Final Project Report

Document information	
Project Title	Precision Conformance Monitoring
Project Number	10.04.02
Project Manager	Leonardo
Deliverable Name	Final Project Report
Deliverable ID	D38
Edition	00.02.00
Template Version	03.00.04
Task contributors	
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Abstract

P10.04.02 was focused on Conformance Monitoring function within the En-Route, TMA and Free Route environments.
The project defined system requirements derived from operational requirements and provided verified prototypes to support operational validations addressing the flight trajectory deviation and conformance monitoring concepts.

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Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
00.00.01	01/09/2016	Draft	Leonardo	Initial draft
00.01.00	19/09/2016	Final	Leonardo	Version for hand-over
00.02.00	01/11/2016	Final	Leonardo	Version updated after SJU assessment

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ACC	Area Control Centre
ARN	ATS Route Network
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATSU	Air Traffic Service Unit
CCD	Continuous Climb Departure
CDA	Continuous Descent Approach
CHAM	Cleared Heading Adherence Monitoring
CLAM	Cleared flight Level Adherence Monitoring
CWP	Controller Work Position
DAP	Derived Aircraft Parameter
DRA	Direct Routing Airspace
DS	DataSet
FIR	Flight Information Region
FL	Flight Level
FRA	Free Routing Airspace
HMI	Human-Machine Interface
IBP	Industrial Based Platform
INTEROP	INTEROPerability
iTEC	interoperability Through European Collaboration
MONA	Monitor AIDS
MTCD	Medium Term Conflict Detection
OFA	Operational Focus Area
OI	Operational Improvement

OSED	Operational Service and Environment Definition
RAM	Route Adherence Monitoring
RNP	Required Navigation Performance
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission
SPR	Safety and Performance Requirements
TC	Tactical Controller
TMA	Terminal Manoeuvring Area
TS	Technical Specification
VR	Verification Report

1 Project Overview

The objective of the project P10.04.02 "Precision Conformance Monitoring" was the enhancement of the existing conformance monitoring tools to improve the support to the ATC controllers in detecting any discrepancies between flown trajectories and planned/cleared trajectories in En-Route and TMA environment.

1.1 Project progress and contribution to the Master Plan

The purpose of the project 10.04.02 was to take care of the functionality and implementation of prototypes concerning the Monitoring Aids function. This functionality encompasses the following functions:

- Flight Trajectory deviation and conformance monitoring: detects if a controlled aircraft deviates from its planned trajectory, notifying deviation warnings to the concerned sectors;
- Tactical Instruction and Clearance conformance monitoring: detects if a controlled aircraft deviates from the issued clearance/instruction and notifies the current executive controller;
- Flight progress monitoring and update: this function keeps the trajectory updated along the progress of the flight. It also detects certain events such as take-off, missed approach and landing.

Starting from a state of the art as expressed in the current iTEC, CoFlight and FASTI requirements, P10.04.02 analyzed and validated operational concepts coming from operative projects ([16], [17], [19], [20], [21], [22]).

The operational concepts were received by operational requirements (SPR, OSED and INTEROP). They were analyzed, supported by specified technical requirements (with P10.04.02 TSs) and validated during exercises with dedicated project prototypes.

The project was organized in three iterative and incremental phases defined in coordination with the operational projects, the evolution of the requirements in input and the validation strategy.

At the beginning of each phase, the analysis of the available operational documentation was performed in order to derive the operational requirements into technical requirements (functional and non-functional). In particular, the project analysed the operational requirements to identify and specify:

- Improvement to existing functionalities
- New algorithms and performances

To ensure full compliance and coverage of the applicable operational requirements, traceability from technical requirements to the operational requirements was maintained.

Based on the technical specification produced and the requested capabilities to support the validation exercises (from the validation plans), prototypes were developed and verified. The verification process resulted in the technical acceptance of the prototypes according the criteria established in the related verification plan and ensured that all the applicable validation needs defined for the target exercises were satisfied.

After the successful verifications and the technical acceptances, the prototypes were provided to the platform owners and operational projects for integration into the IBP platform. During this phase, technical support was essential to correctly configure and tune the prototypes according the specific validation needs. All the needs for changes to the prototype were collected and impact analysis performed. Whenever it was possible the changes were implemented before the exercise. Changes that could not be implemented due to time and effort limitations were collected and considered for specification and implementation in the following prototyping phase.

During the exercises preparation and execution, support and advices in use of the prototypes were provided through a series of training sessions to the controllers involved.

After the validation exercise completion, feedback and recommendation derived from the validation reports were taken into account as input for the following phase.

During its lifecycle, at each phase, the project contributed to maturing Enablers referenced in the integrated roadmap version DS16 [4] through the technical specification, development and testing of the prototype.

Phase 1

The project was tasked to improve existing conformance monitoring to monitor the adherence to the Continuous Descent Approach and Continuous Climb Departure (CDA-CCD) procedures.

