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SESAR 2020 PJ.01-03B Validation Report (VALR) V2 On Going

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00.02.00	04/10/2019	Final version with clarifications on FTS experiment	Paloma Montero-Martin	Final VALR
00.02.01	30/10/2019	Final version with user guidelines removed	Sylvain PRADAYROL	Final VALR

Copyright Statement

PJ.01-03B

This Validation Report (VALR) for the V2 phase is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 731864 under European Union's Horizon 2020 research and innovation programme.

Abstract

This Validation Report aims at describing how the Solution PJ.01-03B is expected to reach V2 ongoing maturity level at the end of Wave 1 through the execution of different validation exercises. Therefore, this document contains both an overview of the context of the validation at Solution PJ.01-03B level in terms of R&D needs, validation targets, stakeholders' expectations, objectives and specific details related to each planned validation activities. This document integrates individual validation reports, described in more detail inside the appendices, for the following exercises by detailing how each of them contribute to the achievement of the Target Maturity Level at Solution PJ.01-03B level:

- EXE. 01-03B.010 V2 Trials planned by DSNA/AIRBUS/Thales
- EXE. 01-03B.020 V2 Fast Time Simulation planned by ACG(COOPANS)/ENAIRE

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1 Executive summary

[…]

This document contains the validation reports of the exercises that were conducted in the context of the Solution PJ.01-03B as part of V2 phase. Starting from the high level description of the validation objectives defined at Solution PJ.01-03B (based also on the inputs provided by reference documents as Transition VALS and the Validation Plan (VALP) [4], this document details how each trial contributes to the achievement of the V2 Target Maturity Level.

In detail, both validation activities are part of this document:

- EXE. 01-03B.0100 V2 Trials planned by DSNA/AIRBUS/Thales. It will be a V2 Real Time Simulation based on a Paris ACC (E-TMA) and Orly approach. Scenario will focus on the facilitation of Continuous Descents Operations through dynamically assigned routes.
- EXE. 01-03B.0200 V2 Fast Time Simulation planned by ACG (COOPANS)/ENAIRE. It will be a V2 Fast time simulation based on Stockholm TMA and focused on departures and arrivals from/to Arlanda (ESSA) and from Bromma (ESSB) airport. The scenario will focus on the facilitation of continuous climb and descent operations though the clearance of optimised Rate of Climb/Rate of descent.

It has to be noted that Individual results on these exercises are provided in the Appendices. The main text of this report aims to integrate the main results obtained.

2 Introduction

2.1 Purpose of the document

This document provides the Validation Report for SESAR Solution PJ.01-03B for the initialisation of V2 phase. V2 phase will be completed in Wave 2 in providing a full PAR and CBA will be assessed at that time. Particularly, statistic on fuel gains should be a major axis of improvement in Wave 2. Also, mixed fleet environment should be analysed in order to improve realism of the experiment. In Pj01-03B RTS, almost all actors were represented in the simulation with ATCO (E-TMA, TMA) and A/L pilots. For S2020 WAVE 2, we except also to integrate approach controller position and, also, to try to expand the evaluation to others TMA.

This VALR describes the results of validation exercises defined in the Validation Plan (VALP) [4], and how they have been conducted, and the report provides a set of relevant conclusions and recommendations.

2.2 Intended readership

This section identifies who can be interested in this document and explain why it is important for them:

- PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB and CTA
- PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA
- PJ.02-01: Wake turbulence separation optimization
- PJ.02-08: Traffic optimization on single and multiple runway airports
- PJ.09-02: Integrated Local DCB Processes
- PJ.09-03: Collaborative Network Management Functions
- PJ.10-02b: Advanced Separation Management
- PJ.14: Enabling aviation infrastructure
- PJ.18-02a: A/G exchanges for RBT management
- PJ.18-04: Management and sharing of data used in trajectory (AIM, METEO)
- PJ.18-06: Performance Based Trajectory Prediction

2.3 Background

Previous work completed relevant to this VALR is SESAR 1 P05.06.02. SESAR 1 areas of interest reflected notably the concerns about the environment and about the impact that aviation is having on it. The growing importance of environmental issues and concerns associated to the will to increase flight efficiency resulted in the fact that, in SESAR2020, additional work had to be foreseen from that perspective. One of the outcomes of SESAR 1 was that with current tools, notably on the ground side, it will be difficult to get more improvements than the ones made with procedural improvements.

Within SESAR 1, the project 05.06.02 proposed initial elements related to an advanced concept where evolutions of the existing technical limitations were considered. Nevertheless, the maturity of this work was quite low (V1 indeed) and it was acknowledged that it deserved more attention. Furthermore, the project also highlighted the fact that using fixed closed loop trajectories for the TMA, even though raising concerns from an operational perspective, was promising from an environmental one and that it could be seen as an enabler of CDOs/CCOs. Currently CDOs and CCOs are still usually performed on a limited scale, and in specific environments. There are therefore several elements of rationale that justify additional work in those areas notably when considering the target of endorsing Advanced CDOs and CCOs identified as the progressive implementation of CDO/CCO ideally from ToD, or to ToC, and in high density operations, employing new controller tools (and enhanced airborne functionalities) to facilitate operations. PJ.01-03B is therefore identified as the solution that takes over the previous findings within this area in order to progress to new propositions for improvements, with a new level of maturity.

2.4 Structure of the document

This document consists of the following chapters:

Chapter 1: This is the Executive Summary.

Chapter 2: This chapter is the introductory part of the document describing its purpose readership and project background.

Chapter 3 : This chapter describes the context of the validations.

Chapter 4 : This chapter presents a consolidated overview of the SESAR PJ03a-01 Solution and Validation Results.

Chapter 5 : This chapter presents Main Conclusions and Recommendations.

Chapter 6 : This chapter provides relevant document references.

