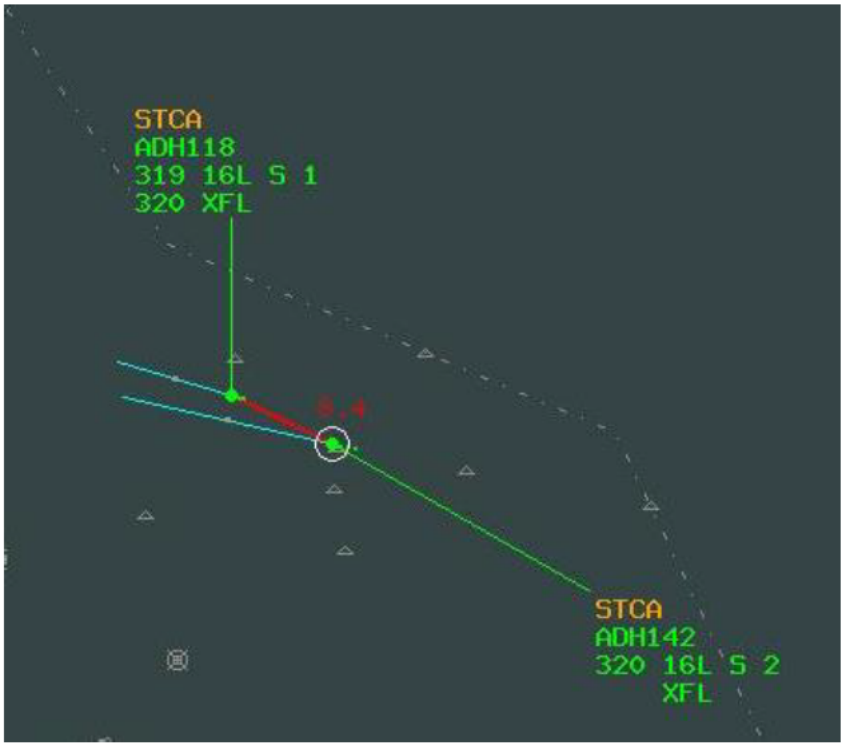


**Figure 43 STCA link b/w pair of aircrafts**

STCA events were listed in a dedicated window, named alarm list (see Figure 44) , which report relevant information about the STCA event:

- a/c pairs call sign
- Urgency of STCA alarm: 3 stages foreseen (orange, red, red with black background)
- FL and sector of 1° a/c
- FL and sector of 2° a/c
- Distance b/w pair of a/c in NM

The STCA window was not unanimously appreciated by ATCOs. Some ATCOs considered the information provided by the window not relevant and cluttering the radar screen. This impact was more critical in the approach sector, were the traffic management is usually more dynamic.
Other controllers, on the other hand, appreciated the STCA window support but they provided some requirements referring the type of information to be provided:

- Highlights (by colour or prioritizing the order) the couple of aircraft in the own sector
- Provide the information of pair of aircraft in conflict (call sing sign, fl, sector etc.) in column not in row. ATCOs highlighted that the most relevant information in case of risk of conflict is the a/c call sign and its flight level. Then, these info should be provided next to each other's.


**Figure 44 STCA alarm list**

In the HMI implemented, the STCA event was displayed by a "STCA" sign reported in line0 in the a/c label (see Figure 45). This choice was considered unanimously critical, because misleading (can be mixed up with the call sing).
ATCOs highlighted that in order to increase their awareness of the potential loss of separation they would appreciated a more clear visual warning, such as a blinking label with a red frame (as currently implemented in Milan) which should allow a more immediate capture of the attention.


**Figure 45 STCA event displayed on a/c label**

The HMI implemented foreseen for the STCA warning three different level of alert, that prioritized the urgency of the ATCO intervention (see Figure 46).
The figures below reported the three STCA status:
STCA sign Orange: 80sec in the linear extrapolation and 100sec in the manoeuvre extrapolation until the loss of separation minima
STCA sign Red: 40 sec. until the loss of separation minima
STCA red with black background: loss of separation minima


**Figure 46: STCA urgency stages-HMI presentation**

The three STCA statuses identified by a colour-coding sign, was considered by ATCOs a misleading feature. They prefer to have a single STCA status, coloured in red. The three level of urgency are not recognised by them as suitable. Controllers report that, as soon as they detect a loss of separation suddenly they react to assure the separation minima b/w aircraft.

**-END OF DOCUMENT-**