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SESAR Solution 53B SPR-INTEROP/OSED for V3 - Part I

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PJ18W2 4DSKYWAYS

SOLUTION 53B: IMPROVED PERFORMANCE OF CD/R TOOLS ENABLED BY REDUCED TRAJECTORY PREDICTION UNCERTAINTY

This document is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 872320 under European Union's Horizon 2020 research and innovation programme.

Abstract

The PJ18-Wave 2 4DSkyways project has continued the research on Trajectory Management (TM) to enable the deployment of the SESAR Trajectory Based Operations (TBO). Solution 53B aims to improve Separation Management and Monitoring Tools (planned and tactical layers) in the En-route and TMA operational environments and therefore to increase the quality of separation management services, reducing controller workload per aircraft and separation buffers, and facilitating new controller team organisations.

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1 Executive Summary

The PJ18-Wave 2 4DSkyways project has continued the research on Trajectory Management (TM) to enable the deployment of the SESAR Trajectory Based Operations (TBO). Solution 53B improves the separation management processes both of the Executive Controller and the Planning Controller by improving the accuracy of the conflict detection and resolution tools at their disposal.

Solution 53B has investigated improvements to the accuracy of the trajectory prediction, which forms the basis of Separation Management tools, with the aim of increasing the quality of separation management services and reducing controller workload per aircraft and reducing separation buffers.

SESAR PJ10-Wave 1 plugged the remaining gaps from the original FASTI and SESAR programmes such that, for the purpose of the wave 2 baseline, Separation Management and Monitoring Tools can be considered as deployed in both En-Route and TMA environments. Solution 53B aims to extract greater benefits from the tools, particularly in complex and high-density airspace, by improving the performance of the tools.

Improved performance of Separation and Monitoring Tools is achieved through the increased accuracy of the Trajectory Prediction (TP) that is obtained thanks to information downlinked from the aircraft (e.g. ADS-C) and higher fidelity meteorological information. As was initially demonstrated in wave 1 (ref VALR), the benefit of improved performance is to allow a finer tuning of conflict detection parameters, resulting in a reduction of “false-positives” and consequent clutter.

Solution 53B has progressed the work that was undertaken in wave 1 solution PJ10-02a (to V2 on-going), and therefore this SPR-INTEROP/OSED inherits much of the concepts and requirements developed by that solution. Note that this Final SPR-INTEROP/OSED for solution 53B is an adaptation of the Initial SPR-INTEROP/OSED that covered both 53A and 53B.

A large team has contributed to the authoring of this document, comprising experts from ANSPs, ATC system providers, avionics and aircraft manufacturers, and safety and human performance who, together, are committed to performing the validation of the concepts and processes described herein.

2 Introduction

2.1 Purpose of the document

The purpose of this document is to describe the operating method and corresponding requirements covering operational, safety, security, performance and interoperability applicable to SESAR Solution PJ18-W2-53B.

2.2 Scope

This is the final SPR-INTEROP/OSED for Solution PJ.18-W2-53B, consolidating all the validated requirements that characterize the solution that form the subject of the validation activities that are described in the Validation Plan (ref [25]) and Validation Report (ref [24]). These requirements cover safety, performance, operational aspects as well as the interoperability aspects related to the technology to support the solution.

2.3 Intended readership

The intended readership for the document are the team members of PJ.18-53B and furthermore:

- Other SESAR Solutions within PJ18 that might depend on Solution 53B:
  - PJ.18-W2-53A: Increased Automation in Planning and Tactical Separation Management
  - PJ.18-W2-56: Air/Ground Trajectory Synchronisation via Lateral and Vertical Complex CPDLC Clearances to Support TBO
  - PJ.18-W2-57: RBT revision supported by datalink and increased automation
- Other SESAR Projects that might have a dependency on Separation and Monitoring Tools:
  - PJ.10: Controller Tools and Team Organisation for the Provision of Separation in Air Traffic Management

Transverse and federating projects;

  - PJ.W2-19: Content Integration

- Stakeholders
  - ANSPs: Management and ATCOs as guidance for the implementation of controller tools
  - Airspace Users: Management and pilots as background information influencing flight operations

2.4 Background

This solution is a progression of the work performed in SESAR Wave 1 by solutions PJ.10-02a2, PJ.10-02b, PJ.18-06a, PJ.18-06b and PJ.31. In particular, improved performance of separation management tools, which forms the subject of PJ.18-W2-53B, is a progression of wave 1 solution PJ10-02a2 (to V2 on-going), and therefore this SPR-INTEROP/OSED inherits much of the concepts and requirements developed by that solution.

SESAR Wave 1 Solution PJ.10-02a2

PJ.10-02a2, "Improved performance in the provision of separation with use of ADS-C/EPP data", addressed the improvement of separation (tactical layer) in the En-Route operational environment through improved ground trajectory prediction. This was achieved using existing information on lateral and vertical clearances that are known to the ground system along with the ADS-C/EPP airborne information.

Two validation exercises were performed at the level of V2 by PANSA/Indra and BULATSA/Airbus.

The PANSA/Indra exercise assessed Planner CD/R tools in an En-route environment using as input a planned trajectory improved by ADS-C (gross mass and speed schedule). In summary the exercise concluded that:

- The predicted time of conflict was much more accurate, when computed with the use of EPP data;
- Actual conflicts were being detected much earlier by MTCD enhanced with EPP data, giving PC much more time for pre-tactical de-conflicting actions ;
- There were no false positives alarms when MTCD was enhanced with EPP.

The BULATSA/Airbus exercise addressed the TMA and transition to En-Route, using CD/R tools that included "what-if" and "what-else" functions, an airspace-avoidance function integrating activated airspace volumes and terrain information, and an enhanced Trajectory Prediction through the use of Mode S and EPP (via ADS-C) data. The results showed strong positive opinions on the concept and usability of the tools, demonstrated the technical feasibility of the solution, and indicated benefits in controller workload, sector productivity, capacity.

The maturity level at the end of the project was judged to be V2 On-going.

SESAR Wave 1 Solution PJ.10-02b

PJ.10-02b, "Advanced Separation Management", introduced a higher level of automation to the decision support tools with the development of controller tools for conflict detection and resolution recommendations as well as monitoring tools for En-route and TMA (medium to very high complexity).

According to the Automation Taxonomy of PJ16.05.01, solution PJ.10-02b addressed the automation level in the domains of Decision and Action Selection and Action Implementation:

- The system proposes one or more decision alternatives to the human and with increasing degree of automation the user may generate alternative options, may only select one of the alternatives or ask the system to generate new options, or the system decides autonomously on the actions to be performed while the user is only informed of its decision;

- The system assists the operator in performing actions. With increasing degree of automation the system provides guidance for execution or automatically perform a sequence of actions after activation by the user. The user maintains control of the sequence or only monitors the sequence. The user will still be able to modify or interrupt the actions.

The advanced separation management tools assessed by PJ.10-02b comprised:

1. Conflict detection and resolution tools: airspace-avoidance functionalities indicating no-fly areas (taking into account fixed and flexible constraints, e.g. weather), Conflict Resolver, and What- next functionalities are built on top of existing tools. Dependency Clustering Tools (showing aircraft that have potential dependencies in the sector between entry and exit level) are a new development;

2. Recommendation tools: Provide a subset of qualified conflict free trajectories which are pre-selected by an algorithm, based on defined quality of service metrics. Enhanced Tactical Window, Corrective Action Tool, and What- next Tool are new tools which are built on existing functionalities. Recommendation Tool, Conflict Resolver and Resolution Advisory are completely new tools;

3. Monitoring Aids: Detect deviations or deviation trends, and monitor predicted behaviour on constraint points or within predefined airspace corridors. The monitoring functionalities in this project (Conformance Monitoring, Conflict Resolver) are built on existing tools.

The maturity level at the end of the project was judged to be V1 Completed.

SESAR Wave 1 Solution PJ.18-06a

PJ.18-06a as a technical solution addressing improvements on the Planned Trajectories, in order to improve their accuracy thanks to the usage of new ADS-C reports, eFPL data and surveillance parameters, together with other algorithm changes derived from common FMS manoeuvres (catch-up manoeuvres and geometric manoeuvres) during the descent phase. This was expected to enable a reduction of the extra safety margins managed by the system tools (implying a reduction of the nuisance alerts) and also to increase the planner controller confidence in the prediction. Together with improved mid-term trajectory management tools and procedures, this should enable the planner controller to better de-conflict traffic by following strategies based on a more precise management of the flight trajectory within the sector in a mid-term horizon.

The improvement to the ground Planned Trajectory was not achieved by the direct utilisation of the received EPP trajectory, but by extracting from the ADS-C reports high level preferences that can be applied to whatever flight intent, such as the preferred speed schedule, which should be reasonably stable as long as there is not a big re-routing or Cost-Index change. Then, the ground TP apply those preferences in its algorithm. Once the new clearance or restriction is communicated to the crew and a new EPP is received for any contract triggering a new sending, this EPP can be checked to confirm if the assumed high level preferences for the manoeuvres are maintained.

Utilisation of high level preferences in this way also allows the computation of alternative trajectories during conflict resolution processes and flight sequencing. Several what-if trajectories would need to be tested in ground to choose the most appropriate one. In order to ensure that those alternative what-if trajectories are also accurate, they should also take benefit from the ADS-C reports, including the EPP trajectory.

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SESAR Wave 1 Solution PJ.18-06b

The PJ18-06b solution grouped TRL4 validation activities related to trajectory prediction improvements and comprised two independent activities:

- Activities related to the improvement to the "Tactical Trajectory", aiming specifically at the use of ADS-C data in a tactical TP algorithm that can operate in a high density high complexity TMA environment, by NATS.
- Activities related to "NM profile improvement using ADS-C" by EUROCONTROL.

The Tactical TP underpins the Tactical decision tools which are a key enabler to realising the benefits of Trajectory Based Operations (TBO). The tactical tools exist to support medium term decision making and are built upon a high resolution trajectory prediction algorithm with a relatively short prediction horizon of up to 30 minutes.

For the tactical trajectory thread, the baseline trajectory predictor that was used for reference is a TP algorithm which has been developed to support the more dynamic manoeuvres in high density / high complexity TMA operations. This tactical TP was enhanced with ADS-C data. Despite the TP being tailored for use in the TMA the anticipated improvements in trajectory prediction performance are likely to also have applicability in the en-route domain.

For the NM activities, the baseline was the ETFMS operational system and its replay infrastructure. No modifications based on ADS-C were made as part of the validation exercise.

SESAR Wave 1 Very Large Scale Demonstration PJ.31 DIGITS

The DIGITS (Demonstration of ATM Improvements Generated by Initial Trajectory Sharing) project assessed the ATM benefits from further usage of TP enhancements for supporting tools (derived from the use of ADS-C data, including EPP), notably in terms of enhancement of conformance monitoring, improvement of predictability, reduction of tactical interventions and improvement of de-confliction of traffic. . As such, it has provided the first comprehensive public documents that explicitly describe the accuracy of the EPP (see 4.1.4.2, Trajectory Prediction Performance).

The demonstration approach took advantage of revenue flights from six participating airlines involving about 92 aircraft by end 2020, equipped with new ATS B2 capabilities, fully integrated in the general commercial traffic, to assess how much the aircraft downlinked 4D trajectory could be used to enhance the controller support tools (controller alerting & decision aids), and thus deliver benefits to the end users, i.e. the controllers in charge of these flights and the Airspace Users.

The availability of ADS-C trajectory data from revenue flights forms a key element within the overall ADS-C roadmap as it allows service providers and ground industry to understand the impact of different airspace users' operating practices on the downlinked data, which may influence the final requirements for integrating this data into ground systems for full operational deployment.

2.5 Structure of the document

This document is structured as follows:

Section 1 is the Executive Summary.

Section 2 is an introductive section that aims to:

- Briefly describe the scope of the solution PJ.18-W2-53B;

- Introduce the background R&D Projects whose results have been considered in this document;
- Introduce all terms and acronyms that are used in the document.

Section 3 describes operational environment and the Solution PJ.18-53B Operating Methods and Use Cases.

Section 4 specifies the Operational, Safety, Performance, and Interoperability Requirements pertinent to Solution PJ.18-53B.

Section 5 lists all applicable and reference documents.

Appendix A provides a description of the Cost and Benefit Mechanisms.

2.6 Glossary of terms

Term	Definition	Source of the definition
Actual Conflict	The term is used in this document synonymously with "True-Positive".	
Closed Loop Clearance	Closed-loop clearance is an ATC tactical clearance consisting in a vector-type instruction (such as heading to or level or rate of descent) followed by a condition to close the instruction in order to resume the planned trajectory (such as a condition of distance, a time, an intercept angle, an intercept altitude or an intercept point)	ATM Lexicon
Cluster	A set of one or more Encounters that should be treated as a whole when determining their resolution	SESAR Program 1 Solution #27
Conflict	Any situation involving aircraft and hazards in which the applicable separation minima may be compromised. Note: this term relates to potential infringements of separation minima. More specifically, it is used in the context of ATCO activities where actions are performed in order to anticipate and resolve conflicts for separation management purposes. This is in contrast to the situations detected and processed by CD/R tools where the terminology used is 'encounters', which relates to the applicable Separation of Interest used by the tool-set, rather than Separation Minima.	SESAR Program 1 Solution #27
Conflict Detection Aid	Conflict detection performed by the CD/R Tool in accordance to a pre-defined time horizon suitable for the operation environment with the objective	SESAR Program 1

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	to alert the ATCO of a potential conflict between an aircraft and a hazard.	Solution #27
Conflict Resolution Aid	Conflict resolution options calculated by the CD/R Tool and presented to the controller which ensures that the separation minima are not compromised between an aircraft and a hazard.	SESAR Program 1 Solution #27
Conformance Monitoring to the CD/R input	A system function which detects and alerts the ATCO in case the aircraft behaviour is not in accordance to the CD/R tool.	SESAR Program 1 Solution #27
Encounter	A situation where an aircraft is predicted to be below the applicable separation of interest with respect to another aircraft, or a designated volume of airspace, classified respectively as “aircraft-to-aircraft”, “aircraft-to-airspace”, “aircraft to terrain” encounters. Note: Encounters relate to the various detection tools and may work to different look-ahead time horizons with different separation criteria, using different trajectories. Different tool configurations can therefore be expected to yield different encounters. The Separation of Interest thresholds are considered with respect to any applicable uncertainty volumes around the predicted aircraft position(s).	SESAR Program 1 Solution #27
False Conflict	The term is used in this document synonymously with “False-Positive”.	
False-Positive	An alert that decreases ATCOs situational awareness and creates increased workload. Therefore, these alerts are unwanted and there should be an aim to decrease a number of such alerts to a minimum.	
Gateway	Gateways are used to connect different route networks to each other. For example, gateways connect Free Route Airspace to a PBN route with vertical constraints network and PBN to arrival routes.	SESAR Program 1 Solution #27
Hazard	The objects or elements that an aircraft can be separated from.	SESAR Program 1 Solution #27

	Note: hazards could be: other aircraft, airspace with adverse weather, terrain, ARES (TSA, CBA, D zone…, etc.)	
Nuisance Alert	The term is used in this document synonymously with "False-Positive".	
Planned Trajectory	The Planned Trajectory represents the stable medium to long term behaviour of the aircraft but may be inaccurate over the short term where tactical instructions that will be issued to achieve the longer term plan are not yet known. It takes into account the planned route and requested vertical profile, strategic ATC constraints, Closed Loop Instructions/Clearances, co-ordination conditions and the current state of the aircraft. Assumptions may be made to close Open Loop Instructions/Clearances issued by tactical controllers. It is calculated within the planning look-ahead timeframe, starting from the Area of Interest of the unit concerned, or the aircraft's current position (whichever is later). It is constrained during all phases of flight by boundary crossing targets (e.g. standing agreements between the Units concerned).	SESAR Program 1 Solution #27
Separation	Spacing between an aircraft and a hazard.	SESAR Program 1 Solution #27
Separation Criteria	A generic term that covers the Separation Minima and the thresholds used for problem identification.	SESAR Program 1 Solution #27
Separation of Interest	The separation threshold below which the proximity of a pair of aircraft or a hazard is considered to be of interest to a controller, for the airspace and conditions concerned. Note: At this point, there may be no actual risk that separation minima are infringed. The values chosen for the various controller activities and tools are larger than the separation criteria in order to provide an adequate margin of safety. The controller and the aids used need to have	SESAR Program 1 Solution #27

	awareness of the applicable separation minima for the airspace concerned. Note: This is a generic term, independent of the planning or tactical layers of separation activity. Particular instances of the Separation of Interest may be applied for each level of separation activity. The actual separation values used take into account aspects such as the type of clearance issued, the requested navigation precision and the airspace rules. They also relate to the type of trajectory used at the specific layer of concern. They may vary according to circumstances such as the geometry of the conflicts/encounters and prevailing conditions such as adverse weather	
Separation Minima	The minimum displacements between an aircraft and a hazard, which maintain the risk of collision at an acceptable level of safety. Note: ICAO Doc 9689 describes the methodology to be used for the determination of Separation Minima	SESAR Program 1 Solution #27 ICAO Doc 9689
Special Use Airspace	A defined volume of airspace designated for operations of a nature such that limitations may be imposed on aircraft not participating in those operations and segregation of that activity is required from other users. It is the general term overarching all type of the airspace that could be used for military purposes e.g. TSA, TRA, R, D, P Military Firing Range, Military Training Area etc. SUA could be subject of application of different ASM levels.	UK CAA CAP 740 EUROCONTROL
Tactical Trajectory	The Tactical Trajectory is calculated within a short look-ahead time (e.g. up to 15 minutes) during tactical ATC operations (sector planning layer). It therefore reflects an accurate view of the predicted flight evolution, starting from the current flight position (generally, as reported by surveillance), with low uncertainty and high precision. It is kept up to date with all clearances, including tactical instructions, except in case of detected deviation. During any open tactical manoeuvres it will also be reflecting those temporary conditions. It is usually determined with a fast update rate (e.g. 5 seconds) and with an optimised Uncertainty	SESAR Program 1 Solution #27

	calculation; to maximise response and minimise the incidence of false alarms.	
True-Positive	A Conflict/alert that should be displayed and it was in fact displayed to controller on their HMI. Improved assessment of planned/desired profile for problems thanks to: improved performance of Conflict Detection support tools ATC sector planning and tactical control (e.g. increased warning times of “true positive” alerts and reduced “false positive”/”nuisance” alert rates) thanks to more accurate predicted trajectory and detection envelopes.	
What-else Probing	A process where several Speculative Trajectories and associated data arising from What-if Probing are assessed for the impact on the occurrence of predicted Encounters. The Speculative Trajectories utilise flight data other than that currently committed or tentatively selected (during What-if Probing operations) by the controller	SESAR Program 1 Solution #27
What-if Probing	A process where a private copy of a Trajectory that is in operational use and associated data is taken and used as a Tentative Trajectory to check the impact of changes to the flight data on the occurrence of predicted Encounters, without affecting the corresponding data for the actual flight. Note: On completion the What-if data and the Tentative Trajectory may be discarded or used to implement an update to the actual flight data and to construct the necessary clearance	SESAR Program 1 Solution #27
What-next Function	A function where conflict-free clearances for potential tactical conflicts that minimise ATCO workload and flight efficiency are identified and recommended to the controller.	SESAR Program 1 PJ10.02b

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
A/C	Aircraft

ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
ANSP	Air Navigation Service Provider
AOC	Aeronautical Operations Control
AoI	Area of Interest
AoR	Area of Responsibility
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
AWA	Adverse Weather Area
BIM	Benefit and Impact Mechanism
CB	Cumulonimbus Cloud
CD/R	Conflict Detection and Resolution
CFL	Cleared Flight Level
CNS	Communication Navigation and Surveillance
CONOPS	Concept of Operations
CPA	Closest Point of Approach
CPDLC	Controller/Pilot Data Link Communications
CR	Change Request
CWP	Controller Working Position
DIGITS	Demonstration of ATM Improvements Generated by Initial Trajectory Sharing
D/L	Datalink
DST	Decision Support Tool
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
EC	Executive Controller
EFPL	Extended Flight Plan
EPP	Extended Projected Profile
ERNIP	European Route Network Improvement Plan
FAB	Functional Airspace Block

FF-ICE/R1	Flight and Flow Information for a Collaborative Environment / Release 1
FIR	Flight Information Region
FL	Flight Level
FMS	Flight Management System
FRA	Free Route Airspace
FUA	Flexible Use of Airspace
GAT	General Air Traffic
HMI	Human Machine Interface
HPAR	Human Performance Assessment Report
IFR	Instrument Flight Rules
INTEROP	Interoperability Requirements
KPA	Key Performance Area
KPI	Key Performance Indicator
LoA	Letter of Agreement
MONA	Monitoring Aids
MSP	Multi Sector Planner
MTCD	Medium-Term Conflict Detection
NM	Nautical Miles
OI	Operational Improvement
OPAR	Operational Performance Assessment Report
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PBN	Performance Based Navigation
PC	Planning Controller
PH	Present Heading
PIRM	Programme Information Reference Model
QoS	Quality of Service
RBT	Reference Business Trajectory
R&D	Research and Development
RNP	Required navigation Performance
R/T	Radio Telephony
RVSM	Reduced Vertical Separation Minima
SAC	Safety Criteria

SAR	Safety Assessment Report
SATCOM	Satellite Communications Datalink
SecAR	Security Assessment Report
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPR	Safety and Performance Requirements
STCA	Short Term Conflict Alert
SUA	Special Use Airspace
SWIM	System Wide Information Model
TBO	Trajectory-Based Operations
TC	Tactical Controller (used interchangeably with "EC")
TCT	Tactical Controller Tool
TMA	Terminal Manoeuvring Area
TP	Trajectory Prediction
TS	Technical Specification
VFR	Visual Flight Rules
XFL	Exit Flight Level

Table 2: List of acronyms

3 Operational Service and Environment Definition

This section describes the operational concept aspects of Solution PJ.18-W2-53B and puts the solution in context with solution PJ.18-W2-53A.

