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Copyright Statement

PJ18W2 4DSkyways

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

This Technical Specification 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

Ground Trajectory Prediction accuracy is one of the cornerstone Enablers for the Trajectory Based Operations (TBO).

The objective of SESAR Solution PJ.18-W2-53B is to improve Separation Management and Monitoring activities in the En-Route and TMA Operational Environments and therefore to increase the quality of Separation Management Services reducing Controller workload and separation buffers and so allowing an increase of ATC Capacity without compromising Safety, among other additional benefits for the Stakeholders.

This document is the Technical Specifications for the SESAR Solution PJ.18-W2-53B, where the focus is set on the improvement of the accuracy of the Ground Predicted Trajectories taking benefit from the usage of Aircraft Derived Data, such as the Extended Projected Profile, and also taking benefit from a more granular and precise Weather forecast. This provides improved Conflict Detection alerts and enables earlier de-confliction strategies by the Air Traffic Controllers.

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1 Executive summary

Ground Trajectory Prediction accuracy is one of the cornerstone Enablers for the Trajectory Based Operations (TBO).

The accuracy of today's ATC predicted Trajectories is limited by the lack of information about, amongst others, Airspace User's preferences or Meteorological data. This limited accuracy implies an uncertainty on future Aircraft position, which increases for longer look-ahead horizons. In addition, as the Density/Complexity of Airspace increases, it is more difficult to design a Conflict-free Ground plan in a mid-term look-ahead horizon. Tactical intervention is then needed to solve a significant number of Conflicts, further contributing to the overall Mid-term uncertainty.

The SESAR Solution PJ.18-W2-53B continues the activities of SESAR Wave 1 Solutions PJ.18-06a and PJ.10-02a2. The objective is to improve Separation Management activities (Planned and Tactical layers) in the En-Route and TMA Operational Environments. The objective is to increase the quality of Separation Management Services by reducing Separation Buffers and decreasing both nuisance and missed alerts. This results in a reduced Controller workload and facilitates new Controller team organisations. This is to be achieved by improving the Ground Predicted Trajectories through the usage of Aircraft Derived Data, such as the Extended Projected Profile, and also taking benefit from a more granular and precise Weather Forecast/Nowcast.

The changes on the Trajectory Prediction are applicable to all Ground Computed Trajectories, and this includes ad-hoc what-if Trajectories that can be created to assess Conflict Resolution actions. So, even if this solution does not target changes on the Conflict Resolution Tools, the process to solve a Conflict will also get benefit from more accurate Trajectory Prediction.

Many conflict detection tools depend on uncertainty volumes, which are defined through the computation of ad-hoc trajectories modelling different assumptions on crew actions and aircraft performance over the same lateral profile. This Technical Specification also proposes improvements on how to use the EPP data to reduce the uncertainty volume through adjustments on those assumptions and this should lead to a reduction of the nuisance alerts.

This document provides a consolidated set of Technical Requirements focused on the best way to use the new available data to improve the Trajectory Prediction and so the Separation Management activities. The solution takes into account PJ18-06a and PJ10-02a2 Validated Requirements, but also the final conclusions and recommendations for further Technical Improvements, such as the computation (and usage) of Performance Coefficients and also the implementation of the Control Laws improvements during the Descent Phase. The solution mainly impacts "Trajectory Prediction and Management" Functional Block in the En-Route / Approach ATC system but also includes some changes on "Monitoring Aids" Functional Block.

Additionally, this document includes some Technical Requirements to improve the MET data, which will also improve the Trajectory Prediction. The Requirements are intended to support the reception and management of improved MET Forecast data from MET service providers, where both the granularity and the frequency of the MET data will be increased. In addition, the MET data could be improved through the reception and processing of ADS-C MET reports within MET providers system, however, this is considered out of the scope of this solution.

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2 Introduction

2.1 Purpose of the document

This document is used to capture and consolidate the Technical Specifications for SESAR Solution PJ.18-W2-53B. The specifications are needed to enable improved Separation Activities on the Ground ATC system and focus on the improvement of the Predicted Trajectory accuracy through the usage of Surveillance parameters (Mode-S and/or ADS-B), ADS-C reports and more detailed Weather Forecast.

These specifications are to be used to develop different System Prototypes for Validation Exercises to be conducted by BULATSA, DFS, PANSA, EUROCONTROL (MUAC) and SKYGUIDE.

This is the Final Version of the Final Technical Specification.

2.2 Scope

This is the final TS/IRS for SESAR Solution PJ.18-W2-53B, for the V3 maturity level Validation activities. It covers Functional and Non-Functional Requirements and has been produced after the Validation results of the different Exercises are analysed and consolidated.

The Requirements on this Technical Specifications are mainly related to the improvements on the En-Route / Approach ATC system, in the scope of the Trajectory Prediction and Management Functional Block, through the following improvements:

- Use ADS-C reported Actual Mass, together with the actual Mode-S TAS in order to improve the initial conditions of the Predicted Trajectories.
- Use ADS-C reported Speed Schedule, EPP Predicted Speeds and stable Mode-S IAS/Mach to improve the Target Speeds along the different Phases of the flight.
- Compare ADS-C reported EPP Vertical Profile with an equivalent Ground computed Profile to identify Performance Coefficients to be used in Ground Trajectory computation.
- Use ADS-C reported EPP Profile to improve the predicted turning Manoeuvres.
- Implement Control Laws improvements during Descent Phase (Catch-up Manoeuvres).
- Refine the assumptions on performance models to define the uncertainty model of the trajectory for conflict detection.

Use a more granular, precise and detailed Weather Forecast. On top of that, this TS includes some further changes and adjustments on other Functional Blocks:

- Monitoring Aids: Mode-S Speed is monitored for Stability.

On the other hand, this TS does NOT cover:

- The availability of the Aircraft Derived Data, such as ADS-C, since it is already considered a baseline functionality available from SESAR Solution #115. Nevertheless, along this TS different solutions for mitigating the lack of relevant data are defined, e.g. the correction of the lack of EPP gross Mass by means of Performance Coefficient computation.

- Other advanced improvements on Conflict Detection or Resolution Tools, since this is also covered by SESAR Solution PJ.18-W2-53A. This includes, for example, the usage of Artificial Intelligence.

- The changes on the MET systems (from MET Service Providers) in order to generate the more detailed and accurate Weather Forecast to be used by the TP:

    - It is expected that MET systems will have access to the ADS-C data through the PJ38 proposed ADS-C Common Service, so no need to further define it in this solution and therefore, this solution defines as assumption the availability of such data in the MET systems.

    - On the other hand, the core functionality to integrate new MET input data, from new sensors, is a functionality that is not strictly related with ATM purposes and already exists in some MET Stakeholders due to their own parallel projects. Therefore, similarly to the previous bullet, this is an assumption for this solution that the functionality already exists.

The Detection of Conflicts with Aircrafts in Hold, the enhanced Display of What-else and the improved Monitoring of adherence to Speed Clearance are not covered in this TS since they will finally not be validated by any partner.

It must be noted that any En-Route or TMA Centre normally computes and manages several types of Trajectories for each flight. Each Trajectory is computed based on different rules, and sometimes even different algorithms. Nevertheless, the improvements of the Trajectories based on ADS-C and Surveillance data is considered applicable to all the Trajectories, since the approach is to respect the applicable Route, Constraints and Clearances of each and every Trajectory, and just improve the way in which the remaining degrees of freedom of each Trajectory are closed. This way, the same Requirements apply for Planned Trajectory and Tactical Trajectory, and for any additional Supporting Trajectory that could be defined (What-if, What-else, Deviation, etc.). A more detailed description of the approach can be found in section 4.2.

Finally, the accuracy of today's TPs is limited by some Technical factors and some Operational factors. The Operational ones are those related with unpredictable future decisions and actions from Human actors, including both ATCOs and the Crew. This includes, for example, Tactical Clearances to solve Conflicts. On the other hand, the Technical factors are related to the absence or inaccuracy of data that is not strictly linked to Human decisions, such as the MET forecast, or the Aircraft Performance.

Considering the previous, the above described TP improvements covered by Solution 53B will minimize the Technical factors contributing to the uncertainty of the Planned Trajectory Prediction. Thanks to this, some initial operational benefits can be directly obtained.

On the other hand, it is out of the scope of this solution the management of the Operational factors. This is planned to be covered by other solutions (PJ.18-W2-S56 & PJ.18-W2-S57), where will be define longer and Complex Conflict-free Clearances to minimize the need for Tactical intervention, obtaining a more stable mid-term flight plan.

2.3 Intended readership

This TS is especially relevant for the following PJ18 solutions:

- Solution PJ.18-W2-53A, also targeting Separation processes, which would be interested in more mature concepts under investigation.
- Solution PJ.18-W2-56, since its Operational Improvements will further contribute to the reduction of the (Operational) uncertainty, and so, could be considered a complementary Solution.

Additionally, this TS is also relevant for other SESAR Wave 2/3 projects/solutions that could be impacted/benefited by a more advanced Separation Tools, including:

- PJ.10: Controller Tools and Team Organisation for the Provision of Separation in Air Traffic Management.
- PJ.38: Downlinking Flight Trajectory for improved ATM Performance.

This TS is also relevant for transverse and federating projects:

- PJ.19: Content Integration.

and also for the following stakeholders:

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

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2.4 Background

During the latest SESAR 2020 Wave 1 Program, some Validation Exercises (and Technical Validation Exercises) were conducted on advanced Separation Tools and Concepts:

- PJ.10-02A (see [10] & [11]): This Solution focused on two elements: first on improvements and testing of Separation Tools in new scenarios, and second on the usage of Aircraft Derived Data to improve the accuracy of the Ground Predicted Trajectories, which would then provide benefits through the Conflict Detection Tools relying on those Trajectories. This Solution can be considered as the main Operational predecessor for the activities in PJ.18-W2-S53B, and reached V2 partial maturity.

- PJ.10-02b (see [12]): This Solution focused on initial Validation Activities of more advanced Conflict Detection and Resolution Tools, as well as initial investigation on safe Complex Clearances which would improve Flight Efficiency while ensuring the Safety of the Flight. It reached V1 maturity.

- PJ.18-06a (see [13] & [14]): This technical Solution focused on the usage of Aircraft Derived Data to improve the Planned Trajectory predicted by Ground Systems, with the intention to enable a better Separation Processes. This solution was intended to reach TRL6 maturity at the end of the Program, and even if the results were promising, it finally remained at TRL4 maturity due to some issues that were found during the Technical Validations. The TVALR in that solution includes some Technical recommendations to be considered in future activities in order to further improve the accuracy of the TP, together with other recommendations more relevant for OSED and TVALP documents. This solution is to be considered the main Technical predecessor for the activities in PJ.18-W2-S53B.

- PJ.18-06b (see [15] & [16]): This technical Solution also focused on the usage of Aircraft Derived Data, but in this case it would feed the Tactical Trajectory instead of the Planned one. The solution was intended to reach TRL4 maturity level. Again, even if the results were promising, it finally didn't reach full TRL4 level. The TVALR in that solution also includes some recommendations for future activities, but are to be tackled in solution PJ.18-W2-S53A.

- PJ.31 (DIGITS) (see [17]): This Very Large Demonstration Exercise, together with its related Open Call "DIGITS-AU" deployed ATS B2 equipment (including FMS and ATSU components) in tens of commercial A320-family Aircrafts from several European airlines. In parallel, Ground prototypes focusing on EPP CWP display, 2D Discrepancies Detection (and TP Improvements) were validated against the revenue flights operated by that group of equipped Aircrafts, in full real conditions, together with a significant analysis of the characteristics of EPP data under different Operational conditions. This project constitutes a very important input to this solution (PJ.18-W2-53B) since it enables the availability of real EPP data in Ground for further prototype Validations (based on a Non-Disclosure Agreement).

All the above mentioned background is now feeding both Solutions PJ.18-W2-S53B and PJ.18-W2-53A, where each Solution will focus on the continuation of the activities. In particular, this solution (PJ.18-W2-53B) will focus on more mature concepts initially tested in solutions PJ.10-02a and PJ.18-06a, implementing the recommendations derived on those Solutions plus some further improvements concerning the Weather Forecast.

There is an important matter related with the target V3 level maturity of this Solution, given that the Solution PJ10-02a only achieved to get a final maturity level of "V2 ongoing" and not fully V2.

The SJU raised a risk that if this solution PJ.18-W2-S53B has an initial maturity level of only "V2 ongoing" coming from PJ.10-2a and therefore, less than V2, it might not be able to reach V3 maturity at the end of Wave2. However, the partners considered that V3 level could be achieved.

So for that, a Gap Analysis was performed, in which the Results of the Maturity Gates of Solutions 10-02a and 18-06a were used to define 18 GAP items, containing the points yet needed to be tackled to fill the last step up to V2 maturity. An analysis was then performed to see how the different 53B Exercises could cover all the different GAP items. The thorough analysis of this coverage is contained on the Solution PJ.18-W2-S53B VALP.

During March 2021 a V2 Checkpoint Webex with the SJU was held, in which this analysis was presented. The conclusion is that the GAP coverage is considered as valid, and the Solution PJ.18-W2-53B can proceed to reaching V3 maturity level on Wave2.

2.5 Structure of the document

On the following section 3, the architectural high level aspects of the Solution are treated: the link with the Enablers and Capability Configurations.

On the section 4, the detailed EATMA diagrams are included on the first subsection, allowing a more detailed architectural description of the Solution. On the second subsection, the Requirements for the Systems can be found. Since this Solution tackles several independent Enablers and Improvements, this section is divided following those different Enablers, and then internally by Domain System and Functional Block.

In Section 5 some recommendations for implementation would be done, however, in this solution, recommendatios with a significant impact in the implementation have not been found, while section 6 provides some key assumptions that are relevant to properly understand the Technical Specifications.

Finally, Section 7 includes a list of the Reference and Applicable Documents for the Solution.

2.6 Glossary of terms

Term	Definition	Source of the definition
Catch-up manoeuvre	Catch-up manoeuvre is defined as the manoeuvre that an aircraft should follow from its current position to reach the Optimal Descent Profile.	SESAR PJ.18-W2-53B TS
Closed-loop	This term is relative to the term closed-loop clearance. A closed-loop clearance is a clearance resulting in a revision of one portion of the agreed trajectory, from a point of the trajectory to	Trajectory Management Document

	another point of the trajectory. Closed clearance can also be from current position of the aircraft with a condition to resume planned navigation which can include a vector until interception of the planned route. A closed clearance can be on any dimension of the trajectory: lateral, vertical, speed … What differentiate this kind of clearance from the open clearance, is that it contains the instruction on how to resume to the initially agreed trajectory. It allows to update and re-calculate a new agreed trajectory up to destination.	
Crossover altitude	Crossover Altitude is the geopotential pressure altitude at which a specified CAS (Calibrated airspeed) and Mach value correspond to the same TAS (True airspeed) value.	SESAR PJ.18-W2-53B TS
Extended Projected Profile	Indicates the Aircraft's Trajectory intent for the next several waypoints as specified in the request either by a number of waypoints or period of time in the future. For each of the waypoint, it includes Latitude, Longitude and when available, waypoint name, Level, Estimated Time of Arrival (ETA), AirSpeed, Vertical type(s), Lateral type(s), Level constraint, Time constraint, Speed constraint. When available, it includes the relevant data for the Trajectory as current gross Mass, and EPP Trajectory intent status. It includes the date and time of computation.	EUROCAE ED-228A
Flight script	Flight Script is a generic term identifying data that describes the trajectory of the flight in terms of 2D route (including the SID and STAR	Trajectory Management Document

	and their published constraints), the Requested Flight Level(s) and the Required Speed(s) and all the known constraints (level, time or possibly speed) associated to a point (that can be a point added to the 2D route). It can also include the clearances issued by ATC that impact the trajectory during Execution. It is not a list of 4 dimensional points but is used as input for the prediction of the four dimensional trajectory of the aircraft. Flight Script evolves through the different flight phases. At filling it represents the intention of the airspace user including constraints being known by him. During execution additional constraints (ATC, DCB) will be added as well as clearances issued by ATC. The ICAO4444 FPL route description (field15) is a Flight Script with minimal set of information. The FIXM (FF-ICE data model) Route Trajectory contains a detailed Flight Script plus additional information like flight specific aircraft performance, 4D trajectory. The Flight Object (ED133A) also contains a Flight Script.	
Managed Guidance Mode	The Aircraft is guided along the lateral, Vertical or Speed profile defined by the FMS (Flight Management System) via its strategic planning system feed by the crew. Lateral, Vertical and Speed profiles are managed by the FMS (accounting for altitude and Speed constraints, as applicable). Note that the Aircraft can be operated with mixed selected and managed modes, i.e. Lateral Guidance SELECTED and Speed	SESAR PJ.18.06a TS (slightly modified by SESAR PJ.18-S53)

	MANAGED or Lateral Guidance MANAGED with Vertical Guidance SELECTED. Note that, for most Aircraft Types, Vertical Guidance MANAGED mode is only available if Lateral Guidance is MANAGED.	
Missed alert	A Conflict/alert that will happen so it should be displayed in advance to controller on their HMI but is not raised until it is close to happen due to uncertainty in the computed trajectories. These kind of alerts increase ATCOs workload since the response time to solve the conflict is lower than in typical conflicts.	SESAR PJ.18-W2-53B TS
Nuisance Alert	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.	SESAR Solution 53A SPR-INTEROP/OSED
Open-loop	This term is relative to the term open-loop clearance. It is defined as an ATC Clearance that does not include a specified or implied point where the restriction on the trajectory ends. Most tactical Clearances take this form; they include heading (including track offset), level, and speed restrictions and exceptionally could also cover rates of climb or descent. Open-loop Clearances are cancelled (closed) by a further instruction from the controller that defines how the flight should revert to the Reference Business Trajectory (RBT).	Trajectory Management Document
Planned Trajectory	The Planned Trajectory represents the stable medium to long term	SESAR P04.07.02 OSED

	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 executive 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).	
Restricted Vertical Manoeuvre	Aircraft (Vertical) manoeuvre where a guidance rule is defined for the Vertical Speed (typically a fixed value or linked to a particular 3D path), and where the thrust is variable (i.e. not fixed to a particular thrust rating)	SESAR PJ.18.06a TS
Selected Guidance Mode	The Aircraft is guided to acquire and maintain the short term navigation targets set by the crew, using the related interface: FCU (Flight Control Unit) target setting knobs. The selected guidance modes are usually used for short term guidance, e.g. to comply with ATC instruction (heading, level, Speed) or for weather avoidance.	SESAR PJ.18.06a TS

Speed Schedule	The calculated or manually entered Speeds the FMS is scheduled to use in the climb, cruise and descent.	EUROCAE ED-228A
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. 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 calculation; to maximise response and minimise the incidence of false alarms.	SESAR P04.07.02 OSED
Unrestricted Vertical Manoeuvre	Aircraft (Vertical) manoeuvre where the Vertical Speed is based on a climbing or Idle Thrust rating, instead of being fixed to a fixed value or linked to a particular 3D path (such as the glide path)	SESAR PJ.18.06a TS

Table 1: Glossary

2.7 Acronyms and Terminology

Term	Definition
ACC	Area Control Centre
ADD	Architecture Description Document
ADES	Aerodrome of DEStination
ANSP	Air Navigation Services Provider
APF	Airline Procedures Files

APP	APProach
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATN	Air Traffic Network
ATS	Air Traffic Services
ATSU	Air Traffic Services Unit
AU	Airspace User
BADA	Base of Aircraft DAta (EUROCONTROL)
CC	Capability Configuration
CFL	Cleared Flight Level
COP	COrdination Point
CPDLC	Controller-Pilot Datalink Communication
CPU	Central Processing Unit
CR	Change Request
DCT	DireCT
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
EPP	Extended Projected Profile
ETA	Estimated Time of Arrival
ETO	Estimated Time of Overflow
FAA	Federal Aviation Administration
FANS	Future Air Navigation Services
FCU	Flight Control Unit
FDP	Flight Data Processor

FL	Flight Level
FMS	Flight Management System
FPL	Flight Plan
GRIB	GRIdded Binary or General Regularly-distributed Information in Binary form
IAS	Indicated AirSpeed
ICAO	International Civil Aviation Authority
ICD	Interface Control Document
IER	Information Exchange Requirement
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
ISRM	Information Services Reference Model
KPA	Key Performance Area
KPI	Key Performance Indicator
ML	Machine Learning
MTCD	Medium Term Conflict Detection
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organisation
NSOV	NAF Service Oriented View
NOV	NAF Operational View
NSV	NAF System View
PSR	Primary Surveillance Radar
OSED	Operational Service and Environment Definition
QoS	Quality of Service
ROCD	Rate of Climb/Descent
SDD	Service Description Document
SESAR	Single European Sky ATM Research Programme

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S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
SoaML	Service Oriented Architecture Modelling Language
SPR	Safety and Performance Requirements
SSR	Secondary Surveillance Radar
STAR	STandard ARrival
SWIM	System Wide Information Model
TAS	True AirSpeed
TFL	Transition Flight Level
TMA	Terminal Manoeuvre Area
TOC	Top Of Climb
TOD	Top Of Descent
TP	Trajectory Predictor
TRL	Technology Readiness Level
TS	Technical Specification
UML	Unified Modelling Language
V&V	Validation and Verification
VLD	Very Large-scale Demonstration
WSDL	Web Services Definition Language
WTQ	Wind, Temperature & QNH info
XSD	XML Schema Definition

Table 2: Acronyms and terminology

3 SESAR Solution Impacts on Architecture

Through this document, several architecture elements from EATMA are identified. The applicable DataSet reference to be considered is DataSet 22.