Appendices: Individual results of the validation exercises can be found in Appendices A to B:

- Appendix A: EXE. 01-03B.010 V2 Trials planned by DSNA/AIRBUS/Thales
- Appendix B: EXE. 01-03B.020 V2 Fast Time Simulation planned by ACG(COOPANS)/ENAIRE

2.5 Acronyms and Terminology

Acronym	Definition
AMAN	Arrival Manager
ATC	Air Traffic Control
ATM	Air Traffic Management
CCO	Continuous Climb Operations
CDO	Continuous Descent Operations
CPDLC	Controller–pilot data link communications
CTA	Controlled Time of Arrival
DCB	Demand-Capacity Balancing
DMAN	Departure Manager (traffic synchronization service)
DTG	Distance To Go
EPP	Extended Projected Profile
ETA	Estimated Time of Arrival
FAF	Final Approach Fix
FL	Flight Level
FMS	Flight Management System
IAF	Initial Approach Fix
KPA	Key Performance Area
LoA	Letter of Agreement
OFA	Operational Focus Areas
OSED	Operational Service and Environment Definition
OSED	Operational Service and Environment Definition
PMS	Point Merge System
RBT	Reference Business Trajectory
RDTL	Required Distance To Land
RMT	Reference Mission Trajectory
RTA	Required Time of Arrivals
RWY	Runway
SAC	Safety Criteria
SESAR	Single European Sky ATM Research Programme

SID	Standard Instrument Departure
STA-FF	Scheduled Time of Arrival over a Feeder Fix (AMAN time)
STAR	Standard Terminal Arrival Route
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPR	Safety and Performance Requirements
SWIM	System Wide Information Model
TMA	Terminal Manoeuvring Area
ToC	Top of Climb
ToD	Top of Descent
TS	Technical Specification
TTL	Time To Lose

Table 1: Acronyms and terminology

3 Context of the Validation

3.1 SESAR Solution PJ.01-03B: a summary

This section provides a description of the SESAR Solution(s) under the scope of the Validation Report, with reference to the applicable EATMA version. It refers to the list of OI steps and enablers associated to the SESAR Solution(s), and whether or not they are addressed by the validation activities described in the document.

SESAR Solution ID	SESAR Solution Description	Master or Contributing (M or C)	Contribution to the SESAR Solution short description	OI Steps ref. (from EATMA)	Enablers ref. (from EATMA)
Solution PJ.01-03B — Dynamic and Enhanced Routes and Airspace	The goal for this Solution is to create an end to end optimised vertical and lateral profile during the TMA phase of flight.	M	Study the feasibility and evaluate the benefits of air/ground intentions sharing for efficient descents from TOD, in medium to high density operations. Evaluate the possibility to improve the flight efficiency even when the aircraft is vectored. Identify the improvements needed to support efficient descents. As the RTS will use an experimental ground system platform, featuring a limited set of ground functionalities and with concurring processes considered as assumptions, the maturity is only expected to progress towards V2, but not reach V2. The validations will mainly address nominal cases.	AOM-0702-B Advanced Continuous Descent Operations	A/C-37a ER APP ATC 120 METEO-03c METEO-04c METEO-05c
		M	Study the feasibility and evaluate the benefits of ADS-C/EPP provision to the ground, to facilitate efficient climbs and descents in TMA. PJ.01-03B will focus on decision support.	AOM-0705-B Advanced Continuous	A/C-37a ER APP ATC 120 METEO-03c

			The maturity is only expected to progress towards V2, but not reach V2.	Climb Operations.	METEO-04c METEO-05c
		C	Only the part concerning the “dynamic use of lateral routes” will be addressed. The maturity is expected to progress towards V2, but not reach V2. Not Addressed	AOM-0806 Dynamic Management of Terminal Airspace Routes and Transition. AOM-0807 Dynamic Management of Sectors in Terminal Airspace.	AAMS-13 METEO-03c METEO-04c METEO-05c NIMS-50

Table 2: SESAR Solution(s) addressed in the Validation Report

3.2 Summary of the Validation Plan

3.2.1 Validation Plan Purpose

Both validation activities are part of this document and are detailed in Appendix A and Appendix B:

- EXE. 01-03B.010 V2 Trials planned by DSNA/AIRBUS/Thales. It was a V2 Real Time Simulation based on a Paris ACC (E-TMA) and Orly approach. Scenario focussed on the facilitation of Continuous Descents Operations through dynamically assigned routes.
- EXE. 01-03B.020 V2 Fast Time Simulation planned by ACG (COOPANS)/ENAIRE. It was a V2 Fast time simulation based on Stockholm TMA and focused on departures and arrivals from/to Arlanda (ESSA) and from Bromma (ESSB) airport. The scenario will focus on the facilitation of continuous climb and descent operations though the clearance of optimised Rate of Climb/Rate of descent.

3.2.2 Summary of Validation Objectives and success criteria

Validation objective and success criteria were described in part 4 of in the Validation Plan (VALP), see [4]; deviations are described on this document (see A.2)

For remind, following VALP table is added in this section to highlight that the initialisation of V2 phase is not completely covering all success validation criteria's because all OI steps were not addressed by both RTS and FTS experiments. Also, linked to limitations and deviations encountered, some OI's steps were not addressed in this initialisation of V2 phase.