3.1 SESAR Solution PJ.18-W2-53B: a summary

Solutions PJ.18-W2-53A and PJ.18-W2-53B, together, improve Separation Management and Monitoring Tools (planned and tactical layers) in the en-route and TMA operational environments in order to increase the quality of separation management services, reducing controller workload per aircraft, reducing separation buffers and facilitating more efficient controller team organisations.

A phased approach was taken that split what was originally described as a single solution into the two sub-solutions 53A and 53B, taking advantage of concepts and technology that are more mature to enable earlier delivery of benefits:

- PJ.18-W2-53B – Improved Performance of CD/R Tools Enabled by Reduced Trajectory Prediction Uncertainty, targeting V3.
- PJ.18-W2-53A – Increased Automation in Planning and Tactical Separation Management, targeting V2.

This is depicted in the following figure below.

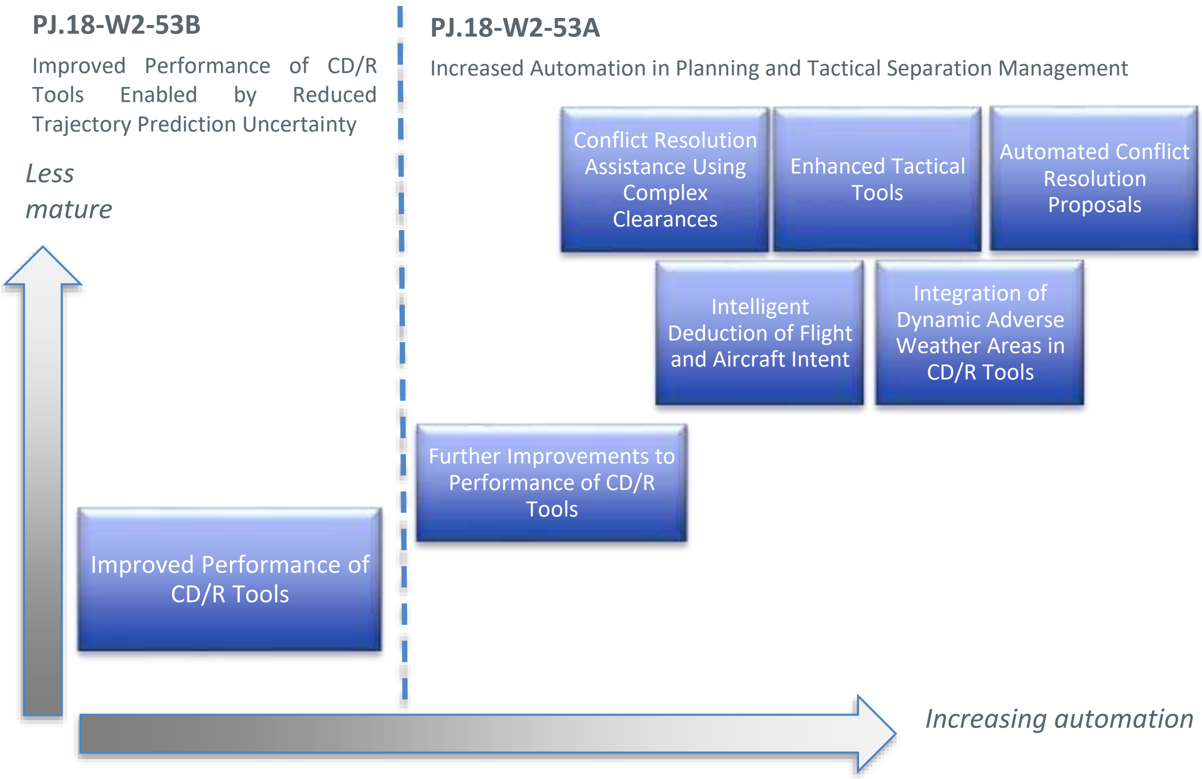

Figure 1 - Solution PJ.18-W2-53A and PJ.18-W2-53B Scope

The table below illustrates the mapping of PJ.18-W2-53B to its wave 1 predecessor solutions and shows how the targeted maturity of its OI steps is consistent with the maturity achieved by the corresponding wave 1 OI steps.

Wave 1 Solution	OI Step	OI Title	Maturity Achieved	Wave 2 Solution	OI Step	OI Title	Maturity Targeted
PJ.10-02a2	CM-0209-b	Conflict Detection and Resolution in En-Route using aircraft data in Predefined and User Preferred Routes environments	V2 ongoing	PJ.18-W2-53B	CM-0209-b	Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in En-Route Predefined and User Preferred Routes environments	V3
PJ.18-06a	POI-0012-IS	ATC Planned Trajectories improvement with new ADS-C reports, eFPL and surveillance information	V2		CM-0212	Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in the TMA	V3

Table 3: Mapping of PJ.18-W2-53B Wave 1 Solutions

Solution PJ.18-W2-53B encapsulates the more mature separation management elements for which V3 maturity is targeted. This solution builds on the work performed in wave 1 solutions PJ.10-02a2 and PJ.18-06a and addresses the improvement of conflict detection and resolution tools that are derived from the improvement of ground Trajectory Prediction (TP) with the use of advanced data from ATS B2 ADS-C reports messages as defined in the EUROCAE standard ED228A and improved meteorological data.

The improvements of ground TP in Solution PJ.18-W2-53B address the use of ADS-C data beyond the items that were studied in wave 1 (gross mass, speed schedule, TOC and TOD altitudes, and the predicted speeds at route points) to address in particular:

- The use of the EPP profile to calibrate the BADA performance model;
- Improvements in the calculations of turning manoeuvres thanks to the use of turn radius and the turning strategy (overfly vs fly-by);
- The implementation of catch-up manoeuvres (modelling the interception of an aircraft in descent with its optimal descent profile)

In addition, the solution encompasses the handling of MET data and other surveillance data from aircraft (NOWCAST from Mode S enhanced surveillance data, ADS-B out reports).

The reduced uncertainty in the TP is expected to improve the usability of existing CD/R tools by reducing the number of false [low probability] conflicts and allow the better identification of actual conflicts. Furthermore, the improved TP should provide a more reliable sector sequence (particularly for vertically evolving flights in complex airspace), easing the burden of coordination and transfer between sectors.

The technical mechanisms that are used to improve the ground TP are described in the Technical Specification; this SPR-INTEROP/OSED describes the operational use that is made of the reduced uncertainty.

Note that, in coordination with PJ.18-W2-56, the OI step CM-0210-b (entitled "Ground Based Flight Conformance Monitoring in En-Route using aircraft Data"), originally considered in the scope of -53B, has been transferred to -56 where its scope has been replaced by the OI step SDM-0207-B.

The OIs addressed by PJ.18-W2-53B with their respective enablers are listed in the table below.

OI Steps ID	OI Steps Title	Enabler ID	Enabler Title	OI Step/Enabler Coverage
CM-0209-b	Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in En-Route Predefined and User Preferred Routes environments	A/C-37a	Downlink of trajectory data according to contract terms (ADS-C) compliant to ATN Baseline 2 (FANS 3/C)	OI step • Full Enabler • Required • Use
		A/C-48a	Air broadcast of position/vector (ADS-B OUT) compliant with DO260B	Enabler • Optional • Use
		ER APP ATC 167	ATC Planned Trajectories improvement with new ADS-C reports, and surveillance information	Enabler • Required • Develop
		ER APP ATC 200	ATC Improvement to receive and use more granular MET forecasts	Enabler • Required • Develop
		ER APP ATC 149a	Air-ground data exchange to support i4D – Extended Projected Profile (EPP)	Enabler • Optional • Use
		ER APP ATC 214	Conflict Detection envelope trajectories improvement with new ADS-C reports	Enabler • Optional • Develop
	Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution	A/C-37a	Downlink of trajectory data according to contract terms (ADS-C) compliant to ATN Baseline 2 (FANS 3/C)	OI step • Full Enabler • Required • Use
		A/C-48a	Air broadcast of position/vector (ADS-B OUT) compliant with DO260B	Enabler • Optional • Use

CM-0212[1]	Tools in the TMA	ER APP ATC 167	ATC Planned Trajectories improvement with new ADS-C reports, and surveillance information	Enabler • Required • Develop
		ER APP ATC 200	ATC Improvement to receive and use more granular MET forecasts	Enabler • Required • Develop
		ER APP ATC 149a	Air-ground data exchange to support i4D – Extended Projected Profile (EPP)	Enabler • Optional • Use
		ER APP ATC 214	Conflict Detection envelope trajectories improvement with new ADS-C reports	Enabler • Optional • Develop

Table 4: SESAR Solution PJ18-W2-53B Scope and related OI steps and enablers

The table below summarizes the high level operational requirements applicable to PJ18-W2-53B in the Concept of Operations (ref [4]), subsequently modified by PJ.19 High Level Requirements For Operational Solutions (ref [26]).

High Level Concept of Operations Requirement ID	High Level Concept of Operations Requirement	Reference to relevant Concept of Operations Sections e.g. Operational Scenario applicable to the SESAR Solution
S53B-HLOR-01	Enhanced Conflict Management shall enhance the following KPIs in the provision of separation in En Route : . En Route Capacity, in particular in dense/congested areas . ATCO Cost Efficiency . Predictability . Flight Efficiency (duration and fuel) While: . maintaining the overall level of Safety at ECAC level Through:	

[1] Enablers assigned via Change Request 07135.

	- Advanced conflict detection and resolution Operations which: o Reduces ATCOs workload linked to active detection and resolution of predicted separation infringements o reduces to the minimum the spurious detection of conflicts o Reduces unnecessary flight deviations in the Areas of Interest o Increases opportunities to optimise trajectories in the Areas of Interest - Resolutions supported by CPDLC closed-loop instructions time permitting Enabled by : o Advanced automation in support of the above operations o most accurate trajectory predictions taking into account aircraft derived data, for conflict detection and resolution probing o more accurate conflict detection parameter settings taking into account available data (including aircraft derived data)	
S53B-HLOR-02	Enhanced Conflict Management shall enhance the following KPIs in the provision of separation in TMA : . TMA Capacity, in particular in dense/congested areas . ATCO Cost Efficiency . Predictability . Flight Efficiency (duration and fuel) While: . maintaining the overall level of Safety at ECAC level Through:	

	- Advanced conflict detection and resolution Operations which: o reduce to the minimum the spurious detection of conflicts o Reduce unnecessary flight deviations in the Areas of Interest o Increase opportunities to optimise trajectories in the Areas of Interest Enabled by : o Advanced automation in support of the above operations o most accurate trajectory predictions taking into account aircraft derived data, for conflict detection and resolution probing o more accurate conflict detection parameter settings taking into account available data (including aircraft derived data)	

Table 5: Link to Concept of Operations

3.1.1 Deviations with respect to the SESAR Solution(s) definition

OI step CM-0210-b has been removed from PJ.18-W2-53B as described in paragraph 3.1, above (change request in process).

3.2 Detailed Operational Environment

This section provides a detailed description of the environment, assumptions, etc. that are applicable to the operational services and enhanced tool functionalities and was established in wave 1 by solutions PJ.10-02a and PJ.10-02b.

3.2.1 Operational Characteristics

This section describes the operational characteristics that support the SESAR Solution PJ.18-W2-53B. It provides all relevant information related to the operational environment, with principles, limitations and assumptions.

The following table is extracted directly from EATMA.

Operational interactions per context (NOV-2)	Operating Environment

[NOV-2] Separation Assurance	En-Route; Terminal Airspace;
Comment	

Table 6: S53B Link to Concept of Operations

3.2.1.1 Airspace Characteristics

During the timeframe of SESAR 2020 the future European airspace organisation is initially based on current ICAO Air Traffic Service (ATS) airspace classifications, regulations and applicable rules, including Visual Flight Rules (VFR) and Instrument Flight Rules (IFR).

Classifications and rules will be adopted consistently by all states, thus ensuring uniformity of their application and a simplification of airspace organization throughout the whole ECAC region.

This will provide a progress towards an airspace continuum where the only distinction is between two airspace classes (i.e. Managed and Unmanaged Airspace).

Airspace use will be optimised through dynamic demand and capacity management, queue management, flexible military airspace structures, free, direct and fixed routing and a reduced number of airspace categories.

A general description of the airspace characteristics is provided by the European Route Network Improvement Plan (ERNIP), Part 1 (refer [13]).

Solution PJ.18-W2-53B addresses En-Route and TMA airspace with mixed operational environment. Traffic density and complexity are defined to be medium to very high as defined in [5].

3.2.1.1.1 Airspace Structure

The airspace considered by solution PJ.18-W2-53B is a managed airspace, where a separation service is provided by ATM services providers.

The vertical scope considered by solution PJ.18-W2-53B extends from Flight Level (FL) 0 to FL660 wherever traffic is controlled. This comprises upper airspace as well as lower airspace (e.g. TMA), but excludes airspace dedicated to final approach and aerodrome vicinity.

The upper airspace is Reduced Vertical Separation Minima (RVSM) up to FL410.

Currently the airspace is divided into separate areas of responsibility (Sectors). The sectors may be grouped together when traffic and operational complexity are low enough and they will be de-grouped when traffic and/or complexity increases. Depending on the local procedures this is initiated by the Operational Supervisor or Flow Manager based on specific operational criteria with an increasing consideration of the controller workload based on the operational complexity instead of the traditional methods using the occupancy and entry counts.

3.2.1.2 Airspace Configuration

3.2.1.2.1 Route Configuration/Network

In Predefined Routes airspace, advanced RNP are in place according to AOM-0404 "Optimised Route Network using Advanced RNP".

A schematic of how this route network might work was developed in SESAR Wave 1 PJ.10-02b (ref [27]), whereby Free-Route Airspace (FRA) is present above FL305[2] and below FRA, "gateways" connect the FRA exit points to the start of a PBN route network (RNP1). This PBN route network provides lateral and potentially vertical constraints to the aircraft along a strictly defined path (PBN route with vertical constraint). These PBN routes with vertical constraints provide separation from each other, enabling the requirement for controller intervention to be minimal. At the end of the PBN route with vertical constraints, the aircraft travel through another "gateway" or letterbox at approximately 7000ft where it then connects to arrival routes to the airport(s) in question. This systemised airspace (PBN route network) is intended to reduce vertical holding, reducing noise and fuel burn.

Departing traffic works in a similar manner but in reverse. Aircraft climb continuously to the gateway/letterbox on route which is the transition point from airspace associated with a single airport and the wider systemised airspace. It then flies along the PBN route with vertical constraint until the next gateway in order to enter the FRA.

A schematic of the PBN routes with vertical constraints network is found in Figure 2. For the pink inbound aircraft, the profile passes a series of windows with vertical upper and lower. These vertical constraints are based on 'not above', 'not below' and 'at' constraints. The blue outbound aircraft follows a route also including a series of windows with vertical upper and lower constraints as well as lateral constraints. Between the windows, aircraft can fly how they wish through the profiles as long as they are within the constraints. For the pink inbound aircraft profile, the upper and lower limits of the route profile are depicted in the black line. After the first window, where the aircraft has to be between FL190 and FL160, the aircraft can fly straight and level until the top of climb where it needs to descend at a maximum rate of descent (which may be based on aircraft/carrier type) to achieve the next maximum constraint at the second window of FL170.

[2] Commission Implementing Regulation (EU) No 2021/116 (superseding 716/2014) directs implementation at least above FL305 of initial Free Route Airspace (during defined periods or on a structurally limited basis) throughout Europe by the end of 2022, and final Free Route Airspace by the end of 2025.

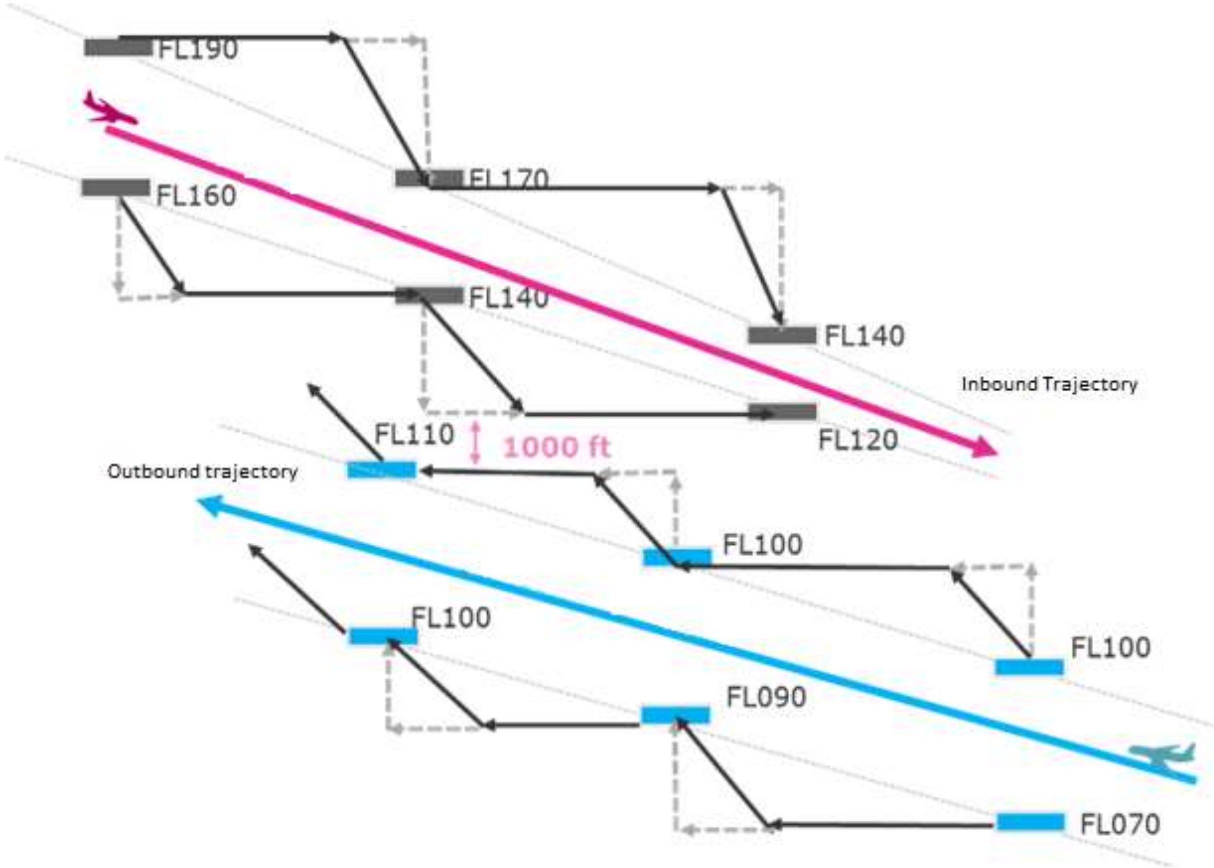

Figure 2: PBN route with vertical constraint network

A series of assumptions was made regarding the PBN routes with vertical constraints:

- PBN routes with vertical constraints for arrivals and departures;
- Aircraft are cleared for a given route along a PBN route with vertical constraint network;
- Aircraft navigate the PBN route within the prescribed vertical constraints at the windows (and between windows);
- All PBN routes with vertical constraints are separated from each other;
- The concept at this stage does not look at losing separation within the PBN route with vertical constraints.