3.1 Target Solution Architecture

3.1.1 SESAR Solution(s) Overview

Today's Trajectories computation is not perfect in particular for planning purpose. The accuracy is limited by the lack of information about, amongst others, Airspace User's Intent and meteorological data. This limited accuracy implies an uncertainty on future Aircraft position, which increases for longer look-ahead horizons.

For Conflict Detection, this uncertainty introduces both Nuisance Alerts and Missed Alerts, which increases for longer look-ahead horizon and for Higher Density/Complexity Traffic. In today's European highest Density/Complexity Airspaces, MTCD Tools (look-ahead horizon around 20 to 30 minutes) have limitations affecting the Efficiency. These limitations have a lower impact for Lower Density Airspaces.

The uncertainty is compensated by larger margins in the Conflict Detection Algorithm that could affect the confidence of the Controller on the Mid-term predicted Aircraft position. Therefore, some Conflicts cannot be solved at Planning level and are required to be solved by Executive Controllers affecting the Flight Trajectory (usually with Open Loop Clearances) impacting the former Mid-term plan.

This Operational Solution addresses improvements on the Trajectories computation, in order to improve their accuracy thanks to the usage of ADS-C Reports (i.e. EPP) and Surveillance parameters, together with other Algorithm changes derived from common FMS Manoeuvres during the descent Phase. This will enable reducing the Conflict Detection envelope managed by the System Tools (implying a reduction of the Nuisance Alerts) and should also increase Planner and Executive Controller's confidence in the prediction. This should enable Planner and Executive Controllers 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.

Change Requests for the modification of ER APP ATC 214 has been introduced with reference the Dataset 22.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
PJ.18-W2-53B Improved Performance of CD/R Tools	Trajectory Prediction and Management	ER APP ATC 167	ATC Trajectories improvement with new ADS-C reports and surveillance information.	Full

Enabled by Reduced Trajectory Prediction Uncertainty	Monitoring Aids	ER APP ATC 167	ATC Trajectories improvement with new ADS-C reports and surveillance information	Full
	Trajectory Prediction and Management	ER APP ATC 214	Conflict Detection envelope trajectories improvement with new ADS-C reports	Full
	Support Functions ER/APP	ER APP ATC 200	ATC Improvement to receive and use more granular MET forecasts.	Full
		ER ATC 157	Enhanced ATC System Support to the Tactical Controller for Conflict Detection and Resolution in En-Route	None (already V3 from Solution #104)
		ER APP ATC 119	Air-Ground Datalink Communication/Protocols for i4D and Controlled Time of Arrival	None (Already V3 from Solution #115)
		ER APP ATC 149a	Air-Ground Datalink Exchange to Support i4D - Extended Projected Profile (EPP)	None (Already V3 from Solution #115)
		A/C-31a	Controller pilot data link communication (CPDLC) compliant with ATN baseline 2 (FANS 3/C)	None (Already V3 from Solution #115)
		A/C-37a	Downlink of Trajectory data according to contract terms (ADS-C) compliant to ATN baseline 2 (FANS 3/C)	None (Already V3 from Solution #115)

Table 3: SESAR Solution PJ.18-W2-S53B Scope and related Functional Blocks/roles & Enablers

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

Enabler	Opt/Req	Deviation
A/C-31a_Controller pilot data link communication (CPDLC) compliant with ATN baseline 2 (FANS 3/C)	Required	No deviations
A/C-37a_Downlink of Trajectory data according to contract terms (ADS-C) compliant to ATN baseline 2 (FANS 3/C)	Required	No deviations
ER APP ATC 119_Air/Ground Datalink Communication/Protocols for i4D and Controlled Time of Arrival	Required	No deviations
ER APP ATC 149a_Air-Ground Datalink Exchange to Support i4D - Extended Projected Profile (EPP)	Required	No deviations
ER ATC 157_Enhanced ATC System Support to the Tactical Controller for Conflict Detection and Resolution in En-Route	Required	No deviations
ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information	Required	Enabler has been modified (CR05324 has been endorsed)
ER APP ATC 214_ Conflict Detection envelope trajectories improvement with new ADS-C reports	Optional	Enabler has been created (CR05916 has been endorsed)
ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts	Required	Enabler has been created (CR05554 has been endorsed)

3.1.1.2 Relevant Use Cases

This Solution improves the Technical accuracy of the Trajectory Prediction functionality thanks to the availability of further and more accurate input data and improved Algorithms.

Trajectory Prediction is a transversal Function supporting many of the Operational Activities described in the OSED (see [9]), for both the provision of Planning and Tactical Separation assurance. The Improvements on the Trajectory accuracy will enable better results (KPIs) on those today's Activities. However, no changes are implemented on new Conflict Detection/Resolution Tools that might change ATCO procedures. In other words: ATCOs will behave as today, but just using better data.

The following Activities are taking benefit from the improved Trajectory Prediction:

- From Planning Separation assurance:
  - Determine Planning problems at offered Entry conditions.
  - Determine safe potential Exit conditions.
  - Assess Trajectory Profile through the AoR for Tactical Controller suitability.
- From Tactical Separation assurance:
  - Modify Trajectory.
  - Assess Planned/desired Profile for problems within AoR/AoI.
  - Establish Necessary Separation.
  - Agree Coordination actions.

In all the previous cases, the Activity depends on some automation functionality to detect Planned or Tactical Conflicts. The detection of those Conflicts is to be done by today's Conflict Detection functionality (no changes) but now being fed by improved and more accurate Trajectories. Note that, depending on specific implementations, some of those improved trajectories might be computed inside a conflict detection tool. However, it is not the intention of this TS to specify any physical architecture to be used.

3.1.1.3 Applicable standards and regulations

This solution is based on the usage of already standardized Information Exchanges between Air and Ground:

- With regards to ADS-C, it is based on the EUROCAE ATS B2 standard, composed of the following documents:
  - ED228A / DO-350A (see [18])
  - ED229A / DO-351A (see [19])
  - ED230A / DO-352A (see [20])
  - ED231A / DO-353A (see [21])

- With regards to the new Surveillance parameters (SSR Mode S and ADS-B), it is based on the following documents:
    - ASTERIX Cat 21 (ADS-B, see [22])
    - ASTERIX Cat 48 (Mode S, see [23])
    - ASTERIX Cat 62 (Tracks, see [24])

3.1.2 Capability Configurations required for the SESAR Solution

SESAR Solution ID and Title	Capability Configurations (CCs) (from EATMA)	Sub-Operating Environment(s) where the CCs operate	Capabilities (from EATMA)	Nodes (from EATMA)	Stakeholders (from EATMA)
PJ.18-W2-53B Improved Performance of CD/R Tools Enabled by Reduced Trajectory Prediction Uncertainty	En-Route ACC	High Complexity Medium Complexity Low Complexity	Aircraft-to-Aircraft Separation Provision (Airspace)	En-Route/Approach ATS	Civil ATS Approach Service Provider Civil ATS En-Route Service Provider
PJ.18-W2-53B Improved Performance of CD/R Tools Enabled by Reduced Trajectory Prediction Uncertainty	Approach ACC	High Complexity Medium Complexity Low Complexity	Aircraft-to-Aircraft Separation Provision (Airspace) Arrival Sequencing	En-Route/Approach ATS	Civil ATS Approach Service Provider Civil ATS En-Route Service Provider

Table 4: List of Capability Configuration required for the SESAR Solution

3.2 Changes imposed by the SESAR Solution on the baseline Architecture

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
ER APP ATC 167	ATC Trajectories improvement with new ADS-C reports and surveillance information.	TP&M Functional Block will improve the ATC computed Trajectories thanks to the usage of Aircraft Data (new ADS-C reports and Surveillance parameters from Mode-S & ADS-B). This data provides useful hints to the TP&M about high-level Airspace User navigation strategy/preferences on how to close the degrees of freedom. In particular: which are the FMS intended Manoeuvres (among all the possible ones) to follow the FMS known Route and Restrictions. Then, the TP&M will take into account this information to make better assumptions on the intended Manoeuvres to follow the Ground current view of the Route and Restrictions (which, in most cases, will include some discrepancies when compared to the FMS ones). In addition, the TP&M will have a more precise view on Aircraft current conditions, improving the accuracy of its calculations. The following data will be considered: • Current gross Mass of the A/C, to improve predictions of A/C performances. • A/C preferred Speeds per Flight Phase, as well as A/C predicted Speeds in cruise points to improve ETO calculation and predictions of Aircraft performance-limited Vertical manoeuvres. • Predicted TopOfClimb and TopOfDescent points, allowing a better identification of the Aircraft perceived Climb/Cruise/Descent Phases scope, and so, allowing a better selection of the Scheduled Speed to be used • Current A/C Speed, to deduce Selected Speeds and/or de-facto preferred Speeds for all flights (even if not ATS B2 equipped). • Turning Manoeuvres strategy, to fine tune their computation.

		• EPP predicted profile, in order to define coefficients allowing to fine-tune the Aircraft Performances computation. Additionally, the TP&M will improve the Trajectories prediction thanks to a default better modelling of common Aircraft preferences during the Descent Phase, concerning the catch-up Manoeuvres from current position to the optimal descent profile
ER APP ATC 214	Conflict Detection envelope trajectories improvement with new ADS-C reports.	TP&M Functional Block will improve the envelope trajectories used to model the uncertainty on conflict detection processes using new ADS-C reports. This data provides useful information about the performances of the flight. The TP&M will use this information to adjust those trajectories minimizing the uncertainty area/volume between them. This will reduce the number of nuisance conflicts, while maintaining the detection of true conflicts.
ER APP ATC 200	ATC Improvement to receive and use more granular MET forecasts	Support Functions ER/APP Functional Block is improved to receive more granular MET forecast from the MET service providers, including improvements both in the time resolution and in the altitude resolution of the forecast.

Table 5: List of changes due to the SESAR Solution

4 Technical Specifications

4.1 Functional architecture overview

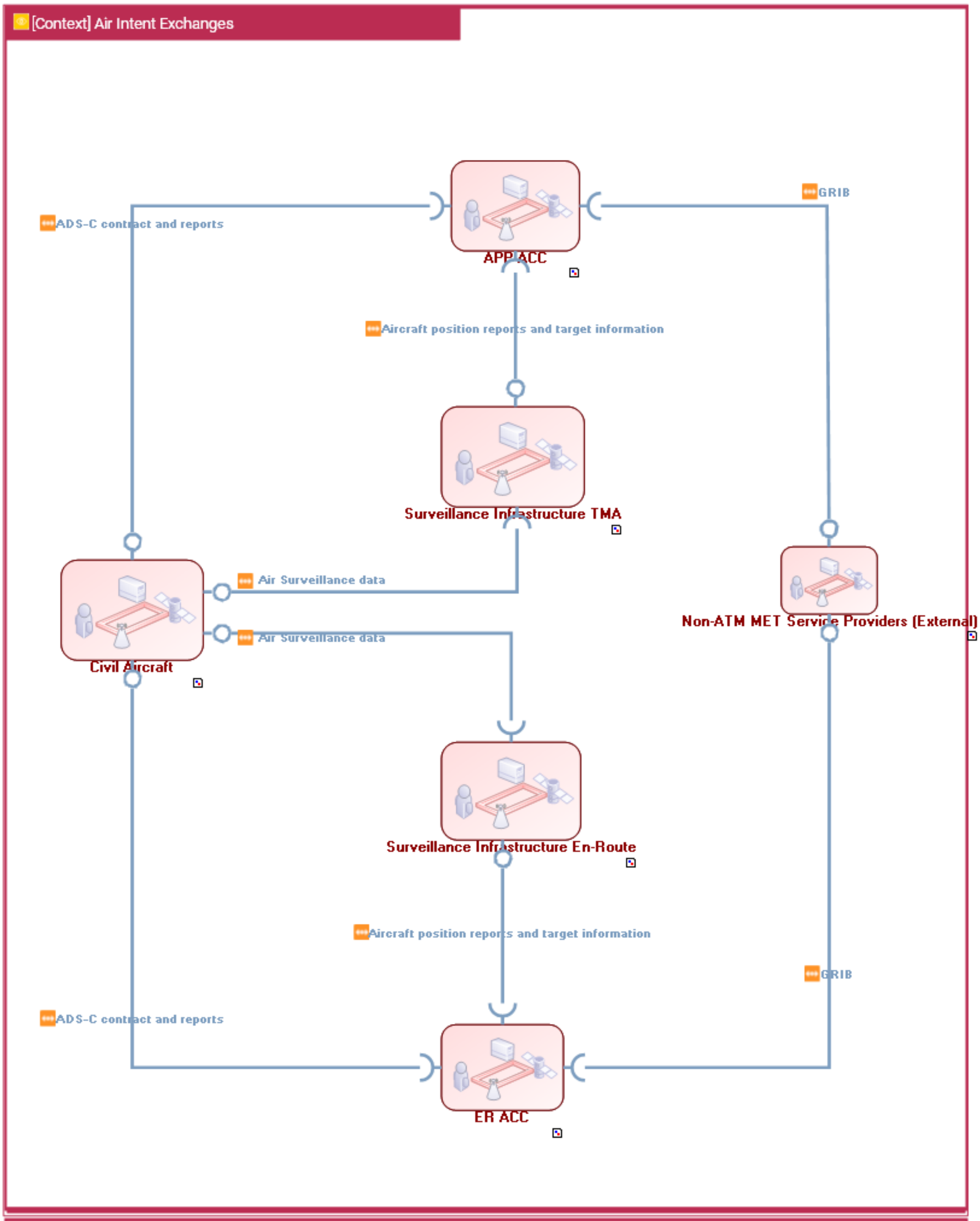
This solution PJ.18-W2-53B is mainly focused on the improvements on the En-Route / Approach ATC System, in the scope of the Trajectory Prediction and Management Functional Block, through the following improvements:

- Use ADS-C reported Actual Mass, together with the actual Mode-S TAS in order to improve the initial conditions of the Predicted Trajectories.
- Use ADS-C reported Speed Schedule, EPP Predicted Speeds and Stable Mode-S IAS/Mach to improve the Target Speeds along the different Phases of the Flight.
- Compare ADS-C reported EPP Vertical Profile with an equivalent Ground computed Profile to identify Performance Coefficients to be used in Ground Trajectory computation.
- Use ADS-C reported EPP Profile to fine tune the predicted Turn Radius on Turning Manoeuvres.
- Implement Control Laws improvements during Descent Phase (Catch-up Manoeuvres).
- Refine the assumptions on performance models to define the uncertainty model of the trajectory for conflict detection.

On top of that, this TS includes some further changes and adjustments on other Functional Blocks:

- Monitoring Aids: Mode-S Speed is monitored for Stability.
- Support Functions ER/APP: Receiving and using more granular MET forecasts from MET Service Providers.

4.1.1 Resource Connectivity view



[NSV-4] Reception of Weather Forecast [ADS-B Ground Station, ATM-MET, Non-ATM MET Service Providers (External), Secondary Radar, Support Functions ER/APP (PJ.18-W2-53A), Support Functions ER/APP (PJ.18-W2-53B), Support Functions ER/APP (PJ.18-W2-53B), Surveillance, Trajectory Prediction and Management (PJ.18-W2-53B)]
[NSV-4] ADS-C Reports Reception [A/G Datalink Communications (PJ.18-W2-53B), A/G Datalink Services (PJ.18-W2-53B), Participant, Trajectory Prediction and Management (PJ.18-W2-53B)]
[NSV-4] Monitor Speed Stability [ADS-B Ground Station, Civil Aircraft, Conflict management (PJ.18-W2-53B), Monitoring Aids, Secondary Radar, Surveillance, Surveillance Infrastructure En-Route, Trajectory Prediction and Management (PJ.18-W2-53B)]
[NSV-4] TP Computation [Conflict management (PJ.18-W2-53B), Controller Human Machine Interaction Management ER/APP (PJ.18-W2-53B), Trajectory Prediction and Management (PJ.18-W2-53B)]

Figure 1: NSV-1 for solution PJ.18-W2-53B

4.1.1.1 Resource Infrastructure view

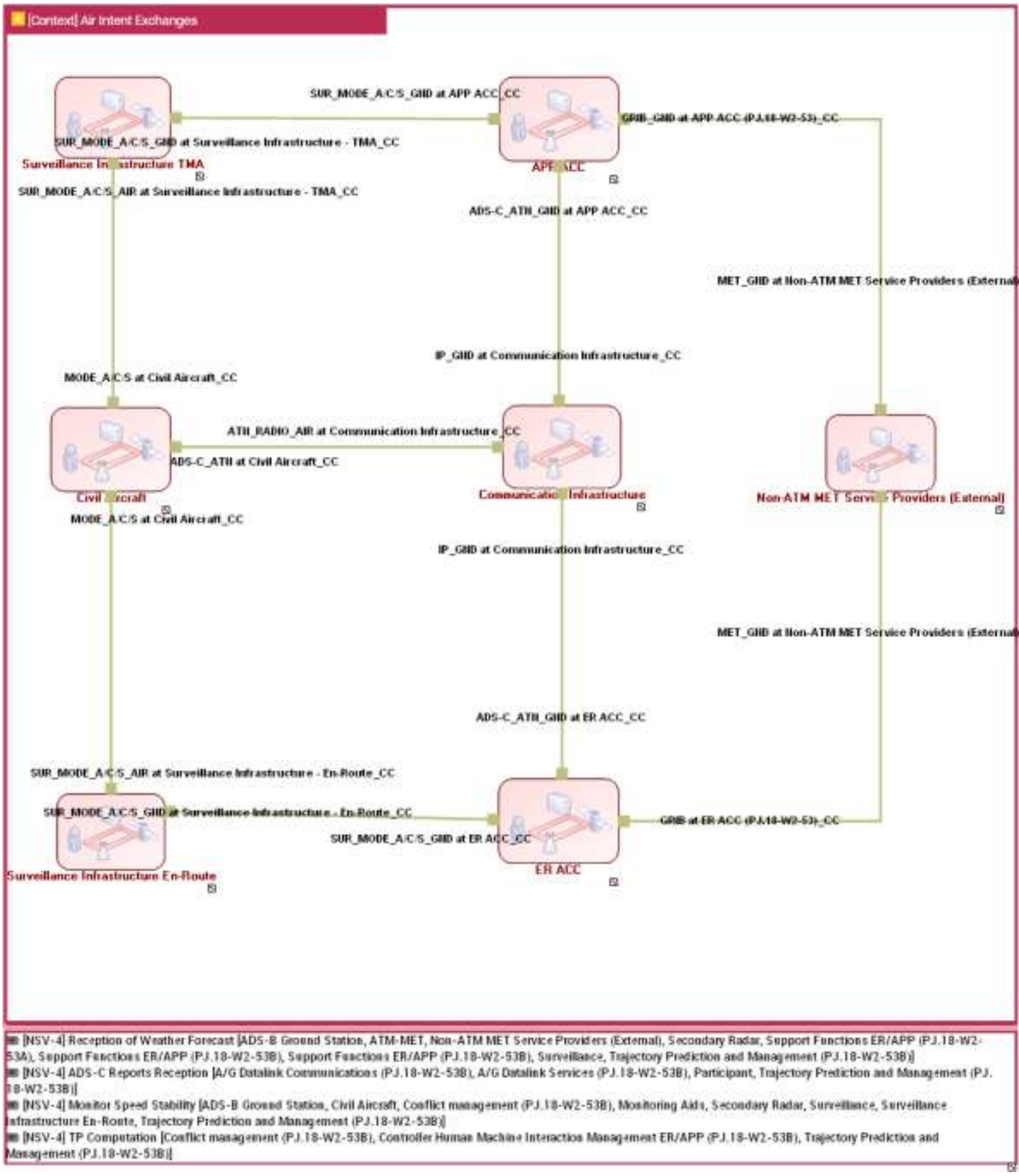


Figure 2: NSV-2 for solution PJ.18-W2-53B

4.1.1.2 Resource Orchestration view – ADS-C reports reception

This is the Technical Use Case showing the processing of a received ADS-C report containing the EPP and/or the Speed Schedule Report.