Id	OBJ-DS18A-PJ0103b-VALS2.001	OBJ-DS18A-PJ0103b-VALS2.002	OBJ-DS18A-PJ0103b-VALS2.003
Title	Operational feasibility and acceptability of PJ01-03b Solution	Strategic benefits of PJ01-03b Solution in relation to airspace management.	ATM Benefits in accordance with Performance Validation Targets.
Description	To assess the feasibility and acceptability from controller's perspectives of PJ01-03b Solution (workload, change of practices, versatility of procedures, situation awareness, perceived	To provide evidences demonstrating the target benefits [provided by sub-solution 01-03b] in the dynamic management of sector and routes.	To perform an initial assessment of the benefits produced by PJ01-01 Solution in terms of predictability, environment/fuel efficiency, airspace capacity, safety and cost efficiency
OIs concerned	AOM-0702-B, AOM-0705-B, AOM-0806	AOM-0806	AOM-0702-B, AOM-0705-B, AOM-0806
Success criteria 1	Positive feedback from controllers, complemented with proofs of feasibility (acceptable quality of service and acceptable level of safety with acceptable level of workload especially for sectors coordination). OBJ-PJ.01.03-V2-VALP-RTS-006 OBJ-PJ.01.03-V2-VALP-RTS-014	Greater range of sector opening options and/or reduction of number of sectors (hence staffing level and ANS costs) required for a given level of traffic (enabled by workload reductions) Not adressed, not part of On-Going V2 target	For the Airport Capacity KPA, benefits in terms of throughput via reduced Arrival separation minima and Arrival spacing buffer, in line with Validation targets. Not adressed, not part of On-Going V2 target
Success criteria 2	Significant fuel saved thanks to closer correlation of the actual trajectories with the ones preferred by the Airspace User, even in high density operations. OBJ-PJ.01.03-V2-VALP-RTS-017	Significant safety benefits thanks to: - increased confidence in conformance to cleared trajectories - improvements in strategically de-confliction of traffic OBJ-PJ.01.03-V2-VALP-RTS-014	For the TMA Capacity KPA, benefits identified in terms of throughput (volume and time) via improved ATFCM / DCB and ASM processes, in line with Validation targets. OBJ-PJ.01.03b-VALP-FTS-0002
Success criteria 3	Significant reduction of tactical level offs even in high density operations. OBJ-PJ.01.03-V2-VALP-RTS-004 OBJ-PJ.01.03-V2-VALP-RTS-012	Significant reduction of interactions (e.g. vectoring instructions) including volume of Air/Ground communications. OBJ-PJ.01.03-V2-VALP-RTS-009 OBJ-PJ.01.03b-VALP-FTS-0001	For the Predictability KPA, benefits identified in terms of reduction of TMA Departure Variability and TMA Arrival Variability per flight, in line with Validation targets. OBJ-PJ.01.03-V2-VALP-RTS-009
Success criteria 4	Reduction of noise impacts on the ground side. OBJ-PJ.01.03-V2-VALP-RTS-017		For the Fuel Efficiency KPA, benefits identified in terms of fuel burn per flight in line with Validation targets. OBJ-PJ.01.03b-VALP-FTS-0003
Success criteria 5			For the Cost Efficiency KPA, benefits identified in terms of direct cost per flight (Controller productivity) in line with Validation targets. OBJ-PJ.01.03b-VALP-FTS-0002
Success criteria 6			For the Safety KPA, net benefit identified in terms of MAC TMA and CFIT. Not adressed, not part of On-Going V2 target

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-001
Objective	To evaluate if the ATCO's HMI is suitable for him/her to assess the new concept
Title	HMI assessment
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
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<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-001-001	Controllers indicate that they can easily identify the aircraft equipage (ADS-C, , RTA capability, …)
CRT- PJ.01.03-V2-VALP-RTS-001-002	Controllers indicate that they can easily identify the status of the operation on board the aircraft (when relevant: flight mode, CTA …)

CRT- PJ.01.03-V2-VALP-RTS-001-003	Controllers confirm that they are able to easily distinguish information of different nature (FDPS vs EPP)
PJ.01.03-V2-VALP—RTS-001-004	Controllers confirm that they can easily identify the constraints given to an aircraft (e.g speed)
PJ.01.03-V2-VALP—RTS-001-005	Controllers indicate that the experimental conditions allowed them to assess the concept to an acceptable way

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-002
Objective	To evaluate if the ATCO's HMI is suitable for him/her to assess the use of "facilitating optimised profiles from TOD"
Title	HMI assessment
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
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[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-002-001	Controllers confirm that tools available on the CWP allow them to perform their tasks in the case they use "facilitating optimised profiles from TOD"
CRT- PJ.01.03-V2-VALP-RTS-002-002	Controllers confirm that they can easily use data about aircraft's intentions

CRT- PJ.01.03-V2-VALP-RTS-002-003	Controllers confirm that tool permits to make efficient coordination with different sectors

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-003
Objective	To assess the operational feasibility, from a controller's perspective, of facilitating optimised profiles from TOD while integrating route and speed constraints requested by efficient flow management in E-TMA.
Title	Operational Feasibility Assessment
Category	<operational feasibility>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

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[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-003-001	The proposed working method permit the controller to perform their task
CRT- PJ.01.03-V2-VALP-RTS-003-002	The information about aircraft descent intentions available for the ATCO permit to facilitate the use of optimised profiles from TOD
CRT- PJ.01.03-V2-VALP-RTS-003-003	Controllers and experts confirm that the sequence provided by the system does not change too many times and allows to build a stable strategy early enough
CRT- PJ.01.03-V2-VALP-RTS-003-004	It is feasible to decide early enough which route to attribute, including the feasibility to decide early enough of a stable strategy

CRT- PJ.01.03-V2-VALP-RTS-003-005	It is feasible for the controller to perform their tasks early enough in the aim to provide the associated instructions to the flight crew in a timely manner (complying with on-board needs concerning optimised descents): voice, CPDLC
CRT- PJ.01.03-V2-VALP-RTS-003-006	The controllers can monitor the flights executing an optimised descent (optimised TOD and dynamically attributed route) as easily and safely as usual
CRT- PJ.01.03-V2-VALP-RTS-003-007	It is feasible for the controllers to deal with several levels of equipage

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-004
Objective	To assess the acceptability from a controller's perspective, of facilitating optimised profiles from TOD while integrating route and speed constraints requested by efficient flow management in E-TMA[1].
Title	Acceptability Feasibility Assessment
Category	<human performance>, <acceptability>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

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[OBJ Suc]