The PBN route network enables a more structured and predictable method of operations, decreasing tactical intervention and enabling routes to become more predictable and efficient. This has the potential to increase capacity, enhance safety and increase environmental performance. At lower levels, a balance is needed between capacity and environmental considerations.

Increasingly, ATS routes of the Air Route Network will be removed as obsolete in Free Route Airspace or will become conditional if required for temporary airspace configurations.

The route network evolves to fewer pre-defined routes with the exploitation of advanced navigation capabilities.

3.2.1.2.2 Free Route Airspace

Free Route Airspace (FRA) is a managed airspace, where aircraft separation is provided via an Air Traffic Service Unit (ATSU) control service, and which allows airspace users to plan their preferred business trajectories without the need to adhere to predefined published routes. According to Commission Implementing Regulation (EU) No 2021/116 “The final objective is the deployment of final FRA in the entire airspace under the responsibility of the Member States involved at least above flight level 305, with no time limit and no reduction on capacity and cross-border FRA between neighbouring states, irrespective of national/Flight Information Region (FIR) boundaries”.

The conflict detection and separation in the FRA is characterised with a distribution of the conflicts over the entire volume of the FRA thus achieving an increased spread of the conflicts as opposed to concentration of the conflicts over certain fixed route crossing points (also known as ‘hotspots’).

There are different characteristics of FRA operations depending whether the neighbouring airspace is also FRA (with no specific entry/exit points between the different AoR) and FRA operations transitioning to/from a fixed route environment (where the transition may be over specific transfer points). Below are some characteristics of FRA operations associated with a) wide-area FRA application and b) FRA transitions to fixed route environment:

- As in the ATC operations within the wide area FRA the conflicts could be distributed over the entire FRA volume and the potential conflicts which are at or near sector boundaries contribute to the operational complexity. Workload related to the integration of traffic over transfer points is reduced significantly.
- The transition from FRA to fixed route operations increases ATCO workload due to the more complex operations necessary for consolidating the traffic given the nature of the interactions. For example, solving a crossing aircraft conflict is less labour intensive than consolidating traffic within certain transfer of control parameters with applicable separation minima.

For both types of FRA operations, the operational factors that will be most significantly impacted are:

- Conflicts detection – By offering more flight planning options, Free Route can reduce bottlenecks in the ATM system and increase airspace / network capacity, but the controller workload per flight, with current tools, is increasing due to the decreased predictability of conflicts. To maintain sector capacity without a detrimental effect on safety this might need to be mitigated by the advanced ATCO support tools available in SESAR;
- Traffic Integration – The workload related to the merging of overflying traffic over the AoR exit points will be reduced significantly. This is not valid for the case when the exit point is within the transition airspace from FRA operations to fixed route network.
- Externally induced complexity – New controller tasks will emerge in order to support external conflict resolution or SUA circumnavigation in airspaces within the immediate vicinity of the AoR boundary.

To an extent these negative effects of FRA application must be counterbalanced. Because of these characteristics the FRA operations need to be supported by improved trajectory predictability and enhanced conflict detection and management tools.

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3.2.1.3 Traffic Characteristics

Traffic characteristics vary by airspace type:

- Upper airspace e.g. above FL285: mainly levelled flights and some descending/climbing aircraft (descending from or climbing to their cruising FLs). The traffic is flying with cruising or next to optimal for the aircraft type airspeed;
- Lower airspace e.g. under FL285: A mix of levelled and descending/climbing aircraft depending on the sector. A higher proportion of aircraft that take off from - or arrive to - airports within the area of interest. The airspeed is constrained in the TMA operations. More heterogeneous traffic is operating within the lower airspace with different range of speeds and climb performance.

3.2.1.3.1 Separation Characteristics

This section puts the SESAR Solution PJ.18-W2-53B separation modes in the context of the SESAR separation modes as defined by the SESAR CONOPS (ref [4]). It positions these separation modes to the operational environment related to airspace complexity. The PJ.18-W2-53B modes have to be tailored to the local environment and performance needs. All modes can be used but individual configuration parameters (e.g. conflict look ahead horizon) should be set according to sector, airspace, and traffic characteristics.

3.2.1.3.2 Separation Minima

Separation minima are expected to continue to be based on guidance, regulations, and factors used in today's environment (ICAO Doc 4444 Procedures for Air Traffic Management – ref [22], especially Chapter 5):

- Vertical separation: FL<= 410 → 1000ft separation (RVSM);
- Horizontal separation: different separation minima apply in different airspace, depending on the kind of airspace (very often it is 5NM in En-route airspace and 3NM in TMA airspace)

The radar separation standard may not be constant throughout the En-route sectors. Different separation standards might be required e.g.:

- A non-RVSM flight that is authorized to fly within an RVSM airspace remains subject to separation standard that is applicable above the RVSM limit (i.e. in a non-RVSM airspace);
- At the edges of multi-radar cover or in the case of a reduction in radar service where the radar separation minimum may be increased to 10 NM;
- The sectors that interface the lower En-route sectors may be operating a lower radar separation standard (procedures ensure that the separation is established prior to transfer of control in this case);
- At the transfer of control points between different FIRs where fixed-route network is in effect, the separation minimums may be increased to 10 NM and other constraints might be in effect (e.g. the succeeding traffic not faster than preceding, else different separation minima must be applied etc.).

Therefore the choice of separation standard is made on a case-by-case basis depending on both the pair aircraft to assess and the airspace where the separation is assessed, and it may not be homogeneous throughout the whole controlled sector. Conflicting aircraft may be in airspace volumes with different separation minima and needs to be taken into account by the CD/R tools in solution PJ.18-W2-53B.

3.2.1.3.3 Traffic characteristics in Free Route Airspace

General Aviation Traffic (GAT) flights, entering and exiting FRA normally do so via the fixed route network. Flights traversing boundaries between ACCs continue to be subject to rules, procedures and Letters of Agreement.

Where required, local procedures may allow GAT flights to flight plan climb/descent entry and/or exit at random points. OAT flights entering and exiting FRA are not confined to fixed entry and exit points (unless they are transitioning from FRA to fixed-route airspace). They may be subject to rules, procedures and agreements for the purpose.

More flexible Flight Planning is made possible thanks to the ability given to plan and re plan routes according to user defined segments, which should positively affect predictability of flights as the controller will have a less of a role in tactically granting routing improvements. At the same time, Airspace Users cost effectiveness and fuel effectiveness together with environmental sustainability (reduced fuel burnt and emissions) are improved. Quantitative results depend directly on the structural limits associated to the FRA (e.g. maximum segment length, possible use of LAT- LON points…). The more freedom the Airspace Users are given in flight planning, the higher are the potential benefits.

Validation activities have shown that FRA has an impact on the location, dispersion and predictability of potential conflicts. Implementation of FRA trajectories over a very wide area can create high traffic variability, convergence phenomenon of traffic flows, and a large number of “hotspots”. Free Routing operations can also increase traffic complexity and Controllers’ workload, conflicts are more difficult to detect and manage, and situational awareness is more difficult to achieve.

Nevertheless, the negative impacts can be mitigated if the Free Routing operations take place in permanently low to medium complexity environments and are supported by appropriate tool support for ATCOs (e.g. by Conflict Detection, tactical trajectory monitoring tools…).

3.2.2 Roles and Responsibilities

The table below is extracted from EATMA and indicates the involved Nodes and their corresponding responsibilities. Solution PJ.18-W2-53B does not change the responsibilities of the nodes.

Node	Responsibilities
En-Route/Approach ATS	Performs all the en-route and approach ATS operations. [RELATED ACTORS/ROLES] Executive controller, planning controller, etc.
Flight Deck	Performs all the on-board AU operations including flight execution/monitoring according to agreed trajectory, compliance with ATC clearances/instructions, etc.

	[RELATED ACTORS/ROLES] Flight Crew
Meteorological Service Provision	Provides at least the minimum weather data as laid down by ICAO in Annex 3 - Meteorological Service for International Air Navigation to ensure safe ATM operations. In most instances a weather provider will provide a wider scope of weather data relevant to the ATM stakeholders/ATM community.

Table 7: Nodes and Responsibilities

SESAR 2020 operational environment, advanced tools and operating methods impact the task allocation between controllers (Extended ATC Planner, Multi Sector Planner (MSP), Planning Controller (PC) and Executive Controller (EC)), thus team structure and communication are also affected.

New sector team arrangements will be used, with new procedures and responsibilities, supported by increasingly sophisticated tools. As well as the traditional Planner-Executive (1P-1E) two-person ATC sector team, sectors will operate with a combined role of Single Person Operations or with the distinct role of MSP where the PC is responsible for the airspace that is under the control of two independent Executive Controllers (1P-2E).

The applicable roles and responsibilities description are available in EATMA.

The current section describes who is involved in the provision of separation (as available in EATMA) and what the responsibilities of the various actors are.

It identifies the changes that the solution PJ.18-W2-53 proposes with respect to the applicable EATMA reference. It provides with the human factor aspects essential for the safe and coherent operation of the Operational Service, particularly in reference to partial implementations, mixed equipage, etc.

3.2.2.1 ATC Sector Executive Controller

The EC has responsibility for traffic management within the sector/AoR and for the executing all tactical tasks to maintain a safe and expeditious flow of traffic within the AoR.

The controller’s principal tasks are, compliance with the ICAO Rules of the Air, other relevant ICAO (e.g. Doc. 4444) and European/National provisions to separate known flights operating within its area of responsibility. Part of these tasks are to issue instructions to pilots for conflict resolution and segregated airspace circumnavigation.

Additionally, s/he monitors the trajectory of aircraft, according to the clearance the aircraft have received.

The responsibilities of the ATC Sector executive controller are focused on the traffic situation, as displayed at the Controller Working Position (CWP) and are very much related to task sharing arrangements within the sector team.

In case the sector operates with no dedicated PC (i.e. multiple SPOs with a single MSP) or the Flight Centric operations are in place, the EC will be in charge of some Coordination tasks with specific needs linked to separation.

The PJ.18-W2-53B Solution in itself does not change the current responsibilities of the ATC Sector Executive Controller. It permits to enhance the aid for separation task, leaving more room for the other control tasks.

3.2.2.1.1 Responsibilities

Among the EC's main responsibilities expressed in EATMA, those that are applicable to the provision of separation and monitoring tasks are:

- Identify conflict risks between:
  - Aircraft;
  - Aircraft and terrain;
  - Aircraft and special use areas;
- Provide separation between controlled flights;
- Monitor flights regarding adherence to flight plan and clearances;
- Monitor the air situation picture;
- Communicate with pilots by means of radio Telephony (R/T) or Data Link (D/L);
- Monitor information on airspace status, e.g. activation/ deactivation of segregated/reserved airspace;
- Monitor the weather situation;
- Provide information regarding adverse weather aiding the crews in their avoidance strategy;
- Monitor aircraft equipment status according to information provided by the system;
- Coordinate with the PC about planned conflict solution strategies based on system derived solution proposals;
- Coordinate the implementation of possibly system derived conflict solutions with the PC;
- Apply appropriate separation to all controlled flights departing the AoR;
- Transfer control of aircraft to the appropriate EC when clear of traffic within his area of responsibility.

Depending on the sector team organization, or where Collaborative Control or Flight Centric ATC operate, the following responsibilities currently assumed by the PC may be delegated to the Executive Controller.

- Co-ordinate entry and exit conditions;
- Resolve boundary problems by re-coordination.

3.2.2.1.2 Changes

The solution PJ.18-W2-53B does not change the roles and responsibilities of the controllers, though it is expected that it might enable earlier, more efficient decision making.

3.2.2.2 ATC Sector Planning Controller

The ATC Sector PC is mainly responsible for planning and coordination of the traffic entering, exiting or existing within the ATC Sector. Furthermore, the PC provides tactical flight control assistance to the ATC Sector Executive Controller.

The PJ.18-W2-53B Solution in itself does not change the current responsibilities of the ATC Sector Planning role. However, the increased accuracy of the tools will allow the planner to advise the executive controller on potential conflicts and their resolution options, and to take an increasingly pro-active role in resolving conflicts through the use of closed-clearances.

3.2.2.2.1 Responsibilities

Among ATC Sector PC main responsibilities expressed in EATMA, those that are applicable to the provision of separation and monitoring tasks are:

- Co-ordinate entry and exit conditions.
- Resolve sector boundary-related issues by performing additional coordination
- Provide early conflict detection and resolution (depending on the Conflict Detection and Resolution tools horizon) if this early resolution brings operational benefit (either on the ground side or the airborne side)
- Check flight-data for possible conflicts and complexity issues within its area of responsibility.
- Plan conflict-free flight path through its area of responsibility.
- Coordinate with the ATC Sector Executive Controller about planned conflict solution strategies, possibly formulated using what-else and what-if probes provided by the system
- Implement solution strategies by communicating trajectory changes to the aircraft through the concerned ATC Sector Executive Controller via Data Link.

3.2.2.2.2 Changes

PJ.18-W2-53 Solution does not change the listed responsibilities of the PC, but it may impact their allotment.

For example, due to better prediction of the encounters and a clear view of dependent aircraft, the PC is more often in position to implement planned conflict resolution strategies. In addition, the visualization of no-fly zones alleviates the planning of flights in advance.

3.2.3 CNS/ATS description:

This section describes the fundamental CNS/ATM services that are part of the solution context.

3.2.3.1 Aircraft Capabilities

The aircraft capabilities remain heterogeneous in the target environment. As a minimum they comply with existing capabilities and standards as described in the relevant Minimum Aviation System Performance Specifications.

The highest level of aircraft capabilities available in the scope of the document can be summarized as follows:

- **Data link**:
    - CPDLC and ADS- Contract (ADS-C) for ATC via ATN (continental flights) (ED228A and ED229A for continental Europe ATS B2);
    - FIS: D-ATIS with ATC via ACARS (ED89A);
    - MET data (winds/temperatures, TEMSI, etc.) with Aeronautical Operations Control (AOC) via ACARS.
- **Navigation** (figures currently being assessed by WG85):
    - 2D RNP1 in en-route and 2D RNP0.3 in approach (2D RNP means lateral containment i.e. not only a required accuracy but also a required integrity and continuity, e.g. the aircraft will remain within +/-1nm 95% of the time and within +/-2nm 99,99% (10^{-7}) of the time for RNP1);
    - Concerning the vertical dimension, the following is required in [16] section 7 “RVSM performance” JAR 25.1325(e) : “*Each system must be designed and installed so that the error in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding instrument calibration error, does not result in an error of more than ± 30 ft per 100 knots speed for the appropriate configuration in the speed range between 1.3 VS0 with wing-flaps extended and 1.8 VS1 with wing-flaps retracted. However, the error need not be less than ± 30 ft*”;
    - The ability to fly published departure and arrival routes containing altitude constraints.
- **Surveillance**:
    - Automatic Dependent Surveillance - Broadcast (ADS-B) in/out via Mode-S 1090 transponder;
    - Terrain Awareness Warning System (TAWS);
    - ACAS for the safety net.

The focus here is mainly on Commercial aircraft (legacy, low fare, regional) and on Business aircraft[3].

There is generally less capability for GA-VLJ-Helicopter and Military aircraft however they have at least minimum equipage for airspace class they use.

According to Commission Implementing Regulation (EU) No 1028/2014, published on 26/09/2014, amending EU Regulation No 1207/2011, by June 2020, all aircraft operating IFR/GAT in Europe and

[3] Mainline and BGA equipage level can be very different

with a maximum certified take-off mass exceeding 5 700 kg or having a maximum cruising true airspeed capability greater than 250 knots are required to carry and operate Mode S Level 2s transponder(s) with Mode S Elementary Surveillance (ELS), Enhanced Surveillance (EHS) (for fixed wing aircraft) and ADS-B 1090MHZ Extended Squitter (ES) capabilities.

According to EC Regulation No 29/2009, as amended by the Implementing Regulations (EU) 310/2015 and 2019/1070, from February 2018 all flights operating as IFR/GAT in the airspace of Western Europe above FL 285, except those which are exempted, are required to be capable of performing CPDLC services as defined in ATN Baseline 1. According to the EUROCONTROL dashboard, in August 2020 the number of equipped flights by FIR varied between 57% and 90%.

The Commission Implementing Regulation (EU) 2021/116 CP1 requires that equipped aircraft downlink trajectory information using ADS-C Extended Projected Profile (EPP) as part of the ATS B2 services. It also required the Deployment Manager to develop a strategy to ensure that at least 20 % of the aircraft operating within the airspace of European Civil Aviation Conference (ECAC) countries, which correspond to at least 45 % of flights operating in those countries, are equipped with the capability to downlink aircraft trajectory using ADS-C EPP as from 1 January 2026.

3.2.3.2 Air-Ground Communication

A great deal of work related to Air-Ground Communications is achieved within the WG78 and WG85 for EUROCAE and SC214 for RTCA which are conjointly in charge of the standards for advanced ATS supported by data communication.

The operational needs expressed by SESAR, NEXTGEN and ICAO OPLINK panel have been considered, in particular the following new air-ground data exchanges required to support 4D operations:

- CPDLC message as voice alternative if not time critical;
- ADS-C EPP to support the automatic downlink of trajectory data (1 to 128 published and/or computed waypoints with associated constraints and/or estimates in the 4 dimensions, etc.). EPP data are needed to get the predicted aircraft's behaviour from aircraft's point of view, which enable the enhancement of separation services. Wind speed and direction are also available in the ADS-C MET Info data-group. For an equipped aircraft, ADS-C contracts can be passed with up to 4 ATSUs and the data are downlinked according to the contract that is negotiated between Ground and Air parties. Three types of contract exist for ADS-C EPP report: "on event, on demand & periodic". The “on event” form of contract can be used to allow the on-board predicted trajectory to be downlinked when for example, at a specified waypoint, it has changed by a specified threshold from the previously downlinked version, in case of an “on demand” contract data is downlinked when required by ground, and the “periodic” report downlinks data in regular intervals. For ATC to be able to take benefit of the EPP during the transit of the TMA, the ADS-C contract would be established prior to departure;

- Mode-S Enhanced Surveillance (EHS) permits to receive downlinked airborne parameters into the ground surveillance system. EHS is mandated in Europe for most airline aircraft. Local wind speed and direction for instance, are valuable data that can be computed based on several data available from EHS.

3.2.3.2.1.1 Voice services

While the ATM Target Concept is oriented toward data exchanges between aircraft and ATM ground systems, voice remains an essential means of communication. It is used for separation notably for time critical clearances and especially in high density environments.

Voice services continue to be based on the premise of one channel per controller/sector and remain an essential means for pilots to get information and to obtain confirmation of the ATC instructions. When more complex instructions or transmissions of long and complex non-routine messages are needed, voice communications help ATCOs and flight crew to better understand each other.

Air traffic control operations and AOC continue to use the allocated VHF spectrum (118-137 MHz) for voice communications. The voice service for 2020 will be complemented by SATCOM for oceanic and remote areas.

