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WORKING PAPER

AIR TRAFFIC MANAGEMENT REQUIREMENTS AND PERFORMANCE PANEL (ATMRPP)

TWENTY SIXTH WORKING GROUP MEETING

Tokyo, Japan, 7 to 11 July 2014

Agenda Item 1: Trajectory Based Operations (TBO)

SESAR comments on TBO

(supported by the response to WP620, WP631 and IP/2)

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SUMMARY

This paper presents some SESAR comments on TBO to the ICAO ATMRPP 25th working group meeting while taking the opportunity to express some answers to WP620 (Australia), WP631(ICCAIA) and IP/2 (USA).

The paper explains that SESAR does not envision a full 4D end-to-end clearance or committed contract. Rather, the TBO concept shall provide a set of criteria defining when a set of capacity or meteo constrained trajectories is "optimized", how such an optimised state is found and coordinated in an iterative dynamic way ***in practice*** and how it is implemented.

The paper further describes the role of the EPP in the trajectory management loop, as envisioned within SESAR.

SESAR has planned to elaborate on the TBO concept in a sub-sequent working paper for the next ATMRPP meeting.

1. INTRODUCTION

1.1 This paper presents some SESAR comments on TBO to the ICAO ATMRPP 25th working group meeting while taking the opportunity to express some answers to WP620 (Australia), WP631(ICCAIA) and IP/2 (USA).

1.2 SESAR has planned to elaborate on the TBO concept in a sub-sequent working paper for the next ATMRPP meeting.

2. THE TBO CONCEPT, NOT SO RADICAL

2.1 The approach taken in WP620 for the development of a TBO concept is well appreciated as it is requirements driven, analytical, well-structured and objective.

In the TBO concept, the introduction of new acronyms shall be avoided to the maximum extent possible, as the subject is already hard enough without being confused by the many new acronyms. Also, it is advised, in addition to aligning with the seven known ATM components (AOM, DCB, AO, TS, CM, AUO, SDM), to align terminology with the FF-ICE document.

It is agreed with WP620, that the TBO concept description should clearly highlight the new paradigm of the known and shared trajectory. However, the word "radical" should not be used to stress that.

2.2 The ultimate goal of TBO cannot be to facilitate the "ideal" or "desired" trajectory, nor to "repair" a trajectory after a disturbance; often facilitating the ideal trajectory will simply not be feasible with many trajectories constrained by e.g. meteo or capacity.

Instead, the TBO concept shall define what "optimized" means in theory (for a set of trajectories when constrained, how to agree dynamically in practice on the "optimized state" in a multi stakeholder environment and how to implement, achieve this "optimized state".

2.3 The notion of a full 4D end-to-end clearance or committed contract is not part of the SESAR TBO concept, as it would create a too rigid structure that does not allow for in-flight optimisation to respond to the unpredictability elements as described in WP601 presented in Toulouse. Reducing flight variability is not a goal in itself. The known and shared trajectory shall be updated with every new manoeuvre resulting from the trajectory management loop.

Coordinated trajectory intent shall include the notion of intrinsic unpredictability, allowing for flexibility to optimize locally. Also the TBO concept needs to facilitate resilience to changing circumstances.

Coordinated constraints should be minimised to the extent required (e.g. AMAN) and to the accuracy required (e.g. ± 2 min) to avoid limiting airborne operations more than is strictly required for separation or planning purposes.

2.4 The SESAR TBO concept does not foresee abandoning the concept of ATC clearances, though scope and composition of a clearance may change e.g. to a composite digitally uplinked clearance. A distinction between the coordinated intent and a clearance or constraint is required. This is illustrated in figure 1.

