



Final Project Report

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Abstract

P5.7.2 has developed (at V2 phase) an operational concept where the separation provision in TMA is supported by advanced tools including MTCD/TCT, "What if/What else" as well as ground conformance monitoring tools. This set of tools will assist the controller team (Planner & Executive) in managing the potentially large number of interacting routes as, in the most complex TMAs.

The use of these tools will allow to ATCo team carrying out its tasks and responsibilities in a better way, expecting to get many benefits mainly, in terms of Safety, Airspace capacity, Cost efficiency and Environment, In a second term some benefits could be obtained also in other KPAs. For sure, these improvements will contribute to get the SESAR Objectives for TMA.

Two research threads have been followed i.e. Medium Density/Medium Complexity (MD/MC) and High Density/High Complexity (HD/HC) in which 4 RTS validation exercises have been run.)

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Acronyms

Acronym	Definition
AEM	Advanced Emission Model
ATC	Air Traffic Control
ATCo	Air traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
CDT	Conflict Detection Tool
D	Deliverable
DOD	Detailed Operational Description
DS	Data Set
EC	Executive Controller
ECAC	European Civil Aviation Conference
E-OCVM	European Operational Concept Validation Methodology
EPP	Extended Projected Profile
FMS	Flight Management System
FTS	Fast Time Simulation
HD/HC	High Density/High Complexity
HP	Human Performance
INTEROP	Interoperability Requirements
KPA	Key Performance Areas
MD/MC	Medium Density/Medium Complexity
MOPS	Minimum Operational Performance Standards
MTCD	Medium Term Conflict Detection
OFA	Operational Focus Area
OI	Operational Improvement
OSD	Operational Service and Environment Definition

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PC	Planner Controller
RNP	Required Navigation Performance
PRNAV	Precision RNAV
RAMS	Reorganized ATC Mathematical Simulator
RNAV	Area Navigation
RTS	Real Time Simulation
R/T	Radio Telecommunications
SAC	Safety Assessment Criteria
SPR	Safety and Performance Requirements
TA	Transversal Areas
TCT	Tactical Control Tools
TMA	Terminal Manoeuvring Area
VALP	Validation Plan
VALR	Validation Report
WL	Workload

1 Project Overview

P05.07.02 addressed research activities to improve Ground Based Separation Provision in multi-airport TMAs. Two threads of research were identified MD/MC TMAs and HD/HC TMAs. A new operating concept was defined by embracing new technical enablers such as Medium Term Conflict Detection tools and Monitoring aids. The operating method has many features for application to both kind of TMAs, but also has some particularities to be applied to each of them. Airspace Capacity, Cost efficiency, Environment/Fuel efficiency, Predictability, Human Performance and Safety KPAs/TAs have been assessed through qualitative and quantitative methods.

1.1 Project progress and contribution to the Master Plan

P05.07.02 has performed all its work aimed to contribute in the maturity of the Operational Concept step 1 "Time Based Operations" as it is stated in the SESAR Master Plan. Within this step, P05.07.02 has been focused mainly on the Conflict Management Operational ATM Service.

The main consumer of the conclusions and recommendations of this project are the ANSPs, for that reason, ANSPs have been deeply involved in the development of the new separation management concept as well as industry and airspace users. In addition, SESAR 2020 projects (specifically PJ10-2A) will take also benefit from the outcome of the project.

E-OCVM guidelines have been followed in the validation activities carried out by P05.07.02. The validation activities performed correspond to V1 & V2 as they are described in the Concept Lifecycle Model of E-OCVM.

During the project progress it was agreed with SJU that P05.07.03 (Collaborative control) and P4.10 (General aviation) contribute to some activities to be developed by P05.07.02. This is the reason why later below these projects are quoted in some descriptions.

STEP 1 v1 phase

The first draft of concept was described based on the information gathered in Detailed Operational Description (DOD). As base for the definition of the concept, different validation activities were undertaken at a V1 stage. This included Third Party workshops, Fast Time Simulations (based on RAMS+AEM), and expert assessment reviews. These workshops and expert assessment reviews involved representatives from Airspace Users, staff associations and industry. The inputs provided by these entities were used for a continuous refinement of the concept, such as rotorcraft and general aviation expectations, ground systems and FMS information exchange aspects and expected evolutions, military traffic needs and air traffic controller behaviours. FTS validation activities were based on a theoretical multi-airport TMA and high capacity needs scenario as stated in the ATM Master Plan. Additionally, a safety working meeting was held as well as several WEBEX sessions with the objective to derive Safety Barriers addressed by P5.7.2 concept and then the Safety Assessment Criteria (SAC).