3.2.3.2.1.2 Data services

Data exchange is progressively introduced for routine communications. Point-to-point air/ground data service link is based on ATN/VDL Mode 2 technology.

This initial step will need to be enhanced and/or complemented to support the full deployment of the ATM Target Concept. It is important to highlight that higher performance (e.g. predictability, security, latency, availability, integrity and throughput) data-links will be required to support advanced services, trajectory exchanges, as well as the increasing air-traffic volumes and density.

To meet the long-term data communication needs, a dual link system is likely to be necessary to cope with the higher availability requirements.

New terrestrial mobile communication technology systems and satellite technologies can provide the advantage to offer complementarities in terms of infrastructure and radio spectrum diversity, and coverage.

3.2.3.3 Ground-Ground communications

The Ground-ground communications are used wherever the local system hosting the separation services needs to communicate with an external ground-based actor (system or human).

3.2.3.3.1 Voice services

While the ATM Target Concept is oriented toward data exchanges ATM ground systems, voice remains an essential means of communication between ATCOs whenever a coordination is needed that cannot completely rely on automated coordination, or whenever time critical decisions require a rapid coordination.

Between ATCOs belonging to different ATM systems, the phone calls remain the major means for communicating by voice.

3.2.3.3.2 Data services

The system hosting the separation services is interfaced with many other ground ATM systems. Technically speaking, there are several means to exchange data between ground-based systems; it mainly depends on the nature of these data and on the capabilities of each ATM system. The following ones concern the exchange of flight data:

<u>AFTN</u> : the Aeronautical Fixed Telecommunications Network is a word-wide telecommunication network using low-speed telex type links and specific International Civil Aviation Organisation (ICAO) protocols. AFTN is namely used for the ATSU’s to communicate with the NM Operations Centre (IFPS and ETFMS).

OLDI : On-Line Data Interchange is used for the exchange of messages relating to inter-centre co-ordination. OLDI is currently the main means of communication between ATSU's for co-ordination and transfer purposes.

B2B : The NM B2B Web Services is an interface provided by the EUROCONTROL Network Manager (NM) for system-to-system access to its services and data, allowing NM customers to retrieve and use the NM information in their own systems, according to their business needs.

The NM B2B Web Services are at the core of the NM Interoperability Strategy and follow SESAR and ICAO SWIM principles, being instrumental to achieve real-time information exchange at global level and to implement Collaborative Global ATFM.

IOP : IOP implements ground-ground flight data exchange between ATC units through the use of Flight Object services as defined by the Flight Object in EUROCAE Ed.133. The main goal of IOP is to improve consistency of Flight Data available to stakeholder systems, thereby improving operational efficiency and safety. When IOP is completely in force, it is expected that the following stakeholders will benefit from IOP:

- Aircraft Operators: improved capacity will bring reduced delays and shorter routes,
- Airports: better information about incoming flights permits better use of airside and landside resources,
- Air Defence: more consistent and up-to-date information on aircraft intentions,
- ATC and ATFM: better information on current and future flights permits better planning of resources,

Supplier Industry: standards based on modern technology permits cost reductions and lower risk.

3.2.4 Applicable standards and regulations

Regulations

There is no specific topic in the field of the regulatory framework to be considered within the SESAR Solution PJ.18-W2-53B, beyond the applicable regulations currently existing.

Standards

For the improvements that take benefits from EPP data, it is critical that EPP standards and/or the use of EPP data by the Ground systems, are mandated in order to rapidly increase the equipage rate. CP1 AF6 Implementing regulation requires all aircraft produced from 31st of December 2027[4] to be equipped with ADS-C EPP capability and all European ground systems to be ADS-C capable by the same date.

[4] This including aircraft belonging to operators based out of Europe.

Applicable standards covering ATS Baseline 2 are:

- Safety & Perf Req. Std. for Baseline 2 ATS Data Com, EUROCAE ED-228A
- Interoperability Req. Std. for Baseline 2 ATS Data Com, EUROCAE ED-229A

FF-ICE/R1 planning and publication services are also applicable in the frame of CP1 AF5. The use of the 4D ATC Flight Plan is expected to enhance the basic accuracy of the TPs, independently of the use of ADS-C.

3.3 Detailed Operating Method

3.3.1 Previous Operating Method

The previous operating methods here described correspond to the baseline considered by the solution PJ.18-W2-53B. It does not necessarily correspond to the current operational situation in all ATS Units.

Separation provision is an iterative process, applied over the conflict horizon. It consists of:

- the detection of conflict, which is based on the current position of the aircraft involved and their trajectories as predicted by the Ground systems, in relation to known hazards;
- the formulation of a solution, including selection of the separation modes, to maintain separation of aircraft from all known hazards within the appropriate conflict horizon;
- the implementation of the solution by communicating the solution and initiating any required trajectory modification; and
- the monitoring of the execution of the solution to ensure that the hazards are avoided with the appropriate separation minima.

The scenario takes place in the Execution phase: from publication to termination on completion of the flight.

In order to ensure separation between aircraft, the Sector Team basically uses two means:

1. Modify the entry conditions in order to initiate a secure transit of the sector (mainly PC role);
2. Modify the transit of the sector (EC role with PC as an assistant at least for coordinating the exit conditions in accordance with the transit modifications).

The controller team currently works as an entity i.e. cooperation is necessary between both Controllers. At least common situation awareness is required in order to avoid misunderstandings.

Managing the vertical part of the trajectory

Current anticipation of aircraft climb performance by ATCOs takes into account a limited number of factors, such as aircraft type, weight of the aircraft – derived also from ADEP/ADES, weather conditions and partially airline preferences. As such, anticipation of climb performance is somewhat limited and subjective. For separation purposes, in order to have more assurance in the expected climb performance of a given flight, the ATCOs often revert to asking the flight crews what is their anticipated rate of climb for a certain vertical segment. Alternatively, ATCOs ask the Flight Crew whether a certain Flight Level can be reached within a time window or over a navigation fix. This increases frequency time and implies workload both on the ground and on the airborne side. Once a rate of climb or a vertical constraint (“be level by…”) is issued to a flight, its execution is closely monitored by the ATCOs.

On the ATCO side a "Plan B" needs to be available throughout the climb segment, to ensure separation in case the climb performance of the aircraft differs from what was anticipated.

The above mentioned workload and uncertainty issues result in Rates of Climb and vertical constraints not being used to assure separation.

Top of descent and the descent profile is not known today by the ATCOs. In some traffic situations, when the descent path of inbounds is conflicting with other traffic, the ATCOs may issue descent clearances earlier or later than the optimal for the flight.

The precise position and time where aircraft will reach the en-route cruise level (top of climb) is also not known to the ATCOs today. The controllers might verify the FPL regarding planned altitudes of the flight, which could be used as an estimation of when the flight would be ready to climb. The planned altitude information is contained in the FPL and normally is associated with a navigational fix. For FRA operations where the navigation fixes are separated with significant distance along the flight trajectory, coordinates are used to indicate when the aircraft intends to climb. These methods are not precise enough and provide the ATCOs with only a general understanding about the route segment where the aircraft would be able to climb. Often due operational reasons (wind speed and direction, previous deviation from the intended trajectory etc.) the filed altitude in the FPL does not correspond to the operationally desired one. Currently, having to ask the flight crew and to receive the required information increases frequency use time and incurs additional workload on both ground and airborne side. In some traffic situations when a climb is an option to solve a conflict, the ATCOs might issue a climb clearance earlier than planned as it would be often the preferable option (instead of vectoring or descent) to the flight crew.

Managing the lateral part of the trajectory

Current working methods to resolve conflicts are based on the EC issuing vectors to the aircraft involved. Alternatively, the PC may coordinate a resolution of a conflict with the upstream sector, where the upstream EC would issue a heading, direct to, different FL or certain speed assignment to the aircraft involved. Where CPDLC is available, in some environments, the PC is able to uplink clearances in certain circumstances to the flight crew, thereby avoiding the direct involvement of the EC.

For efficiency purposes, after vectoring instructions are used, the controllers pay significant attention to when the closest point of separation is reached in order to safely resume the flights to their initial trajectories. Depending on the airspace organisation and traffic characteristics, when several conflicts are being solved with vectoring (e.g. for 3 or more conflicting pairs) the controller workload associated with monitoring increases exponentially.

The current operational method is characterised with ATCOs issuing more open-loop vectoring clearances than closed-loop. In order to issue a closed-loop vectoring clearance the controller has to be able to verify with the system functionalities that, after the determined closest point of separation with the hazard, the aircraft could be safely returned to its planned trajectory.

Adverse weather can have a particularly high impact on controller workload and, consequently, sector capacity. Convective weather is normally displayed at the controller workstation, but its location is imprecise and often slightly behind the actual situation. As a result, controllers pass information about adverse weather to the aircrew, but wait for the aircrew to request eventual avoidance manoeuvres, which limits the controller's ability to plan ahead.

Operational Scenario Description

Separation provision is an iterative process, applied to the conflict horizon. It consists of:

- the detection of conflict, which is based on the current position of the aircraft involved and their trajectories as predicted by the Ground systems, in relation to known hazards;
- the formulation of a solution, including selection of the separation modes, to maintain separation of aircraft from all known hazards within the appropriate conflict horizon;
- the implementation of the solution by communicating the solution and initiating any required trajectory modification; and
- the monitoring of the execution of the solution to ensure that the hazards are avoided with the appropriate separation minima.

The scenario takes place in the Execution phase: from publication to termination on completion of the flight.

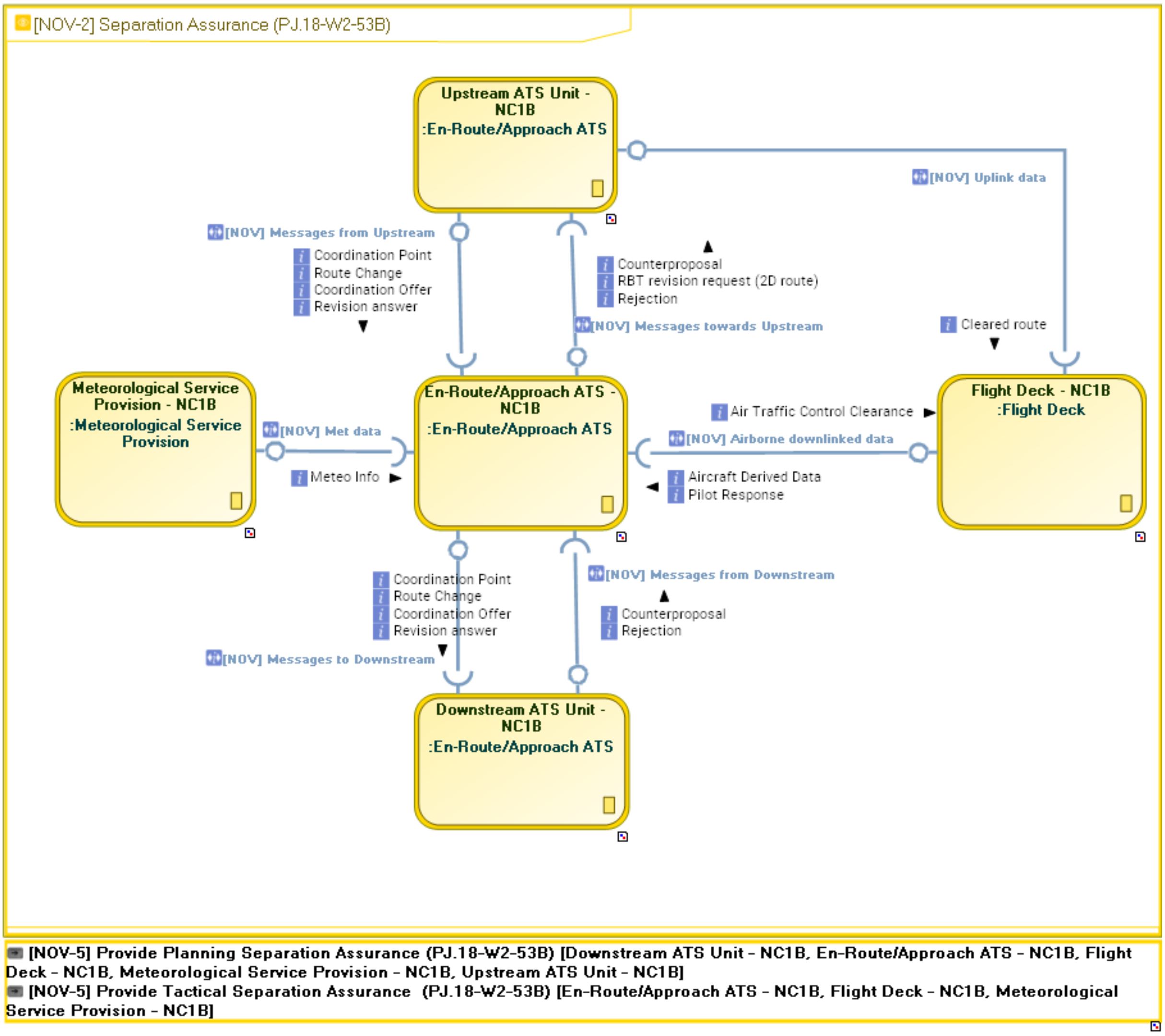

Figure 3: Overview- Separation Assurance

3.3.1.1 Provide Planning Separation Assurance

Separation assurance at planning level is a continuous process triggered on a cyclic basis in order to detect and solve potential interactions between (pairs of) aircraft and between aircraft and restricted airspace that are within his/her area of interest, at every step of the coordination process (e.g. receipt of an offer, selection of a suitable sector exit level etc.). According to the ATSU/ ATC team configuration, planning separation can be provided by the MSP and/or the PC.

Conflict resolution in planning terms may involve the identification of alternative co-ordination conditions (level, route, profile etc.) at either the entry and/or exit boundaries of the AoR.

The use of Medium Term Conflict Detection tools and What-if or What-else probing tools permit to support detection of problems at Entry/Exit and along planned flight trajectory within AoR/AoI.

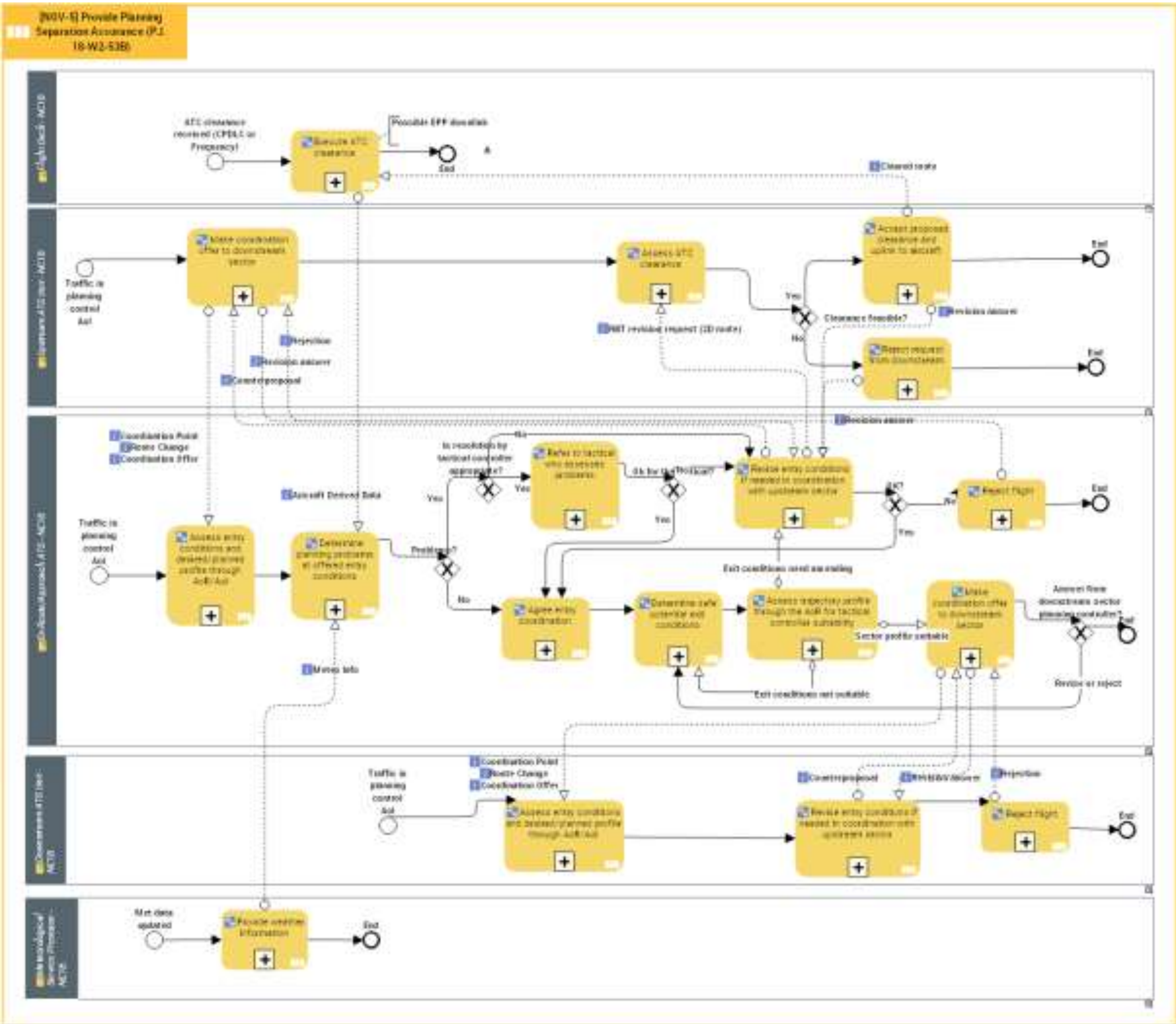

Figure 4: Overview- Provide Planning Separation Assurance

Activity	Description
Agree entry coordination	Inform previous sector and tactical controller that the coordination is accepted (can be fully supported by automation).
Assess trajectory profile through the AoR for tactical controller suitability	The planning controller looks along the flight path in his/her AoR to assess whether the anticipated exit conditions or any in-AoR constraints present an unacceptably high level of difficulty for the tactical controller to achieve (e.g. due to conflicting flights within the sector). Note: The planning controller AoR may comprise several tactical AoRs.
Determine planning problems at offered entry conditions	Looking along the flight path within his/her AoR, the planning controller assesses the entry conditions of the flight and, taking into account any separation/complexity issues, determines: - The possibility to remove any unnecessary pre-tactical and/or procedural constraint which was so far applicable for the flight - The potential need to apply additional constraints Note: The planning controller AoR may comprise several tactical AoRs.
Determine safe potential exit conditions	The planning controller looks at the characteristics of the flight and its expected trajectory profile through his/her AoR, gaining an overview of potential issues and optimisation opportunities within his/her AoI and potentially anticipating new exit conditions if necessary. Note: The planning controller AoR may comprise several tactical AoRs.
Refer to tactical who assesses problems	The planning controller highlights issue to the tactical controller. The tactical controller makes a decision whether he/she accepts the responsibility for monitoring and/or resolving the problem or whether a revised sector entry coordination is required.
Assess entry conditions and desired/planned profile through AoR/AoI	The planning controller looks at the characteristics of the flight and its expected trajectory profile through his/her AoR, gaining an overview of potential issues and/or optimisation opportunities (e.g. ARES early deactivation) within his/her AoR. Note: The planning controller AoR may comprise several tactical AoRs.
Execute ATC clearance	The airborne trajectory in the FMS active flight plan is updated with the clearance, which may lead to EPP downlink depending on the established ADS contract terms.
Make coordination offer to downstream sector	Having identified appropriate exit conditions, coordination offer is made to next planning AoR for their consideration.
Provide weather information	This activity involves handling requests and proving weather information concerning the flight or mission activity, in standardised

	format like WXXM. Broadcast services where weather information is distributed in regular intervals is also handled by this activity.
Reject flight	If the flight cannot be reasonably accepted into the sector the coordination is to be rejected.
Revise entry conditions if needed in coordination with upstream sector	Entry coordination is amended as required in agreement with offering sector.