Identifier	Success Criterion

CRT- PJ.01.03-V2-VALP-RTS-004-001	No additional tactical interventions in comparison with the reference
CRT- PJ.01.03-V2-VALP-RTS-004-002	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
CRT- PJ.01.03-V2-VALP-RTS-004-003	Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
CRT- PJ.01.03-V2-VALP-RTS-004-004	The ATCO is as much in control of the situation as with the baseline (situational awareness, monitoring possibilities, anticipation capacity, fall-back capability)

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-005
Objective	To assess how the priority given to capacity impacts the ability to accept facilitating optimised profiles from TOD
Title	Capacity Assessment
Category	<performance>, <operational feasibility>, <human performance>, <acceptability>
Key environment conditions	Nominal conditions, Traffic sample 2025, Hub Airport with complex layout, Regional Airport
V Phase	

[OBJ Trace]

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[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-005-001	Controllers and experts indicate that the management of traffic (sequencing and priority given to capacity) still allows to facilitate optimized profiles for sufficient amount of flights
CRT- PJ.01.03-V2-VALP-RTS-005-002	Controllers and experts indicate that controllers' workload is maintained at an acceptable level optimised profiles are facilitated, compared to the baseline

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-006
Objective	To evaluate if the ATCO's HMI is suitable for him/her to use "dynamic attribution of routes"
Title	HMI assessment
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
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[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-006-001	Controllers confirm that tools available on the CWP allow them to choose alternative routes in an efficient way
CRT- PJ.01.03-V2-VALP-RTS-006-002	Controllers confirm that they are able to easily identify which route has been given to aircraft
CRT- PJ.01.03-V2-VALP-RTS-006-003	Controllers and experts confirm that routes can be sent to the aircraft in an efficient manner
CRT- PJ.01.03-V2-VALP-RTS-006-004	Controllers confirm that tool permits to make efficient coordination with different sectors

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-007
Objective	To assess the operational feasibility of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.
Title	Operational Feasibility Assessment
Category	<operational feasibility>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0046
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0047
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-007-001	The proposed working method permit the controller to perform their task

CRT- PJ.01.03-V2-VALP-RTS-007-002	The information given by E-AMAN services permit to the ATCO to easily attribute a route
CRT- PJ.01.03-V2-VALP-RTS-007-003	Controllers and experts confirm that information given by E-AMAN does not change too many times and allows to build a stable strategy early enough
CRT- PJ.01.03-V2-VAL-RTS-007-004	It is feasible for the controllers to monitor the execution of alternative route
CRT- PJ.01.03-V2-VALP-RTS-007-005	It is feasible for the controllers to deal with several levels of equipage

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-008
Objective	To assess the operational feasibility of recovering from a situation where dynamic attribution of route fails or is not sufficient (while still in nominal conditions) and fall back on today's method (based on vectoring)
Title	Operational Feasibility Assessment
Category	<operational feasibility>
Key environment conditions	Nominal conditions,
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0030
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0031
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0032
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0033
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0035
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0036
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0037
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0038
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0041
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0042
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-008-001	When, in nominal conditions, the new method application must be interrupted while in progress, the ATCO can revert to the current method (based on vectoring), with no decrease of the safety level, keeping the workload at an acceptable level, and with no impact on the sequencing task.
CRT- PJ.01.03-V2-VALP-RTS-008-002	When, in nominal conditions, the new method application is not possible, the ATCO can use the current method (based on vectoring), with no impact on safety, and reasonable impact on workload and on the sequencing task.

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-009
Objective	To assess the acceptability of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.
Title	Acceptability Feasibility Assessment
Category	<human performance>, <acceptability>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0046
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0047
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-009-001	No additional tactical interventions in comparison with the reference
CRT- PJ.01.03-V2-VALP-RTS-009-002	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline

CRT- PJ.01.03-V2-VALP-RTS-009-003	Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
CRT- PJ.01.03-V2-VALP-RTS-009-004	The ATCO is as much in control of the situation as with the baseline (situational awareness, monitoring possibilities, anticipation capacity, fall-back capability)

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-010
Objective	The objective was to evaluate if the ATCO's HMI is suitable for him/her to use "Permanent Resume Trajectory", through the following criterion
Title	Acceptability Feasibility Assessment
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0030
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0031
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0032
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0033
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0035
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0038
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0041
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-010-001	Controllers confirm that tools available on the CWP allow them to use Permanent Resume Trajectory

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-011
Objective	Assess the operational feasibility of using Permanent Resume Trajectory, through the following criteria.
Title	Acceptability Feasibility Assessment
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0030
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0031
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0032
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0033
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0038
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0041
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT-PJ.01.03-V2-VALP-RTS-011-001	The proposed working method permit the controller to perform their task

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-012

Objective	Assess the acceptability of using Permanent Resume Trajectory, through the following criteria
Title	Acceptability Feasibility Assessment
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0030
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0031
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0032
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0033
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0038
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0041
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-012-001	No additional tactical interventions in comparison with the reference
CRT- PJ.01.03-V2-VALP-RTS-012-002	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
CRT- PJ.01.03-V2-VALP-RTS-012-003	Controllers and experts indicate that no misunderstanding between information and clearances are induced by the use of a "Permanent Resume Trajectory"

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-013
Objective	feasibility & acceptability of new operational methods from a pilot point of view
Title	Safety

Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0006
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0013
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0022
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0025
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0035
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0036
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0037
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0042
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-013-001	Pilots indicate that they can easily adapt their way of working with PJ01-03B new operational methods proposal
CRT- PJ.01.03-V2-VALP-RTS-013-002	Pilot confirm that new operational methods don't decrease level of safety and are acceptable with regards to their procedures (information's received on time to update FPLN or execute manoeuver requested)

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-014
Objective	Evaluate how ADS-C (EPP) data can facilitate CDO operations -
Title	EPP data sharing
Category	<operational feasibility><human performance>

Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0021
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0023
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0026
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0043
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0044
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0045
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0051
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0052
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-014-001	Issues linked with EPP uncertainty are assessed by both pilots and controllers
CRT- PJ.01.03-V2-VALP-RTS-014-002	The needs about EPP data from a controller's perspective are correctly identified and the added value of the EPP data from a controller's perspective when dealing with CDO operations is confirmed

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-015
Objective	Evaluate pilot workload with new operational method
Title	Pilot workload
Category	<operational feasibility><safety><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0000
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-015-001	Pilots assess and confirm increase of workload is acceptable with regards to increase of flight efficiency
CRT- PJ01.03-V2-VALP-015-002	Pilots confirm that workload associated to new operational methods does not decrease safety.