It starts with the ADS-C Report being received from the Aircraft through the standard ATS B2 services (as described in the EUROCAE documents [18], [19], [20] & [21]). It ends once the ADS-C report has been processed and the data destined to improve the TP has been internally stored.

It involves the following Functions:

- **Receive Message from ATN Network**: (Baseline function) - This function provides the means to receive air-Ground datalink communication messages through standardised datalink communication protocols, relaying on the ATN Network
- **Decode and store ADS-C report**: (Baseline function) - This function decodes and validates an incoming ADS-C Downlink message, such as an ADS-C report, matching the ATS B2 ICD.
- **Validate ADS-C downlinked data (TP)**: (New function) – This function checks that the provided ADS-C data is not corrupted, so that the included data can be used to improve the predicted Trajectories.
- **Update FMS-Perceived Flight Phase**: (New function) – This function checks the contents of the received ADS-C report to identify the Flight Phase changes from the perspective of the A/C system, since this is relevant for the appropriate usage of reported Speeds.
- **Compute Performance Coefficients**: (New function) – This function compares the EPP profile with a Ground computed EPP profile to detect limitations on the Ground Performance model, and identifies some coefficients to correct it.
- **Store ADS-C report data**: (New function) - This function will store internally the ADS-C reported information for further usage, potentially completing the information with previously received ADS-C reports.

Note: the current Use Case does not force a Trajectory recomputation following the reception of an ADS-C Report with new parameters. Freedom for implementation is left to different industrial ATC system providers to trigger a Trajectory recomputation when new ADS-C parameters are received, or to just store those ADS-C reported parameters for subsequent Trajectory recomputations, based on the usual system triggers.

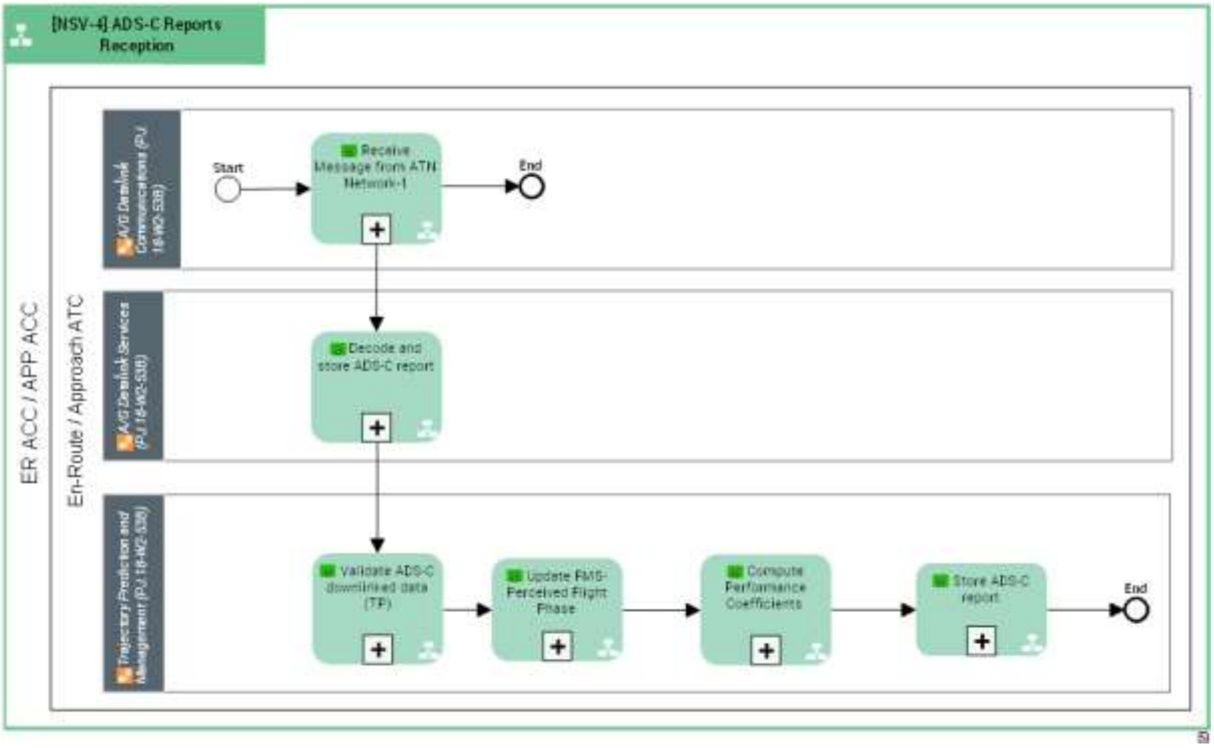


Figure 3: NSV-4 for the reception of the EPP data

4.1.1.3 Resource Orchestration view – Monitor Speed Stability

This is the Technical Use Case showing the improved usage of the extended Surveillance parameters received from Mode-S and/or ADS-B, focusing on the Speed information.

It starts when either the ADS-B or the Mode-S data are received from a Civil Aircraft through the corresponding Surveillance infrastructure. It ends once the Stable Speed (if any) has been identified.

It involves the following functions:

- **Surveillance**: (Baseline function) – This function receives the surveillance information from different sources (PSR, SSR, ADS-B) and combines them to generate a single surveillance picture for the rest of the ATC system.
- **Monitor Speed Stability**: (New function) – This function will check the air Speed information received through ADS-B and/or Mode-S in order to identify that the Aircraft is maintaining a constant air Speed, to ensure this stable Speed can be taken into account (extrapolated) in subsequent Trajectory predictions.

Note: the current Use Case does not force a Trajectory recomputation following the identification of a new Stable Air Speed. Freedom for implementation is left to different industrial ATC system providers to trigger a Trajectory recomputation when new Stable Air Speed is detected, or to just store such Actual Air Speed for subsequent Trajectory recomputations, based on the usual system triggers.

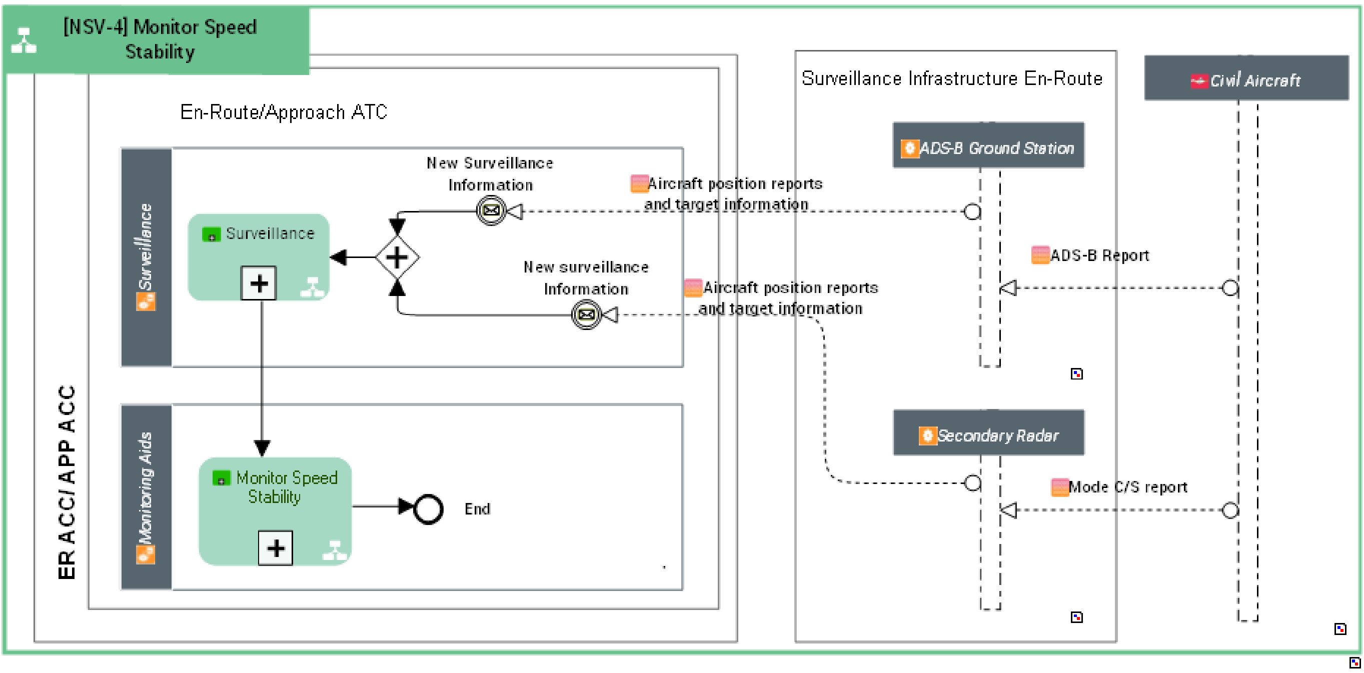


Figure 4: NSV-4 for the Conformance Monitoring and Speed Stability detection

4.1.1.4 Resource Orchestration view – Reception of Weather Forecast

This is the Technical Use Case showing the ATC System behaviour when receiving a Weather Forecast.

It only includes one single function, which is triggered when the new weather forecast is received:

- **Store Meteorological Information**: (Improved function) – This function is responsible to decode the received weather forecast data and replace the previous one. In Solution PJ.18-W2-53B, it is improved to properly manage an improved granularity of the weather forecast, on the time, altitude and geographical resolution.

Note: the current Use Case does not force a Trajectory recomputation following the reception of a new Weather Forecast. Freedom for implementation is left to different industrial ATC System providers to trigger a Trajectory recomputation when new Weather Forecast is received, or to just store the received Weather Forecast for subsequent Trajectory recomputations, based on the usual system triggers.

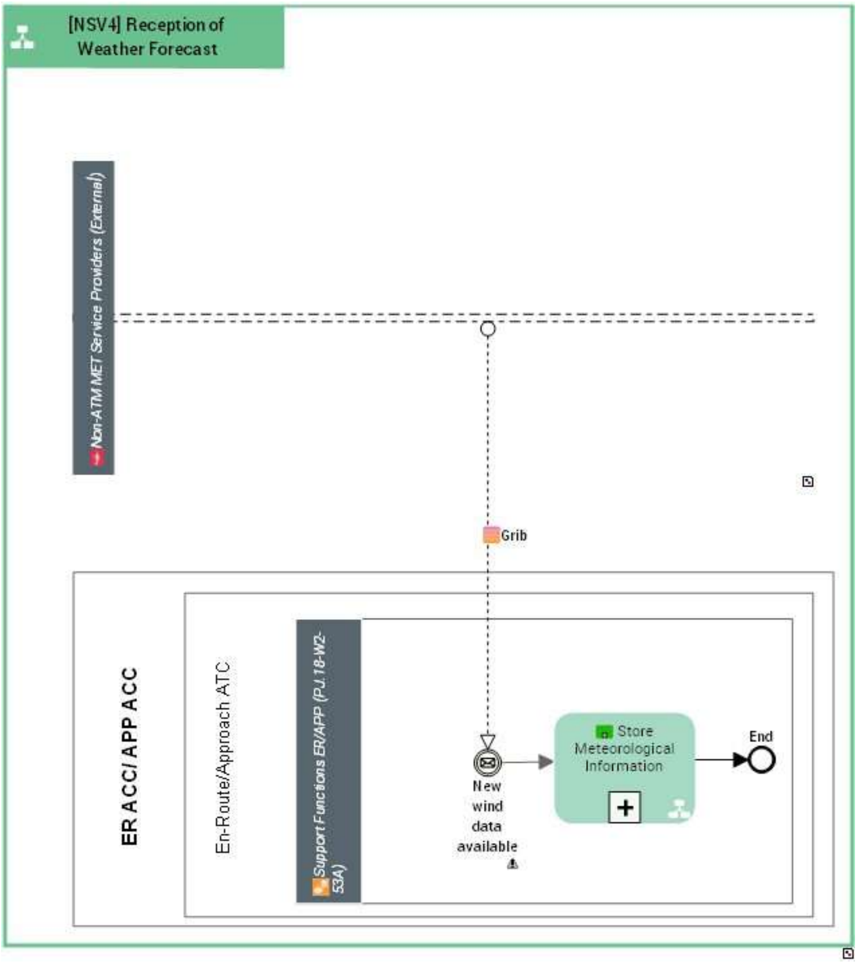


Figure 5: NSV-4 for the Reception of Weather Forecast

4.1.1.5 Resource Orchestration view – TP Computation and Conflicts Detection

This is the Technical Use Case showing the TP computation process, which has been improved thanks to the usage of EPP data, the extrapolation of Stable Speed and the improved MET data.

The focus is set on the pure TP computation Algorithm, and not on the triggers of this computation Algorithm. Indeed, in an ATC system, there are many reasons why the Trajectory might be computed, and it is not the intention to be explicit enumerating all of them. Even more, depending on industrial choices, the reception of an EPP (or the detection of a Stable Speed) could trigger a Trajectory recomputation. Alternatively, the data could be stored and used in subsequent Trajectory recomputation. This way, it is not the intention to specify when a Trajectory shall be computed but how to improve it whenever it needs to be computed.

This particular Use Case starts on an update of the Flight Script, and involves the following functions:

- **Identify Initial Conditions for Trajectory**: (Improved function) – This function is responsible to identify which will be the starting point and conditions for the Trajectory. In Solution PJ.18-W2-53B, it is improved to properly manage the initial Speed and the Mass.

- **Identify Applicable Weather Conditions**: (Improved function) – This function will search for the applicable Weather Conditions, which are relevant for the Trajectory computation. In Solution PJ.18-W2-53B, it has been improved to take into account a more granular and detailed weather information coming from MET stakeholders, and also to use in a regressive way the current actual MET Grid (potentially this MET Grid would be enriched with ADS-C MET reports derived from all equipped Aircrafts, however, this is out of the scope of this solution).

- **Identify Guidance Control Laws**: (Improved function) – Taking as input the Flight Script and initial conditions, this function will identify the Manoeuvres to be executed by the Aircraft to comply with the Flight Script. In Solution PJ.18-W2-53B, it has been improved to use ADS-C reports data, detected Speed stability and also to implement the catch-up Manoeuvres in Descent Phase.

- **Apply Performances Model**: (Improved function) – This function will apply the Ground mathematical Performances model to identify the physical consequences of the identified Aircraft Manoeuvres under the existing meteorological conditions. In Solution PJ.18-W2-53B, it has been improved to use the correction coefficients for the Ground Performance model that are derived from the ADS-C EPP data, and also to adjust envelope trajectories used for conflict detection function in order to minimize the uncertainty area/volume between them.

- **Add Uncertainty Volume**: (Baseline function) – This function adds to the Tactical Trajectories some uncertainty volume in both lateral and Vertical dimensions.

- **Search for Trajectory conflicts**: (Baseline function) – This function will compare the different Trajectories computed by the system for different flights, in order to find those which are predicted to be closer that certain separation thresholds.

- **Display Trajectory and detected conflicts**: (Baseline function) – This function shows the improved Trajectory information to the ATCO, together with the conflicts that have been detected.

Note that this process is applicable for any Trajectory to be computed in Ground ATC System. The differences between them could be linked to the details on the Flight Script. A good example could be a What-if flight, whose Flight Script would include the changes being assessed. This way, it would also support Conflict Resolution Activities, since it would help to identify the potential Conflicts of tentative and speculative Resolution Actions.