Table 8: Provide Planning Separation Assurance

3.3.1.2 Provide Tactical Separation Assurance

This process describes how the controller (mostly the Executive, and sometimes the Planning) detects and solves potential trajectory profile problems between (pairs of) aircraft and between aircraft and restricted airspace that are within his/her AoR or even within others' AoR when new collaborative control operating procedures apply. The goal is to address any remaining potential interactions that have been highlighted by the Planning Controller and achieve the overall trajectory profile targets set by him/her.

Conflict resolution in tactical terms may involve the identification of different solutions, e.g. by modifying the trajectory laterally, vertically or in terms of speed adjustments. In the envisaged operational environment priority should be given to solutions that impose a minimum deviation from the RBT.

The use of Tactical Conflict Detection tools, conformance monitoring and electronic coordination tools support tactical separation assurance: detection of problems at along planned flight trajectory within AoR/AoI.

In order to assess tactical conflict resolution options ATCOs are provided with What-if probing tools or what-else propositions.

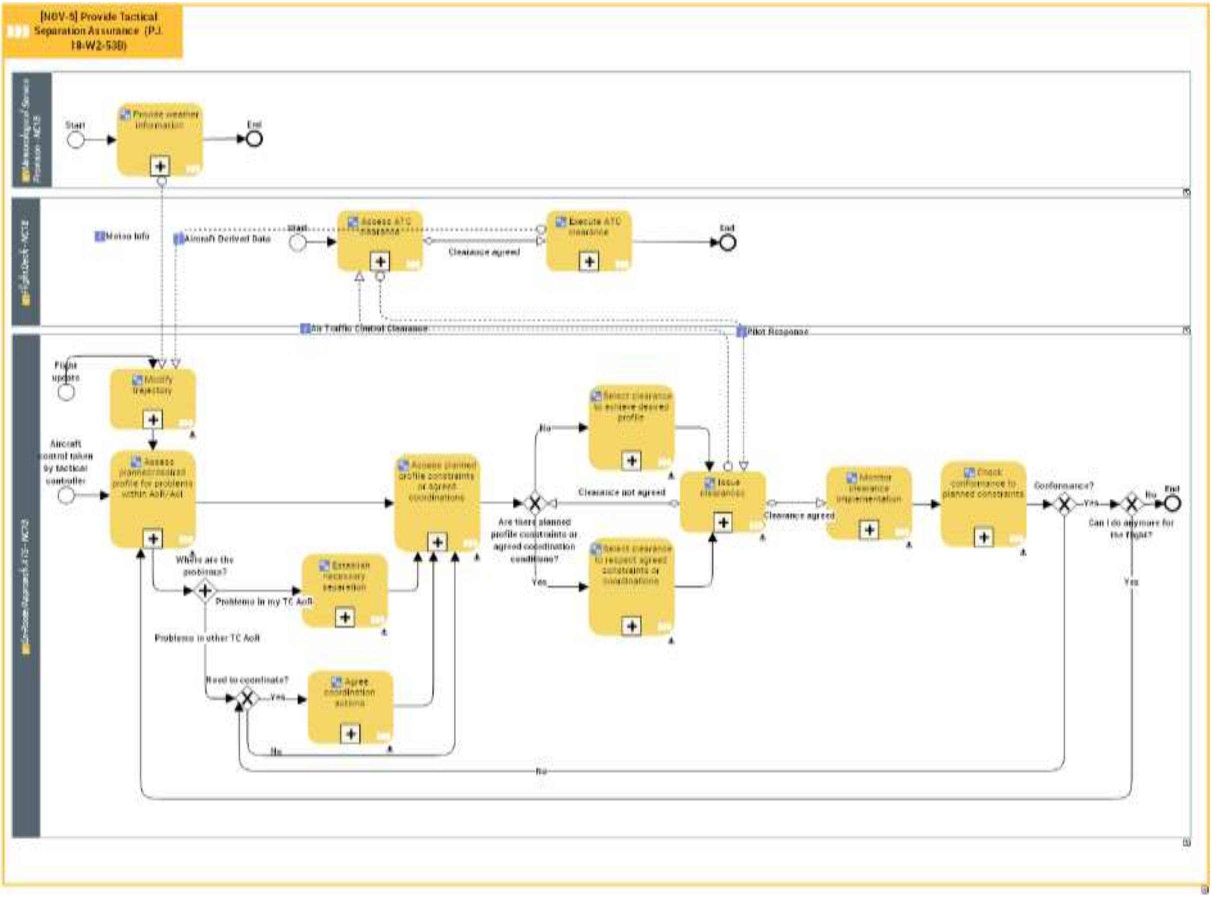

Figure 5: Overview- Provide Tactical Separation Assurance

Activity	Description
Agree coordination actions	Except with the new collaborative control procedures where the traditional requirement to coordinate traffic at all sector boundaries is removed, the Executive Controller will coordinate the appropriate actions when he/she: - Identifies a planned/profile trajectory profile problem that concerns other tactical AoR. - Realises that conformance to planned constraints is not achievable anymore after the issue of the clearance. This coordination is improved thanks to new interoperability capabilities enabling increased support tools efficiency and the Executive Controller could delegate this task to the Planning Controller.

	Note: In MSP configuration, more flexible/optimised solutions can be set up due to extended situation awareness (both tactical sectors are known traffic to the planner).
Assess ATC clearance	The flight crew assess the impact of the clearance from a safety/flight execution perspective and inform ATC about their decision of either accept or reject it. The reason for rejection is also communicated to facilitate amendment from ATC. ATC clearance and associated pilot response can be communicated by either voice or datalink messages depending on the particular situation.
Assess planned profile constraints or agreed coordinations	Assess whether there are any planned constraints or agreed coordination actions to consider in order to select the clearance accordingly.
Assess planned/desired profile for problems within AoR/AoI	Determine whether there are any problems between the aircraft's trajectory profile and other flights' trajectory profiles through his/her AoR or even through others' AoR (if collaborative control procedures apply) to achieve overall profile targets set by the Planning Controller. This monitoring activity is run in a cyclic basis to identify and classify potential interactions between flights under tactical control, including interactions already highlighted by the planning controller as pending conflicts. Conflicts between aircraft and between aircraft and restricted airspace are detected by comparing the set of predicted trajectories modelling the behaviour of the aircraft in order to identify potential losses of minimum separation.
Check conformance to planned constraints	Both executive and planning controllers, assisted by a conformance monitoring tool, monitor the progress of the aircraft and check that conformance to planned constraints is achieved. If they are no longer achievable, they will need to be revised.
Establish necessary separation	Determine what actions need to be taken to maintain necessary separation.
Execute ATC clearance	The airborne trajectory is updated and activated in the FMS, which may lead to EPP downlink depending on the type of clearance and the established ADS contract terms.
Issue clearances	The agreed conditions are implemented by issuing one or more clearances.
Monitor clearance implementation	Both executive and planning controllers, assisted by a conformance monitoring tool, monitor the progress of the aircraft with respect to the given clearance to ensure that the problem is solved.

Select clearance to achieve desired profile	If there are not planned constraints or agreed coordination actions to respect, the Executive Controller will select the clearance to achieve the desired trajectory profile.
Select clearance to respect agreed constraints or coordination	If there are planned constraints or agreed coordination actions, the Executive Controller will select the clearance to respect them.
Modify trajectory	The trajectory is recalculated with modified meteorological or downlinked data.
Provide weather information	This activity involves handling requests and proving weather information concerning the flight or mission activity, in standardised format like WXXM. Broadcast services where weather information is distributed in regular intervals is also handled by this activity.

Table 9: Provide Tactical Separation Assurance

3.3.2 New SESAR Operating Method

This section describes the new features and their associated use cases. Use cases are described with reference to the process models "Provide Planning Separation Assurance" and "Provide Tactical Separation Assurance" detailed above.

3.3.2.1 Use Cases

3.3.2.1.1 Improved Performance of CD/R Tools

3.3.2.1.1.1 Description

Solution PJ.18-W2-53B takes advantage of better quality information on aircraft intent (downlinked from the aircraft via ADS-C) and higher fidelity winds aloft to improve both the controller's situational awareness (e.g. knowledge of top of climb/descent, sector sequence, etc) and the performance of the existing CD/R tools.

The improved performance of existing CD/R tools is achieved as a consequence of obtaining a more accurate trajectory prediction that makes use of downlinked aircraft intent and improved meteorological data (forecasts and spot winds reported from aircraft). This reduces the uncertainty in the conflict prediction, allowing a reduction in low probability conflicts (clutter) and more reliable/earlier detection of real conflicts. In addition to the planned trajectory, this also applies to the calculation of what-if and what-else trajectories.

The following use cases are defined:

- Provide Tactical Separation Assurance with Reduced Uncertainty
- Provide Planning Separation Assurance with Reduced Uncertainty

3.3.2.1.1.2 Use Case: Provide Planning Separation Assurance with Reduced Uncertainty (53B)

Purpose

This use case describes how the process "Provide Planning Separation Assurance", as described in section 3.3.1.1, is improved thanks to Improved Performance of Planning CD/R Tools derived from the use of aircraft intent received using ADS-C and higher fidelity information on winds aloft.

Compared to the process "Provide Planner Separation Assurance", the following improvements are expected:

- A drop in false positive detection rate, thanks to the better accuracy of the TP, matching more with real aircraft trajectory;
- An anticipated display and categorization of detected encounters, thanks to a significant reduction of longitudinal uncertainty;
- More precision in the determination and assessment of resolution options.

In complex airspace, where the sector sequence can depend on aircraft performance, the assessment of sector entry and exit conditions might be improved thanks to improved accuracy in ATC Planned Trajectory.

Trigger

The use case is initially triggered when control of the flight is activated in the concerned sector.

Start Condition: Traffic in planning control AoI (see Figure 4) and the flight intent (taking into account EPP) has been correctly integrated into the ground system.

Main Flow

[Activity] Determine planning problems at offered entry conditions

The EC/PC team is alerted to the presence of a conflict by the conflict detection tool. The EC/PC team analyses the conflict to determine if it is a correct or nuisance alert.

Less uncertainty in the planned trajectory prediction

- Predicts more reliable if aircraft is able to meet entry conditions within an acceptable tolerance
- Reduces the "false positive"/undesirable alert rates
- Increases "true positive" alert rates

[Activity] Agree entry coordination

- no change -

[Activity] Determine safe potential exit conditions

The PC assesses the exit coordination details (possibly proposed by the ground system) ensuring they are compliant with any LoA restriction or flight level allocation scheme and that the time and partner are correct.

Improved determination of safe potential exit conditions thanks to reduced uncertainty/improved accuracy in ATC Planned Trajectory using airborne downlinked MET and Trajectory (EPP) data.

- Reduces the number of potential separation conflicts
- Predicts more reliable if aircraft is able to meet exit conditions within an acceptable tolerance

[Activity] Assess trajectory profile through the AoR for tactical controller suitability

Improved assessment of trajectory profile.

- Less uncertainty in the planned trajectory prediction reduces the number of potential separation conflicts
- increased warning times of “true positive” alerts.

[Activity] Make coordination offer to downstream sector

- no change -

Alternate Flow

[Activity] Assess entry conditions and desired/planned profile through AoR/AoI

The PC analyses the flight details and confirms that the attitude of the radar position symbol and track data block are consistent (assisted by the conformance monitoring of the system).

The PC sees that according to the attitude of the track that the aircraft will not work with their sector.

The PC coordinates with the upstream sector and agrees with them that the flight will be transferred to a different sector.

Alternate Flow

[Activity] Determine safe potential exit conditions

The PC assesses the exit coordination details and ascertains that either:

- The flight level is not compliant with any LoA restriction or flight level allocation scheme
- The coordination time is incorrect
- The coordination partner is incorrect.

The PC modifies the exit coordination details (possibly to values proposed by the system) to ensure correct transmission.

Success End State

The coordination details at entry and exit are correct within acceptable limits.

Potential conflicts are accurately identified.

Failed End State

The coordination details at entry and exit are outside of acceptable limits.

Too many unwanted (nuisance) conflicts are identified.

A potential conflict is not detected with at an acceptable timeframe. In this case, the conflict is identified in the process “Provide Tactical Separation Assurance”.

3.3.2.1.1.3 Use Case: Provide Tactical Separation Assurance with Reduced Uncertainty (53B)

Purpose

This use case describes how the Executive Controller uses the Improved Performance of Tactical CD/R Tools to efficiently and safely provide tactical separation assurance between flights.

This use case refers to the process "Provide Tactical Separation Assurance", as described in section 3.3.1.2.

Preconditions

The flight intent (taking into account EPP) has been correctly integrated into the ground system.

Trigger

The use case is initially triggered when control of the flight is assumed by the Executive Controller.

Main Flow

[Activity] Assess planned/desired profile for problems within AoR/AoI

Improved assessment of planned/desired profile for problems thanks to:

- reduced uncertainty/improved accuracy in ground trajectories using airborne downlinked data (EPP, Mode S)
- improved performance of Conflict Detection support tools ATC sector planning and tactical control (e.g. increased warning times of "true positive" alerts and reduced "false positive"/"nuisance" alert rates) thanks to more accurate predicted trajectory and detection envelopes
- automatic detection of aircraft conflicting with aircraft in hold

[Activity] Establish Necessary Separation

The EC determines what actions need to be taken to maintain necessary separation. Enhanced what-else information indicates whether a speculated CFL to solve a conflict would be achievable within the required time horizon.

[Activity] Issue clearances

The EC instructs the flight crew and implements the agreed conditions by issuing one or more clearances using CPDLC if non time critical.

[Activity] Agree coordination actions

Improved coordination actions thanks to:

- improved accuracy in ATC Trajectory using airborne downlinked data (EPP, Mode S)
- improved performance of Conflict Detection support tools for ATC sector planning l (e.g. increased warning times of "true positive" alert rates and reduced "false positive"/"nuisance" alert rates)

[Activity] Modify trajectory

- no change -

Alternate Flows

None.

Success end state

Significant reduction of false alerts detected for the tactical conflict.

Failed end state

None.

3.3.3 Differences between new and previous Operating Methods

Activities (in EATMA) that are impacted by the SESAR Solution	Current Operating Method (PJ.10.02a1)	New Operating Method (PJ.18-W2-53B)
Provide Planning Separation Assurance		
Determine planning problems at offered entry conditions	CD/R tools assist the controller by showing potential conflicts based on the planned trajectory.	Improved accuracy of ground trajectories using downlinked ADS-C data. Reduction in “false positive” conflict detections. Increase of “true positive” conflict detections.
Determine safe potential exit conditions	CD/R tools assist the controller by showing potential conflicts based on the planned trajectory.	Reduction in “false positive” conflict detections. Increase of “true positive” conflict detections.
Assess trajectory profile through the AoR for tactical controller suitability	CD/R tools assist the controller by showing potential conflicts based on the planned trajectory.	Reduction in “false positive” conflict detections. Increase of “true positive” conflict detections.
Provide Tactical Separation Assurance		
Assess planned/desired profile for problems within AoR/AoI	CD&R tools assist the controller by showing potential conflicts based on the planned and tactical trajectories.	Improved accuracy of ground trajectories using airborne downlinked data (EPP, Mode S) Improved performance of Conflict Detection support tools (e.g. increased warning times of “true positive” alerts and reduced “false positive”/”nuisance” alert rates)

Establish Necessary Separation	What-if and what-else probes indicate potential conflicts on possible resolution trajectories.	Enhanced what-if or what-else information indicates whether a speculated CFL to solve a conflict would be achievable within the required time horizon.
Agree coordination actions	The planned trajectory, updated by conformance monitoring, can assist the controller in planning the coordination conditions.	Improved accuracy in ATC Trajectory using airborne downlinked data (EPP, Mode S) Improved performance of Conflict Detection support tools (increased warning times of “true positive” alert rates and reduced “false positive”/”nuisance” alert rates)

Table 10: Differences between new and previous Operating Method

4 Safety, Performance and Interoperability Requirements (SPR-INTEROP)

This section provides the operational requirements of the solution. Ref [17] states that "**Operational** requirements are requirements that capture the SESAR Solution essential capabilities, operational processes, qualitative and quantitative parameters/indicators to satisfy the needs and desired performances of an activity", and that they take the form:

"The <stakeholder type> shall be able to <capability>."

The description of requirements in this section has followed these conventions. However, it must be understood that placing requirements at the level of the stakeholder (in this case "En-route & Approach ATS") does not allow to expose in the OSED the requirements that are target for automation systems. This is particularly unhelpful given that Solution 53 entirely focussed on the use of advanced automation. Furthermore, the HLOR which form the parent to these operational requirements, support the use of advanced automation as the only enabler.

Therefore, the implications on the automation system have been described in the "Rationale" for the requirements, to act as a top-level link to the technical specification.

To aid readability, **the capability requirements are placed on the ATCO**, rather than En-Route and Approach ATS. This is not considered as a deviation from the process as the requirements are in any case allocated to a role.

The requirements specified in this document are considered additional to those specified by standards related to the underlying technology.

4.1.1 Operational Requirements

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-UU01.0001
Title	Adaptation to quality and reliability of the trajectory
Requirement	The Separation Assurance process shall adapt itself to the quality and reliability of each flight's predicted trajectory.
Status	<validated>

Rationale	Replaces REQ-10.02a2-SPRINTEROP-EPP0.0001, 0002 and 0003. The CD&R tools are expected to be tuned for each flight's TP accuracy, depending - among others - on ADS-C data validity and augmentation mode. Augmentation options to be documented in the TS/IRS, ex. - Using downlinked mass and speeds - Calibration of TP engine based on EPP Vertical profile - 2D or 3D Extrapolation of EPP based on ATC hypotheses EXE-008 BULATSA/Airbus EXE-009 DFS EXE-010 MUAC EXE-012 Skyguide
Category	<Operational><Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.18-W2-53B
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-01
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-02
<ALLOCATED_TO>	<Activity>	Assess planned/desired profile for problems within AoR/AoI
<ALLOCATED_TO>	<Activity>	Determine planning problems at offered entry conditions
<ALLOCATED_TO>	<Role>	ATC Sector Executive Controller
<ALLOCATED_TO>	<Role>	ATC Sector Planning Controller
<ALLOCATED_TO>	<Sub-Operating Environment>	En-Route
<ALLOCATED_TO>	<Sub-Operating Environment>	Terminal Airspace

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-UU01.0002
Title	Awareness of ADS-C Availability and Validity for A Flight

Requirement	The ATCO shall be able to identify flights for which ADS-C data has been received and is valid.
Status	<validated>
Rationale	Replaces REQ-10.02a2-SPRINTEROP-EPP0.0001, 0002 and 0003. Validity might comprise - No ADS-C data at all or Invalid data - ADS-C data validated by Surveillance (radar and / or ADS-B) as regards current position and velocity vector - ADS-C data with no Surveillance check The FMS mode selection (Lateral, Vertical, Speed & Time in either Selected or Managed Mode) can affect the accuracy of the EPP, but it might still be usable perhaps with a different reliability (figure of merit). EXE-008 BULATSA/Airbus EXE-009 DFS EXE-010 MUAC EXE-011 PANSA – Validity check not made by the system EXE-012 Skyguide
Category	<Operational><Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.18-W2-53B
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-01
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-02
<ALLOCATED_TO>	<Activity>	Assess planned/desired profile for problems within AoR/AoI
<ALLOCATED_TO>	<Activity>	Determine planning problems at offered entry conditions
<ALLOCATED_TO>	<Role>	ATC Sector Executive Controller
<ALLOCATED_TO>	<Role>	ATC Sector Planning Controller
<ALLOCATED_TO>	<Sub-Operating Environment>	En-Route

<ALLOCATED_TO>	<Sub-Operating Environment>	Terminal Airspace

4.1.2 Safety Requirements

This section contains safety requirements that have been elicited following the process described in ref [10].