STEP 1 v2 - first iteration phase

P05.07.02 conducted a first set of Step 1 V2 activities for MD/MC and HD/HC environments.

For MD/MC environment, the EXE-05.07.02-VP-738 was performed taking into account two scenarios. The first scenario was Rome TMA (Italy) and the second one the Northern TMA in Spain. Both validations were run on different Real Time simulation platforms, involving Air Traffic Controllers as well as pseudo-pilots.

Similarly, for HD/HC environment, the EXE-05.07.02-VP-740 was performed. The scenario selected for this exercise was London TMA as an important and representative TMA with very high capacity needs.

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The addressed OIs in both validation exercises were:

- CM-0206 Conflict Detection and Resolution in the TMA using trajectory data,
- CM-0208-A Automated Flight Conformance Monitoring in the TMA in Step 1.

Validation exercises were run on:

EXE-05.07.02-VP-738 (Italian scenario): e-DEP platform

EXE-05.07.02-VP-738 (Spanish scenario): SACTA 4.1 platform

EXE-05.07.02-VP-740 (UK Scenario): ACE platform

STEP 1 v2 - second iteration phase

In order to refine the operational concept, P05.07.02 conducted a second set of Step 1 V2 activities for MD/MC and HD/HC environments. So, two additional RTS exercises involving Air Traffic Controllers and pseudo-pilots were carried out.

For MD/MC environment, the EXE-05.07.02-VP-741 was performed taking into account again two scenarios. The first one was Rome TMA (Italy) and the second one the Northern TMA (Spain). Both validations were run on different Real Time simulation platforms, involving Air Traffic Controllers as well as pseudo-pilots.

For HD/HC environment, the EXE-05.07.02-VP-743 was performed taking into account airspace part of London TMA.

The addressed OIs addressed in this second iteration were:

- CM-0206 Conflict Detection and Resolution in the TMA using trajectory data,
- CM-0208-A Automated Flight Conformance Monitoring in the TMA in Step 1.
- CM-0606 Separation Management in the TMA using Pre-defined Routes with 2D RNP Specifications.

For MD/MC environment P05.07.03 validates (VP EXE-267) the following OI:

- CM-0305 Sector Team Operations Adapted to New Responsibilities and Operating Procedures involving reduced Coordination in the TMA

Results from this validation activity were included in the OSED and VALR of P05.07.02

Validation exercises were run on:

EXE-05.07.02-VP-741 (Italian scenario): e-DEP platform + GRACE platform

EXE-05.07.02-VP-741 (Spanish scenario): iTEC platform

EXE-05.07.02-VP-743 (UK Scenario): ACE platform

EXE-05.07.03-VP267 (Spanish scenario): iTEC platform

Code	Name	Project contribution	Maturity at project start	Maturity at project end
CM-0206	Conflict Detection and Resolution in the TMA using trajectory data	The project has demonstrated the feasibility of a new operating method based on the usage of MTCD/TCT for detecting conflicts what can result in an improvement in the separation provision	V0	V2
CM-0208-A	Automated Ground Based Flight Conformance Monitoring in the TMA in Step 1	The project has demonstrated the feasibility of a new operating method based on the usage of Monitoring aids for detecting non conformance with planned or cleared trajectories, what can result in an improvement in the separation provision	V0	V2
CM-0606	Separation Management in the TMA using Pre-defined Routes with 2D RNP Specifications	The project has demonstrated that it can be very helpful to develop a new tool which allocates automatically new published routes within the TMA aimed to facilitate aircraft separation. Some initial parameters for defining this new tool have been assessed; however further research activities are required.	V0	V1

The results and outcomes from P05.07.02 will be used as base for future works.

1.2 Project achievements

CM-0206: After validation activities it can be stated that the proposed operational concept is feasible (V2 maturity level achieved) in any TMA single or multi airport under MD/MC environment. Separation management in TMA supported by CDT is feasible and allows achieving the allocated Performance Targets. A better task balance within ATC team could be achieved. A safe implementation of this concept is based on new PC/EC working methods and PC/PC coordination procedures, both of them supported by the system.

Under HC/HD environment, the feasibility of the concept has not been completely validated due to the existence of some pending elements that need some further developments (additional V2 activities are needed).

CM-0208-A: Conformance monitoring function allows reducing monitoring activity to ATCo, what impacts positively on the separation activity to be carried out. Additionally, the usage of the conformance monitoring aid allows a safer implementation of this concept.

CM-0606: The implementation of a functionality that allocates 2D RNP pre-defined routes in an automated way, in order to provide separation in between two flights sharing the same planned route, has been positively valued by ATCos.