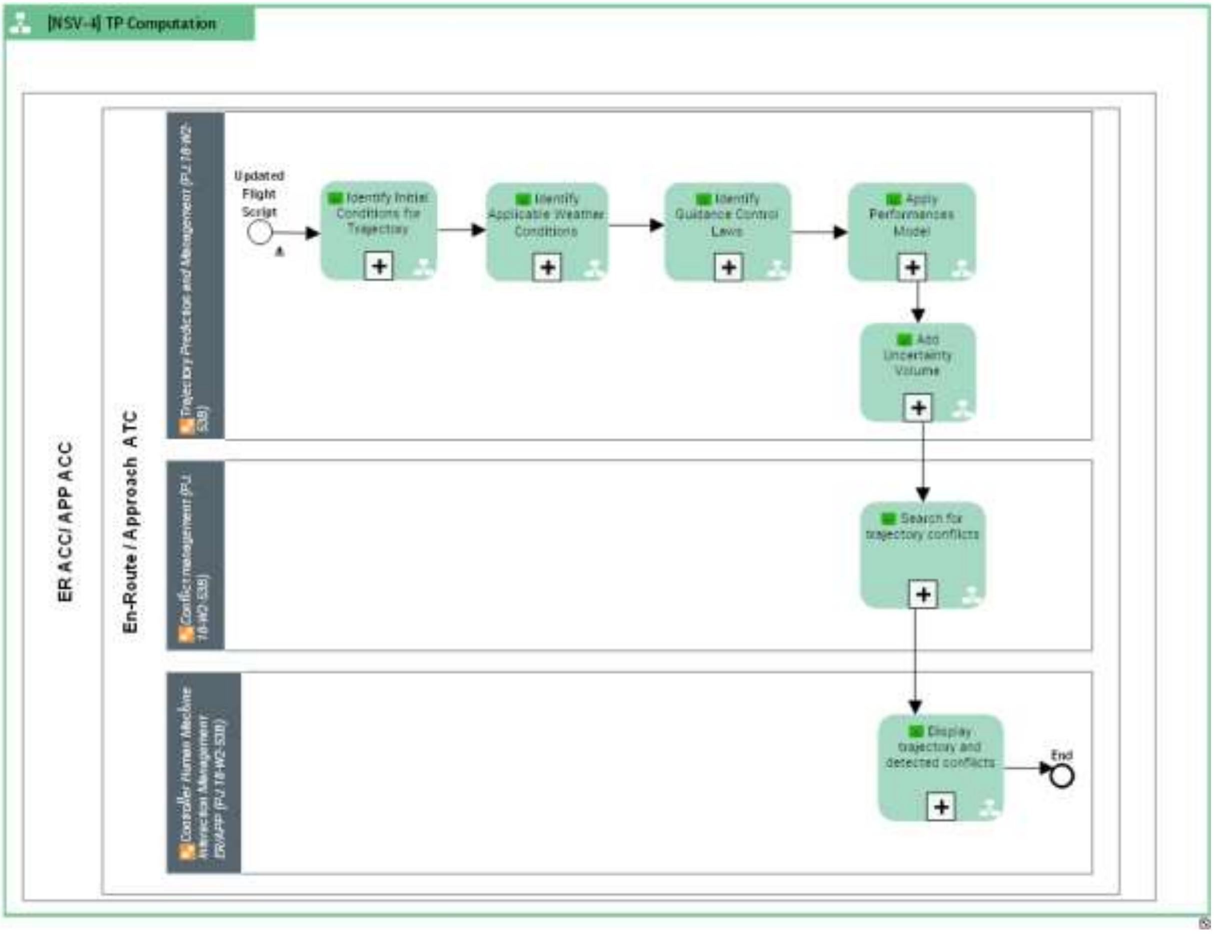


Figure 6: NSV-4 for the Trajectory Computation and Conflict Detection process

4.1.2 Resource Composition

The following Functional Blocks within En-Route/Approach ATC Technical System have been duplicated in order to create New Functions for them:

- A/G Datalink Communications
- A/G Datalink Services
- Conflict management
- Controller Human Machine Interaction Management ER/APP
- Monitoring Aids
- Support Functions ER/APP
- Trajectory Prediction and Management

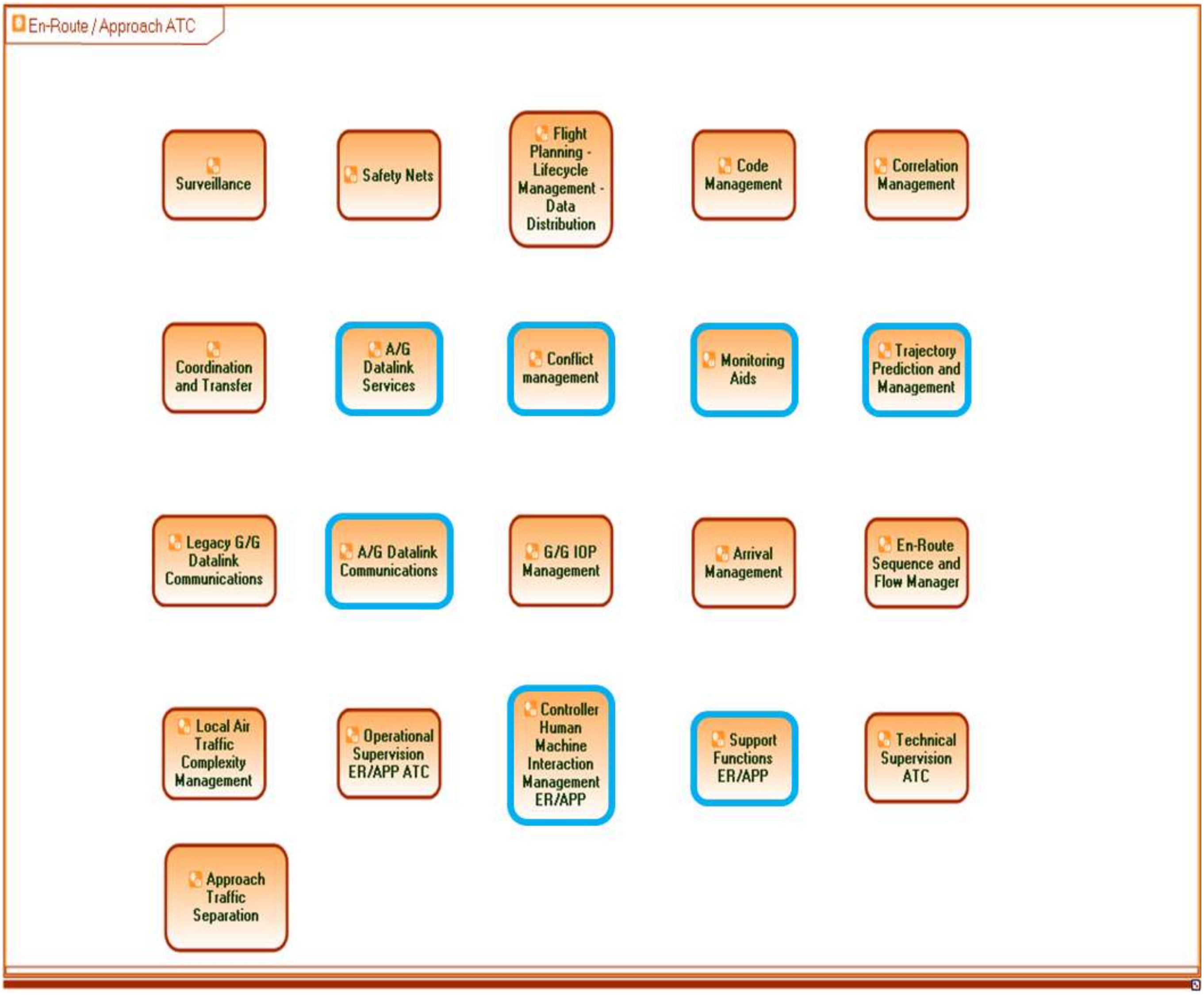


Figure 7: En-Route/Approach ATC (PJ.18-W2-53B) Technical System Artifact Assembly diagram

4.1.3 Service view

Not applicable. Legacy technologies (Datalink, Surveillance, MET GRIB) are not to be described as services. No new SWIM services have been developed.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4.2 Functional and non-Functional Requirements

4.2.1 Improvements on Trajectory Prediction from ADS-C data

4.2.1.1 Introduction

The Trajectory Prediction is a key process within an ATC System. It consists on predicting a list of 4D Positions (Lat/Long, Altitude and Time) representing the most likely Aircraft Trajectory for a given Flight Script. This Script includes different information depending on the specific Trajectory which is being computed (Planned, Tactical, What-if, What-else, etc.), but can include information about the (Expanded) Route, Open or Closed Loop Clearances and existing Level/Speed/Time Restrictions (either derived from a published Procedure, Letter of Agreement, or manually set by a Controller action).

From a 2D perspective, and where a Closed Loop 2D Clearance is existing, the Trajectories are computed intercalating “straight” segments (geodesic lines) between the Route Points with Turning Manoeuvres on those Points. This TS includes some Requirements to improve those Turning Manoeuvres based on ADS-C data, and also some Technical means to improve the 3D Profile and Estimated Time Over the Points.

In the following subsections, some details are provided about the TP inputs and the TP process, focusing on the Vertical & Longitudinal analysis, which is the most complex to understand. In other words, on the parameters related to the Total Energy (kinetic + potential) of the Aircraft.

4.2.1.1.1 TP Inputs

Any Trajectory computation depends on the following groups of parameters:

- Trajectory Initial Aircraft Conditions: The Aircraft Status at the point where the Trajectory is going to start. This includes not only the 4D Position of the Aircraft, but also other parameters such as the Aircraft Speed and Mass.

  This typically corresponds to the current Aircraft conditions, but this is not always the case. Trajectories might start at other 4D Positions, such as the estimated Take-off Position/Time (while the Aircraft is still taxiing or at the gate) or the entry COP for Inbound Flights (while the Aircraft is still being controlled by an Upstream ATSU and Surveillance data is not yet available).

- Flight Script: The set of mandatory targets that must be achieved or fulfilled by the Trajectory. These data can be seen as “what” the Trajectory shall achieve, but without completely restraining all the details on the Manoeuvres to be executed to achieve those targets. Several parameters, such as the shape of the Turning Manoeuvres, the utilised Speed… are often not included in the Flight Script, and this leaves several Open Degrees of Freedom remaining on several dimensions of the Trajectory. Among all the infinite options, the AU will choose “how” to proceed to maximize its Business Objectives.

  Note that ATCOs can force particular Manoeuvres (Turning, Speed, etc.) to be executed. When done, this will be considered as part of the Flight Script, and so part of the “what.” But, if looking for Flight Efficiency, this should be done only when strictly necessary for Separation purposes, since this kind of forced Manoeuvres prevents the AU from selecting more efficient Manoeuvres.

- Weather conditions: The current and Forecasted Weather conditions all along the Trajectory, including Winds & Temperature data (among other data).
- Airspace User Intent: Rules helping to select the particular Aircraft Guidance Control Laws that close the aforementioned Open Degrees of Freedom from the Flight Script, trying to anticipate the decisions to be taken by the FMS/Crew on the most convenient way for the AU to navigate under the conditions of the Flight Script.
- Aircraft Performance Model: The Mathematical Model allowing the computation of the Aircraft Performances (Lift, Drag, Thrust, etc.), for a given Aircraft Conditions and a given Guidance Control Law, while affected by a given Meteorological conditions. These Performances allow estimating changes on the Aircraft conditions (including 4D Position, Speed and Mass).

The quality of the information managed by Ground TP for each of the above parameters is limited, and there is a good opportunity to improve many of those inputs thanks to the new data exchanges between Aircraft and Ground ATC System. This Technical Specification provides the necessary Requirements to improve them using Aircraft Derived Data:

- Initial conditions: through the Actual Speed and Mass information.
- Weather conditions: through receiving an improved Weather Forecast generated by MET systems taking into account actual MET data measured by the Aircrafts.
- Airspace User Intent: through having better information about intended Speeds and turning Manoeuvres.
- Aircraft Performance Model: through the definition of Performance Coefficients deduced from a comparison between the EPP Profile and a Ground equivalent Profile.

There is also some uncertainty on the Flight Script. Nevertheless, this uncertainty is not a Technical uncertainty, but an Operational uncertainty on the future ATCO actions. SESAR Solutions PJ18-W2-56 and PJ18-W2-57 will focus on this topic through the exchange of more Complex and longer term Clearances which will limit the frequency of Tactical actions, and so reducing the uncertainty on the Flight Script.

4.2.1.1.2 TP process description

In order to better understand the Requirements defined in this TS, it is convenient to describe, from a high level perspective, which is the state-of-the-art TP process when computing a Trajectory. It is not intended to modify the whole process itself, so this section just makes a rough description, introducing some terminology later used on the Requirements.

A Trajectory is a discrete list of points, calculated iteratively in Steps. The size of those Steps might be defined as a Time Duration or as a Distance, but it typically has a small value (around 10 seconds, or 2 NM). This size is consequence of a compromise between the precision needed vs the CPU computation resources, and might vary depending on the length of the Trajectory (and of course between different Systems).

For each Step, the following terms can be defined:

- Step Initial Aircraft Conditions: The Step Final Aircraft Conditions of the previous Step, or the Global Trajectory Initial Aircraft Conditions in the very first Step.
- Step Target Aircraft Conditions: Representing the Desired Conditions, different to the Initial ones. They are defined as a 2D Target Position, a Target Altitude and a Target Speed. Nevertheless, the 2D Manoeuvres are out of the scope of this TS, and so will be ignored in the rest of the Document.
- Step Selected Manoeuvre: The Manoeuvre selected to evolve from the Initial to the Target Aircraft Conditions.
- Step Final Aircraft Conditions: The modified Aircraft conditions resulting of the application of the Step selected Manoeuvre during the duration of the Step. These are not necessarily equal to the Target Conditions: since the duration of the Step is limited, the Manoeuvre typically needs to be applied during several Steps in order to reach the Target Conditions (for example, reaching the Cruise Level).

Example: An Aircraft is at FL120, current Speed is IAS 310 (its intended Climb Speed), and neither Speed nor Altitude Restrictions are planned, so the Aircraft is assumed to Climb to the first Cruise Level.

- Step Initial Aircraft Conditions: FL120, IAS 310, etc.
- Step Target Aircraft Conditions: FL350, IAS 310 / Mach 0.78 (intended Climb Speed).
- Step selected Manoeuvre: Clean configuration, Climb Thrust setting, Pitch to maintain IAS.
- Step final Aircraft Conditions: FL125, IAS 310 (Transition Altitude still not reached).

This process is iteratively repeated, until the Final Aircraft Conditions reach the Target Ones.

4.2.1.2 Improvements on the Trajectory Initial Aircraft Conditions

The quality of the information managed by Ground TPs about the Initial Aircraft Conditions can be considered good enough concerning the 4D Position, especially when this Position corresponds to the Current Aircraft Position while it is under Radar coverage area. On the other hand, in those cases where the Initial Conditions are based on the Entry COP, or Estimated Take-off Time, the quality would be poorer, since the estimations are done by other external Systems, or based on certain rules resulting from statistical analysis of previous similar Flights.

Nevertheless, some improvements could be achieved for other parameters of the Initial Aircraft Conditions. Those improvements are considered more relevant in some cases, due to the Global vs Local effect of any adjustment on each parameter. In particular:

- The Actual Mass affects the Performances during the whole duration of the Flight. Currently, TPs estimate the Trajectory Initial Mass based on assumptions on the Take-off Weight (neither the Payload nor the Fuel are known, and have to be estimated). However, significant errors might be made on those assumptions (especially on the Payload estimation), and so, any improvement on the information of the Mass is very useful.

- The Actual Current Speed provides significant information about the Aircraft Current Kinetic Energy. Since the TP engines are usually based on Total Energy Models, an error on, for example, the estimation of the Initial Energy in Climb implies an error on the estimation of the total Time to reach the Final Cruise Energy (Altitude + Speed).

On the other hand, there are other parameters such as the instantaneous Pitch, or the Roll Angle, whose global effect on the Trajectory is considered low, since the TPs assume instantaneous transitions of those parameters when computing a Trajectory.

4.2.1.2.1 Initial Mass estimation

The Airspace Users have a good estimation of the Take-off Mass, since they know the number of boarded passengers, the weight of the checked-in luggage and the amount of Fuel loaded in the Aircraft. However, as the Aircraft is never weighted at the gate, and the real weight of each passenger with its carry-on luggage is unknown, the Take-off Mass will always be an estimation, but surely a more accurate estimation than the ones made by the current Ground TPs.

On top of that, the Aircraft can also measure the actual Fuel consumption, while Ground ATC Systems have to estimate it (nevertheless, those estimations are not so bad).

Therefore, Airspace User information allow to better estimate the Mass at one known Position. Once this is available, the Ground System can estimate a reasonable Mass for whatever different Trajectory Initial Position. Of course, any updated information of the Aircraft Actual Mass for any following Point will reduce the remaining imprecision around the Fuel consumption derived from Ground estimations.

In the following Requirements, a "Mass Report" shall be understood as an Aircraft Mass reported for a particular 4D Position, received through an ADS-C Report. Additionally, when referring to the "Reference Mass," it shall be understood as the Mass content received within the Mass Report. Finally, when referring to "Reference Mass Position," it shall be understood as the Position included in the "Mass Report," for which the Reference Mass is provided.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0001.0010
Title	Reception and recording of the latest "Mass Report"
Requirement	When receiving a Mass Report for the Flight, the En-Route / Approach ATC System SHALL store it, updating any previously received Mass Report, unless it refers to an Upstream Reference Mass Position.
Status	<validated>
Rationale	As defined before, a "Mass Report" is an Aircraft Mass reported for a particular 4D Position.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store ADS-C report
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0001.0020
Title	Trajectories starting at "Reference Mass Position"
Requirement	When computing any Trajectory starting at the Reference Mass Position, the En-Route / Approach ATC System SHALL consider the Reference Mass as the Initial Mass for the Trajectory computation.
Status	<validated>

Rationale	The Mass is valid only on the reported Position. For any Trajectory starting in a different Position, it is needed to assume there is a certain consumption.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify initial conditions for Trajectory
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0001.0030
Title	Trajectories starting at a Position different from the Reference Mass Position
Requirement	When computing any Trajectory starting at any Position different from the Reference Mass Position, the En-Route / Approach ATC System SHALL estimate the Fuel that the Aircraft has consumed to navigate from the Reference Mass Position to the Trajectory Initial Position, and subtract it from the Reference Mass in order to estimate the Initial Mass for the Trajectory computation.
Status	<validated>
Rationale	The Algorithm for estimating the Mass consumption is left to implementation decisions, but assumed to be depending on the Distance covered, the Total Energy Change (Altitude and Speed) and the Aircraft Performances Mathematical Model.

Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify initial conditions for Trajectory
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0001.0040
Title	Initial Mass with no Reference Mass
Requirement	When computing any Trajectory, if there are no Mass Reports for the Aircraft, the TP&M SHOULD estimate its Initial Mass by adding to the Aircraft's Operational Empty Weight an estimation of the Fuel needed to execute the Flight (based on the Distance to the Destination Aerodrome) and also the estimated Payload On-board.
Status	<validated>
Rationale	This is a non-mandatory Requirement, as not being specific to the TS scope (being legacy for some partners but not for others). The details are left unspecified since this is considered an implementation choice.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify initial conditions for Trajectory
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.2.2 Initial Speed estimation

As previously mentioned, the Initial Speed defines the Initial Aircraft Kinetic Energy.

Some TPs assume that the Initial Speed, at the Initial Trajectory Position, is equal to the Target Speed at such initial Trajectory Position. This means that the selected Manoeuvre, for the first Step, will maintain the Initial Speed, so no acceleration or deceleration is implemented from the Initial Speed to the Target one in the first Step(s). This can be done in two ways:

- Either assuming that the Trajectory Initial Speed is already equal to the Target Speed. This is the case when the Trajectory does not start at the current Aircraft Position, but on a future Position, such as an Entry COP.
- Either assuming that the Target Speed is equal to Aircraft Current Speed (the Initial Speed). Obviously, this second approach only makes sense in those cases where the Initial Speed can be measured (instead of estimated), and so, only makes sense when the Trajectory starting Point is corresponding to the Current Position of the Aircraft.

With the following Requirements, the objective is to polish the information about the Initial Total Energy of the Aircraft, assuming that the Initial Speed can be different from the Target Speed. This is only to be applied for those Trajectories starting at the Current Position of the Aircraft, and therefore, when there is correlated Surveillance information for that Flight including the Current Actual Speed.

The Total Energy Models (such as BADA) include simplifications regarding the computation of the Aircraft's Kinetic Energy, since this is based on the True Air Speed (instead of the Ground Speed). This way, the focus will be set on the usage of the actual True Air Speed. Legacy Surveillance functions will filter-out the impact of gusts of wind that might cause erratic behaviours.

Note: for those cases where there is not Actual Speed information available for the Initial Position (when the Trajectory does not start at the Current Position), the current logic would be maintained, and so, the Aircraft Speed will be assumed to be the Target one (or the Take-off Speed when the Trajectory starts at the Departure Aerodrome). In future sections, some details are provided about the Target Speed. Those Requirements indirectly impact this Initial Speed estimation in these cases.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0001.0050
Title	Current True Air Speed to be considered as Initial Trajectory Speed
Requirement	For Trajectories starting from the Current Aircraft Position, the En-Route / Approach ATC System SHALL consider as the Initial Speed of the Aircraft the Current True Air Speed.
Status	<validated>
Rationale	It is an implicit assumption that the Aircraft is correlated in the Ground System.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify initial conditions for Trajectory
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.3 Improvements in the Airspace User Intent

In this area, the Ground TPs manage the information of the worst relative quality compared to other areas.