4.1.2.1 Hazards and their causes/effects

HAZARD-ID	Description of hazard	Potential cause(s)	Potential effect(s)
Hz#01 PC	Failure of PC to assess correctly planned/desired profile for problems in AoI/AoR	ATCO receives corrupted data (credible inaccurate data)	▪ The pre-tactical conflict may evolve into planned tactical conflict to be solved by TC, increasing TC's workload
		The CD tool identifies potential conflicts which are nuisance ones	▪ increased PC's workload in identifying nuisance alerts from true alerts
Hz#01 TC	Failure of TC to assess correctly planned/desired profile for problems in AoI/AoR	ATCO receives corrupted data (credible inaccurate data)	▪ The planned tactical conflict may evolve into imminent infringement
		The CD tool identifies potential conflicts which are nuisance ones	▪ Increased TC's workload in identifying nuisance alerts from true alerts
Hz#02	TC fails to establish necessary separation	TC receives corrupted data (credible inaccurate data)	▪ TC fails to establish proper resolution strategy to avoid imminent infringement ▪ TC fails to establish proper resolution strategy creating knock on effect and increasing workload
		PC fails to execute resolution strategy to establish separation at entry	▪ TC fails to establish proper resolution strategy to avoid imminent infringement
Hz#03	CD&R tool failure to detect the conflict	CD&R tool receives corrupted data (credible inaccurate data) Non availability of required data (ADS-C/EPP) due to legacy aircraft	▪ If the conflict is within pre-tactical horizon, then it may evolve into planned tactical conflict to be solved by TC, increasing TC's workload ▪ If the conflict is within tactical horizon, the planned tactical

HAZARD-ID	Description of hazard	Potential cause(s)	Potential effect(s)
			conflict may evolve into imminent infringement
Hz#04	CD&R tool failure to support the ATCO in the resolution of the conflict	Corrupted data (credible inaccurate data) causes CD&R tool to propose inadequate resolution strategy Corrupted data (credible inaccurate data) causes CD&R tool to fail to provide a resolution strategy Non availability of required data (ADS-C/EPP) due to legacy aircraft	▪ If the conflict is within pre-tactical horizon, then it evolves into planned tactical conflict to be solved by TC, increasing TC's workload ▪ If the conflict is within tactical horizon, the planned tactical conflict evolves into imminent infringement ▪ Inadequate resolution strategy may create knock on effect increasing ATCO's workload

4.1.2.2 Safety Requirements; description and rationale

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0001
Title	Data Verification
Requirement	The data received through ADS-C and other external sources (MET provider data) shall only be used once verified and checked for timeliness, accuracy, completeness and consistency.
Status	<validated>

Rationale	Hz#01 Hz#02 Reliance on technical systems in trajectory prediction and conflict detection and resolution tasks requires that the data presented to and used by the controller in performing their tasks is accurate. If the controller is not able to rely on the data without additional verifications the performance benefits related to controller workload reduction are negated and workload may even increase as compared to the baseline. A principle of "figure of merit" can be attached to the data provided by external sources. EXE-009 DFS
Category	< Functionality >< Performance> <Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0002
Title	Nuisance Alerts
Requirement	The rate of nuisance alerts shall be reduced as compared to the current operating method.
Status	<validated>

Rationale	Hz#01 Hz#04 The Solution is expected to improve the accuracy of the Trajectory Prediction (TP) function as a result of downlinked data from the aircraft (e.g. ADS-C) and higher fidelity meteorological information. The improved performance is expected to allow improved and more accurate conflict detection parameters, resulting in a reduction of “false-positives” – or nuisance alerts. As a result, the controller workload related to identifying and managing nuisance alerts is expected to be reduced. Feedback EXE-008 (BULATSA): Although the level of "false positive" conflicts wasn’t measured explicitly, the positive results for workload, situational awareness, etc, together with the ATCOs’ positive feedback indicate that the number of such events was reduced. Validated by EXE-012 (Skyguide)
Category	< Functionality >< Performance><Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0003
Title	Impact of Resolution on Other Aircraft
Requirement	The controller shall have the capability of resolving a conflict without creating new conflicts.
Status	<validated>
Rationale	Hz#02 Hz#04 In order to reduce the controller workload the improved CD/R tools should not create additional conflicts (knock-on effect) which may negate the benefits gained from the improved performance. The conflict resolution proposed by the CD/R tool shall be holistic, taking into consideration other possible conflicting trajectories. This can take the form of what-if and what-else.
Category	< Functionality >< Performance><Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0004
Title	Detection of True Conflicts
Requirement	The enhanced TP shall contribute to the CD/R tool detecting true conflicts with a greater accuracy than the current TP and CD/R tools.
Status	<validated>
Rationale	Hz#03 The benefit of an enhanced CD/R tool should be measurable in both the reduced number of nuisance alerts as well as improved detection of true conflicts.
Category	< Functionality >< Performance><Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0005
Title	Aircraft Equipage
Requirement	Where the controller's separation process is adapted according to aircraft ADS-C equipage, the availability of ADS-C data related to a specific flight (aircraft equipage) shall be displayed to the controller in an unambiguous manner.
Status	<validated>
Rationale	Hz#04 SRS-102 CD/R relies on aircraft intent received using ADS-C (downlinked speed, trajectory) and the improvement of the wind model. However, in a mixed mode environment, not all aircraft may be equipped with ADS-C. Therefore, if the controller's separation process is adapted to the ADS-C equipage, the controller needs to be aware of the capabilities associated with the CD/R function for such flights to avoid over-reliance on the CD/R capabilities when they cannot be accommodated by aircraft equipage. EXE-009 (DFS). EXE-012 (Skyguide): implemented through the use of ADS-C equipage and a figure of merit displayed to the controller.

Category	< Functionality >< Performance><Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0006
Title	Non-equipped Aircraft
Requirement	When legacy aircraft (non- ADS-C/EPP -equipped) are participating in a conflict detection and resolution event, the ATM system shall use existing CD/R tool capabilities and parameters.
Status	<Validated>
Rationale	Hz#04 SRS-102 In a mixed mode environment, the ATM system should support conflict detection and resolution for both ADS-C/EPP equipped and non-equipped aircraft and provide conflict detection alerts and resolution strategy based on the capabilities of the CD/R tool supporting non-equipped aircraft to ensure that separation is maintained. EXE-008 (BULATSA) EXE-012 (Skyguide)
Category	< Functionality >< Performance><Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0007
Title	Contingency procedures for improved TP failure
Requirement	Contingency procedures should be in place for transition to conventional TP and CD/R tools in case of improved TP failure or lack of data (ADS-C/EPP).
Status	<Validated>
Rationale	Lack of EPP data
Category	<Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0008
Title	Contingency procedures for corrupted data
Requirement	Contingency procedures should be in place for transition to the conventional TP and CD/R tools in case corrupted data is received.
Status	<Validated>
Rationale	Corruption of EPP data
Category	<Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0009
Title	CD/R tool reversion
Requirement	TP and CD/R tools shall dynamically revert to "conventional" functioning mode (management of flight data without ADS-C/EPP) and use FDP based TP functions as an input.
Status	<Validated>
Rationale	Corruption of EPP data
Category	<Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0010
Title	ATCO notification for reverting
Requirement	ATCOs shall be informed with the appropriate notification (system reverting to reference scenario TP and CD/R tools performance).
Status	<Validated>
Rationale	Corruption of EPP data

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Category	<Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0011
Title	Conflict detection confidence level
Requirement	The information about the conflict detection quality assessment (figure of merit) should be available to ATCOs, allowing them to adapt their strategies and approach according to it, if deemed necessary.
Status	<Validated>
Rationale	SRS-103
Category	<Safety>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SAF1.0012
Title	Frequency of failure
Requirement	The frequency of failure of CD/R tools due to corrupted ADS-C/EPP data shall not be greater than 3.33E-04 .
Status	<In progress>
Rationale	SRS-104 SRS-105 SRS-106 SRS-107
Category	<Safety>

4.1.3 Security Requirements

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SEC1.0001
Title	ADS-C Data Integrity

Requirement	The ATS Unit shall verify and ensure the integrity of received ADS-C data.
Status	<in progress>
Rationale	The information used by ATC has to be trustable.
Category	<Security>

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-SEC1.0002
Title	ADS-C Data Protection
Requirement	The ATS Unit shall ensure that received ADS-C information is only distributed to external agencies that are authorised to receive it.
Status	<in progress>
Rationale	The required level of confidentiality of ADS-C information must be ensured.
Category	<Security>

4.1.4 Performance Requirements

4.1.4.1 Conflict Detection QoS

This section describes performance requirements that are considered applicable to both the PC-Aid and TC-aid, though the specific values and parameters (e.g. warning time) would be tailored for the specific user.

These requirements are driven from the Benefits and Impact Mechanism (BIM) given in Appendix A of this document. The BIM describes two system changes resulting from improved TP accuracy, which can be summarized as follows:

a) Borderline encounters are more accurately identified either as potential conflicts or non-conflicts, which allows more efficient management and monitoring of potential conflicts, and perhaps a reduction in the number of “unnecessary” resolutions;

b) An increase in the potential to detect true conflicts (i.e. where controller action is required), which will allow resolution actions to be performed earlier.

These features are addressed characterized by two distinct qualities that are described below as the system tuning envelope and the system dynamic range. These qualities are considered relevant from an operational concept point-of-view as their impact on working method and procedures can be identified. However, from a system point-of-view, this quality of service ultimately is achieved if the TP meets given performance requirements, which has the advantage of being more readily measurable/testable. For this reason, underlying TP performance requirements are also provided.

It is important to note that these requirements make frequent reference to assumptions that the flights proceed in conformance with the flight intent, as known to the ground system, and no further ATC instructions are given that change the flight intent within the given prediction horizon. To attempt to fulfil these assumptions, the prediction time is normally adapted in function of the expected frequency of tactical instructions (typically higher frequency and therefore shorter prediction time in lower sectors and TMA). However, the requirements nevertheless describe a potential level of performance which, in reality, will never be fully met and "reliability of the trajectory" is therefore considered one of the factors that the controller must judge when analysing a potential conflict.

4.1.4.1.1 System Tuning Envelope

If limits are defined denoting "safe" and "unsafe" separation, a notification of an encounter can be termed "desired" if, in the absence of controller intervention, the resulting separation would be less than the safe limit; if a "desired" encounter is not notified, it is termed "missed". The converse is an encounter where, in the absence of controller intervention, the separation would be greater than the safe limit; a notification of this encounter would be termed a "nuisance".

Note that these separation limits are not expected be larger than the radar separation minima; procedures often require the controller to positively assure separation even where the trajectories appear to be nominally separated. Note also that these definitions of "missed" and "nuisance" encompass only aspects of prediction algorithm accuracy and are distinct from notifications that could be termed "false" that result from incorrect input parameters or logic – e.g. incorrect exit level entered or incorrect application of filters.

Uncertainty can be represented as a prediction error in the trajectories that can be approximated as a statistical distribution. This then allows the probability of an encounter being safe or unsafe to be calculated and, by implication, the probability that a conflict notification is desired or a nuisance.

To take into account the uncertainty in the trajectory, conflict detection tools can be tuned by means such as a separation buffer or conflict probability threshold; a large buffer will result in few desired notifications being missed, but will generate many nuisance notifications. Thus a tuning envelope can be derived, defining the range of performance with a given TP error, as shown for four TP error values (e.g. for different time horizons) in the figure below.

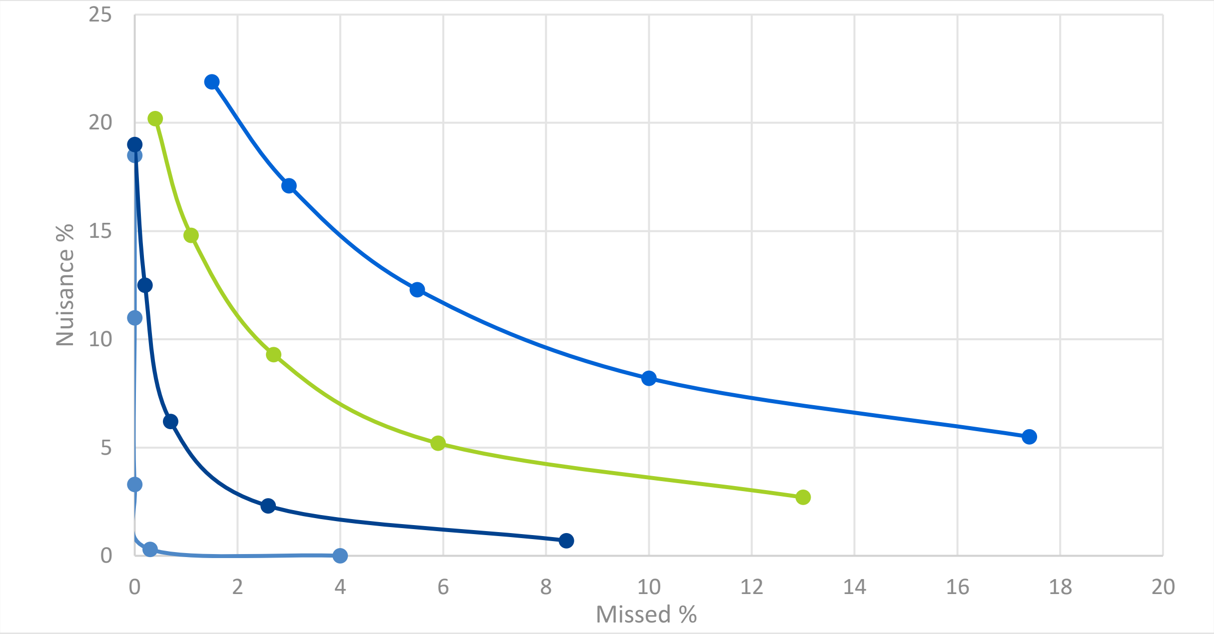

Figure 6: Conflict Detection Tuning Envelope

The tuning of CD/R parameters is essentially a trade-off between providing adequate warning time for the proper management of conflicts and avoiding cluttering the display with too much unreliable and unstable information. However, experience shows that controller confidence in the CD/R tool is diminished if its detection of potential conflicts does not match their own, leading them to believe them the CD/R tools is not functioning correctly - see P04.07.02-D21 Validation Report (ref [28]).

[REQ]

Identifier	REQ-10.02a-SPRINTEROP-UU01.3100
Title	System Tuning Envelope
Requirement	The parameters governing the notification of potential conflicts shall be tuned such that missed and nuisance notifications at given prediction times meets locally-defined values, given the following assumptions: • the input data are reliable; • aircraft data (trajectory, speed schedule, mass, performance, etc) is downlinked via ADS-C; • no unexpected aircraft manoeuvre will occur in the time horizon.
Status	<validated>

Rationale	The achievable values for the trade-off between missed alerts and nuisance alerts will be known once the trajectory accuracy is known. It is expected that the “locally-defined values” mentioned in the requirement will represent a performance improvement compared to the reference. 1/ The warning horizon, definition of safe separation and the required nuisance and missed parameters are defined according to local working method and procedures 2/ Operationally desired accuracy of MET data is given in Attachment B of ref [19]. 3/ assuming no unexpected manoeuvre means that the conflictual situations in the period can be initially detected. EXE-010 MUAC – Analysis of error in vertical rate with and without the use of EPP. Analysis of time at Initial Approach Fix with and without improved meteorological data. EXE-011 PANSA – Analysis of error in vertical rate with and without the use of EPP. EXE-012 Skyguide – Analysis of error in position, time, flight level and TAS with and without the use of EPP. EXE-007 CRIDA – Analysis of TP errors with and without EPP. Validation of Tuning Envelope graph[5].
Category	Performance

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.18-W2-53B
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-01
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-02
<ALLOCATED_TO>	<Activity>	Assess planned/desired profile for problems within AoR/AoI
<ALLOCATED_TO>	<Activity>	Determine planning problems at offered entry conditions

[5] EXE-007 was performed in the scope of solution PJ.18-W2-53A.

<ALLOCATED_TO>	<Role>	ATC Sector Executive Controller
<ALLOCATED_TO>	<Role>	ATC Sector Planning Controller
<ALLOCATED_TO>	<Sub-Operating Environment>	En-Route
<ALLOCATED_TO>	<Sub-Operating Environment>	Terminal Airspace

4.1.4.1.2 Dynamic Range

An element of “added value” described in ref [18] is the classification of encounters according to severity, which is used by the controller in assessing encounters and prioritising the resolution of potential conflicts. An aim of the encounter classification is to distinguish those encounters that have a high probability of developing into conflicts, which should therefore be actioned with priority, from those with greater uncertainty, for which it might be more efficient to let run.

To support this notion of classification, another way to consider the performance of the CD/R tool is in the relation between the calculated (predicted) nominal separation of an encounter and the probability that the “unsafe” separation limit would be breached if no intervention were made. In this context, the dynamic range can be considered as the rates at which the conflict probability decreases as the predicted minimum separation increases, as shown in Figure 7. The very shallow line shows a poorly performing CD/R tool with low dynamic range, where the prediction error distribution is such that very little certainty can be derived from encounter. At the other extreme, a highly performant CD/R tool is characterized by a large dynamic range, demonstrated by the steep curve.

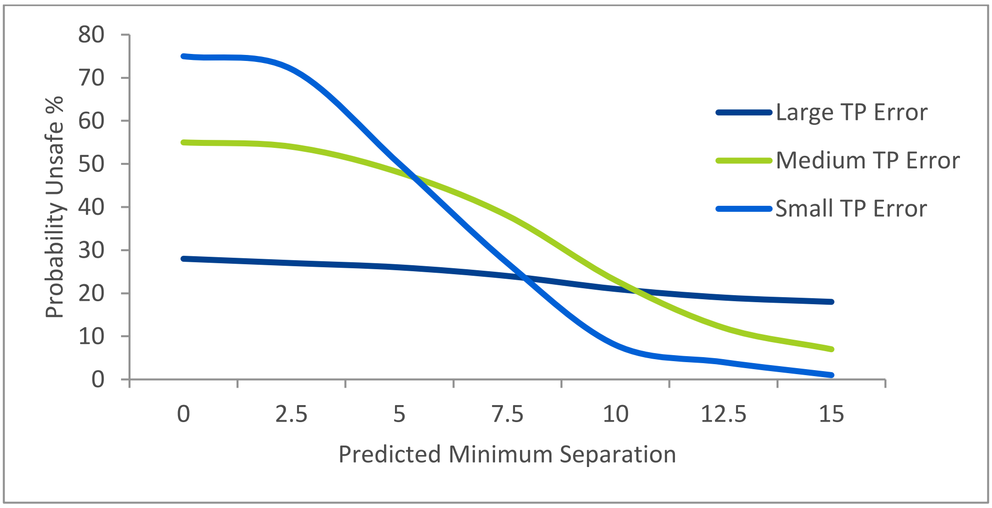

Figure 7: Probability Unsafe With Given Predicted Minimum Separation

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-UU01-3110

Title	System Dynamic Range
Requirement	The dynamic range of probability that encounters result in separation less than a given “safe” separation at given prediction horizons shall meet locally-defined criteria, given the following assumptions: • the input data are reliable; • aircraft data (trajectory, speed schedule, mass, performance, etc) is downlinked via ADS-C; • no unexpected ATC aircraft manoeuvres will occur in the time horizon.
Status	<validated>

Rationale	The dynamic range defines the ability to distinguish high probability conflicts from low-probability conflicts. Where the system calculates a nominal minimum separation, the dynamic range may be the differential of conflict probability with increasing nominal separation. It is expected that the “locally-defined criteria” mentioned in the requirement will represent a performance improvement compared to the reference. 1/ The time horizon, definition of safe separation and the required nuisance and missed parameters are defined according to local working method and procedures 2/ Operationally desired accuracy of MET data is given in Attachment B of ref [19]. 3/ assuming no unexpected ATC action means that the conflictual situations in the period can be initially detected. EXE-010 MUAC – Analysis of error in vertical rate with and without the use of EPP. Analysis of time at Initial Approach Fix with and without improved meteorological data. EXE-011 PANSA – Analysis of error in vertical rate with and without the use of EPP. EXE-012 Skyguide – Analysis of error in position, time, flight level and TAS with and without the use of EPP. EXE-007 CRIDA – Analysis of TP errors with and without EPP. Validation of Dynamic Range graph.[6]
Category	Performance

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.18-W2-53B
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-01
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-02

[6] EXE-007 was performed in the scope of solution PJ.18-W2-53A.