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Performance benefits obtained from the implementation of the new operational concept in MD/MC environment, after executing V2 validation exercises, are shown just below. These P05.07.02 benefits contribute to the global OFA 03.03.02 performance targets that have been incorporated just as a reference in between brackets:

- Predictability: (OFA 03.03.02 Target -2.75%) Reduction on arrival (28.1%) and departure (6.8%) TMA variability.
- Environment/Fuel Efficiency: (OFA 03.03.02 Target - 0.15% fuel burnt) Reduction fuel burnt (-3.6%) and flown time (-2.1%).
- Safety: All Safety Validation Objectives were fulfilled. Some failure cases were provoked, however a positive final conclusion stated that the human barrier i.e. Executive controller worked properly.
- HP: Trust level was acceptable and situational awareness was better than reference scenarios. Current CDT prototype was considered safe and controllable although not fully satisfactory yet to support removal of flight trajectory constraints in TMA. Conformance monitoring was highly rated. Separation Management in the TMA using predefined routes with 2D RNP specifications was scored high effective and high confidence by ATCOs.
- Capacity: TMA Airspace Capacity (OFA 03.03.02 Target +5%). It has been satisfied obtaining values from 2.99% to 8.33% of increase by using WL values coming from non-invasive techniques.
- Cost efficiency - ATCO Productivity (OFA 03.03.02 Target +1.5%). It has been clearly satisfied obtaining values from 2.23% to 6.12% of increase by using WL values coming from non-invasive techniques.

It is clear that these capacity and cost efficiency values should not be understood as simultaneous but as a trade-off, which will depend on the needs of each ECAC TMA. From an ECAC area perspective, within TMAs, depending on the traffic demand vs declared capacity ratio, there will be some of them that will obtain capacity benefit (i.e. when this ratio is higher than 1) and other ones cost efficiency benefit (i.e. when this ratio is equal or less than 1).

Performance benefits obtained from the implementation of the new operational concept in HD/HC environment after executing V2 validation exercises are:

For the HD/HC environment assessment of the KPAs was primarily via qualitative assessment (subjective ATCO feedback) and supported by quantitative assessment where appropriate, and therefore focussed on determining whether the Concept has the potential to provide the required benefits.

- TMA Airspace Capacity (improvement via a reduction in ATCO workload per aircraft) - Subjective assessment determined that when using the Concept tools ATCOs could provide a better service to the aircraft, reduce interventions and optimise use of the airspace. Quantitative assessment determined that there was on average a reduction in R/T usage.
- Safety – Subjective assessment determined that the Concept has the potential to improve safety in a HD/HC environment; however there is a need to clearly define Mops, provide adequate training and further develop the Concept to support planning for the Executive ATCO.
- Environment/Fuel Efficiency - Quantitative assessment determined that there was no change in fuel burn when using the Concept tools compared to current day (paper based) operations. Subjective assessment determined that when taking into account the maturity of the Concept, and ATCO experience on the baseline system (multiple years) compared to the Concept (1-2 days training), the Concept has the potential to provide a Fuel Efficiency benefit.
- Cost efficiency (improvement via a reduction in ATCO workload per aircraft). Subjective assessment determined that ATCO workload was at an acceptable level when using the Concept tools in a HD/HC environment.

- Predictability – Subjective assessment determined that the Concept tools have the potential to reduce tactical interventions and so improve the predictability of aircraft. Quantitative assessment also determined that the Concept tools have the potential to improve aircraft predictability, but that predictability is heavily influenced by the behaviours of the preceding sector in the aircraft sequence.

1.3 Project Deliverables

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

Reference	Title	Description
D75	MD MC Multi airport TMA V2b Validation Report VP738-VP741	<p>This Validation Report describes the results, conclusions and recommendations for the V2 (Step 1) RTS activities covered by EXE-738 and EXE-741 concerning MD/MC environments. Both exercises were run on two different scenarios: Italian and Spanish ones.</p> <p>EXE-741 Italian scenario provides results about the P04.10 contribution to the OI CM-0606</p> <p>Moreover, EXE-267 (conducted by P05.07.03) results are also included in this VALR.</p> <p>This document provides a reminder of the objectives identified in the VALP, the scenarios in which the exercise validation have been run as well as the results of the simulations concerning the effect of the use of enhanced ATC tools like Conflict detection (MTCD), conflict resolution, What if and Conformance monitoring in Medium density/ Medium complexity TMA.</p>
D76	HD HC Multi airport TMA V2b Validation Report VP740-VP743	<p>This Validation Report describes the results from activities contributing to the validation of P05.07.02, Development of 4D Trajectory-Based Operations for Separation Management Using RNAV/PRNAV. It includes two activities: EXE-740 and EXE-743 which specifically focus on “separation management concept and tools in a high density/high complexity environment” and aim at assessing feasibility and refining the concept at V2 level. These exercises were both conducted as a workshop/Real Time Simulation (RTS).</p>
D77	Preliminary V2 OSED for Step 1	<p>This V2 OSED details the Preliminary Operational Concept for Step 1 Separation Management in TMA for HD/HC and MD/MC environments through the use on enhanced separation tools like MTCD, What-If and monitoring tools. It also includes the “Collaborative Control” concept for MD/MC that focuses on Controller Team Organisation; specifically Roles and Responsibilities within a Trajectory Based Operation within TMA Airspace .</p> <p>This document has been updated taking into account the results from VP738 & VP741 for MD/MC and from VP740 and VP743 for HD/HC; additionally</p>