In this phase the prototypes were involved in technical verification only ([6],[8]).

Phase 2

The project was aimed to improve conformance monitoring defined in Phase1 with new separation aids in the En Route Environment

Phase 2 prototypes were involved in two validation exercises ([7], [9], [10], [12]).

The following table lists all the Enablers relevant for this phase of the project and the improvement in the maturity level which Phase2 contributed to:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
ER ATC 91	ATC System Support for Advanced Conformance Monitoring in En-route Airspace	The project contributed by providing advanced tools aimed to ATC System Support for Direct and Free Routing	TRL2	TRL6
ER APP ATC 104	Adapt Controller Tools to Use Enhanced Trajectory data	The project contributed by providing advanced tools aimed to ATC System Support for Advanced Conformance Monitoring in En Route Airspace	TRL2	TRL6

Phase 3: Improve Phase2 conformance monitoring with new separation aid in the TMA Environment

Phase 3 prototype was involved in one validation exercise ([11], [13]).

The following table lists all the Enablers relevant for this phase of the project and the improvement in the maturity level which Phase2 contributed to:

Code	Name	Project contribution	Maturity at project start	Maturity at project end

APP ATC 94	ATC tools in support of RNP for Approach/TMA	The project contributed by providing advanced tools aimed to ATC System Support for Advanced Conformance Monitoring in Approach/TMA	TRL2	TRL5

Phase2 and Phase3 validation exercises were both in Release 5 exercises [24].

The project contributed to the following SESAR solutions:

- Solution #10-02A ”Improved Performance in the Provision of Separation"
- Solution #27 ”Enhanced CD/R Services for En-Route Controllers"
- Solution #32 "Free route through the use of direct routing"
- Solution #33 "Free route through free routing for flights both in cruise and vertically evolving above a specified flight level”

1.2 Project achievements

The requirements for an enhanced Conformance Monitoring tools were defined and included in the 10.04.02 Technical Specification [15].

Such requirements contain a number of Functional and non-Functional Improvements to the baseline Conformance Monitoring tools (state-of-the-art at the beginning of the SESAR program) defined taking into account the new operational concepts.

A description of the new functionalities and features of SESAR Conformance Monitoring as an improvement compared to FASTI and as contribution to Solution #27 are described in the following:

- heading monitoring: monitoring of lateral deviation while a heading clearance is provided; A new Alert (CHAM) is provided when the flight is not conforming the issued clearance;
- rate monitoring: rate change, using of actual vertical rates, is taken into account during an evolving phase when an aircraft is about to start its evolution or is about to reach its cleared FL. The main aim is to minimize false alert by getting a more realistic prediction;
- Potential coordination failure monitoring;
- Comparison of Mode S DAP with clearance input from controllers;
- Detection of Level Bust.

According to the VR (Verification Report), the added value and the usability principle of the assessed Conformance Monitoring were approved by the ATCO.
MONA was essential for detection of deviations of the aircraft behavior from the hypothesis from the predicted 3D trajectory model (lateral route deviation, vertical flight level and vertical rate deviations).
MONA shall instantaneously trigger an alert in case of an obvious deviation such as turn in the opposite direction or descending instead of climbing.
MONA shall be mandatory in FRA as ATCO need to be assured that the aircraft follows its planned trajectory without any deviation as flight routes very much in FRA from one flight to another. The controllers cannot remember precisely the routes of all the flights they integrated.
MONA principle was judged as being acceptable for an operational use.

P04.07.02 Final Report specifies that MONA was proven useful and adapted to lower airspace with many evolving flights and even deemed strongly needed in a Free Route Environment (DRA/FRA),

where it is hard to spot if a turn is due to a user preferred planned route or to an unexpected manoeuver.

Controllers reported that MONA really improved their Situation Awareness of an unexpected behavior. Furthermore, in FRA the MONA helped also to detect any deviation from the planned route, as controllers did not always know which route flights were flying. In fact, when a pilot performed an unexpected manoeuver, ATCOs could often not know whether a turn inside the sector was planned or not without displaying the flight leg; thus detecting a deviation from the route becomes much harder (controllers have to remember the route of each flight). In this context, MONA seems mandatory in FRA to maintain an acceptable level of Situation Awareness.
In addition, all ATCOs confirmed that the proposed design (with the suggested improvement) was adapted whatever the route network.

1.3 Project Deliverables

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

Reference	Title	Description
D44	Consolidated conformance monitoring system requirements	This deliverable consists in a document collecting a set of final consolidated TS requirements updated in consideration of the consolidated set of input OSED provided by P4.7.2 and P5.7.2. This document represents the result of the update of phase 2 and phase 3 TS documents. Main functionalities which have been addressed and improved are the CHAM alert (monitoring of lateral deviation while a heading clearance is provided) and a specific module that takes into account rate change during an evolving phase when an aircraft is about to start its evolution or is about to reach its cleared Flight Level (with the main aim to minimize false alert by getting a more realistic prediction).