<ALLOCATED_TO>	<Activity>	Assess planned/desired profile for problems within AoR/AoI
<ALLOCATED_TO>	<Activity>	Determine planning problems at offered entry conditions
<ALLOCATED_TO>	<Role>	ATC Sector Executive Controller
<ALLOCATED_TO>	<Role>	ATC Sector Planning Controller
<ALLOCATED_TO>	<Sub-Operating Environment>	En-Route
<ALLOCATED_TO>	<Sub-Operating Environment>	Terminal Airspace

4.1.4.2 Trajectory Prediction Performance

Trajectory prediction performance is described here not as operational requirements but as targets by which the conflict detection QoS can be validated. In this version of the document, baseline targets are specified. These will be updated in the final version with validated targets with different improvement techniques applied (e.g. ADS-C, improved MET, etc.).

The process for measuring TP accuracy is described in the EUROCONTROL Specification of Trajectory Prediction (ref [23]) based on the following principles:

- The performance of the TP is evaluated by means of a statistical analysis on a large sample of data in order to reduce the effect of individual anomalies, quantifying accuracy by means of a number of KPIs.
- The measurement of trajectory accuracy is performed by comparing truth data, in the form of radar tracks, with calculated and updated trajectories.
- Portions of flights are selected where the flight is cleared, and the aircraft operated, in accordance with the flight intent as described by the functional requirements.
- Performance is specified for three basic metrics (longitudinal, lateral and vertical accuracy), applicable to both the planned and tactical trajectories, and specializing these with various conditions under which they are measured.

Three components of accuracy are identified corresponding to the longitudinal and vertical dimensions, and these are further specialised under level flight, climb and descent. The TP is expected to make use of certain information such as meteorological conditions, track state vectors, etc., for which a given level of accuracy is assumed.

The derivation of signed mean error indicates any bias present in the trajectory calculation. The standard deviation of the error indicates the spread of the error and can be used to calculate the limits of an aircraft position at a given moment in time with a given probability. The peak error might indicate an incorrect logic or aircraft model, or the deviation of the aircraft from the flight intent.

Initial values of TP accuracy had been obtained from measurements taken from various operational systems by EUROCONTROL. These have now been superseded by measurements taken in PJ.18-W2-53B exercises. Note also that PJ.31 DIGITS has also produced figures of accuracy of the downlinked EPP. Notable in this respect are:

- Longitudinal error of 0.03 NM/min at 2 standard deviations for flights in full managed mode;
- Vertical error standard deviation of 80 feet/min (measured for a 12 minute prediction).

Assumptions are made on the accuracy of input data to the TP function as specified in the table below:

Meteorological Conditions[7]	**Peak Error**
Wind vector error	7 knots
Temperature error	2^0 C
Track State Vector[8]	
Position error when in uniform motion	120m
Along-track speed error when in uniform motion	1.5 m/sec

Table 11: Input Metrics

4.1.4.2.1 Longitudinal Accuracy

Longitudinal error represents the difference between the estimated progress at a point in time determined from the trajectory and the actual progress determined by the system track. Measurements are taken at fixed intervals over a defined period for aircraft in cruise, climb and descent phases. In all cases, the measurements are taken only when the aircraft is in conformance with the flight intent for the duration of the measurement period.

Longitudinal Prediction Error (NM per minute of prediction)	Magnitude of Mean	Standard deviation
Cruise phase (FL200 – FL299)	0.1 NM/min	0.2 NM/min
Cruise phase (FL300 – FL600)	0.1 NM/min	0.2 NM/min
Climb phase (FL200 – FL299)	0.2 NM/min	0.6 NM/min
Climb phase (FL300 – FL600)	0.2 NM/min	0.4 NM/min
Descent phase (FL200 – FL299)	0.2 NM/min	0.6 NM/min
Descent phase (FL300 – FL600)	0.2 NM/min	0.6 NM/min

Table 12: Longitudinal Prediction Error[9]

4.1.4.2.2 Vertical Accuracy

Vertical error is measured in terms of the difference between the estimated vertical position at a moment in time as determined from the trajectory and the actual vertical position of the aircraft at

[7] Peak meteorological errors have been chosen such that they encompass achievable forecast values as documented in the EATMP - Met Data in ATM – Final Report.

[8] Values taken from the Radar Surveillance Standard for En-Route and Major Terminal Areas, Table 7A – Accuracy requirements En-Route assuming dual SSR coverage.

[9] This longitudinal prediction error is assumed to grow linearly in the covered prediction horizon which is 20 minutes in cruise phase and 10 minutes in climb/descent phases.

that moment in time, and is a result of the vertical rate used by the trajectory prediction differing to the actual vertical rate.

As with longitudinal error, measurements are taken at fixed intervals over a defined measurement horizon. Measurement points are taken at FL 250 and FL 300, with measurements starting only once the aircraft has a continuous climb/descent through the measured level. Note that this does not necessarily imply that the aircraft need be cleared immediately through the measured level, providing that subsequent clearances are issued in sufficient time that the vertical rate has not reduced for stopping at an intermediate level.

Vertical Prediction Error (feet per minute of prediction)	Magnitude of Mean	Standard deviation
Climb phase (FL200 – FL299)	100 feet/min	300 feet/min
Climb phase (FL300 – FL600)	100 feet/min	200 feet/min
Descent phase (FL200 – FL299)	100 feet/min	300 feet/min
Descent phase (FL300 – FL600)	100 feet/min	200 feet/min

Table 13: Vertical Prediction Error

4.1.5 Interoperability Requirements

[REQ]

Identifier	REQ-18-W2-53B-SPRINTEROP-UU01.4010
Title	ADS-C Data Exchange
Requirement	An ATSU shall receive trajectory data from the aircraft using data link.
Status	<validated>
Rationale	Previously REQ-10.02a2-SPRINTEROP-IOP0.0002. Having aircraft downloaded data such as ADS-C EPP reports can be used to compute a more accurate trajectory and therefore improve conflict detection tools. The capability comprises the following: • Set up an ADS-C Contract with an ADS-C Equipped A/C • Specify the TMR (Trajectory Management Requirements) • Receive and process the related ADS-C reports, including the EPP Corresponding interoperability requirements are defined in ref [21]. EXE-008 BULATSA/Airbus EXE-009 DFS EXE-010 MUAC EXE-011 PANSA EXE-012 Skyguide (TMR requirements not used).
Category	< IER >

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ.18-W2-53B
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-01
<SATISFIES>	<High Level Operational Requirement>	S53B-HLOR-02
<ALLOCATED_TO>	<Information Flow>	Execute ATC clearance o--> Modify trajectory
<ALLOCATED_TO>	<Information Flow>	Execute ATC clearance o--> Determine planning problems at offered entry conditions
<ALLOCATED_TO>	<Role>	ATC Sector Planning Controller
<ALLOCATED_TO>	<Role>	Executive Controller
<ALLOCATED_TO>	<Sub-Operating Environment>	En-Route
<ALLOCATED_TO>	<Sub-Operating Environment>	TMA
<ALLOCATED_TO>	<Activity View>	Provide Planning Separation Assurance
<ALLOCATED_TO>	<Activity View>	Provide Tactical Separation Assurance

5 References and Applicable Documents

5.1 Applicable Documents

Content Integration

[1] EATMA Guidance Material 2019

[2] EATMA Community Pages

[3] SESAR ATM Lexicon

Content Development

[4] Concept of Operations, 2019

System and Service Development

N/A

Performance Management

[5] Performance Framework 2019

[6] Guidance for Producing Benefit and Impact Mechanisms, 2014

Validation

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

[8] Validation Targets 2019

System Engineering

[9] Requirements and V&V Guidelines, 2020

Safety

[10] Safety Reference Material, 2018

[11]Guidance to Apply the Safety Reference Material, 2018

Human Performance

[12]Human Performance – Guidance Reference Material, 2020

Environment Assessment

N/A

Security

N/A

5.2 Reference Documents

[13]European Route Network Improvement Plan (ERNIP), Part 1, European Airspace Design Methodology Guidelines - General principles and technical specifications for airspace design, Edition 1.6, June 2016

[14]ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[10]

[15]Guidance Material for Human Performance Automation Support, SESAR Joint Undertaking Project 16.05.01, Deliverable D04, Luca Save et.al., Brussels, February 2013

[16]JAA TGL6 Administrative and Guidance Material "Guidance Material on the Approval of Aircraft and Operators for Flight in Airspace above Flight Level 290 where a 300M (1,000 ft) Vertical Separation Minimum is applied

[17]SESAR 2020 Requirements and Validation Guidelines, Edition 00.02.01, 1 May 2020.

[18]SESAR Solution PJ.10-02a SPR/INTEROP/OSED for V3, Edition 00.01.03, 7 November 2019

[19]ICAO Annex 3, Meteorological Service for International Air Navigation

[20]EUROCAE Safety and Performance Requirements Standard for Baseline 2 ATS Data Communications, ED-228A

[21]EUROCAE Interoperability Requirements Standard for Baseline 2 ATS Data Communications, ED-229A

[22]ICAO Procedures for Air Navigation Services Air Traffic Management, PANS-ATM Doc. 4444

[23]EUROCONTROL Specification of Trajectory Prediction, Edition 2.0, 3 March 2017

[24] D2.2.105 SESAR Solution 53B VALR for V3 (Draft)

[25] D2.2.004 SESAR Solution 53B Validation Plan for V3 Part I ed. 02_00_00

[26]SESAR High Level Operational Requirements for Wave 2 Solutions. PJ.19 D2.0.002.

[27]SESAR Solution PJ.10-02b SPR/INTEROP/OSED for V1, Edition 00.01.01, 2 August 2018

[10] The EUROCAE ED-78A has been used as an initial guidance material. ED-78A is useful, but is not an applicable document, because it mostly addresses the V4-V5 phases, whilst the SESAR R&D programme is focussed on development (V1-V2-V3, and because of its partial compliance with safety regulatory requirements).

[28] SESAR P04.07.02-D21 Validation Report

Appendix A Cost and Benefit Mechanisms

A.1 Stakeholders identification and Expectations

This section describes the stakeholders involved in PJ.18-W2-53B:

Stakeholder	Involvement	Why it matters to stakeholder
ANSP	Direct: Through the participation in SESAR 2020 as Partners. Indirect: Not all European ANSP are involved but they will be impacted by SESAR 2020. To provide KPIs to monitoring performance	• Expect to optimise the airspace throughput through a reduction of the ATCO workload, without too many trajectory changes. • Expect to increase the capacity and predictability with accurate trajectories • Expect to improve cost efficiency through a reduction of false conflicts. • Improved cost efficiency by a reduction of unnecessary interactions and trajectory changes. • Expect to maintain or increase the level of safety with a reduction in the number of conflicts. • Expect to increase the adherence of the trajectory to Airspace Users' preferences taking into account their priorities. • Expect to gain ATCO situational awareness through a good conflict detection performance (nuisance alerts and accuracy) • Expect to improve quality of service taking into account the ATCO considerations. • Expect to obtain evidence of the feasibility of the Separation Management whilst considering the AUs preferences. • Be alerted as soon as possible of pre-tactical, planned tactical and ATCO induced tactical conflicts to improve conflict management.

Airspace User: Airlines, Business aviation	Direct To provide background information influencing flight operations Consideration of aircraft intent (pilot) for generating likely trajectories updating information. To provide KPIs to monitoring performance Indirect: Performs all the on-board AU operations including a flight execution according to a planned trajectory, compliance to ATC instructions, etc.	• Expect to reduce the fuel burn by means of fewer unnecessary trajectory changes • Expect to decrease Pilot workload by reducing the number of unnecessary interactions. • More alignment between trajectory and separation management will ease following the airline policies with regard to fuel consumption. • More alignment between trajectory and separation management will prevent the ATC to issue penalising or unfeasible clearances.
SESAR Join Undertaking (SJU)	Direct involvement through leadership in SESAR 2020	• Ensure the concept definition and validation activities comply with the general SJU approach. • Expect to gather evidence of the positive, negative or neutral benefits obtained with the concept. • Expect to gather evidence that support the achievements obtained with the validation of the concept.

Table 14: Stakeholder's expectations for solution PJ.18-W2-53B

A.2 Benefits mechanisms

This chapter provides description of the benefit mechanisms for the different operational improvements considered within PJ.18-W2-53B. The following Legend describes the meaning of the symbols reported in the Benefit and Impact Mechanism:

Column Title	Box Shape	Column Description
Feature	Feature	Introduces one of the new features that the project is bringing to the world of ATM
Impact Area	Impact Area A	Sub categories used to group indicators and positive/negative impacts to help orient the reader (may not always be necessary)
Indicators	Indicator A	Aspects which can be measured (or calculated from other metrics) to identify if the expected positive and negative impacts are actually realised. These need to be measured in the validation exercises
Positive or Negative Impacts	Impact 1	Describes the expected positive or negative impacts
KPA	KPA 1	KPAs linked to the positive or negative impacts

Table 15: Benefit Mechanism Syntax – Columns

The boxes in these columns are linked by numbered arrows, which represent the mechanisms.

1	The numbers provide links to the mechanism descriptions in the text.

Table 16: Benefit Mechanism Syntax – Mechanisms

The arrows associated with the Indicators and the Positive or Negative Impacts are:

	A beneficial decrease e.g. a reduction in CO_2 emissions (indicator) or a reduction in controller workload (positive impact)
	A detrimental increase e.g. an increase in CO_2 emissions (indicator) or an increase in controller workload (negative impact)
	A beneficial increase e.g. an increase in no. of movements (indicator) or an increase in safety (positive impact)
	A detrimental decrease e.g. a reduction in no. of movements (indicator) or a reduction in safety (negative impact)
	A change in the indicator, a positive or negative impact is expected but with current knowledge the direction is still not clear. Can be coloured to show the main expectation. It is preferable to use a direction arrow, however this is provided as a 'last resort', for example where input from a TA expert is required.

Table 17: Benefit Mechanism Syntax – Coloured Arrows

A.2.1 Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in en-route predefined and user preferred routes environments - CM-0209-b

Description

Controller's separation management tasks are improved by having a more reliable identification of potential conflicts, allowing earlier decision-making and reducing the time spent analysing and monitoring low probability [false] conflicts. Increased reliability in conflict detection and resolution is achieved through the use of aircraft derived data (including A/C trajectory data as defined in ATS B2 standards) and a high-resolution wind model, to reduce the uncertainty in the prediction of the trajectory.

Stakeholder – Air Navigation Service Provider

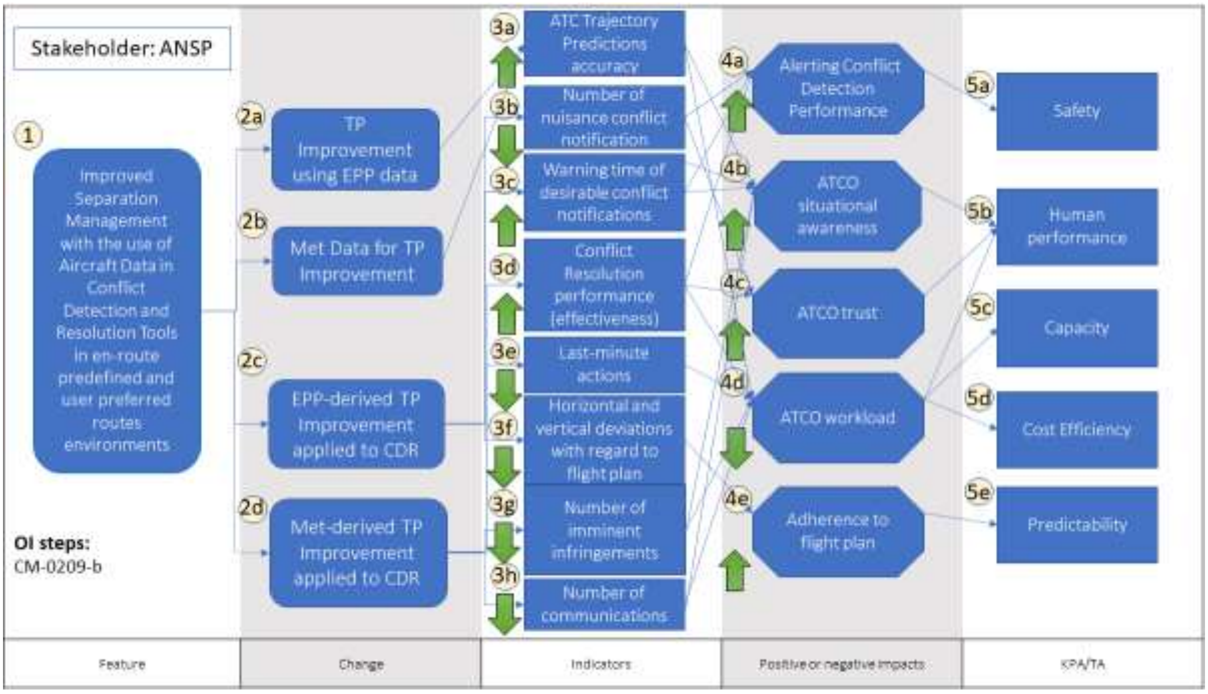

Figure 8: BIM_CM-0209-b- ANSP

Feature:

(1) Improved performance of tactical CD/R tools using Airborne Data in en-Route: The performance of the CD/R tool will be improved thanks to the introduction of EPP data and Meteo into the TP and CDR supporting tools. Consequently, these will be improved to solve conflicts by proposing new and better solutions.

Changes:

(2.a) TP improvement using EPP data: The introduction of the EPP into the TP will enhance its performance, as it will provide better awareness about the flight and aircraft intent.

(2.b) Met Data for TP improvement: The introduction of meteo data enables the enhancement of the prediction with increased look ahead times.

(2.c) EPP-derived TP improvement applied to CD/R: The reduced uncertainty in the TP is expected to improve the usability of existing CD/R tools.

(2.d) Met-derived TP improvement applied to CD/R: The application of the enhancements of the predictions due to the introduction of meteo data is expected to improve the usability of the existing CD/R tools.

Indicators:

(3.a) ATC trajectory predictions accuracy: The TP accuracy (Horizontal and Vertical) can be defined as a function of the look-ahead time. The indicator reflects the improvement brought by the new features.

(3. b) Number of nuisance conflict notifications: See Section [reference to 4.1.3.2.1]. If limits are defined denoting "safe" and "unsafe" separation, a notification of an encounter can be termed "desired" if, in the absence of controller intervention, the resulting separation would be less than the safe limit; if a "desired" encounter is not notified, it is termed "missed". The converse is an encounter where, in the absence of controller intervention, the separation would be greater than the safe limit; a notification of this encounter would be termed a "nuisance".

(3. c) Warning time of desirable conflict notifications: The indicator reflects when the tool provides a conflict notification with enough integrity about it (i.e. it considers the conflict warning to be desirable and it is not termed as "nuisance").

(3. d) Conflict resolution performance (effectiveness): The effectiveness of a conflict resolution tool is associated with feasible and efficient support in conflict resolution and can be measured not only by the adherence of the proposed instruction with the one applied by the ATCO to solve the detected conflict (objective evaluation), but also by the ATCO's consideration of the proposed instruction in the construction of the resolution of the conflict (subjective evaluation).

(3. e) Last-minute actions: It is also expected that the improved conflict resolution will provide more effective assistance to the ATCOs, thereby allowing earlier decision making and reducing last-minute actions to maintain/restore separation. The indicator considers the time prior the conflict for the initial ATCO clearance to resolve an unsafe predicted separation. It is an objective indicator, subject to a provision of the boundaries to consider "Last-minute" or "timely" actions.

(3. f) Horizontal and vertical deviations with regard to flight plan: The indicator reflects the En-Route Horizontal and Vertical Deviations, as defined by the SESAR Performance Framework 2019 (see EFF1, KEP and KEA definitions of PRU).

(3.g) Number of imminent infringements: Improved conflict resolution performance and consequent decrease of probing activities by the ATCO will allow earlier decision making and reducing the time to maintain/restore separation.

