Final Project Report

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Abstract

Project P04.07.02 focused on two main activities, on one hand the definition and the assessment of services to assist the Air Traffic Controller (ATCOs) in their separation tasks in En-Route and on the other hand the elaboration of the Free Route concept (in coordination with relevant projects within WP4, W7/13 and WP11).

P04.07.02 was part of the Single European Sky ATM Research (SESAR) story-board step1. .

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ANSP	Air Navigation Service Provider
AoR	Area of Responsibility
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
CCR	Coordination Context Risks
CD&R	Conflict Detection & Resolution
COS	Conflict Organiser and Signaller
CTO	Control Time Over
DRA	Direct Routing
EAP	Extended ATC Planning
EPP	Extended Projected Profile
FRA	Free Routing
IBP	Industrial Based Platform
ICR	Interest Context Risks
IOP	InterOPerability
MONA	Monitoring Adherence
MTCD	Medium-Term Conflict Detection
OFA	Operational Focus Area
RM	Risk Module
SESAR	Single European Sky ATM Research
TC-SA	Time Constraint through Speed Adjustment
TCT	Tactical Controller Tool
TRACT	Trajectory Adjustment through Constraints of Time
VALP	Validation Plan

VALR	Validation Report
XFL	Exit Flight Level

1 Project Overview

The project 04.07.02 started its activities in April 2010.

The project had two objectives.

The first one was to study new services to assist En-Route ATCOs. The project focused on the following En-Route provision services:

A Conflict Detection & Resolution (CD&R) Service fully dedicated and designed primarily for the tactical controller (Tactical Controller Tool (TCT))

A CD&R Service fully dedicated and designed primarily for the planning controller (Medium-Term Conflict Detection (MTCD))

A CD&R Service designed to reduce conflicts number (Trajectory Adjustment through Constraints of Time (TRACT))

Those three services were planned to be supported by dedicated enhanced conformance monitoring services.

The second objective consisted in the contribution to the elaboration of the Free Route concept. In this domain, the project performed several validation exercises in Free Route environment: Direct Routing (high to very high complexity environment) and Free Routing (low to medium complexity environment).

1.1 Project progress and contribution to the Master Plan

P04.07.02 contributed to two Master Plan key features:

« Optimized ATM Network Services » (Free Route activities)

« Advanced Air Traffic Services » (CD&R activities)

Ten trials have then been performed on different platforms provided by two industrial partners and involving three Air Navigation Service Provider (ANSPs). This allowed the project to demonstrate TRACT and MTCD technical feasibility and to validate Monitoring Adherence (MONA) and TCT services. In parallel specific DRA and FRA implementations have been validated.

P04.07.02 participated to 3 SESAR Solutions, mentioned hereafter:

KPA/ Trans. Area SESAR Sol			
Solution #27 "Enhanced Tactical Conflict Detection & Resolution (CD&R) services and conformance monitoring tools for En-Route " (1)	Safety Increases due to proposed services that ease separation tasks	Human Performance is improved because workload is reduced, and situational awareness and team communication are improved.	Capacity is improved due to a reduced controller workload per flight
Solution #32 "Free Route through the use of Direct Routing"	Safety Free Route operations do not adversely impact safety	Env./ Fuel Efficiency Env. / Fuel efficiency is improved due to trajectory optimization	Predictability is improved as in-flight variability is reduced
Solution #33 "Free Route through Free Routing for Flights both in cruise and vertically evolving above a specified Flight Level"			

The CD aids to PC and TC proposed in P04.07.02 are based on innovative approaches and comprise enhanced or new functionalities. The project contributions regarding CD&R services are summarized in the table below, along with the OIs addressed by the project.