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		outcomes from VP267 run within P05.07.03 are also included.
D78	Preliminary V2 SPR for Step 1	This document provide a set of safety and Performance requirements based on the outcomes of the V2 validation phase
D79	Preliminary V2 INTEROP for Step 1	This document is the INTEROP for air traffic services (ATS) supported by data communications for SESAR Step 1 Separation Management in TMA. This V2 INTEROP refines the first version of the INTEROP (P05.07.02 - M032). This version is based on the V2 OSED and considers the results of the validation exercises EXE-738, EXE-740, EXE-741 and EXE-743
D80	MD MC Multi airport TMA V2b Validation Plan VP738-VP741	This document is the Validation Plan for EXE-738 and EXE-741, V2 activities that were run by ENAIRE and ENAV within P05.07.02. Both RTS exercises were run in two different scenarios (Rome TMA (Italy), Northern TMA (Spain)) aimed to validate different elements or processes of the concept in such a way the results can be considered as complementary each other. The document includes also: • the P04.10 contribution to mature OI CM-0606, taking part into P05.07.02 by designing new 2D-RNP routes and using the NLR simulation cockpit (general aviation cockpit); and • P05.07.03 contribution which focuses on Controller Team Organisation; specifically Roles and Responsibilities within a Trajectory based Operation within TMA Airspace (Collaborative Control Thread).
D81	HD HC Multi airport TMA V2b Validation Plan VP740-VP743	This document is the Validation Plan for EXE-740 and EXE-743, V2 activities that were run by NATS within P05.07.02

1.4 Contribution to Standardisation

P05.07.02 has finished as V2 stage. The objective of V2 stage is to demonstrate the feasibility of the proposed operating method, so it is not usual, at this stage, to have conclusions aiming to contribute to standardisation; additionally, due to the scope of the project it is not foreseen to contribute to standardisation.

Nevertheless, in the framework of CM-0606, it is clear that an uplink capability will be required. This capability could be related with Dynamic RNP datalink/navigation capability. Therefore, it is considered worthy to follow closely the outcome of the standardisation work performed on this matter by EUROCAE and RTCA working groups (i.e. WG-78, SC-214 respectively).

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1.5 Project Conclusion and Recommendations

The project concludes that:

- A feasible concept has been developed to enhance the separation management in TMAs (Medium Density / Medium Complexity & High Density / High Complexity ones).
- The proposed operating concept would contribute to achieve the validation targets allocated on; i.e. Safety, predictability, airspace capacity, cost efficiency, environment/fuel efficiency and human performance.
- The contribution to the specification of the addressed OIs i.e. CM-0206, CM-0208-A and CM-0606 via operational, interoperability, safety and performance requirements is fully aligned with ATM Master Plan DS15.
- Trajectory prediction is the key topic for the new separations tools.
- CM-0206 has been evolved up to achieve partial V2 maturity level
- CM0208-A has been evolved up to achieve V2 maturity level.
- CM-0606 has been evolved up to achieve V1 maturity level
- The final evolution of these OIs to fully achieve a V3 maturity will have to be carried out within SESAR 2020 framework, by using P05.07.02 material as starting point.

The project recommends for future development that:

For the HD/HC environment

- Support to the planning needs of the Executive Controller is developed.
- Improved requirements are assessed for flight recognition of neighbouring sector traffic (i.e. to correctly identify the flights of interest to a TMA controller).

For the MD/MC environment,

- Requirements are explored to reduce undesired risks (false positives) being displayed to the controller and to improve vertical risk detection methods.

Additionally, for both MD/MC and HD/HC environments, trajectory prediction arises as the key topic that has to be evolved to enable "separation management on TMA" concept developed within P05.07.02 and to bring the expected benefits. The use of EPP and better weather information are enablers, may be not the only ones, expected to contribute to improve the accuracy of the trajectory prediction.

2 References

- [1] SESAR Programme Management Plan, Edition 03.00.01
- [2] [European ATM Master Plan](#)
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