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-016
Objective	Identify traffic condition limitations with regards to CDO optimization
Title	Flight efficiency benefits
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0002
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0009
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0048
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-016-001	PJ01-03B team assess and confirm from which level of traffic, controllers can't authorized CDO optimization

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-017
Objective	Identify new operational method noise impact and fuel efficiency
Title	Flight efficiency benefits
Category	<operational feasibility><safety><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0001
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-017-001	PJ01-03B team evaluate theoretical noise impact of new operational method in comparison of current operational method (if data available)
CRT- PJ01.03-V2-VALP-017-002	PJ01-03B team evaluate theoretical fuel efficiency of new operational method in comparison of current operational method (if data available)

[OBJ]

Identifier	OBJ-PJ.01.03-V2-VALP-RTS-018
Objective	Assess the operational feasibility, from a controller's perspective, to provide “When ready descend” clearances in E-TMA

Title	Flight efficiency benefits
Category	<operational feasibility><human performance>
Key environment conditions	Nominal conditions, Traffic sample TBD, Hub Airport with complex layout
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0005
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0007
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0009
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0010
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0012
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0051
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0052
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT- PJ.01.03-V2-VALP-RTS-018-001	The proposed working method permit the controller to perform their task
CRT- PJ01.03-V2-VALP-018-002	The information about aircraft descent intentions available for the ATCO permit to facilitate the use of optimised profiles from TOD
CRT- PJ01.03-V2-VALP-018-003	The controllers can monitor the flights executing an optimised descent as easily and safely as usual
CRT- PJ01.03-V2-VALP-018-004	No additional tactical interventions in comparison with the reference
CRT- PJ01.03-V2-VALP-018-005	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
CRT- PJ01.03-V2-VALP-018-006	Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
CRT- PJ01.03-V2-VALP-018-007	The ATCO is as much in control of the situation as with the baseline (situation awareness, monitoring possibilities, anticipation capacity, fall-back capability)

[OBJ]

Identifier	OBJ-PJ.01.03b-VALP-FTS-0001
Objective	Demonstrate the benefits provided by ROC/ROD clearance to manage aircraft crossings in terms of Human Performance
Title	Impact in Human Performance
Category	<performance>
Key environment conditions	High Complexity TMA
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0054
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT-PJ.01.03b-VALP-FTS-0001-001	TMA ATCO is able to handle at least the same number of aircraft movements in its area of responsibility per ATCO hour on duty considering the operational concept under assessment

[OBJ]

Identifier	OBJ-PJ.01.03b-VALP-FTS-0002
Objective	Demonstrate the benefits provided by ROC/ROD clearance to manage aircraft crossings in terms of Airspace Capacity
Title	Impact in Airspace Capacity
Category	<performance>
Key environment conditions	High Complexity TMA

V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0055
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT-PJ.01.03b-VALP-FTS-0002-001	TMA ATCO is able to handle at least the same number of aircraft movements in its area of responsibility considering the operational concept under assessment

[OBJ]

Identifier	OBJ- PJ.01.03b-VALP-FTS-0003
Objective	Demonstrate the benefits provided by ROC/ROD clearance to manage aircraft crossings in terms of Environment (focus area Flight Efficiency)
Title	Impact in Environment
Category	<performance>
Key environment conditions	High Complexity TMA
V Phase	V2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	PJ.01-03B
<COVERS>	<ATMS Requirement>	REQ-01-03B-SPRINTEROP-0055
<COVERS>	<Sub-Operating Environment>	TMA High Complexity
<COVERS>	<Sub-Operating Environment>	TMA Medium Complexity
<COVERS>	<Validation Target>	FEFF
<COVERS>	<Validation Target>	CEF2

[OBJ Suc]

Identifier	Success Criterion
CRT-PJ.01.03b-VALP-FTS-0003-001	Reduction in fuel burn of aircrafts flying an optimised ROC/ROD
CRT- PJ.01.03b-0003-VALP-FTS-0003-002	Reduction of CO2 emissions from flying more optimised climb and descent profiles
CRT-PJ.01.03b-VALP-FTS -0003-003	Reduce the number of tactical level outs

3.2.3 Validation Assumptions

This section is developed in each specific exercise report.

3.2.4 Validation Exercises List

[...]

[EXE]

Identifier	EXE. PJ.01-03B -VALP-V2-01
Title	DSNA/AIRBUS V2 Trials
Description	V2 Real Time Simulation based on a Paris ACC (E-TMA) and Orly (LFPO) approach. The scenario will focus on the facilitation of Continuous Descent Operations through dynamically assigned routes.
Expected Achievements	Improvement in fuel efficiency
V Phase	<V2>
Use Cases	<UC1> (partially), <UC2>, <UC3> from the SPR-INTEROP/OSED
Validation Technique	Real Time Simulation
KPA/TA Addressed	SAF PRD CAP CEF
Start Date	26/11/2018
End Date	07/12/2018
Validation Coordinator	DSNA/Airbus

Validation Platform	DSNA/TMA SIMULATION PLATEFORM/Pass@TM (Airbus prototype) VSIB (Thales prototype)
Validation Location	DSNA/DTI (Toulouse)
Status	<in progress>
Dependencies	None