For a particular Aerodynamic Configuration, there are three variables impacting the Aircraft movement: Thrust, Altitude and Speed, but only two can be controlled simultaneously. Accordingly, the following Manoeuvres, or Control Laws, can be considered:

- Speed and Thrust controlled. There is a Thrust setting which implies having a Thrust possibly different from the Drag. This will imply changes on the Total Aircraft Energy, while on the other hand, the Speed control implies changes on the Kinetic Energy. The difference between the changes on the Total Energy and the changes on Kinetic Energy constitute the changes on the Potential Energy, which translates to changes on the Altitude. This way, setting a Speed-And-Thrust Law implies having a variable Altitude, with the variations depending on Aircraft Performance Model.

  This kind of Manoeuvres are often referred by Airspace Users as “unrestricted” Manoeuvres, and constitute the optimal climbing and descending manoeuvre in absence of any restriction for the concerned flight. They may be computed by the FMS typically based on the Cost Index.

- Speed and ROCD controlled. In this case, it is necessary to compute the Thrust value which allows the forced changes on Kinetic and Potential Aircraft Energy.

  This kind of Manoeuvres is used, for example, on Cruise, where the Cruise Speed and Altitude are to be maintained. Additionally, these Manoeuvres can be applied on Descent Phase, when some shallow Descent Manoeuvres are chosen to avoid intermediate steady Phases in presence of an anticipated descending Clearance.

- ROCD and Thrust controlled. Similar to the previous ones, where there are changes on the Kinetic Energy now being caused by the other controlled variables, and also depending on Aircraft Performances.

  This kind of Manoeuvres is not commonly used, but one example could be the final (steady) deceleration manoeuvre implemented just before intercepting the glide path.

There is one additional and quite common Manoeuvre where only one of the variables is controlled: the Thrust is controlled, but the Speed and Altitude are left variable. This usually happens during acceleration in Climb or deceleration in Descent, and there is some additional Degree of Freedom regarding the sharing of the available Energy between changes on Speed and changes on Altitude.

In BADA model, this is solved by the usage of a fixed Sharing Percentage. While the sharing strategy could be improved, the global influence on the Trajectory would be low, and so those improvements are not considered by the moment.

The FMS/Aircrew select the most appropriate Manoeuvre or Control Law to evolve from its Initial Aircraft Conditions to its Target Aircraft conditions, and then selects a different one to maintain those Target Aircraft conditions as long as they do not change.

This way, this section focuses on providing Requirements for the appropriate selection of the Manoeuvre or Control Laws for different portions of the Trajectory (which of the above possibilities

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should be applied at each moment) and how to better parameterize the applicable Manoeuvres or Control Laws considering the new information provided by the Airspace User. This can be done by defining first which the Target Aircraft conditions are, and then selecting the appropriate Control Law to reach those conditions, and also which is the Control Law for maintaining those conditions when reached.

Among all the above Manoeuvres and parameters, this section will focus on certain changes and key aspects:

- The selection of the appropriate Control Law from the above list from the current Aircraft Position during Descent Phase, since the default law selected by ATC Systems up to now is not the optimal one intended by the Airspace Users.

- The selection of the most appropriate Target Speed, for which new downlinked information can help to better close-out Degrees of Freedom.

On top of the previous Manoeuvre selections, which have a strong focus on the Vertical Profile, additional improvements can be added to better model some aspects on the Turning Manoeuvres, including not only the strategy (Fly-by vs Fly-over) but also the Rate of Turn.

4.2.1.3.1 Selecting the most appropriate Control Law

This section is intended to provide further information on the FMS intended Control Laws for the Climb and Descend Manoeuvres, and propose further R&D activities to improve the TP to align to those FMS intended Manoeuvres.

4.2.1.3.1.1 High level view on FMS intended Manoeuvres

From a general perspective, the AU Intent during climbing Manoeuvres is to consider, as Target Aircraft conditions, their Scheduled Speed and the Cruise Level. Their intended Manoeuvre, and so the Aircraft behaviour in absence of any restriction, is to set a Climb Thrust setting that ensures first a quick transition from the Current Speed to the Target Scheduled one (CAS or Mach) and then, a longer evolution towards the Initial Cruise Altitude or the new Cruise Altitude on a Step Climb. This is the predicted Profile by the FMS, and is also the selected Manoeuvre during the Climb Phase when the Aircraft needs to climb to any higher altitude.

On the other hand and now focusing on the Descent, the general policy for the FMS Trajectory prediction is to compute firstly an Optimal Descent Profile based on an Idle Thrust Descent at constant Speed, being initiated as late as possible, but ensuring that all the descending Restrictions are achieved. Additionally, and in-between existing Restrictions, the Optimal Descent Profile policy is to avoid the intercalation of levelled segments. This way, if an Idle Thrust descent is too steep, another Manoeuvre based on a constant Vertical Speed is selected, and a Thrust value is derived from it.

This predicted Optimal Descent Profile is relevant for an appropriate selection of the descending manoeuvre to be applied/navigated when the Aircraft has already initiated the Descent Phase. Constituting an Optimal Profile, the idea is to follow it as long as it is compatible with the current Clearances. Nevertheless, during such Phase, the Aircraft might be forced to deviate with respect to this Optimal Profile.

This way, the selection of the descending Manoeuvre depends on the A/C relative Position against the Optimal Descent Profile:

- The A/C Position is considered to be below the Optimal Descent Profile when there is any downstream point in the Optimal Descent Profile whose altitude is equal (or higher) than the altitude of the concerned position.

- The A/C Position is considered to be above the Optimal Descent Profile when all the downstream points of the Optimal Descent Profile have an altitude which is lower than the altitude of the concerned position.

This way, the selected descending Manoeuvre is:

- When below the Optimal Descent Profile, the Manoeuvre will be a shallow descent, based on a fixed Vertical Speed Law, equal to -1000 ft/m (when above FL100) and equal to -500 ft/m (when below FL100).

- When above the Optimal Descent Profile, the Manoeuvre will be a steep descent based on an Idle Thrust setting, spoilers usage and setting a higher Speed (adding a delta).

Of course, when being ON the Descent Profile, the Manoeuvre will be the one needed to follow this Descent Profile, and this means selecting the same Manoeuvre than the one used to compute the Vertical Profile.

This way, the final Trajectory is a combination of two Trajectories:

- First, a Trajectory starting at the Initial Aircraft Conditions, following the "selected" Manoeuvre explained above until the point where this Trajectory crosses the Optimal Descent Profile.

- Second, the Optimal Descent Profile from the crossing point up to its end.

When the Aircraft is still in Climb and Cruise Phases, this would mean that the whole predicted Descent Profile is the Optimal Descent Profile, since the crossing point would be found at the Final Cruise Altitude, and would be considered to be the predicted TOD point.

On the other hand, if the Aircraft is already in Descent Phase:

- If it has been cleared to follow its Optimal Descent Profile, the first part of the Trajectory (to Catch-up the Optimal Descent Profile) will be minimal.

- If there are significant deviations from this Optimal Descent Profile, the first part of the Trajectory will be longer.

This can be better explained with the following figure. The solid lines represent the part of the Trajectories that, combined, form the overall predicted Trajectory. The dashed lines represent the "leftover" part of the Trajectories.

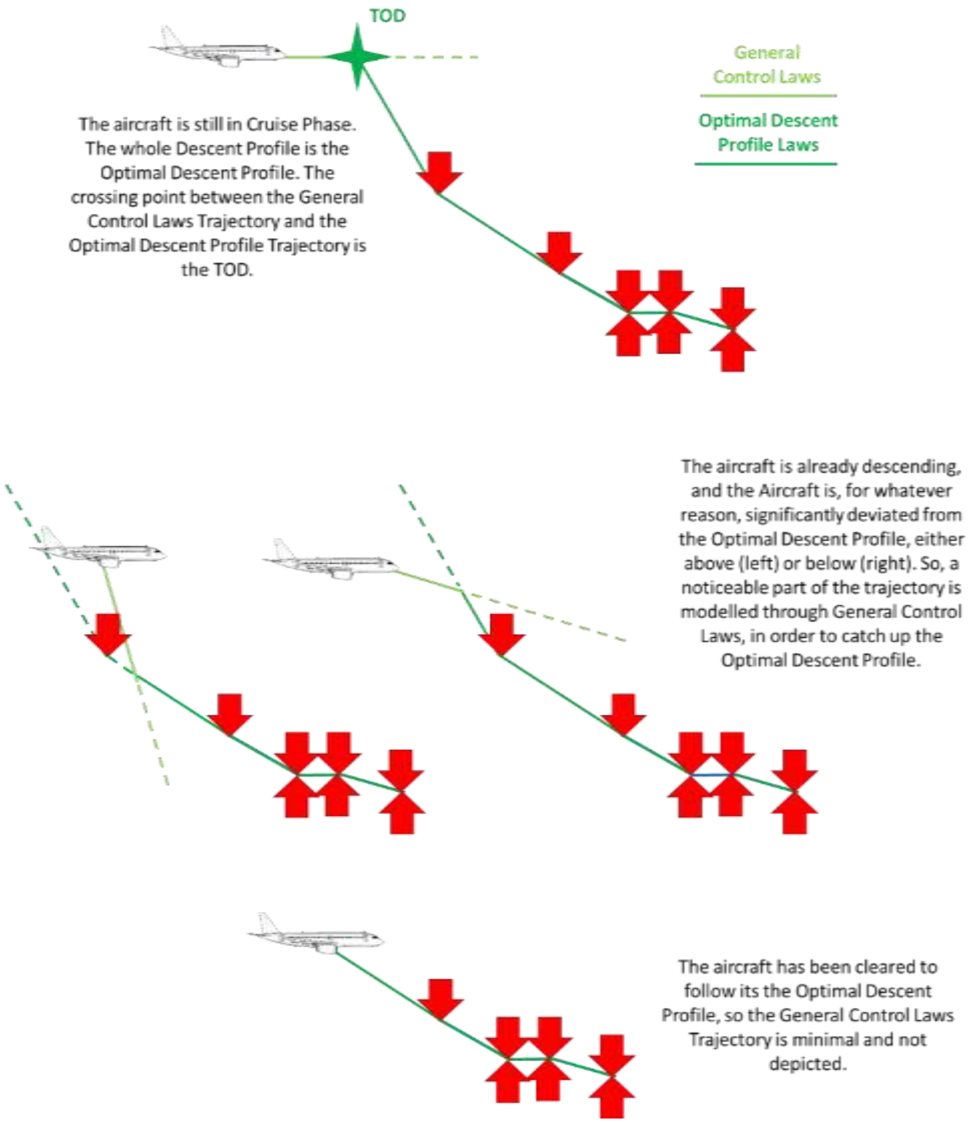

Figure 8: Combined Trajectory examples

Note that, even assuming an ideal nominal situation, with the A/C having followed the agreed Flight Plan on Full Managed Mode during all Descent, any modifications on the Route/Restrictions (such as a DCT) will trigger an Optimal Descent Profile recomputation with new targets. This new Optimal Descent Path is likely to be displaced, so the Aircraft would not be over it and a General Control Laws Trajectory would be needed to catch-up this new Optimal Descent Profile from current Aircraft Position.

4.2.1.3.1.2 Catch-up Manoeuvres

The operational TPs are always setting Idle Thrust rating in all descending Manoeuvres. This results into steep profiles. Nevertheless, due to existing descending Restrictions (from STAR or Approach procedures) and also due to potentially anticipated descend Clearances, it is necessary to insert levelled segments in-between the steep Manoeuvres. This makes the Trajectories to look like a stair.

On the other hand, as explained in the previous section, in order to manage existing descending Restrictions and anticipated Clearances, the FMSs intent is to smooth the descend profile, avoiding the need to insert levelled segments. This is done both in the Catch-up Manoeuvres (where -1000 ft/m and -500 ft/m are shallower Manoeuvres than an Idle Thrust rating Manoeuvre) and in the Geometric Manoeuvres in-between consecutive Restrictions.

The Catch-up Manoeuvre is propagated until the point where it crosses the Optimal Descending Profile derived from the existing descending Constraints. This way, the length of this Manoeuvre depends on those Constraints. In those cases where the FMS and the FDP have a different set of descending constraints, the length of this Catch-up Manoeuvre will be different, and some inaccuracy will exist on the FDP in the mid-term. However, the synchronization of descending Constraints is managed by solution PJ.18-W2-56, which is targeting V2 and so is still immature. This way, this catch-up Manoeuvres proposed in this section will improve the short term prediction, but will enable the further benefits once the constraints synchronization is validated and deployed.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0002.0010
Title	Catch-up from below
Requirement	In absence of restricted/forced Manoeuvres, for descending Manoeuvres below the computed Optimal Descent Profile, the En-Route / Approach ATC System SHALL assume that the Aircraft will implement a manoeuvre based on an altitude law: • Descending at -1000 ft/min (while Step Altitude is above FL100). • Descending at -500 ft/min (otherwise).
Status	<validated>
Rationale	To avoid inserting sub-optimal levelled segments within the Descent Phase Profile.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B

<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws.
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0002.0020
Title	Catch-up from above
Requirement	In absence of restricted/forced Manoeuvres, for descending Manoeuvres above the computed Optimal Descent Profile, the En-Route / Approach ATC System SHALL assume that the Aircraft will implement a steep descending Manoeuvre based on: • Idle Thrust rating. • Acceleration to a higher Speed (Target Speed + Delta) • Spoilers deployment.
Status	<validated>
Rationale	To ensure catching-up the Optimal Profile and facilitate that the Trajectories are landing at the ADES.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation

<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws.
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.3.2 Speed targets depending on FMS-perceived Flight Phases

The Requirements hereafter described on this section about the FMS-perceived Flight Phase are intended only to be applied to the selection of the most appropriate Speed values, without modifying other legacy functionalities on the FDP dependent on a local legacy definition of the Flight Phase. It is neither the intention of the TS to modify the local FDP definition of the Cruise Level(s).

A typical Flight follows three main Phases: Climb, Cruise and Descent. While the FMS distinguish other additional sub-Phases, they can be included on the mentioned ones for our purposes.

From a general perspective, the Climb Phase covers the segment of the Trajectory from the take-off until the Top Of Climb. The Cruise Phase goes from the Top Of Climb to the Top Of Descent. Finally, the Descent Phase goes from the Top Of Descent to the landing.

This way, in order to properly define the Flight Phases, it is necessary to define the Top Of Climb and Top Of Descent positions. According to the ED-228A document, which provides the Aircraft understanding of this points:

- The Top Of Climb refers to the position where the Initial Cruise Altitude is reached.
- The Top Of Descent refers to the position where the Aircraft starts descending from its Final Cruise Altitude.

Within the Flight Plan, the AUs use RFL(s) to request the Cruise Level(s). Nevertheless, RFL(s) are also used to include some intermediate Restrictions during Climb and Descent Phases, to avoid entering certain congested Airspaces. Different FMS models can manage differently RFLs and Cruise Levels, and pilots can manually modify the Cruise Level(s) in the FMS at any time. Thus, a common Ground-Air view on the Flight Phases cannot be guaranteed without a permanent access to updated FMS information.

However, even without this full synchronization, the Ground predictions can be enhanced. As long as they are allowed to, the AUs will fly at its intended Scheduled Speed. Since the FMS manages the Speed, and this strongly depends on FMS perception of the Flight Phase, the Ground TP could predict future Speed changes if it can anticipate the conditions where the FMS will change its perceived Flight Phase.

Thanks to the newly received AU information (ADS-C reports), the TP&M can have a better view on the FMS perception of the Flight Phases and transition points. According to the ATS B2 standard:

- The Climb Speed Schedule will be provided as long as the flight has not reached its Initial Cruise Altitude, and so, remains in Climb Phase. Then, it may no longer appear on the Speed Schedule report.
- The Cruise Speed Schedule will be provided as long as the Flight has not started the Descent Phase. Then, it may no longer appear on the Speed Schedule report.
- The EPP includes the TOC and TOD points, whose altitude will be equal to, respectively, the Initial and Final Cruise Altitudes considered by the FMS.

Note that this is out of the scope of this TS to propose any change on the ATC System related with a conformance check/alignment of the FMS perceived Cruise Levels and the Ground Planned Cruise Levels. The TS just focuses on the most appropriate Speed selection.

On the following diagram, a visual overview of the Speed Phase changes is portrayed to better explain the Requirements in this section.

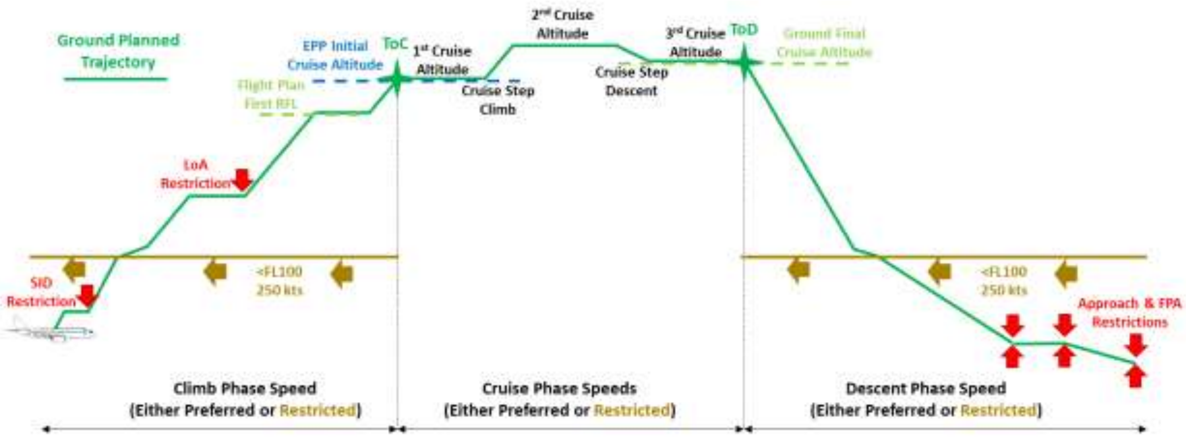

Figure 9: Overview of Phases/Speeds application

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0010
Title	Flight Phases
Requirement	When computing any Trajectory, the En-Route / Approach ATC System SHALL identify which is the initial FMS-perceived Flight Phase (Climb/Cruise/Descent) and identify the points where the Phase is predicted to change.
Status	<validated>
Rationale	The selection of the appropriate Aircraft Speed depends on the FMS-perceived Flight Phase.

Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0020
Title	Identification of “EPP Initial Cruise Altitude”
Requirement	The En-Route / Approach ATC System SHALL define the value of the “EPP Initial Cruise Altitude” matching with the Altitude of the point qualified as Top Of Climb on the last received EPP (if existing).
Status	<validated>
Rationale	Within the EPP only one point can be qualified as the Top Of Climb, and only one point as the Top Of Descent. Note that, as Flight advances, those points might be removed from the EPP. Nevertheless, in those cases, the identification of the Initial and Final Cruise Altitudes is not so relevant. See following Requirements.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store ADS-C report
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0030
Title	Identification of “EPP Final Cruise Altitude”
Requirement	The En-Route / Approach ATC System SHALL define the value of the “EPP Final Cruise Altitude” matching with the altitude of the point qualified as Top Of Descent on the last received EPP.
Status	<validated>
Rationale	Within the EPP only one point can be qualified as the Top Of Climb, and only one point as the Top Of Descent. Note that, as flight advances, those points might be removed from the EPP. Nevertheless, in those cases, the identification of the Initial and Final Cruise Altitudes is not so relevant. See following Requirements.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception

<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store ADS-C report
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

In the following sections, some Requirements are included to properly manage the FMS-perceived Flight Phases, in order to align with the Aircraft the conditions to change between them and have a better understanding on the scope of application of the Speed Schedule ADS-C report.