Code	Name	Project contribution	Maturity at project start	Maturity at project end
CM-02XX & CM-02YY (2)	Conflict Detection and Resolution in En Route using trajectory data in Predefined and User Preferred Routes environments	In the different P04.07.02 exercises, a TCT has been tested and validated, two MTCD have been tested but not validated (Risk Module (RM) and Conflict Organiser and Signaller (COS))	V1	V3 for CM-02XX V2 for CM-02YY
CM-0207-A	Automated Ground Based Flight Conformance Monitoring in En Route in Step 1	Different MONA implementations have been tested and validated in the different P04.07.02 exercises.	V2	V3

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1 At the time of the writing, solution #27 final title, as specified here, was not yet officially published. The action is however launched at SJU level.
2 After solution #27 final scope and review, this OI will be split in two parts: one to address the TCT (TC aid), temporary named CM-02XX and one to address the MTCD (PC aid), temporary named CM-02YY.
Due to time constraints, these new OIs will not belong to DS16 and will be published later, after the project closure.

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		One was embedded in TCT, and another one was an enhanced trajectory monitoring tool		
CM-0403-A	Early Conflict resolution through CTO allocation in STEP1	TRACT technical feasibility and operational acceptability have been tested	V1	V2
AOM-0500	Direct Routing for flights both in cruise and vertically evolving for cross ACC borders and in high & very high complexity environments.	One specific DRA implementation has been tested. Cf. 1.2	V1	V3
AOM-0501	Free Routing for Flights both in cruise and vertically evolving within low to medium complexity environments.	One specific FRA implementation has been tested. Cf. 1.2	V1	V3

1.2 Project achievements

According to the different exercises led in P04.07.02, it appeared that

The new CD&R service dedicated to the TC (TCT) has been proven efficient from FL100 and above (CM-02XX). Also conflicts for flights in vertical transition could be reliably detected.

The new CD&R service dedicated to PC (MTCD) has been deemed strongly needed in Free Route environment because of lack of repetition scheme and new conflict configurations. It will however need further work as the two implementations tested within the project were not sufficient to be fully usable and useful for the ATCOs (CM-02YY)

The enhanced conformance monitoring service (MONA) has been proven useful and adapted to lower airspace with many evolving flights and even deemed strongly needed in a Free Route Environment, where it is hard to spot if a turn is due to a user preferred planned route or to an unexpected manoeuver (CM-0207-A)

The new CD&R service designed to reduce number of conflicts (TRACT) is compatible with ATCOs work, and V2 results show that it may be interesting to keep a decomplexification loop in the whole ATC process. (CM-0403-A)

Experimentations in DRA (AOM-0500) in high to very high complexity environment and in FRA (AOM-0501) in low to medium complexity have led to highlight unusual conflict situations, which will require specific tools to be handled.

The two tables below (one per objective) present the key results (right column) obtained through validations led or involving P04.07.02 during SESAR1. In order to highlight the effective contribution, each result is linked to the relevant initial issue (left column) it will contribute to solve.

Note: The recommendations and S2020 envisaged follow-up are detailed in §1.5.

First Objective : assess services to assist En-Route ATCOs

Initial known issue (baseline)	Key results of P04.07.02
One of the main drawbacks of current CD tools for the PC (MTCD) is the rate of irrelevant detected conflicts which is often deemed too high.	The proposed pioneer approach for CD aids to the PC consists in showing only the most probable conflicts 20' ahead of time discarding detected conflicts that have lower probabilities of persisting. This approach has been brought to V2 maturity through the integrated exercises 04.03-VP-797 and 04.03-VP-798
The coordination tasks or the tasks yielding coordination actions require high workload.	Enhanced or new services related to coordination such as: Improved What If level probe showing conflicts that occur if a given XFL is applied Integrated Coordination provides an automatic assessment of certain types of traffic offered to the sector at the entry boundary. Conflict Risk Display which constantly displays a complete list of conflicts including: Coordination Context Risks (CCRs) which shows planning encounters when the encounter is predicted to be within the PC's Area of Responsibility (AoR); Interest Context Risks (ICRs) which shows planning encounters but only one of the flights is within the PC's AoR. Have been V2 validated in exe 04.07.02-VP-501
In environment with many evolutive flights such as in lower airspace (till FL100) MTCD are no more efficient and a specific assistance service to the TC appear necessary.	A CD/R service dedicated to the TC (Tactical Controller Tool) with a look ahead horizon of 6-7 minutes and a Conflict Resolution functionality (What-Else Probing) for lateral and vertical clearances is proposed. It was proved efficient till FL100 and was V3 validated in Release 5 exe 04.07.02-VP-175
The ATCO workload required for separation is high and is anticipated to be even higher in step 1 environments due for example to higher traffic loads and Free Route.	The objective is to reduce the complexity of the traffic (in terms of number of potential conflicts) to be handled by controllers. Increase safety and capacity. To this end the TRACT service (formerly TC-SA) performs early conflict dilution through allocation of CTO to appropriate Aircraft. The CTO is computed so that there is minimal impact on speed adjustments to the involved aircraft, in order to preserve as much as possible their optimal flight profile. This service has been brought to V2 maturity through exercises 04.07.02-VP592.
If an aircraft deviates from the calculated ground system trajectory or the ATCO's tactical clearances (heading, vertical rate) a warning need to be raised accordingly with the applied CD&R services.	A new MONA adapted to lower airspace with many evolutive flights has been V3 validated in Release 5 exe 04.07.02-VP-175 and exe 04.03-VP-798