1.4 Contribution to Standardisation

No standardisation activities were performed within the scope of the project.

1.5 Project Conclusion and Recommendations

10.04.02 prototypes in the validation activities was mainly involved to validate the following objectives:

- Eligibility of flights. The system shall be able to perform conformance monitoring on all correlated flights with a planned trajectory.
- Lateral and Vertical conformance. The system shall be able to detect lateral and vertical deviation on eligible flights.
- Deviation warnings. The system shall generate deviation warnings in a timely manner, when required.

- HMI Output. The system shall provide an interface to a suitable controller working position (CWP) to visualise flights that violate thresholds and do not follow the planned trajectory.
- Conformance monitoring thresholds. The system shall use conformance monitoring thresholds adapted to the flight situation.
- Recalculation of a planned trajectory. The system shall be able to trigger recalculation of a planned trajectory.

ATCO reported that Conformance Monitoring really improved their situation awareness simply by alerting them when a pilot did a wrong maneuver. Furthermore, the MONA helped also to detect any deviation from the planned route as controllers did not always know which route flights were flying. In fact, when a flight was turning inside the sector, they could often not know if it was planned or not without displaying the flight leg; thus detecting a deviation from the route becomes much harder (controllers have to remember the route of each flight).

According to the Validation Report, TMA Airspace capacity is increased at least a 5%.
B4.1 project (Development & maintenance of the ATM Performance and business aspects of the European ATM Enterprise Architecture) states that it's thanks to Conformance Monitoring functions and that the workload is reduced at least 9.53%.

In terms of further research, the P10.04.02 has to adapt to future needs in En-Route & Approach ATC Systems.

It is recommended to:

- improve MONA, especially to avoid the false positive RAM & CLAM;
- confirm the operational needs to monitor the vertical speed of aircraft as some "abnormal" vertical speeds are normal (no pilot's error, no deviation);
- provide the system with the coordinated clearance to avoid MONA false positive alert;
- investigate the capability to acknowledge MONA alerts to silence some nuisance alerts related either to inter-ATSU coordination or to any other corner-cases;
- take into account hysteresis and/or confirmation time in the triggering conditions/threshold to let time to the pilot to perform the clearance;
- improve the HMI of CLAM alert in order to ensure a sufficient level of detection by ATCOs;
- improve the trajectory prediction, which is a very important element regarding MONA functions;
- support TC monitoring of route adherence for FRA of flights both in cruise and vertically evolving across ACC/FIR boundaries.

2 References

[1] SESAR Programme Management Plan, Edition 03.00.01

[2] European ATM Master Plan

[3] Multilateral Framework Agreement ("MFA") signed between the SJU, EUROCONTROL and its 15 selected members on August 11, 2009, amended on 14 June 2010, 19 October 2010 and 2 July 2012

[4] B.01 D84, Integrated Roadmap DS16 Release Note, 00.01.00, 25/05/2016

[5] 10.04.02 D05, Initial conformance monitoring requirements

[6] 10.04.02 D18, Thales prototype delivery sheet phase 1, 00.02.00, 02/04/2012

[7] 10.04.02 D19, Thales prototype delivery sheet phase 2, 00.01.00, 29/10/2015

[8] 10.04.02 D24, Thales verification report phase 1, 00.01.00, 21/03/2012

[9] 10.04.02 D25, Thales verification report phase 2, 00.01.00, 30/10/2015

[10] 10.04.02 D32, Indra prototype delivery sheet phase 2, 00.01.00, 29/10/2015

[11] 10.04.02 D33, Indra prototype delivery sheet phase 3, 00.01.00, 29/04/2016

[12] 10.04.02 D36, Indra verification report for phase 2, 00.01.00, 29/10/2015

[13] 10.04.02 D37, Indra verification report for phase 3, 00.01.00, 29/04/2016

[14] 10.04.02 D42, Initial conformance monitoring requirements phase 2, 02.00.00, 14/09/2015

[15] 10.04.02 D44, Consolidated conformance monitoring system requirements, 00.01.00, 19/09/2016

[16] P04.07.02 D23, Final MTCD/TCT Safety and Performance Requirements_4, Edition 00.03.04

[17] P04.07.02 D28, OSED_4, Edition 00.01.00

[18] P04.07.02 D37, Free Route Operational Service and Environment Definition (OSED) for Step 1 - Iteration 2, Edition 00.02.00

[19] P04.07.02 D63, Free Route Safety and Performance Requirements (SPR) for Step 1, Edition 00.00.06

[20] P05.07.02 D77, Preliminary V2 OSED for Step 1, Edition 00.01.00

[21] P05.07.02 D78, Preliminary (V2) SPR for Step 1, Edition 00.01.00

[22] P05.07.02 D79, Preliminary (V2) INTEROP for Step 1, Edition 00.01.00

[23] Final Project Report Template, 03.00.04, 27/01/2016

[24] Release 5 Plan V0.3, 00.03.00, 17/10/2014

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