The Requirements focus on the conditions to change between FMS-perceived Flight Phases. Those conditions are to be applied to identify:

- Which is the FMS perceived Flight Phase at the Aircraft's current position (i.e. the Initial Phase for Trajectory prediction)
- When to change from one FMS-perceived Flight Phase to another along the Trajectory prediction.

The conditions are common for both. For example: the change from Climb to Cruise depends on levelling at the Initial Cruise Altitude. This way: if the Ground TP detects that the Aircraft has already levelled at the Initial Cruise Altitude, it will consider that the FMS-perceived Flight Phase at the Aircraft's Current Position has already changed to Cruise. But if the Aircraft has not yet levelled at the Initial Cruise Altitude, the Ground TP will consider that the FMS-perceived Flight Phase will change to Cruise in the first predicted Trajectory point where the Aircraft is predicted to level at the Cruise Level.

4.2.1.3.2.1 Transition between Climb and Cruise

The FMSs will change from Climb to Cruise Phase when the Aircraft reaches the FMS Initial Cruise Level. This way, knowing this Initial Cruise level is useful to predict the Phase change.

The FDP needs to identify a transition between FMS-perceived Climb and Cruise Phase’s logic in two scenarios. First: the TP needs to be aware of which is the current FMS-perceived Flight Phase, so it will compare the current Aircraft conditions with the triggering conditions/events of this change. Second: along a prediction, the TP need to identify if any of the predicted future points fulfils the conditions to change from FMS-perceived Climb to Cruise Phases.

Since the triggering conditions are identical in both scenarios, one single Requirement is enough to describe them.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0040
Title	Transition between Climb and Cruise

Requirement	The En-Route / Approach ATC System SHALL consider that the FMS-perceived Flight Phase is Climb until the A/C levels at an altitude higher or equal to the "EPP Initial Cruise Altitude", or a Ground-defined Initial Cruise Altitude in absence of EPP one, and change it to Cruise henceforth.
Status	<validated>
Rationale	This Requirement is valid to identify actual changes at current position and to identify, along a prediction, the point where the FMS-perceived Flight Phase is predicted to change.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

Following ATS B2 Requirements, the Speed Schedule Report has to be filled depending on the FMS perception of the Flight Phase. For example: when a Speed Schedule ADS-C report still includes Cruise and Descent Scheduled Speeds, but does no more include the Climb Scheduled Speed, the FMS “definitely” switched the Flight Phase to Cruise. In nominal conditions, the FMS will never switch back to the Climb Phase, and so the Speed Schedule ADS-C report will never more include the Climb Scheduled Speed.

This way, the main driver to detect that the FMS switched from Climb to Cruise Phase is the almost “definitive” absence of the Climb Scheduled Speed. The “definitive” switch from Climb to Cruise Phase by the FMS guarantees a stable Trajectory Processing for the Ground System, synchronized with the FMS processing.

Consequently, the Ground Trajectory will be processed using hereafter the Cruise Scheduled Speed, also if computing a climb to a higher altitude.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0050
Title	Climb to Cruise FMS-perceived Flight Phase change forced by ADS-C report
Requirement	When receiving a Speed Schedule ADS-C report not including Climb Scheduled Speeds while the En-Route / Approach ATC System considers the FMS-perceived Flight Phase is still Climb, the En-Route / Approach ATC System SHALL consider that the FMS-perceived Flight Phase is now Cruise.
Status	<validated>
Rationale	Mainly applicable to scenarios where the Aircraft might be forced to keep an altitude close (but below) its requested cruise level (the Ground ATC does not provide the final CFL equal to the cruise level). In that scenario, the crew might decide to force manually the change to Cruise Phase.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Update FMS-Perceived Flight Phase
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

In very rare exceptions, there could be a change back to Climb from Cruise On-board. If this happens, then the Speed Schedule would include again the Climb Speeds. Thanks to that, the TP can be aware of this change and adapt back the FMS-perceived Flight Phase.

If there were continuous changes between Climb & Cruise, the stability of the prediction could be questioned. Nevertheless, since the change back to Climb only happens in very rare exceptional cases, the risk of having an unstable prediction is negligible.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0060
Title	Cruise to Climb FMS-perceived Flight Phase change forced by ADS-C report
Requirement	When receiving a Speed Schedule ADS-C report that includes Climb Scheduled Speed(s) and in which a new "EPP Initial Cruise Altitude" can be identified, if the En-Route / Approach ATC System considers that the FMS-perceived Flight Phase is Cruise or Descent, then the En-Route / Approach ATC System SHALL change back and consider that the FMS-perceived Flight Phase is Climb.
Status	<validated>
Rationale	Mainly applicable to non-nominal (and exceptional) cases, as explained above. Also applicable to scenarios where the ADS-C report received is the first one for that flight, and so there was no previous knowledge by Ground TP of the "EPP Initial Cruise Altitude".
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Update FMS-Perceived Flight Phase
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

In the following examples is described the impact of a lack of synchronization between the FMS perceived Flight Phase and the Ground Planned one.

Example 1: First RFL not being considered as Cruise Level by the FMS

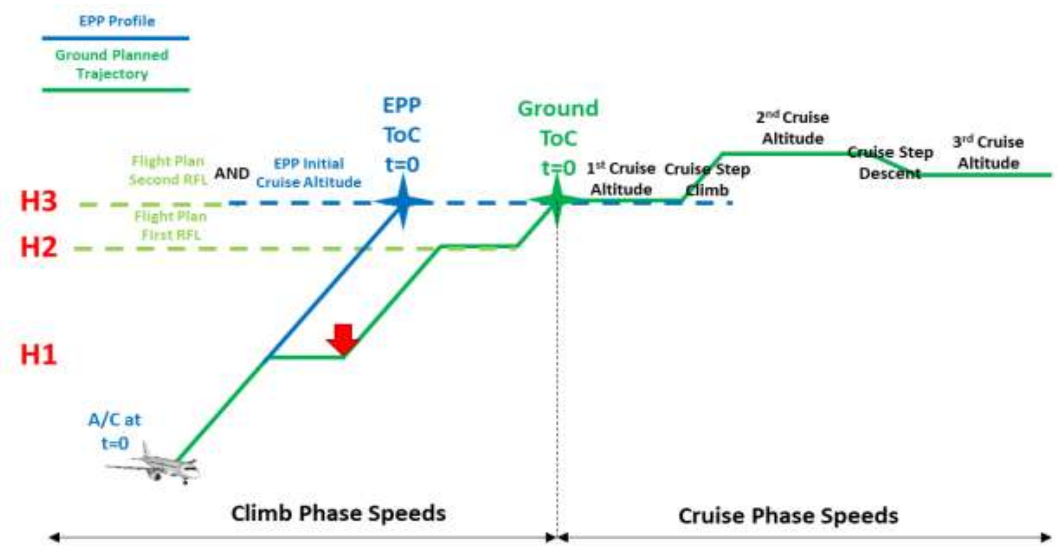

Figure 10: Example 1 Initial scenario

The Ground and Air Trajectories are NOT fully synchronized.

Note: t=0 in the above figure, as well as the rest of the figures on this section, shall not be understood as "Aircraft in Ground". The t=0 represents a generic point during the Climb Phase of the flight. The EPPs are considered as already available at t=0, and the Ground TP has already taken into account the reported data to improve its prediction.

At t=0, Ground has a predicted Trajectory including two intermediate level segments.

- The first levelling, at H1, is caused by a LoA altitude restriction, of which the FMS is not aware.
- The second levelling, at H2, is a RFL, present in the filled Flight Plan. This FMS does not manage this RFL as a Cruise level (for whatever reason).

So, the EPP Trajectory available at t=0 does not predict these intermediate level offs, and thus it predicts a continuous climb until reaching the Initial Cruise Level.

The A/C won’t effectively enter on Cruise Phase until reaching this ToC Altitude, regardless of the 2D position. Knowing this, the ATC can make a prediction using Climb Speeds until reaching the “EPP Initial Cruise Altitude” (H3), and Cruise Speeds onwards.

Let’s see what would happen as time advances.

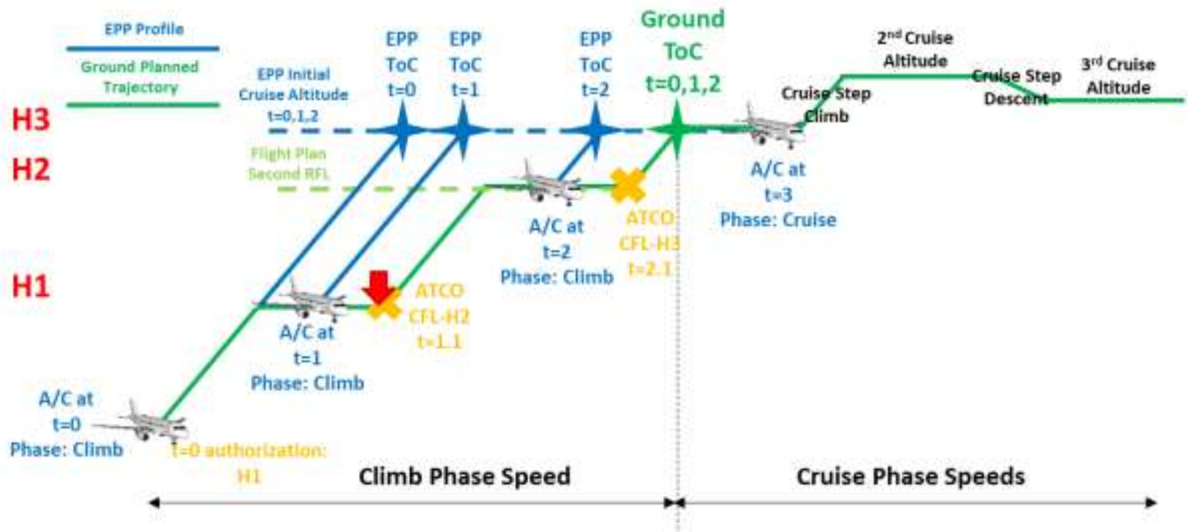

Figure 7: Example 1 Dynamic evolution

- At t=0, the A/C is cleared to H1 Altitude, so the pilot has set H1 as a Selected Altitude. The FMS does not integrate Selected Altitudes Below its ToC Altitude, so, although the A/C will effectively level at that altitude, the EPP generated at t=0 does not include the levelling.
- At t=1, the A/C has levelled at H1. The EPP generated at t=1 show a drift on the EPP ToC position. The A/C remains at Climb Speed.
- At t=1.1, the LoA Restriction is surpassed. The ATCO instructs a CFL to H2, and the pilot sets H2 as the new Selected Altitude.
- At t=2, and t=2.1, the situation is similar to the situation at t=1 and t=1.1 respectively
- At t=3, the A/C has reached the EPP Initial Cruise Altitude, entering on Cruise Phase and setting Cruise Speed, just as was predicted by Ground predicted Trajectory since t=0.

So, the Ground predicted Trajectory effectively anticipates the real future behaviour on Speed management of the A/C, even if the Trajectories were not synchronized, since it was predicting at t=0 that the Cruise Phase would start at H3, thanks to the usage of TOC predicted altitude from EPP.

Example 2: Ground is not planning to level the Aircraft at the FMS perceived Initial Cruise Altitude

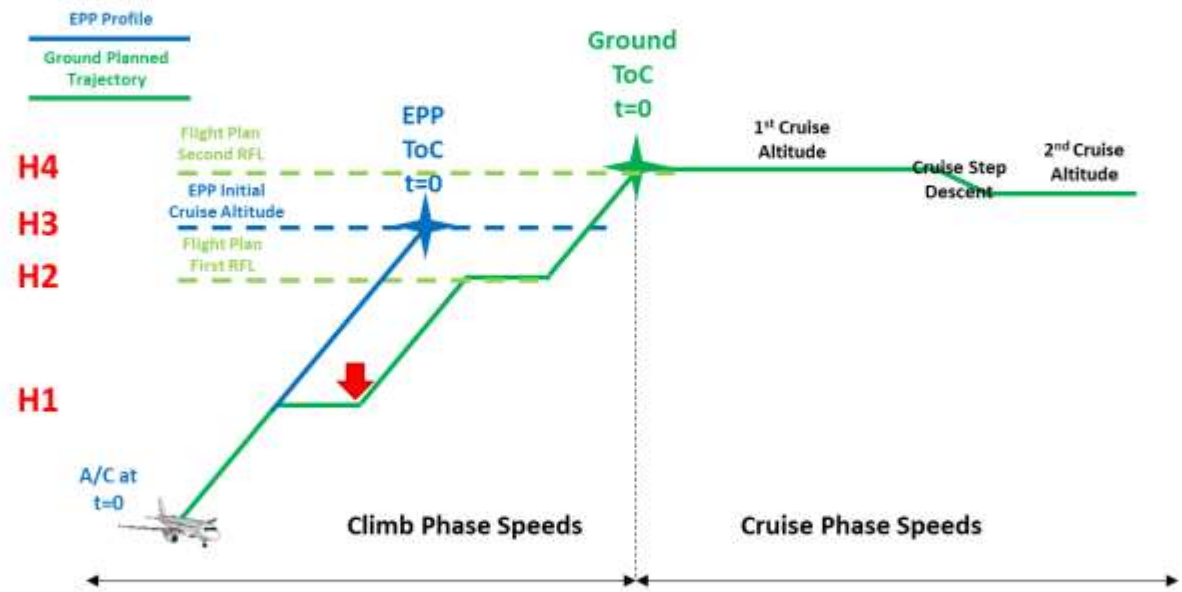

Figure 8: Example 2 Initial scenario

As it can be seen, the Ground TP should start considering the Cruise Phase Speeds once its Trajectory levels at a higher altitude than the EPP Initial Cruise Altitude (H4 instead of H3). In the next figure, a dynamic evolution of the flight is shown:

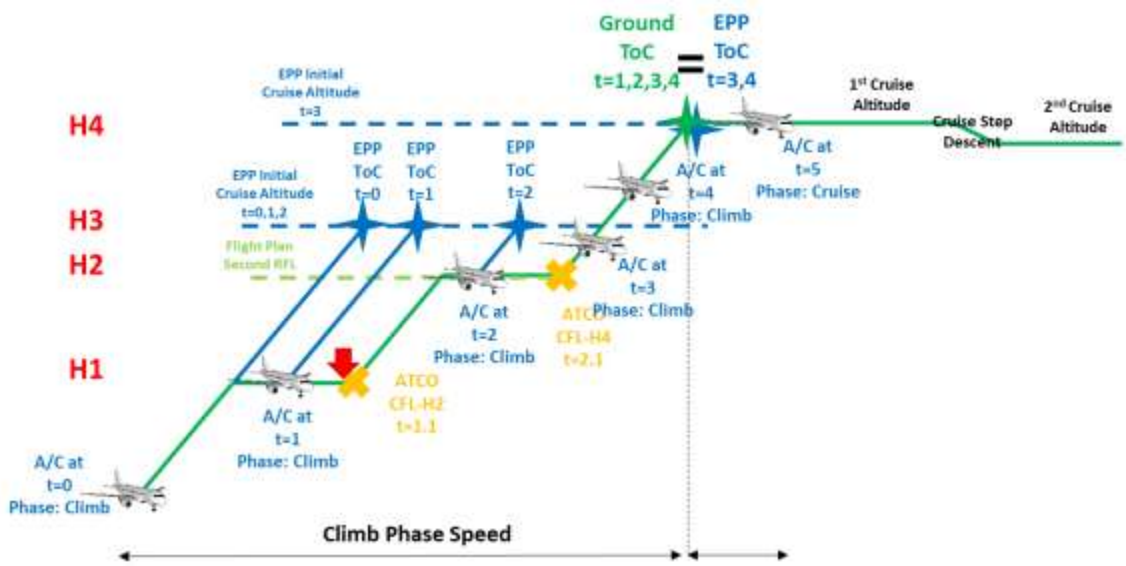

Figure 9: Example 2 Dynamic evolution

The dynamic evolution is similar until t=2.1. At that time, a CFL is instructed and introduced by the pilot as a Selected Altitude (SFL). As this altitude is above the FMS RFL/ToC Altitude, the FMS integrates it on the Airborne Plan, updating the FMS Initial Cruise Altitude. Thus, the EPP received on t=3 shows the updated ToC at the new altitude, and this will be the altitude where the FMS will start using the scheduled cruise Speed.

4.2.1.3.2.2 Transition between Cruise and Descent

The FMSs will change from Cruise to Descent Phase when the Aircraft leaves its known Final Cruise altitude.

In this case, it is not so relevant the EPP Top of Descent altitude, because the Final Cruise altitude on the FMS can change as a reaction to ATCO Clearances/instruction (it could become higher or lower).

Let's assume, for example, that an ATCO is planning a new Cruise Level to be applied from a certain position not yet reached by the Aircraft. This position is still not too close to the TOD position, but is situated after any other previously FMS-planned Cruise Level change.

This can be managed in the Ground Trajectory, but will probably not be shared with the Aircraft until it is close to such certain position. When the Aircraft receives the new instruction/Clearance, the crew will set a new selected level in the FCU, and the FMS will modify its Final Cruise altitude.

This way, the idea is that the Aircraft might have a wrong perception of the Final Cruise altitude, and it is better to rely on the Ground known one.

The difference with the Climb Phase is that, even if the ATCO instructions/Clearances can also change the FMS Initial Cruise Altitude, they can only make it to be higher, but not lower. This is: a lower selected level in the FCU during Climb does not trigger a change of the Initial Cruise Level in the FMS. This can only be the result of a manual pilot action in the MCDU, and this is a very unusual action. On the other hand, it is quite usual to have stepped climbs, with intermediate levelled areas during the Climb which are lower than the FMS perceived Initial Cruise Altitude. In those cases, it will still be the EPP Initial Cruise Altitude the one triggering the change on the Phase.

For the above reasons, the usage of the EPP Last Cruise altitude is not so relevant, unless this is a result of a correction (see following Requirements).

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0070
Title	Transition between Cruise and Descent
Requirement	After changing FMS-perceived Flight Phase to Cruise, the En-Route / Approach ATC System SHALL consider that the FMS-perceived Flight Phase is Cruise until the A/C leaves the Ground-defined "Ground Final Cruise Altitude", and change the FMS-perceived Flight Phase to Descent henceforth.
Status	<validated>

Rationale	Similarly to the Climb-Cruise transition Requirement, this Requirement is applicable both for: • Identifying actual changes at current position • During a prediction, identifying the point where the FMS-perceived Flight Phase will change to Descent Phase.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

Following ATS B2 Requirements, if a Speed Schedule ADS-C report does no more include the Cruise Scheduled Speed, the FMS “definitely” switched the Flight Phase to Descent. In nominal conditions, the FMS will never switch back to the Climb or Cruise Phase, and so the Speed Schedule ADS-C report will never more include the Cruise Scheduled Speed.

This way, the main driver to detect that the FMS switched from Cruise to Descent Phase is the almost “definitive” absence of the Cruise Scheduled Speed. The “definitive” switch from Cruise to Descent Phase by the FMS guarantees a stable Trajectory Processing for the Ground System, synchronized with the FMS processing.