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Second Objective: contribution to Free Route concept elaboration:

Initial Problem	Key results of P04.07.02
Current ATC and ATM are based on predefined routes which airlines must use for planning their flights. However, in regards of the current weather conditions, taxes or other specific airlines criterion these routes may not be optimal. Today's, Free Route initiatives in Europe are not harmonised and are mainly limited to be designed at ACC/FIR level (and not at a larger geographical scale).	The project consolidates the description of the operational services and environment of Free Route operations, as well as associated safety and performance requirements, through two P04.07.02 OSED and one SPR deliverables (04.07.02-D36, 04.07.02-D37, 04.07.02-D63) Because of the transversal nature of the Free Route concept, the P04.07.02 Free Route OSED and SPR are consolidating contributions from various other projects (of the OFA03.01.03) to address not only ATC and separation aspects, but also flight planning / execution aspects and network management aspects. The P04.07.02 Free Route SPR distinguishes two Free Route concept of operations, i.e. Use of En-route DCT segments (managed though the Route Availability Document) to provide more flight planning options to AUs across ACC/FIR boundaries – direct routing option Possibility to plan for user-defined routings inside significant blocks of Free Route Airspace above a certain flight level associated with acceptable level of complexity – Free routing option Free Route concept of operation as implemented in the exercise 04.03-VP-798 (and other exercises of OFA 03.01.03 validation path) has been brought to V3 maturity through subject to R5 SE#3 outcome.(3)
Operational feasibility and benefits of the Free Route concept (both direct routing and free routing options),as well as the minimum Flight Level and associated acceptable complexity level for Free Routing Airspace must be assessed	The project contributes to two integrated exercises 04.03-VP797 (V2) and 04.03-VP798 (V3 Release5) in order to assess Free Route operations (AOM-0500 and AOM-0501) with a focus on ATC and separation aspects. The ATC Tools services supporting Step 1 Free Route operations have been brought to V3 maturity through the exercise 04.03-VP-798, subject to R5 SE#3 outcome.

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3 Tested DRA was long range crossborder DCTs in addition to existing ARN Network, and Tested FRA was a free planification of published waypoints, with no possibility to plan Lat/Long points, and with some PLN restrictions (max distance & min distance between 2 PLN waypoints, LOA constraints derivated from existing one on operational sectors, mandatory back on existing network before leaving FRA via floor FL)

1.3 Project Deliverables

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

Reference	Title	Description
D28	OSED_4	This OSED is the final OSED of the project. It summarizes the OR of the services studied in the project and takes into account the validation results. Previous versions have been produced through D22, namely preliminary OSED_4 and D10, namely OSED_3
D05	Validation Report_1	This deliverable contains the results of 3 V2 exercises : VP170 (DSNA), VP172 (DFS), and VP172 (NATS)
D09	Validation Report_2	This deliverable contains the results of 2 V2 exercises : VP592 (DSNA) and VP594 (DFS)
D18	Validation Report_3	This deliverable contains the results of the DFS exercise VP175.
D21	Validation Report_4	This deliverable contains the results of the NATS exercise VP501.
D23	Final MTCD/TCT Safety and Performance Requirements_4	This is the final MTCD/TCT SPR in the project. This document takes into account all validation results.
D62	Final TRACT Safety and Performance Requirements_4	This is the final SPR for TRACT in the project. This document will take into account all validation results.
D37	Free Route Operational Service and Environment Definition (OSED) for Step 1 - Iteration 2	This is the final OSED for Free Route which summarizes concept after first validation results. This document will be the last OSED and further validation results will appear in Free Route SPR (D63) cited above.
D63	Free Route Safety and Performances Requirement (SPR) for Step 1	This is the Free Route SPR This document will take into account all validation results.