[EXE Trace]

Linked Element Type	EXE. 01-03B.010 V2
<SESAR Solution>	
<Sub-Operating Environment>	
<Validation Objective>	OBJ-PJ.01.03-V2-VALP-RTS-001OBJ-PJ.01.03-V2-VALP-RTS-002 OBJ-PJ.01.03-V2-VALP-RTS-005 OBJ-PJ.01.03-V2-VALP-RTS-008 OBJ-PJ.01.03-V2-VALP-RTS-009 OBJ-PJ.01.03-V2-VALP-RTS-013 OBJ-PJ.01.03-V2-VALP-RTS-014 OBJ-PJ.01.03-V2-VALP-RTS-015 OBJ-PJ.01.03-V2-VALP-RTS-016 OBJ-PJ.01.03-V2-VALP-RTS-017 OBJ-PJ.01.03-V2-VALP-RTS-018

Table 3: Validation Exercise layout

[EXE]

Identifier	EXE-PJ.01-03B-VALP-V2.02
Title	A-CDO/CCO facilitation though the provision of an optimised ROC/ROD – FTS (ENAIRE/INECO)
Description	Fast Time Simulation at Stockholm TMA (High complexity TMA) to assess the performance of the conflict resolution through the provision

	of optimised ROC/ROD to aircraft crossings, with the support of a conflict detection and resolution tool. Various independent variables will be tested, such as: • EPP equipped aircraft (traffic mix %) • EPP information stability (reliability of predicted trajectory, uncertainty bubble of EPP, Mental safety buffer for ATCOs, ROC variation limits)
Expected Achievements	Reduce Emissions Reduce fuel burn Ensure the facilitation of CDO/CCO by reducing the number of tactical level offs
V Phase	V2
Use Cases	Use Case 4: Crossing of departures from two nearby airports Use Case 5: Crossing of departing aircraft and an arriving aircraft (from/to the same airport)
Validation Technique	Fast time simulation
KPA/TA Addressed	TMA Capacity, Environmental Sustainability, Flight Efficiency, Human Performance
Start Date	Q2 2018
End Date	Q4 2018
Validation Coordinator	ENAIRE/INECO
Validation Platform	RAMS PLUS
Validation Location	Ineco premises, Madrid
Status	<in progress>
Dependencies	

[EXE Trace]

Linked Element Type	EXE. 01-03B.020 V2
<SESAR Solution>	

<Sub-Operating Environment>	
<Validation Objective>	OBJ-PJ.01.03b-VALP-FTS-0001 OBJ-PJ.01.03b-VALP-FTS-0002 OBJ-PJ.01.03b-VALP-FTS-0003

Table 4: Validation Exercise layout

3.3 Deviations

3.3.1 Deviations with respect to the SJU Project Handbook

No event and decisions led to a deviation with respect to the SJU Project Handbook.

3.3.2 Deviations with respect to the Validation Plan

The deviations from the planned activities were the following:

- As the “Descend when ready” from the cruise FL use case was not assessed, the validation objectives OBJ-PJ.01.03-V2-VALP-RTS-003 and OBJ-PJ.01.03-V2-VALP-RTS-004 were not assessed. The new objective OBJ-PJ.01.03-V2-VALP-RTS-018 was created to address the “Descend when ready” procedure in E-TMA
- Due to technical limitations, all aircraft were EPP and RTA equipped although in certain runs, the ATCOs were asked not to instruct CTAs,
- Due to technical limitations, no speed advisory tool was available.
- KPI actually not covered.

4 SESAR Solution PJ01-03B Validation Results

4.1 Summary of SESAR Solution PJ01-03B Validation Results

As the EXE. 01-03B.010 RTS and the EXE. 01-03B.020 FTS had no Validation Objective in common, the Validation Results are listed in A.3.1 and B.3.1 respectively.

4.2 Detailed analysis of SESAR Solution Validation Results per Validation objective

4.2.1 OBJ-PJ.01.03-V2-VALP-RTS-001 Results

Description:

Evaluate if the ATCO's HMI is suitable for him/her to assess the new concept.

Success criteria:

- Controllers indicate that they can easily identify the aircraft equipage (ADS-C, RTA capability, …)
- Controllers indicate that they can easily identify the status of the operation on board the aircraft (when relevant: flight mode, CTA, …)
- Controllers confirm that they are able to easily distinguish information of different nature (FDPS vs ADS-C/EPP)
- Controllers confirm that they can easily identify the constraints given to an aircraft (e.g speed)
- Controllers indicate that the experimental conditions allowed them to assess the concept in an acceptable way

Conclusion:

Despite missing information on the ATCO's HMI, this HMI was suitable for the controllers to assess the new concept.

4.2.2 OBJ-PJ.01.03-V2-VALP-RTS-002 Results

Description:

Evaluate if the ATCO's HMI is suitable for him/her to assess the possibility to provide "When ready descend" clearances in E-TMA.

Success criteria:

- Controllers confirm that tools available on the CWP allow them to perform their tasks in the case they provide “When ready descend” clearances in E-TMA”
- Controllers confirm that they can easily use data about aircraft’s intentions

Conclusion:

The possibility to provide “When ready descend” clearances in E-TMA was assessed and controllers said they could instruct such clearances. However, the EPP information displayed on the ATCO’s HMI (TOD, ETO, FL, speed), although usable, was not much used. Indeed, the controllers did not feel the need to use “raw” EPP data displayed on their HMI, mainly because there was no such need in their working method. This result is dependent on the conditions of this exercise, but it gives an indication that a simple display of “raw” EPP data is not sufficient to bring useful information to the ATCO.

4.2.3 OBJ-PJ.01.03-V2-VALP-RTS-003 and OBJ-PJ.01.03-V2-VALP-RTS-004

These two objectives were not addressed. See 3.3.2.