As a consequence the Ground Trajectory will be processed using hereafter the Descent Scheduled Speed, also if remaining levelled for a while at a high altitude.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0080
Title	Cruise to Descent FMS-perceived Flight Phase change forced by ADS-C report

Requirement	When receiving a Speed Schedule ADS-C report not including Cruise Scheduled Speed while the En-Route / Approach ATC System considers the FMS-perceived Flight Phase is still Cruise, the En-Route / Approach ATC System SHALL consider that the FMS-perceived Flight Phase has now changed to Descent.
Status	<validated>
Rationale	Mainly applicable to scenarios where the Ground is considering a quite low En-Route Cruise level close to the end of the flight (maybe due to a TFL coordinated at the centre entry), but being low, the Aircraft already considers to be descending to the ADES.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Update FMS-Perceived Flight Phase
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

In very rare exceptions, there could be a change back to climb or cruise from descent on-board. If this happens, then the Speed Schedule would include again the Cruise and maybe also Climb Speeds. Thanks to that, the TP can be aware of this change and adapt the FMS-perceived Flight Phase. If there were continuous changes between climb, cruise and descent, the stability of the prediction could be questioned. Nevertheless, since the change back to climb/cruise only happens in very rare exceptional cases, the risk of having an unstable prediction is negligible.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0090

Title	Descent to Cruise FMS-perceived Flight Phase change forced by ADS-C report
Requirement	When receiving a Speed Schedule ADS-C report that includes Cruise Scheduled Speed(s) and in which a new "EPP Final Cruise Altitude" can be identified, if the En-Route / Approach ATC System considers that the FMS-perceived Flight Phase is Descent, then the En-Route / Approach ATC System SHALL change back and consider that the FMS-perceived Flight Phase is still Cruise, and will consider that the FMS-perceived Flight Phase will change to Descent when the Aircraft leaves the identified "EPP Final Cruise Altitude".
Status	<validated>
Rationale	Mainly applicable to non-nominal and exceptional scenarios, as explained above. Also applicable to scenarios where the Aircraft has received a descent Clearance, but the cleared level is not so low, and the Aircraft understands this level as a new cruise altitude, while the Ground TP considered this level as the beginning of the Descent Phase.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Update FMS-Perceived Flight Phase
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.3.2.3 Speed selection when FMS-perceived Flight Phase is Climb

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0100
Title	Intended Climb Speed
Requirement	The En-Route / Approach ATC System SHALL define the "Intended Climb Speeds", specified as a pair of values of CAS and Mach.
Status	<validated>
Rationale	The crossover altitude would be the transition point between both values (fixed CAS below the crossover altitude, and fixed Mach above it).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0110
Title	Intended Climb Speed selection

Requirement	In order to identify the "Intended Climb Speeds", the En-Route / Approach ATC System SHALL consider the following options (in descending priority order): • Climb scheduled Speed provided in the last received ADS-C report(s). • Off-line defined default intended climbing Speed applicable to that flight (such as the ones provided in BADA APF files).
Status	<validated>
Rationale	This Requirement is just to identify the best possible intent, but other Speeds (non-intended ones) might be targeted. See following Requirements.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

If there is a stable IAS/Mach Speed different from the intended ones, and there are no known Restrictions, it should be considered a pilot manual selection. This Speed would be almost certainly being flown on Selected Speed mode, and, even if it is not the most economic one (not being the one of the Speed Schedule), the pilot has decided to fly at that Speed for whatever reason, and it is reasonable to propagate this Speed downstream. Nevertheless, if the stable Speed is the FMS intended one, then it can be assumed that the pilot is maintaining the FMS intent.

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In case the Aircraft maintains a stable IAS during Climb Phase, it is assumed that there could be a cross-over altitude with the intended Mach. This intended Mach is the one identified in the previous Requirement.

Note that, below FL100, there is a Speed restriction: AT OR BELOW IAS 250, while most jet Aircrafts would have a higher Optimal Climb Speed. This way, maintaining an IAS 250 stable Speed below FL100 is the result of the restriction, and so would not be considered by the Algorithm.

NOTE: Some partners are currently concerned about lack of stability that could be caused by using the measured Air Speed, derived from previous studies concerning such information. This Requirement needs to be further discussed.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0120
Title	Monitor stable Climb Speed
Requirement	The En-Route / Approach ATC System SHALL monitor the actual A/C IAS and Mach Speeds while the FMS-perceived Flight Phase is Climb, and consider that: • The IAS is stable if the maximum difference between the IAS value of the last configurable number of tracks and the mean value of the IAS of all those tracks is lower than a configurable threshold. • The Mach is stable if the maximum difference between the Mach number of the last configurable number of tracks and the mean value of the Mach number of all those tracks is lower than a configurable threshold In both cases, the mentioned mean value of those last tracks is the one to be considered as the stable Speed.
Status	<validated>
Rationale	It is needed to monitor the actual IAS/Mach Speeds, since the pilot might have manually selected a Speed different from the FMS intended one.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System

<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0130
Title	Ignore invalid stable IAS Climb Speed
Requirement	The En-Route / Approach ATC System SHALL ignore the detected stable IAS Climb Speed if the difference in percentage between the intended IAS Climb Speed and the detected stable IAS Climb Speed is higher than the difference between the intended Mach Climb Speed and: • The detected stable Mach Climb Speed (if the Mach Climb Speed was detected to be stable) or • The current Mach Climb Speed (otherwise)
Status	<validated>
Rationale	This is to ensure the system filters out any detected stable Speed when it seems not reasonable, considering the current Aircraft Speed and its intent.
Category	<Functional>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids

<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0140
Title	Ignore invalid stable Mach Climb Speed
Requirement	The En-Route / Approach ATC System SHALL ignore the detected stable Mach Climb Speed if the difference in percentage between the intended Mach Climb Speed and the detected stable Mach Climb Speed is higher than the difference between the intended IAS Climb Speed and: • The detected stable IAS Climb Speed (if the IAS Climb Speed was detected to be stable) or • The current IAS Climb Speed (otherwise).
Status	<validated>
Rationale	This is to ensure the system filters out any detected stable Speed when it seems not reasonable, considering the current Aircraft Speed and its intent.
Category	<Functional>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0150
Title	Determination of the target Speed on Climb
Requirement	During computation steps belonging to the FMS-perceived Climb Phase, the En-Route / Approach ATC System SHALL assume that the target Speed is (in descending priority order): • The Speed restriction/Clearance value if existing (and applicable). • The last measured stable Climb Mach Speed (if existing and different from the Intended Climb Mach Speed by a percentage higher than a configurable threshold variable) • The last measured stable Climb IAS Speed, as long as the step altitude remains below the crossover altitude with the Intended Mach Speed, and just if it is different from the Intended Climb IAS Speed by a percentage higher than a configurable threshold variable) • The "Intended Climb Speeds" otherwise.
Status	<validated>
Rationale	This TS does not specify the applicable Speed Restrictions. This is defined according to the Flight Script, and varies among different Trajectories (Planned, Tactical, what-if, etc.).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws

<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

In the above Requirement, note that Speed Restrictions might not imply a fixed value, but a range of allowed values (such as "AT OR LESS" or "AT OR MORE" Restrictions). In these cases, there is a degree of freedom that can be closed with the following (and lower priority) values, such as the stable Speed or intended Speed. This way, if the following Speed to be applied is within the allowed range, it shall be applied, but if it is out of the range, the closest value within the range is to be considered.

4.2.1.3.2.4 Speed selection when FMS-perceived Flight Phase is Cruise

The Cruise Phase usually will generally take place above the Crossover Altitude and flown at a nearly constant Mach, but in some particular cases, some sections could be below that altitude, and so a utilization of CAS Speed would be needed.

Several Cruise segments can exist, each one with its own Speed Target (as explained in following Requirements, where the Speed prediction on EPP Cruise points is checked).

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0200
Title	Intended Cruise Speed
Requirement	The En-Route / Approach ATC System SHALL define the "Intended Cruise Speeds", specified as a set of CAS/Mach values, being each value applicable to a Cruise Phase segment.
Status	<validated>
Rationale	It might happen that there is only one segment, covering the whole Cruise Phase.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation

<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

In some Aircrafts, especially for long Routes, a certain Cruise acceleration could be foreseen, and the Initial Cruise Speed would be lower than the final one. In addition, the Final Cruise Speed could be low in preparation for a Descent Phase to be started in some flights. This way, detailed information on the Speed on each Route point would be needed to properly model this acceleration.

This information can be obtained from the EPP and/or the standard FPL. However, using this information might not be obvious when there are discrepancies with regards to the Ground Route & Restrictions.

This way, for the Cruise Phase, it is recommended to use this detailed Speeds to detect planned changes, assuming that a certain traceability between the concerned EPP/eFPL points and the flight plan can be established (no detailed Requirements are to be written on this traceability topic).

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0210
Title	Intended Cruise Speeds selection
Requirement	In order to identify the Intended Cruise Speeds, the En-Route / Approach ATC System SHALL consider the following options (in descending priority order): • Cruise scheduled Speed(s) and predicted Speeds on EPP cruise points, provided in the last received ADS-C report(s). • Cruise Speed(s) provided within the standard FPL (fields F15a and F15c). • Off-line defined default intended cruise Speed applicable to that flight (such as the ones provided in BADA APF files).
Status	<validated>
Rationale	Similar to previous Phase, but considering also the intermediate Route point targets, as well as considering Flight Plan fields.

Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

If there is a stable IAS/Mach Speed different from the intended ones, and there are no known Restrictions, it should be considered a pilot manual selection. This Speed would be almost certainly being flown on Selected Speed mode, and, even if it is not the most economic one, the pilot has decided to fly at that Speed for whatever reason, and it is reasonable to propagate this Speed downstream. Nevertheless, if the stable Speed is the FMS intended one, then it can be assumed that the pilot is maintaining the FMS intent.

In case the Aircraft maintains a stable IAS during Cruise Phase, it is assumed that there could be a cross-over altitude with the intended Mach. In a similar way, if the Mach is stable, there could be a cross-over altitude with the intended IAS. In both cases, the intended Mach / IAS is the one identified in the previous Requirement.

Note that, below FL100, there is a Speed restriction: AT OR BELOW IAS 250, while most jet Aircrafts would have a higher optimal climb Speed. This way, maintaining an IAS 250 stable Speed below FL100 is the result of the restriction, and so would not be considered by the algorithm.

NOTE: Some partners are currently concerned about lack of stability that could be caused by using the measured air Speed, derived from previous studies concerning such information. This Requirement needs to be further discussed.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0220
Title	Monitor stable Cruise Speed

Requirement	The En-Route / Approach ATC System SHALL monitor the actual A/C IAS and Mach Speeds while the FMS-perceived Flight Phase is Cruise, and consider that: • The IAS is stable if the maximum difference between the IAS value of the last configurable number of tracks and the mean value of the IAS of all those tracks is lower than a configurable threshold. • The Mach is stable if the maximum difference between the Mach number of the last configurable number of tracks and the mean value of the Mach number of all those tracks is lower than a configurable threshold In both cases, the mentioned mean value of those last tracks is the one to be considered as the stable Speed.
Status	<validated>
Rationale	Similar to previous Phase.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0230
Title	Ignore invalid stable IAS Cruise Speed

Requirement	The En-Route / Approach ATC System SHALL ignore the detected stable IAS Cruise Speed if the difference in percentage between the intended IAS Cruise Speed and the detected stable IAS Cruise Speed is higher than the difference between the intended Mach Cruise Speed and: • The detected stable Mach Cruise Speed (if the Mach Cruise Speed was detected to be stable) or • The current Mach Cruise Speed (otherwise)
Status	<validated>
Rationale	Similar to previous Phase.
Category	<Functional>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0240
Title	Ignore invalid stable Mach Cruise Speed

Requirement	The En-Route / Approach ATC System SHALL ignore the detected stable Mach Climb Speed if the difference in percentage between the intended Mach Climb Speed and the detected stable Mach Climb Speed is higher than the difference between the intended IAS Climb Speed and: • The detected stable IAS Climb Speed (if the IAS Climb Speed was detected to be stable) or • The current IAS Climb Speed (otherwise)
Status	<validated>
Rationale	Similar to previous Phase.
Category	<Functional>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0250
Title	Determination of the target Speed on Cruise

Requirement	During computation steps belonging to the FMS-perceived Cruise Phase, the En-Route / Approach ATC System SHALL assume that the target Speed is: • The Speed restriction/Clearance value if existing (and applicable). • The last measured stable Cruise Mach Speed, as long as the step altitude remains above the crossover altitude with the Intended IAS Speed, and just if it is different from the Intended Cruise Mach Speed by a percentage higher than a configurable threshold variable) • The last measured stable Cruise IAS Speed, as long as the step altitude remains below the crossover altitude with the Intended Mach Speed, and just if it is different from the Intended Cruise IAS Speed by a percentage higher than a configurable threshold variable) • The "Intended Cruise Speeds" otherwise.
Status	<validated>
Rationale	Similar to previous Phase.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.3.2.5 Speed selection when FMS-perceived Flight Phase is Descent

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0300
Title	Intended Descent Speed
Requirement	The En-Route / Approach ATC System SHALL define the "Intended Descent Speeds", specified as a pair of values of CAS and Mach.
Status	<validated>
Rationale	Similar to previous Phases.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0310
Title	Intended Descent Speed selection

Requirement	In order to identify the "Intended Descent Speeds", the En-Route / Approach ATC System SHALL consider the following options (in descending priority order): • Descent scheduled Speed provided in the last received ADS-C report(s). • Off-line defined default intended Descent Speed applicable to that flight (such as the ones provided in BADA APF file).
Status	<validated>
Rationale	Similar to previous Phases.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

If there is a stable IAS/Mach Speed different from the intended ones, and there are no known Restrictions, it should be considered a pilot manual selection. This Speed would be almost certainly being flown on Selected Speed mode, and, even if it is not the most economic one (not being the one of the Speed Schedule), the pilot has decided to fly at that Speed for whatever reason, and it is reasonable to propagate this Speed downstream. Nevertheless, if the stable Speed is the FMS intended one, then it can be assumed that the pilot is maintaining the FMS intent.

In case the Aircraft maintains a stable Mach during Descent Phase, it is assumed that there could be a cross-over altitude with the intended IAS. This intended IAS is the one identified in the previous Requirement.

Note that, below FL100, there is a Speed restriction: AT OR BELOW IAS 250, while most jet Aircrafts would have a higher optimal climb Speed. This way, maintaining an IAS 250 stable Speed below FL100 is the result of the restriction, and so would not be considered by the algorithm.

NOTE: Some partners are currently concerned about lack of stability that could be caused by using the measured air Speed, derived from previous studies concerning such information. This Requirement needs to be further discussed.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0320
Title	Monitor stable Descent Speed
Requirement	The En-Route / Approach ATC System SHALL monitor the actual A/C IAS and Mach Speeds while the FMS-perceived Flight Phase is Descent, and consider that: • The IAS is stable if the maximum difference between the IAS value of the last configurable number of tracks and the mean value of the IAS of all those tracks is lower than a configurable threshold. • The Mach is stable if the maximum difference between the Mach number of the last configurable number of tracks and the mean value of the Mach number of all those tracks is lower than a configurable threshold In both cases, the mentioned mean value of those last tracks is the one to be considered as the stable Speed.
Status	<validated>
Rationale	Similar to previous Phases.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability

<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0330
Title	Ignore invalid stable IAS Descent Speed
Requirement	The En-Route / Approach ATC System SHALL ignore the detected stable IAS Descent Speed if the difference in percentage between the intended IAS Descent Speed and the detected stable IAS Descent Speed is higher than the difference between the intended Mach Descent Speed and: • The detected Stable Mach Descent Speed (if the Mach Descent Speed was detected to be Stable) or • The current Mach Descent Speed (otherwise)
Status	<validated>
Rationale	Similar to previous Phases.
Category	<Functional>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0340
Title	Ignore invalid stable Mach Descent Speed
Requirement	The En-Route / Approach ATC System SHALL ignore the detected stable Mach Descent Speed if the difference in percentage between the intended Mach Descent Speed and the detected stable Mach Descent Speed is higher than the difference between the intended IAS Descent Speed and: • The detected stable IAS Descent Speed (if the IAS Descent Speed was detected to be stable) or • The current IAS Descent Speed (otherwise)
Status	<validated>
Rationale	Similar to previous Phases.
Category	<Functional>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Monitor Speed Stability
<ALLOCATED_TO>	<Functional block>	Monitoring Aids
<ALLOCATED_TO>	<Function>	Monitor Speed Stability
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0003.0350
Title	Determination of the target Speed on Descent

Requirement	During computation steps belonging to the FMS-perceived Descent Phase, the En-Route / Approach ATC System SHALL assume that the target Speed is: • The Speed restriction/Clearance value if existing (and applicable). • The last measured stable Descent Mach Speed, as long as the step altitude remains above the crossover altitude with the intended IAS Speed, and just if it is different from the intended Descent Mach Speed by a percentage higher than a configurable threshold variable) • The last measured stable Descend IAS Speed (if existing and different from the intended Descent IAS Speed by a percentage higher than a configurable threshold variable) • The "Intended Descent Speeds" otherwise.
Status	<validated>
Rationale	Similar to previous Phases.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.3.3 Improving turning Manoeuvres

This section includes Requirements for improving both the turn radius and the turning strategy (fly-by vs fly-over) using information from the EPP.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0004.0010
Title	Use of EPP information to enhance turning manoeuvre computation
Requirement	When computing the turning manoeuvre for named waypoints, the En-Route / Approach ATC System SHALL use the EPP transition strategy for that point if: • This Waypoint, and also the Previous and Next Waypoints, are also part of the EPP Route, • The Waypoint in the EPP contains, as Lateral Type, either "flyby"/"fixedRadiousTransition" or "Overfly". • The altitude at the current Trajectory step is within a configurable Threshold around the predicted altitude on the concerned EPP point. • The Speed (IAS/Mach) at the current Trajectory step is within a configurable Threshold around the predicted Speed (IAS/Mach) on the concerned EPP point.
Status	<validated>
Rationale	For points not fulfilling this conditions, the En-Route / Approach ATC System will just still use its legacy algorithm for identifying the transition strategy for the turning manoeuvre.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)

<ALLOCATED_TO>	<Function>	Identify guidance control laws
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

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4.2.1.4 Improvements on Aircraft Performance Model

4.2.1.4.1 Limitations on the current Aircraft Performance model

The Aircraft Performance Models used by modern TPs is quite accurate, but has two main limitations that need to be properly understood: the existing A/C variants and the Flight-specific AU preferences for engine management and operation.

The most popular Aircraft types, such as the A320 and the B737 have tens of different variants. Those variants might differ on the engines, and/or on some modern aerodynamic options. Nevertheless, the 4 characters ICAO Aircraft type for all those variants remains the same, so the ATC system cannot distinguish the variant used for each flight.

As a mitigation measure, one option could be to include in the flight plan some further information allowing to identify the specific variant being used. Nevertheless, this would not solve the issue. The modern Aircraft Performance Models contain only one variant per Aircraft type, while it would be needed to ensure that each variant should have their own Model, and this would be a very expensive approach.

On top of that, there is a second limitation: the Flight-specific AU preferences for the engine management and operation. It is usual that AUs define some de-rating policy for the engine, so that the stress on the Aircraft Engines is reduced and the lifetime of the Engine is improved. While the modern Aircraft Performance Models include an approach to compute a reduced climb power, the flight plans are not containing any information about the de-rating policy for the flight, and it constitutes a sensitive information which is unlikely to be added.