Deliverables IDs and Names are based on the last schedule approved baseline of the 6th November 2015.

1.4 Contribution to Standardisation

There has been no direct contribution to standardisation from the project. However, the outcomes of produced Validation Plans (VALPs) and Validation Reports (VALRs) are made available for supporting standardisation activities (such as operational specifications definitions).

1.5 Project Conclusion and Recommendations

Project 04.07.02 has been investigating on different possible improvements regarding ATC. It has been deeply involved in SESAR Solution#27 through the CD&R Tools that have been validated in ten experimentations led by three ANSPs. It has also been involved in SESAR Solution#32 and Solution#33 through a Free Route background in its activities.

Four approaches have been experimented regarding CD&R tools.

One service (TCT) more oriented toward TC, with a trajectory prediction module taking tactical clearances into consideration.

TCT Maturity : Fully achieved

One service (TRACT) using automatic resolution via CTO sent by CPDLC to aircraft.

TRACT Maturity : technical feasibility and operational acceptability reached.

Two other services (RM and COS) more oriented toward PC, with always the same operational need: detect conflicts with the best ratio between "Full detection of all conflicts" and "No false positive detection were provided". Indeed, those two paths are not compatible, and a compromise has always to be found.

RM & COS Maturity : technical feasibility and operational acceptability reached

Additional features have been also proposed to help ATCOs dealing with high workload situations such as "What if" and "What else" tools and MONA.

MONA : Fully achieved

Moreover, the project contributed to the description of the operational services and environment for Free Route operations. It has taken part in the transversal Free Route process, by addressing workload analysis in FRA and in DRA. Some assumptions have been taken, and some restrictions have also to be considered while reading P04.07.02 results. Details are available in the validation reports either produced by the project or for which the project has contributed to.

The Free route results tend to confirm that Free Route activities are possible according to the experimentations limitations, as long as some ad-hoc CD&R tools are deployed to help ATCOs dealing with their usual controlling tasks which become more difficult in such environment.

Free Route Maturity : Fully achieved for DRA and FRA implemented

Recommendations for further investigations, notably through S2020, are the following:

Develop coordination activities within CD&R services, especially through InterOPerability (IOP), to improve the way tools are operating

Improve the trajectory prediction, which is the most impacting element regarding CD&R services operability and efficiency. This could include on the one hand the improvement of prediction accuracy, through ADS-B Extended Projected Profile (EPP) data downlink, or through ground TP features improvement for instance. And in another hand the anticipation of the conflicts earlier through other services and Air Traffic Flow and Capacity Management (ATFCM) roles (such as Extended ATC Planning (EAP)) to reduce tactical clearances and ensure a better adherence to planned trajectory.

Evaluate further CD&R services' needs, benefits and operability in all types of environment, with for example a higher complexity of traffic

Investigate enhanced MTCD solutions, which have not been successfully addressed in V3 in this SESAR Solution

Further investigation on TRACT concept in future activities (Algorithm, HMI)

2 References

[1] SESAR Programme Management Plan, Edition 03.00.01

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[20] SESAR P04.07.02, Validation Report_4, D21, Edition 00.01.01, 15/07/2016

[21] SESAR P04.07.02, Preliminary OSED_4, D22, Edition 01.00.00, 15/01/2016

[22] SESAR P04.07.02, Final MTCD/TCT Safety and Performance Requirements_4, D23, To be issued (26/08/2016)

[23] SESAR P04.07.02, Final Safety Assessment Report_4, D61, To be issued (26/08/2016)

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