In the absence of a clearance, an "unsafe" situation can develop into a separation infringement. The indicator parallels (3.e), and it will clearly define the boundary for what is considered "imminent".

(3.h) Number of communications: The number of communications can be measured as:

1. The absolute number of communications for given scenario.
2. The number of communications per aircraft for a given scenario.
3. The number of communications required to solve effectively a predicted unsafe situation.

The trajectory predictor will propose a solution considering the different options and possible induced conflicts, so the controller just need to indicate to the pilot what to do in that moment. The number of communications will be reduced because there will not be any imminent conflict which requires a lot of coordination about controllers and pilots and also, that actions will not increment the number of induced conflicts.

Positive and negative impacts:

(4. a) Alerting conflict detection performance: There will in an increase in the performance due to the use of EPP and Meteo dat.

(4. b) ATCO situational awareness: The ATCO will be assisted by more effective CD/R Tools that will improve her/his awareness of conflicts and provide resolutions strategies assisting controller in the conflict management and avoiding last-minute actions to restore/maintain separation.

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(4.c) ATCO trust: Associated with feasible and efficient support in conflict detection and resolution (i.e. less nuisance conflict alerts and proposed resolution is the one applied by the ATCO to solve the conflict or has been taken into consideration by the ATCO in the construction of the conflict resolution).

(4.d) ATCO workload: Increasing the effectiveness of the conflict detection and resolution tool, there will be a reduction of ATCO workload because the alerts and resolution proposals will be optimised and accurate.

(4.e) Adherence to flight plan: The adherence to the Flight Plan is increased due to fewer trajectory changes due to unnecessary interactions.

Key Performance Areas:

(5. a) Safety: More effective conflict resolution notifications and the improved awareness of ATCO for resolution of conflicting strategies might contribute to more efficient conflict management, with the consequent safety benefits.

(5. b) Human performance: ATCO workload and Situational Awareness benefits might impact on an ATCO successful and smooth accomplishment of tasks and duties, with positive effect on Human Performance.

(5. c) Capacity : A reduction of ATCO workload can translate to an increment in the number of flights per controller, increasing the airspace capacity.

(5. d) Cost efficiency: The reduction of ATCO workload can improve ATCO productivity and thus possibly increasing the number of flights per ATCO hours on duty (G2G ANS Cost Efficiency)

(5. e) Predictability: A more reliable and accurate trajectory prediction can lead to solve conflicts earlier, which can have a positive impact in predictability as fewer deviations from the planned profile are expected.

Stakeholder – Airspace User

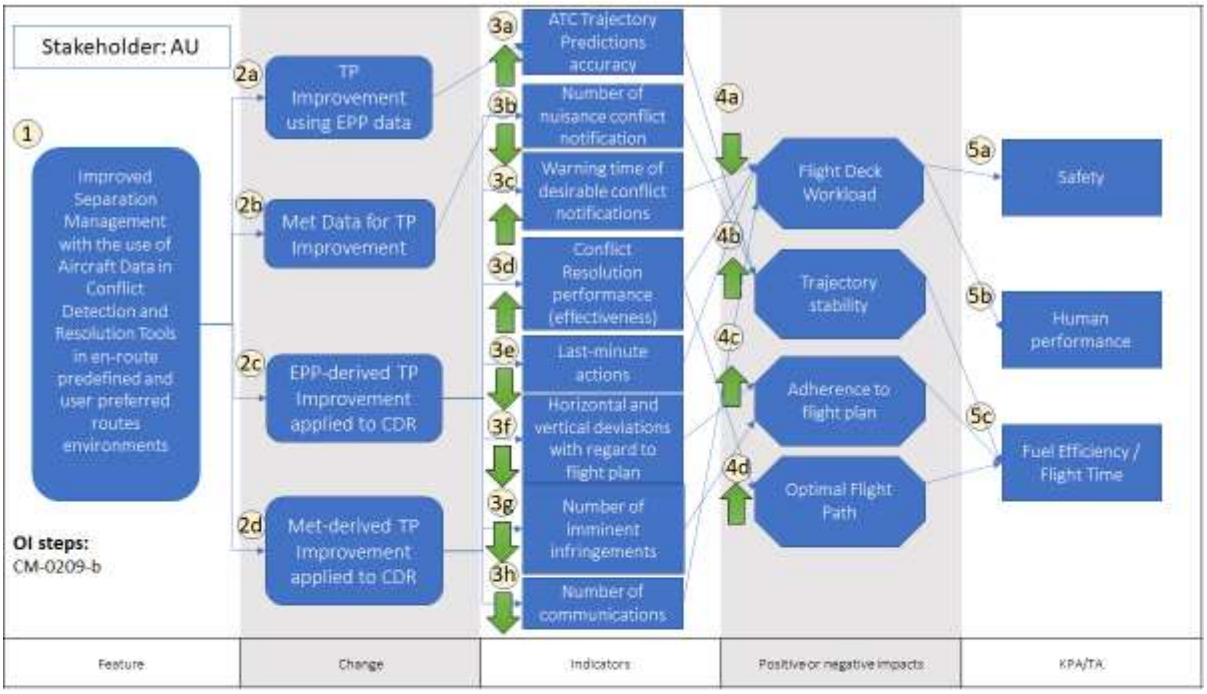

Figure 9: BIM_CM-0209-b- AU

Feature

(1) Improved performance of tactical CD/R tools using Airborne Data in en-Route: See above under ANSP.

Changes:

(2.a) TP improvement using EPP data: See above under ANSP.

(2.b) Met Data for TP improvement: See above under ANSP.

(2.c) EPP-derived TP improvement applied to CD/R: See above under ANSP.

(2.d) Met-derived TP improvement applied to CD/R: See above under ANSP.

Indicators:

(3.a) ATC trajectory predictions accuracy: See above under ANSP.

(3. b) Number of nuisance conflict notifications: See above under ANSP.

(3. c) Warning time of desirable conflict notifications: See above under ANSP.

(3. d) Conflict resolution performance (effectiveness): See above under ANSP.

(3. e) Last-minute actions: See above under ANSP.

(3. f) Horizontal and vertical deviations with regard to flight plan: See above under ANSP.

(3.g) Number of imminent infringements: See above under ANSP.

(3.h) Number of communications: See above under ANSP.

Positive and negative impacts:

(4. a) Flight Deck workload: Aircrew workload might be reduced due to the fewer instructions, the use of auto-load, and less A/G communications.

(4. b) Trajectory stability: Conflicts are solved earlier, and therefore, the flown trajectory is more stable than without the change.

(4.c) Adherence to flight plan: The adherence to the Flight Plan is increased due to fewer trajectory changes due to unnecessary interactions.

(4.d) Optimal flight path: An optimal flight will reduce the fuel burned and the flight time.

Key Performance Areas:

(5. a) Safety: The number of induced tactical conflicts would decrease due to the flight-deck workload, thanks to the greater stability of the aircraft trajectories and fewer communications.

(5. b) Human performance: Human performance is improved due to the reduction in aircrew workload and the increased situational awareness of the aircrew.

(5. c) Fuel efficiency/ Flight time: Fuel burn will be reduced as aircraft are less likely to level-off at an intermediate level or to be climb/descend at a non-optimal rate.

A.2.2 Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in the TMA - CM-0212

Description

The controller's separation management tasks are improved by having a more reliable identification of potential conflicts, allowing earlier decision-making and reducing the time spent analysing and monitoring low probability [false] conflicts. Increased reliability in conflict detection and resolution is achieved through the use of aircraft derived data (including A/C trajectory data as defined in ATS B2 standards) and a high-resolution wind model, to reduce the uncertainty in the prediction of the trajectory.

Stakeholder – Air Navigation Service Provider

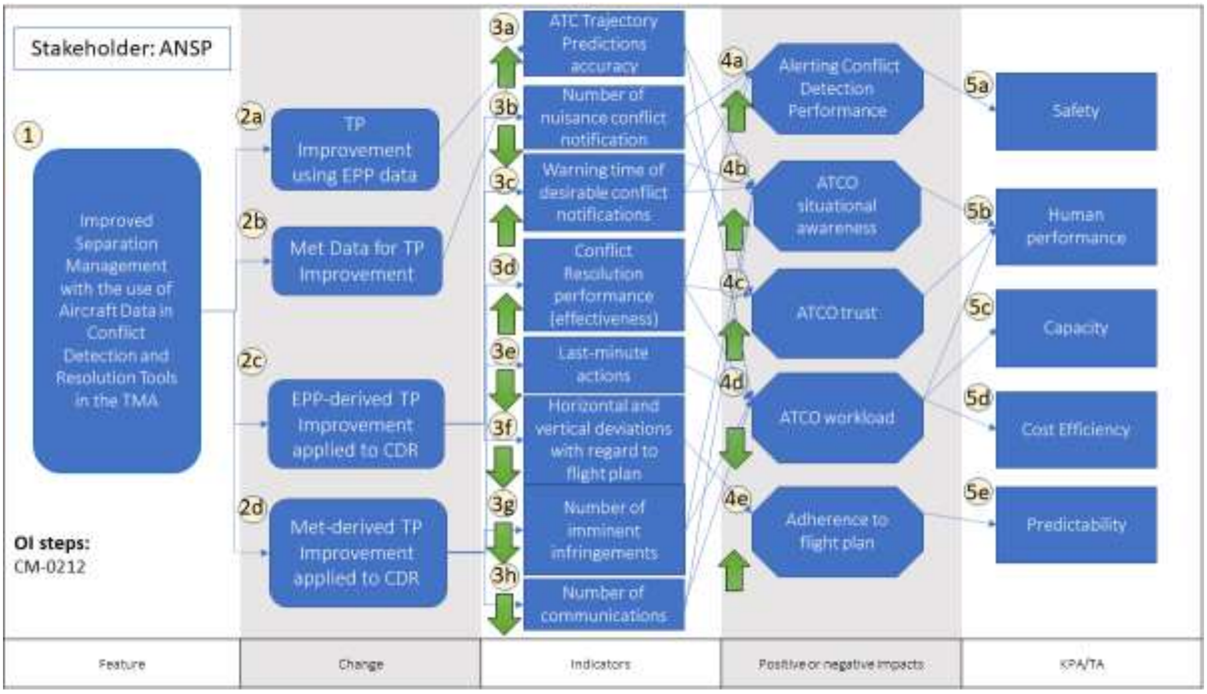

Figure 10: BIM_CM-0212- ANSP

Feature:

(1) Improved performance of tactical CD/R tools using Airborne Data in the TMA: The performance of the CD/R tool will be improved thanks to the introduction of EPP data and Met. As a consequence, the TP will be improved in order to solve tactical conflicts in the TMA and propose new and better solutions.

Changes:

(2.a) TP improvement using EPP data: The introduction of the EPP into the TP will enhance its performance, as it will provide better awareness about the flight and aircraft intent.

(2.b) Met Data for TP improvement: The introduction of meteo data enables the enhancement of the prediction with increased look ahead times.

(2.c) EPP-derived TP improvement applied to CD/R: The reduced uncertainty in the TP is expected to improve the usability of existing CD/R tools.

(2.d) Met-derived TP improvement applied to CD/R: The application of the enhancements of the predictions due to the introduction of meteo data is expected to improve the usability of the existing CD/R tools.

Indicators:

(3.a) ATC trajectory predictions accuracy: The TP accuracy (Horizontal and Vertical) can be defined as a function of the look-ahead time. The indicator reflects the improvement brought by the new features.

(3. b) Number of nuisance conflict notifications: See Section [reference to 4.1.3.2.1]. If limits are defined denoting "safe" and "unsafe" separation, a notification of an encounter can be termed "desired" if, in the absence of controller intervention, the resulting separation would be less than the safe limit; if a "desired" encounter is not notified, it is termed "missed". The converse is an encounter where, in the absence of controller intervention, the separation would be greater than the safe limit; a notification of this encounter would be termed a "nuisance".

(3. c) Warning time of desirable conflict notifications: The indicator reflects when the tool provides a conflict notification with enough integrity about it (i.e. it considers the conflict warning to be desirable and it is not termed as "nuisance").

(3. d) Conflict resolution performance (effectiveness): The effectiveness of a conflict resolution tool is associated with feasible and efficient support in conflict resolution and can be measured not only by the adherence of the proposed instruction with the one applied by the ATCO to solve the detected conflict (objective evaluation), but also by the ATCO's consideration of the proposed instruction in the construction of the resolution of the conflict (subjective evaluation).

(3. e) Last-minute actions: It is also expected that the improved conflict resolution will provide more effective assistance to the ATCOs, thereby allowing earlier decision making and reducing last-minute actions to maintain/restore separation. The indicator considers the time prior the conflict for the initial ATCO clearance to resolve an unsafe predicted separation. It is an objective indicator, subject to a provision of the boundaries to consider "Last-minute" or "timely" actions.

(3. f) Horizontal and vertical deviations with regard to flight plan: The indicator reflects the En-Route Horizontal and Vertical Deviations, as defined by the SESAR Performance Framework 2019 (see EFF1, KEP and KEA definitions of PRU).

(3.g) Number of imminent infringements: Improved conflict resolution performance and consequent decrease of probing activities by the ATCO will allow earlier decision making and reducing the time to maintain/restore separation.

In the absence of a clearance, an "unsafe" situation can develop into a separation infringement. The indicator parallels (3.e), and it will clearly define the boundary for what is considered "imminent".

(3.h) Number of communications: The number of communications can be measured as:

1. The absolute number of communications for given scenario.
2. The number of communications per aircraft for a given scenario.
3. The number of communications required to solve effectively a predicted unsafe situation.

The trajectory predictor will propose a solution considering the different options and possible induced conflicts, so the controller just need to indicate to the pilot what to do in that moment. The number of communications will be reduced because there will not be any imminent conflict which requires a lot of coordination about controllers and pilots and also, that actions will not increment the number of induced conflicts.

Positive and negative impacts:

(4. a) Alerting conflict detection performance: There will in an increase in the performance due to the use of EPP and Meteo dat.

(4. b) ATCO situational awareness: The ATCO will be assisted by more effective CD/R Tools that will improve her/his awareness of conflicts and provide resolutions strategies assisting controller in the conflict management and avoiding last-minute actions to restore/maintain separation.

(4.c) ATCO trust: Associated with feasible and efficient support in conflict detection and resolution (i.e. less nuisance conflict alerts and proposed resolution is the one applied by the ATCO to solve the conflict or has been taken into consideration by the ATCO in the construction of the conflict resolution).

(4.d) ATCO workload: Increasing the effectiveness of the conflict detection and resolution tool, there will be a reduction of ATCO workload because the alerts and resolution proposals will be optimised and accurate.

(4.e) Adherence to flight plan: The adherence to the Flight Plan is increased due to fewer trajectory changes due to unnecessary interactions.

Key Performance Areas:

(5. a) Safety: More effective conflict resolution notifications and the improved awareness of ATCO for resolution of conflicting strategies might contribute to more efficient conflict management, with the consequent safety benefits.

(5. b) Human performance: ATCO workload and Situational Awareness benefits might impact on an ATCO successful and smooth accomplishment of tasks and duties, with positive effect on Human Performance.

(5. c) Capacity : A reduction of ATCO workload can translate to an increment in the number of flights per controller, increasing the airspace capacity.

(5. d) Cost efficiency: The reduction of ATCO workload can improve ATCO productivity and thus possibly increasing the number of flights per ATCO hours on duty (G2G ANS Cost Efficiency)

(5. e) Predictability: A more reliable and accurate trajectory prediction can lead to solve conflicts earlier, which can have a positive impact in predictability as fewer deviations from the planned profile are expected.

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Stakeholder – Airspace User

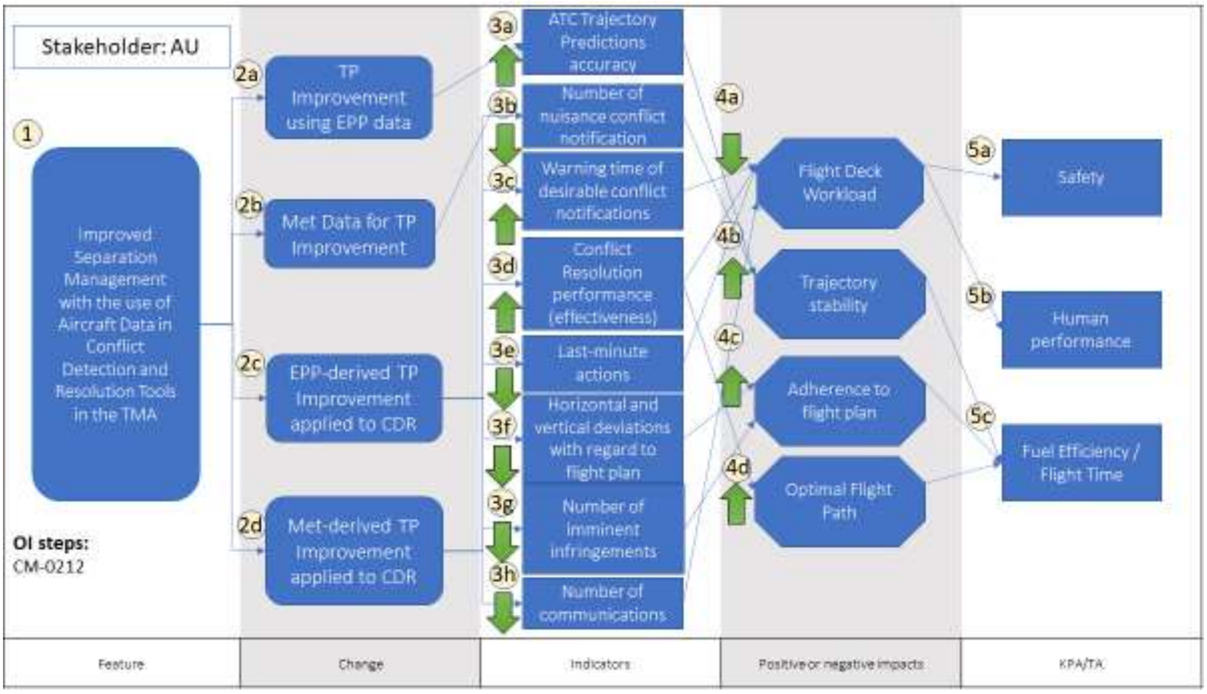

Figure 11: BIM_CM-0212- AU

Feature

(1) Improved performance of tactical CD/R tools using Airborne Data in the TMA: See above (ANSP).

Changes:

(2.a) EPP-derived TP improvement applied to CD/R: See above under ANSP.

(2.b) Met-derived TP improvement applied to CD/R: See above under ANSP.

(2.c) Met Data for TP improvement: See above under ANSP.

(2.d) Met Data for CDR Improvement: See above under ANSP.

Indicators:

(3.a) ATC trajectory predictions accuracy: See above under ANSP.

(3. b) Number of nuisance conflict notifications: See above under ANSP.

(3. c) Warning time of desirable conflict notifications: See above under ANSP.

(3. d) Conflict resolution performance (effectiveness): See above under ANSP.

(3. e) Last-minute actions: See above under ANSP.

(3. f) Horizontal and vertical deviations with regard to flight plan: See above under ANSP.

Positive and negative impacts:

(4. a) Flight Deck workload: Aircrew workload might be reduced due to the fewer instructions, the use of auto-load, and less A/G communications.

(4. b) Trajectory stability: Conflicts are solved earlier, and therefore, the flown trajectory is more stable than without the change.

(4.c) Adherence to flight plan: The adherence to the Flight Plan is increased due to fewer trajectory changes due to unnecessary interactions.

(4.d) Optimal flight path: An optimal flight will reduce the fuel burned and the flight time.

Key Performance Areas:

(5. a) Safety: The number of induced tactical conflicts would decrease due to the flight-deck workload, thanks to the greater stability of the aircraft trajectories and fewer communications.

(5. b) Human performance: Human performance is improved due to the reduction in aircrew workload and the increased situational awareness of the aircrew.

(5. c) Fuel efficiency/ Flight time: Fuel burn will be reduced as aircraft are less likely to level-off at an intermediate level or to be climb/descend at a non-optimal rate.