4.2.1.4.2 EPP profile as a reference for the Performance Model

While the FDPs have no access to the information about the Aircraft type variant or the AU de-rating policies, the on-board FMS is fully aware on those elements. Its internal Performance model is optimized for the specific type/variant, and any thrust de-rating policy is injected to the FMS as an input parameter for the Trajectory computation and flight optimization algorithms.

The EPPs are computed by the FMS, and so, are representative of the true Aircraft Performance model. There is an opportunity for the FDPs to use the EPP modelled Vertical Manoeuvres in order to fine tune the internal Performance model of the FDP for that specific flight.

4.2.1.4.3 Technical proposal to fine tune FDP performance model

[REQ]

Identifier	REQ-18-W2-S53b-TS-0005.0010
Title	Compute coefficients on EPP reception
Requirement	When receiving an EPP, the En-Route / Approach ATC System SHALL compare the EPP Vertical Profile with an FDP-computed temporal Vertical Profile using the available Aircraft Performance Model, in order to identify coefficients allowing to fine tune the Ground Aircraft Performance Model.
Status	<validated>
Rationale	Those coefficients are needed to minimize the errors from erroneous/limited Ground Performance model or also the lack of the EPP gross Mass Value.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Compute Performances coefficients
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0005.0020
Title	Computing a temporal Vertical Profile for the comparison

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Requirement	In order to isolate from 2D or 3D discrepancies between the FMS and the FDP flight plans, the En-Route / Approach ATC System SHALL compute a temporal Vertical Profile which ignores the current flight plan Route and restriction, but instead tries to mimic the EPP profile: • It starts at the ADS-C reported position, and sets the current gross Mass, if included on the EPP, or the FDP estimated mass if not. • From 2D perspective, it follows a Route based on the 2D position of each of the points included in the EPP • It defines altitude and Speed Restrictions matching the ones existing in the EPP points. • It models the Speed to match the predicted Speeds shown in the EPP points • It SHALL use the ATC system latest MET data available
Status	<validated>
Rationale	Comparing Performances between non-aligned Trajectories (for example, flying at different Speeds) would not provide good Performance coefficients. This MET data could be enriched by ADS-C MET reports if the MET provider has received and processed the data.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Compute Performances coefficients
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100

<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0005.0030
Title	Compare EPP and Ground profiles
Requirement	Once this temporal profile is obtained, the En-Route / Approach ATC System SHALL compare the Vertical Speed for those climbing and descending Manoeuvres which are based on a Thrust rating law, where: • All climbing Manoeuvres are assumed to be based on a Thrust rating law. • For the descend Manoeuvres, only those in-between the Top Of Descend and the very first descending restriction (if any) will be assumed to be based on a Thrust rating law.
Status	<validated>
Rationale	It was considered that, in general, comparing other Manoeuvres where the thrust rating is not fixed would not provide a good indication of the physical Performance of the Aircraft, as in constant V/S or geometric segments. However, some cases have been found during the test for an Upper Centre, which does not have any information of the Descent Procedure Restrictions, where it can be useful to apply the Performance Coefficients in order to mirror the Vertical Speed of a Geometric Manoeuvre, even if ATC system does not know the constraint contained in the on-board system. Therefore, some more investigation is recommended on the applicability of applying Performance Coefficients ALSO on some manoeuvres that are not based on a Thrust rating law.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System

<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Compute Performances coefficients
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0005.0040
Title	Identify Performance coefficients at equivalent altitudes
Requirement	Following the comparison, the En-Route / Approach ATC System SHALL compute the ratio between the EPP Vertical Speed and the FDP computed Vertical Speed at equivalent altitudes. This gives a list of a dimensional Performance Coefficients with values applicable for sets of levels (differentiating Climb and Descent). $Coefs = \frac{EPP\ Segment\ Vertical\ Speed}{BADA\ Segment\ Vertical\ Speed}$
Status	<validated>

Rationale	Here below, a list of a dimensional Performance Coefficients example is shown: For Climb • 10000ft-15000ft Coef 1.2 • 150000-19000ft Coef 1.3: For Descent: • 19000ft-15000ft Coef 0.92 • 150000-10000ft Coef 0.91: Considering that the EPP gross Mass is available for the flight, and that the MET models from FMS and ATC system are aligned, this Performance Coefficient mainly accounts for the Difference on the Available Power (Thrust-Drag) due to the lack of precise information of the pure BADA model. However, if the EPP gross Mass has not been received, these Performance Coefficients are computed on the same way. In that case, the performance Coefficients take into consideration at the same time both the Difference on the Available Power and the effect of the mass difference between the Real one and the FDP estimated mass ((Thrust-Drag)/Mass).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Compute Performances coefficients
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0005.0050
Title	Using coefficients during Trajectory computation
Requirement	For any subsequent Trajectory computation, the En-Route / Approach ATC System SHALL perform the ROCD computations taking into account the computed Coefficients during those Vertical and/or Speed change Manoeuvres based on a Thrust rating law. Any ROCD computation based on a Thrust-Rating law manoeuvre is multiplied by the Performance coefficient applicable for this Level and kind of Manoeuvre. ROCD'=ROCD*Coeff(Cl/Des)
Status	<validated>
Rationale	Those coefficients are physical Performance inputs that are valid even if the computed Trajectory does not match perfectly the EPP profile. Considering that the EPP gross Mass is available for the flight, and that the MET models from FMS and ATC system are aligned, this Performance Coefficient mainly accounts for the Difference on the Available Power (Thrust-Drag) due to the lack of precise information of the pure BADA model. However, if the EPP gross Mass has not been received, these Performance Coefficients are computed on the same way. In that case, the performance Coefficients take into consideration at the same time both the Difference on the Available Power and the effect of the mass difference between the Real one and the FDP estimated mass ((Thrust-Drag)/Mass).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation

<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Apply Performances Model
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.1.4.4 Other improvements on uncertainty envelope trajectories

Some Conflict Detection tools are not relying on a unique and accurate trajectory, but on the definition of an uncertainty area or volume for some vertical manoeuvres, where the conflict will be detected if the uncertainty area/volume of two or more flights are overlapping at any moment in time.

In order to support those tools, trajectories are computed on different scenarios to define the envelope of such uncertainty area/volume. Those scenarios include variations in:

- Certain aspects on the flight script, such as modelling certain reaction time for the crew to some clearances, where those aspects could be applied differently to help to define this uncertainty. Being part of the script, this is NOT to be covered by this TS.
- Performance model itself, where the different envelope trajectories are computed with an optimistic or pessimistic performance model.

Today, due to the significant uncertainty on the vertical performance of the aircraft, those optimistic and pessimistic models are designed to cover a wide spectrum of possible performance characteristics. While this guarantees detecting all true conflicts, the drawback is the high rate of nuisance alerts.

Thanks to the EPP data, the uncertainty on the aircraft performance is significantly reduced, and this allows narrowing the uncertainty area/volume.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0007.0010
Title	Adjusting performance model on uncertainty envelope trajectories
Requirement	If EPP data to the target level of a manoeuvre that starts at the current position of the aircraft is available, the System SHALL calculate improved detection envelopes based using as limits: • The default performance model available, without considering the fine-tuning process based on EPP data • The improved performance model, using the fine tuning coefficients derived from the EPP data.
Status	<validated>
Rationale	The EPP manoeuvre predictions' accuracy allows limiting the possible volumes in the airspace that the aircraft may occupy on climbs and descents. Note that those uncertainty envelope trajectories, as any other trajectory, are expected to be improved using other EPP data, such as the mass, speeds and turning manoeuvres.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Apply Performances Model
<ALLOCATED_TO>	<Enabler>	ER APP ATC 214_Conflict Detection envelope trajectories improvement with new ADS-C reports
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.0001

4.2.2 Improvements on MET Data

More accurate MET forecasts received from external stakeholders are required to improve the MET data used to compute Trajectories. The MET data improvements can be achieved through improving either the resolution of the data provided or the quality of the inputs used by those stakeholders to compute their predictions.

4.2.2.1 Improving the quality of MET forecasts

[REQ]

Identifier	REQ-18-W2-S53b-TS-0006.0010
Title	MET WTQ format
Requirement	The En-Route / Approach ATC System SHOULD be able to receive and compile meteorological data for Wind Temperature and QNH information (WTQ) according to standardised GRIB2 format.
Status	<validated>
Rationale	Usage of the latest grid-based MET data format standard.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Reception of Weather Forecast
<ALLOCATED_TO>	<Functional block>	Support Functions ER/APP (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store Meteorological Information
<ALLOCATED_TO>	<Enabler>	ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0006.0020

Title	WTQ area coverage
Requirement	The En-Route / Approach ATC System SHALL support MET information adapted to the horizontal Area Of Interest of the ANSP.
Status	<validated>
Rationale	The horizontal area shall be adaptable, e.g. to the Area Of Interest of the ANSP.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Reception of Weather Forecast
<ALLOCATED_TO>	<Functional block>	Support Functions ER/APP (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store Meteorological Information
<ALLOCATED_TO>	<Enabler>	ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0006.0030
Title	Vertical Resolution of WTQ data
Requirement	The En-Route / Approach ATC System SHALL support at least the Vertical levels of the WAFS (World Area Forecast System) WTQ data sets. ICAO WAFS Levels (Annex 3): Flight Levels 50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 210 (450 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 320 (275 hPa), 340 (250 hPa), 360 (225 hPa), 390 (200 hPa), 410 (175 hPa), 450 (150 hPa), 480 (125 hPa) and 530 (100 hPa);

Status	<validated>
Rationale	The given Flight Levels are required for a sufficient Vertical granularity, especially at challenging meteorological conditions like storm fronts or inverse weather situations.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Reception of Weather Forecast
<ALLOCATED_TO>	<Functional block>	Support Functions ER/APP (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store Meteorological Information
<ALLOCATED_TO>	<Enabler>	ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0006.0031
Title	Increase of Vertical Resolution of WTQ data
Requirement	The En-Route / Approach ATC System SHOULD be scalable to support a future increase of the number of Vertical Levels of WTQ information, at least up to 30 Levels.
Status	<in progress>
Rationale	This increase of defined Vertical Levels would imply a great increase in size of the GRIB2 messages, which can create issues on some interfaces or components. The System should already be designed with this potential increase in mind. The use of up to 30 Vertical Levels has been suggested as feasible for the near future, but this value is not final.
Category	<Adaptability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Reception of Weather Forecast
<ALLOCATED_TO>	<Functional block>	Support Functions ER/APP (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Store Meteorological Information
<ALLOCATED_TO>	<Enabler>	ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0006.0040
Title	Time step resolution consideration of WTQ information
Requirement	The En-Route / Approach ATC System SHALL support grid-based MET information with a time resolution of at least one hour.
Status	<validated>
Rationale	Available research results demonstrated that the average integrated vector error of the wind Speed can be decreased significantly when using a temporal resolution of 1 hour instead of 3 hours for example.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] Reception of Weather Forecast
<ALLOCATED_TO>	<Functional block>	Support Functions ER/APP (PJ.18-W2-53B)

<ALLOCATED_TO>	<Function>	Store Meteorological Information
<ALLOCATED_TO>	<Enabler>	ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

[REQ]

Identifier	REQ-18-W2-S53b-TS-0006.0050
Title	Centred time step use of a WTQ forecast window
Requirement	When computing a Trajectory, the En-Route / Approach ATC System SHALL use the MET data, typically provided at full hours with a time window of plus/minus 30 minutes around the forecast time.
Status	<validated>
Rationale	Together with the forecast resolution of one hour, a centred use of the time window reduces the average integrated wind vector error further. Example: TP from 14:30 until 15:29 shall use the 15:00 data set. This means a TP at 14:32 and 15:15 will both use the data set of 15:00.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] TP Computation
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Identify Applicable Weather Conditions
<ALLOCATED_TO>	<Enabler>	ER APP ATC 200_ATC Improvement to receive and use more granular MET forecasts.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01.3100

<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-UU01-3110

4.2.3 Safety Requirements and other Non-Functional Requirements

The objective on this section is to propose some Requirements to mitigate the risk of using Aircraft Derived Data that might be corrupted, either intentionally (due to a security breach) or either accidentally. Additionally, other Non-Functional Requirements are also proposed.

[REQ]

Identifier	REQ-18-W2-S53b-TS-0100.0010
Title	Filtering outliers
Requirement	The En-Route / Approach ATC System SHALL check the downlinked data (including gross Mass, Speed schedule and EPP profile) for credibility prior to use it in ATC applications.
Status	<validated>
Rationale	This credibility check is intended to remove outliers. Examples: • Mass exceeding the Maximum Take-off Weight. • Speeds exceeding Maximum Operational Speeds for the concerned Aircraft Type. • Etc.
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Function View>	[NSV-4] ADS-C Reports Reception
<ALLOCATED_TO>	<Functional block>	Trajectory Prediction and Management (PJ.18-W2-53B)
<ALLOCATED_TO>	<Function>	Validate ADS-C downlinked data (TP)
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

[REQ]

Identifier	REQ-18-W2-S53b-TS-0100.0020
Title	Configurable ADS-C contracts
Requirement	The En-Route / Approach ATC System SHALL support defining the ADS-C contract parameters in a configuration file to allow testing multiple choices for the Periodic and/or Event ADS-C contracts.
Status	<validated>
Rationale	For the baseline ATS B2 implementation on ANSP centres, this possibility of local configuration of contracts would be the normal situation. However, for the ADS-C Common Service implementation, it is the Common Service which configures this contract parameters. The selection of the configuration parameters should be taken jointly by all the stakeholders interested on accessing the data, based on the common interest.
Category	<Maintainability>, <Adaptability>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ18-W2-53B
<ALLOCATED_TO>	<System>	En-Route / Approach ATC System
<ALLOCATED_TO>	<Enabler>	ER APP ATC 167_ATC Trajectories improvement with new ADS-C reports and surveillance information.
<SATISFIES>	<ATMS Requirement>	REQ-18-W2-53B-SPRINTEROP-SAF1.0001

5 Recommendation for Implementation

As a result of the V3 Maturity Gate, some recommendations have been obtained from SJU. Firstly, it is recommended to carry out future researches for the processing the ADS-C MET reports on the MET providers systems, in order to produce enhanced MET predictions to be sent to and used by the ground trajectory prediction and conflict detection & resolution tools. This recommendation was raised since MUAC and KNMI (Royal Dutch Meteorological Institute) concluded that the quality of the ADS-C wind speed, wind direction and temperature are quite good and it can improve the current MET Data.

In addition, it is proposed to allow MET service providers to receive relevant ADS-C MET reports directly from the ADS-C Common Service.

On the other hand, it is recommended to further investigate in detail the degraded modes for conflict detection and resolution tools due to corrupted but credible ADS-C EPP data, and analyse the impact on the above-mentioned tools when an aircraft changes its speed profile, and hence until a new EPP be downlinked and processed it behaves in a different way than what would be expected.

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6 Assumptions

6.1 Non Synchronized Flight Script

The approach followed to describe the Trajectory prediction improvements is based on taking information from the ADS-C and then using this information to improve the results of the TP.

However, there is an exception for this: the selection of the most appropriate control law (see 4.2.1.3.1), where the Requirements provide a general rule to be applied independently on the information received through ADS-C for that Aircraft (and even independently on the availability of ADS-C information).

The reason behind this choice is the assumption that there is a lack of synchronization between the existing Vertical and Speed constraints on both the FDP and in the FMS. Since some of the Manoeuvres to be executed depend on that, it is preferable to define the most common Manoeuvres selection logic existing in today's FMS.

Another reason is that Ground FDPs need to anticipate the Manoeuvres that will be done by the Aircraft in what-if scenarios. By definition, those what-if scenarios are not known by the Aircraft, and so the EPP data cannot be used to know which will be the selected manoeuvre. Therefore, the only way to properly manage what-if predictions is to define better default Manoeuvres.

6.2 Mass availability, and impact in Performances

Today's revenue Aircrafts are downlinking the actual Aircraft Mass, and this TS depends on such data in order to improve the Performances. Nevertheless, the Mass report (as many other fields in ADS-C reports) is optional, and could be considered sensitive information by Airspace Users, so there is a certain risk that this information is not available for some Aircrafts.

Within Solution 53B, it is assumed that the Mass report will be available in the ADS-C reports.

However, in case this assumption is not correct, it must be noted that the improvements described in section 4.2.1.4 are expected to minimize the impact of the lack of Mass Reports in the Trajectory Prediction Performance improvements, as the application of the Performance Coefficients would already correct the mass difference as one of the inner factors.

6.3 MET systems improvements

This TS does not include Requirements to the MET systems, since it is assumed it is out of the scope of the current TS and even the full SESAR 2020 R&D program.

Some MET systems are already making parallel projects to improve their core business on improving their weather forecasting services. This is a core functionality not strictly linked to any SESAR activity. The solution PJ.18-W2-53B will just assume that the MET systems have been already improved outside SESAR, and therefore, will just use those parallel developments to measuring the impact on Trajectory accuracy and Separation KPIs.

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7 References and Applicable Documents

7.1 Applicable Documents

Content Integration

[1] D5.11 EATMA Guidance Material

[2] EATMA Community pages

[3] SESAR ATM Lexicon

[4] D2.3 PJ.19-W2: ADD 2020

Content Development

[5] B4.2 D106 Transition Concept of Operations SESAR 2020

System and Service Development

[6] D2.4 PJ.19-W2: Service Roadmap 2020

Validation

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

System Engineering

[8] SESAR 2020 Requirements and Validation Guidelines

7.2 Reference Documents

[9] SESAR Solution PJ.18-W2-53 SPR-INTEROP_OSED (D2.2.001)

[10] SESAR Solution PJ.10-02a1 and PJ.10-02a2: TS/IRS V2 V3 (D4.2.020)

[11] SESAR Solution PJ.10-02a1 and PJ.10-02a2: VALR V2 V3 (D4.2.110)

[12] SESAR Solution PJ.10-02b-V2 – VALR (D5.1.030)

[13] SESAR Solution PJ.18-06a-TRL6 – TS/IRS (D5.2.120)

[14] SESAR Solution PJ.18.06a-TRL6 – TVALR (D5.2.110)

[15] SESAR Solution PJ.18-06b-TRL4 – TS/IRS (D5.1.060)

[16] SESAR Solution PJ.18-06b-TRL4 – TVALR (D5.1.050)

[17] DIGITS PJ31and DIGITS-AU Integrated Demonstration Report (D1.2)

[18] SAFETY AND PERFORMANCE REQUIREMENTS STANDARD FOR BASELINE 2 ATS DATA COMMUNICATIONS (BASELINE 2 SPR STANDARD), ED228 A, March 2016

[19] INTEROPERABILITY REQUIREMENTS STANDARD FOR BASELINE 2 ATS DATA COMMUNICATIONS (BASELINE 2 INTEROP STANDARD), ED229 A, March 2016

[20] INTEROPERABILITY REQUIREMENTS STANDARD FOR BASELINE 2 ATS DATA COMMUNICATIONS, FANS 1/A ACCOMMODATION (FANS 1/A - BASELINE 2 INTEROP STANDARD), ED230 A, March 2016

[21] INTEROPERABILITY REQUIREMENTS STANDARD FOR BASELINE 2 ATS DATA COMMUNICATIONS, ATN BASELINE 1 ACCOMMODATION (ATN BASELINE 1 - BASELINE 2 INTEROP STANDARD), ED331 A, March 2016

[22] CAT021 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 12 Category 21, Edition 2.4 (June 2015)

[23] CAT048 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 4 Category 48 (Appendix A), Edition 1.9, July 2017

[24] CAT062 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 9 Category 062, Edition 1.18, August 2018

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Appendix A Service Description Document (SDD)

Not applicable.

-END OF DOCUMENT-