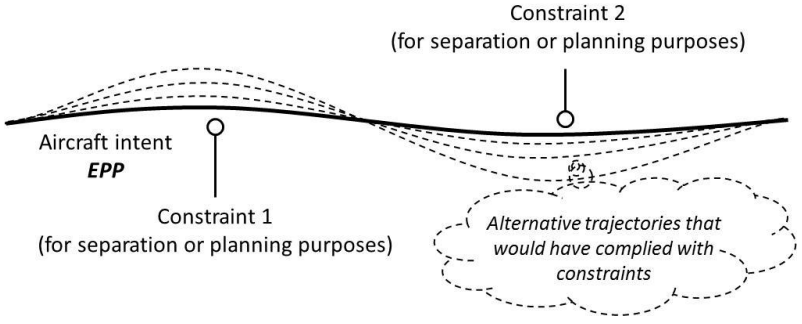

Figure 1 – The "contract" is limited to constraints, not to the full 4D-trajectory

2.5 In section 5 of WP620, the proposed Table of Contents of the TBO concept, insufficienty covers a number of points that have been previously addressed in the WP620. In particular it is advised to include:

- WP620 section 1.2 d "multi actor framework"
- WP620 section 1.2 e "uncertainty, unpredictability"
- WP620 section 1.2 e "what if scenarios"
- WP620 section 1.2 f "inter-regional coordination"
- WP620 section 4.4.9 "prerequisites"
- WP620 section 4.4.10 "events"

In addition, it is suggested to describe the impact of TBO on the existing seven known ATM components (AOM, DCB, AO, TS, CM, AUO, SDM).

2.6 With respect to IP/2, the notion of "Trajectory Option Sets" is similar to options under investigation used in the negotiation of the SESAR Shared Business Trajectory (SBT). It is noted that this notion so far has been described as an FAA proposal in FIXM 3.0.

2.7 From the IP/2 it remains unclear to what extend the FAA TBO concept allows for airborne trajectory changes. The SESAR TBO concept foresees an evolving stepwise clearance, which does allow for airborne downstream changes subject to TBO coordination principles under definition.

2.8 The IP/2 states in section 3.11 ".... maintain the trajectory within the performance windows corresponding to the clearance ... " which leaves sufficient freedom to address the notion of unpredictability and uncertainty. Monitoring compliance is obviously essential. However, it is insufficiently clear in IP/2 what "compliance" means. As previously stated, from a SESAR perspective, compliancy to a frozen 4D-trajectory would be too rigid, does not allow for in flight optimization, and would require complete trajectory de-confliction from the negotiation phase all the way to landing, making any trajectory negotiation phase practically impossible.

3. THE EXTENDED PROJECTED PROFILE

3.1 SESAR supports the development and use of the ADS-C EPP. Though today's ATC trajectory predictors are already quite accurate, their scope is limited to the ANSPs boundaries. Also they lack detailed aircraft parameters only known on-board and – more importantly – they cannot take into account any pilot intention and/or airline policy that is unknown to the ground systems.

3.2 The EPP extends the trajectory prediction beyond ANSP boundaries, allowing to share the trajectory with downstream centres for tactical planning, complexity management, AMAN and DCB purposes. Note that this requires further ground-ground synchronization of the trajectory between all involved ground actors.

3.3 The EPP enables a closed trajectory management loop, by confirming that the aircraft's FMS is consistent with any issued lateral or vertical constraints and/or target time, so long as they have been armed by the flight crew.

3.4 The EPP shall not be interpreted as a contract but rather as intent. It reflects the future trajectory predicted by the FMS, taking into account any coordinated constraints. As such it should also be

emphasized that the EPP does not represent the ideal trajectory, but rather the trajectory optimized by the airspace user, given any constraints stemming from ATC, DCB and MET and known to the FMS.