4.2.4 OBJ-PJ.01.03-V2-VALP-RTS-005 Results

Description:

Assess how the priority given to capacity impacts the provision of “When ready descend clearances” in E-TMA.

Success criteria:

- Controllers and experts indicate that the management of traffic (sequencing and priority given to capacity) still allows to facilitate optimized profiles for sufficient amount of flights
- Controllers and experts indicate that controllers’ workload is maintained at an acceptable level optimised profiles are facilitated, compared to the baseline

Conclusion:

In the context of this exercise, “When ready descend” clearances were not considered compatible with a high traffic load, or a high traffic complexity.

An insufficient training time with regard to the concept’s novelty and to the procedural changes may have contributed to this negative result, as well as the lack of tools to compensate for less control on the start of descent.

4.2.5 OBJ-PJ.01.03-V2-VALP-RTS-006 Results

Description:

Evaluate if the ATCO's HMI is suitable for him/her to dynamically attribute E-TMA routes.

Success criteria:

- Controllers confirm that the tools available on the CWP allow them to choose alternative routes in an efficient way
- Controllers confirm that they are able to easily identify which route has been given to aircraft
- Controllers and experts confirm that routes can be sent to the aircraft in an efficient manner
- Controllers confirm that the coordination tool permits to make efficient coordinations with different sectors

Conclusion:

The ATCO's HMI was suitable for him/her to dynamically attribute E-TMA routes, despite a defect on the EC's HMI in a specific situation.

The working methods must take into account the EPP update delay. A coordination with PJ18-02a is needed, to ensure this point is fully addressed and consider PJ18-02a work's outputs.

It is recommended that further work address more completely handover occurring during the dynamic attribution of route's process, to anticipate gaps, especially concerning coordinations.

4.2.6 OBJ-PJ.01.03-V2-VALP-RTS-007 Results

Description:

Assess the operational feasibility of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.

Success criteria:

- The proposed working method permit the controller to perform their task
- The information given by E-AMAN services permit to the ATCO to easily attribute a route
- Controllers and experts confirm that information given by E-AMAN does not change too many times and allows to build a stable strategy early enough
- It is feasible for the controllers to monitor the execution of alternative route
- It is feasible for the controllers to deal with several levels of equipage

Conclusion:

During this exercise, it was feasible to use the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.

It was possible to use the sequence and the delays proposed by the AMAN to build a stable strategy and attribute routes to absorb the delays. However an earlier stabilization of the sequence would be worth investigating. Indeed, the earlier the sequence is stabilized, the more risks there are to have to change it later, with a negative impact on the workload.

The application of the new concept entails a transfer of a part of the controller's activity from the active control task to the monitoring task. Limitations of the available tools and proposed working method may have negatively impacted the monitoring activity during the validation runs. Solutions are already envisaged to deal with this issue.

4.2.7 OBJ-PJ.01.03-V2-VALP-RTS-008 Results

Description:

To assess the operational feasibility of recovering from a situation where dynamic attribution of route fails or is not sufficient (while still in nominal conditions) and fall back on today's method (based on vectoring).

Success criteria:

- When, in nominal conditions, the new method application must be interrupted while in progress, the ATCO can revert to the current method (based on vectoring), with no decrease of the safety level, keeping the workload at an acceptable level, and with no impact on the sequencing task.
- When, in nominal conditions, the new method application is not possible, the ATCO can use the current method (based on vectoring), with no impact on safety, and reasonable impact on workload and on the sequencing task.

Conclusion:

It is feasible to recover from a situation where dynamic attribution of route either fails or is not sufficient (while still in nominal conditions) and fall back on today's method (based on vectoring). In the context of this exercise, both methods (dynamic attribution of routes and vectoring) could be used together in a consistent way.

4.2.8 OBJ-PJ.01.03-V2-VALP-RTS-009 Results

Description:

To assess the acceptability of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.

Success criteria:

- No additional tactical interventions in comparison with the reference
- Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
- Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
- The ATCO is as much in control of the situation as with the baseline (situation awareness, monitoring possibilities, anticipation capacity, fall-back capability)

Conclusion:

From a controller's perspective, it is acceptable to use the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, in nominal conditions. However the controllers did not feel as much in control of the situation as with the current procedures and working method. Indeed the new working method substitutes an active control task for a monitoring task.

It is recommended to further evaluate the concept providing the controllers with tools adapted to the activity's changes.

4.2.9 OBJ-PJ.01.03-V2-VALP-RTS-010 Results

The objective was to evaluate if the ATCO's HMI is suitable for him/her to use "Permanent Resume Trajectory", through the following criterion.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-010-001: Controllers confirm that tools available on the CWP allow them to use Permanent Resume Trajectory

For technical reasons and time limitations, the prerequisites to address this objective were not available: no ground tool to support the ATCO for anticipating the end of vectoring to pass it to the flight crew, current EPP standards and resulting implementation do not contain the virtual turning point when the aircraft is vectored (see 5.2.3 for a recommendation on this point). It was decided that the scenario would be only to evaluate the PRT from an on-board point of view. From the ground side, it was decided to instruct headings as in today's operations and provide a rough distance on heading generally when it was requested by the pilot (the ATCO acted as if he/she did not know the PRT functionality). The working method did not request the ATCO to check the route on the CWP.

For these reasons this objective was no longer relevant and thus not addressed.

4.2.10 OBJ-PJ.01.03-V2-VALP-RTS-011 Results

The objective was to assess the operational feasibility of using Permanent Resume Trajectory, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-011-001: The proposed working method permit the controller to perform their task

The proposed working method was simplified, and only consisted in providing, when possible, the distance along track and/or the waypoint/leg intended for capture after a heading instruction. The objective was to tune the trajectory on board in order to make it consistent with the controller intent (anticipate the end of vectoring point / capture initial route point), without significantly impacting his workload.