3.5 WP601 addresses ATC clearances as they are applied in current operations, as well as their expected evolution. The impact of – not yet issued - ATC clearances cannot be known to the FMS. Understanding the interactions of ATC clearances and the EPP will be necessary.

a) In the horizontal dimension, it is foreseen that en-route open-loop 2D clearances will become less used thanks to the up-linking of lateral route revisions, which will include the radar heading and resume instruction.

b) In the vertical dimension, the current practice of not having aircraft cleared by default to climb and descend according to their fligh plan is expected to remain in use in both en-route and TMA. The EPP will not reflect the vertical evolution as per the current clearance, but rather the desired vertical profile as per the active flight plan (e.g. if a flight is maintaining FL200 and waiting to be cleared to cruise level, the EPP will show a profile as if the flight was going to be cleared to climb immediately, whether this is the case or not). SESAR is investigating the use of uplinked vertical constraints needed to ensure separation. The EPP-enhanced TP is expected to be useful to assess which vertical constraints may be reasonably expected to be complied with.

3.6 Though the EPP closes the loop for trajectory management, the trajectory management loop (TBO) is broader as it also consists of event detection, generation and evaluation of solutions, taking and applying decisions. Besides the EPP showing the aircraft intent being compliant with coordinated constraints, generation and evaluation of solutions also requires insight in the boundaries of what is physically possible for an aircraft to achieve. For example, the ETO min/max, when downlinked, constrains the solution space. This is illustrated in figure 2.

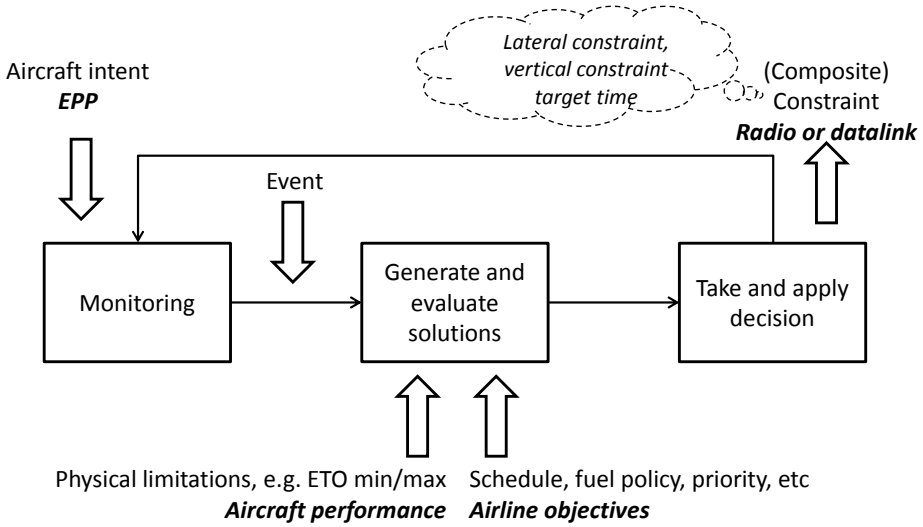

Figure 2 – Trajectory Management Loop

3.7 The argument that aircraft and airline parameters are only known on-board is valid to a limited extent. The airline operations centre could also play a role in either providing these parameters or providing trajectory predictions. Depending on its function in the TBO concept, and depending on accuracy characteristics, either the trajectory prediction from an ANSP, from the FMS, or from the airline

operations centre may be used. Some of the benefits, mentioned in WP631, are still under validation within SESAR. The optimal systems architecture is currently under investigation through SESAR's 4D architecture study.

4. BEST CAPABLE BEST SERVED

4.1 The notion of Best-Capable-Best-Served (BCBS), as mentioned in section 3.6 of WP631, is supported as a mechanism to drive innovation by a supporting business model.

4.2 However, this notion of Best-Capable-Best-Served (BCBS) is only an objective. It needs further refinement to understand and assess its potential operational impact in a mixed-equipage environment.

4.3 Once refined, it should feed into the trajectory management loop of the TBO concept.

5. ACTION BY THE MEETING

5.1 The meeting is invited to:

a) note and review the contents of this working paper;

b) endorse the proposed line of action in paragraph 4.2 (refine BCBS)

c) endorse the requirements to the TBO concept in paragraphs 2.2, 2.3, 2.4, 2.5, 3.4 and 3.6

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