4.2.11 OBJ-PJ.01.03-V2-VALP-RTS-012 Results

The objective was to assess the acceptability of using Permanent Resume Trajectory, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-012-001: No additional tactical interventions in comparison with the reference
- Success criterion CRT- PJ.01.03-V2-VALP-RTS-012-002: Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
- Success criterion CRT- PJ.01.03-V2-VALP-RTS-012-003: Controllers and experts indicate that no misunderstanding between information and clearances are induced by the use of a "Permanent Resume Trajectory"

During the evaluation, the use of the Permanent Resume Trajectory never led to additional tactical intervention in comparison with the reference. The ATCOs were not aware whether the PRT was computed / used in the aircraft or not, and so, it did not modify their behaviour nor induce any additional instruction. However, some information such as the end of vectoring point, or the leg to be captured were provided by the ATCOs to the pilot.

4.2.12 OBJ-PJ.01.03-V2-VALP-RTS-013 Results

The objective was to assess the feasibility & acceptability of new operational methods from a pilot point of view, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-013-001: Pilots indicate that they can easily adapt their way of working with PJ01-03B new operational methods proposal
- Success criterion CRT- PJ.01.03-V2-VALP-RTS-013-002: Pilot confirm that new operational methods do not decrease level of safety and are acceptable with regards to their procedures (information's received on time to update FPLN or execute manoeuver requested)

Conclusion:

PJ01-03B new operational methods proposal has been judged rather easy and understandable (regarding dynamic attribution of route, delay time sharing, flight efficiency thanks to "descent when ready" method and EPP sharing) by pilots involved in the experiment because the experimental conditions were enough representative of operational conditions to evaluate the concept: the network of alternatives route created within the concept seems applicable to Paris E-TMA from an airborne side (of course, if approved by ATCO).

However, some limitations appears and recommendations has been explained in Annex A, on CPDLC usage (route clearance message, confirmation of ATC instruction reception), on Navigation Data Base overload risks etc… That's why further investigations will probably be needed.

From Thales pilots' point of view, using the Permanent Resume Trajectory improved perceived safety level as it enables to display a vertical deviation even in heading mode.

Pilots' recognized that the concept of dynamic attribution of route allows anticipation of aircraft Energy management and so eases management of deceleration, even more with Continuous Descent Approach FMS function, through a better situation awareness which contributes to reinforce safety.

4.2.13 OBJ-PJ.01.03-V2-VALP-RTS-014 Results

The objective was to evaluate how ADS-C (EPP) data can facilitate CDO operations, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-014-001: Issues linked with EPP uncertainty are assessed by both pilots and controllers

Conclusion:

The exercise allowed to address issues linked with EPP uncertainty. In particular discrepancies between the FMS hypotheses and the ground expectations, especially about speed, may impact the dynamic route attribution consistency and disturb the controllers' activity.

The EPP data contain information which may solve this issue: the necessary analysis cannot be done by the controllers, but could be done automatically by the ground system.

As long as the use of EPP profile by the ATCOs is transparent to the pilot and does not add more mental charge or uncertainties, which was the case here, it is acceptable from a Human factors point of view on the airborne side.

4.2.14 OBJ-PJ.01.03-V2-VALP-RTS-015 Results

The objective was to evaluate pilot workload with new operational method, through the following two criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-015-001: Pilots assess and confirm increase of workload is acceptable with regards to increase of flight efficiency

- Success criterion CRT- PJ01.03-V2-VALP-RTS-015-002: Pilots confirm that workload associated to new operational methods does not decrease safety.

Conclusion:

EPP and dynamic routes allocation functionalities are either transparent for the pilot (EPP) or equivalent to changing the STAR on the ARRIVAL FMS page. Furthermore, no added task or uncertainties was identified by concept implementation: pilots seems to be comfortable with safety aspects (no impact reported) with these new operational methods allowing flight efficiency within “descent when ready” method on closed routes.

Pilots’ also pinpointed that the cockpit simulated systems on a computer instead of a real cockpit led to higher mental workload ratings than expected, additional experiment in more realistic environment will be of interest in terms of crew workload impact evaluation.

No pilot reported that PJ01-03B new operational methods proposal could jeopardize the safety of the flight because a trend of self-rated mental workload reduction has been identified during the experiment.

4.2.15 OBJ-PJ.01.03-V2-VALP-RTS-016 Results

The objective was to identify traffic condition limitations with regards to CDO optimization

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-016-001: PJ01-03B team assesses and confirms from which level of traffic, controllers can’t authorized CDO optimization

This objective’s results were collected at the same time as OBJ-PJ.01.03-V2-VALP-RTS-018 results.

Conclusion:

From a ground side perspective, and in the context of this exercise, the “when ready descend” procedure was not considered compatible with a high traffic load, or a high traffic complexity. The ATCOs indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and when there is time for a closer monitoring of the traffic.

4.2.16 OBJ-PJ.01.03-V2-VALP-RTS-017 Results

The objective was to identify new operational method noise impact and fuel efficiency, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-017-001: PJ01-03B team evaluate theoretical noise impact of new operational method in comparison to current operational method (if data available)
- Success criterion CRT- PJ.01.03-V2-VALP-RTS-017-002: PJ01-03B team evaluate theoretical fuel efficiency of new operational method in comparison to current operational method (if data available)

Conclusion:

Regarding airborne simulators results, noise data are not directly available. However, as detailed in Annex A, dynamic route attribution eases CDO and "recruising" procedure enables to stay higher longer on a closed path, and therefore, reduces global noise footprint on ground.

Even if a quantitative analysis is not relevant due to experiment limitations (important lateral dispersion observed even on a same traffic sample and traffic conditions, too low sample for statistics, ATC sectors operational representativty), the experimentation permits to identify a trend. As expected theoretically, dynamic route coupled with re-cruising operation improve the fuel efficiency compared to a geometrical descent between BEVOL and ODILO. It is clearly more efficient to stay higher longer, at a recruise level and to recompute another top of descent followed by an idle descent segment, instead of starting a geometric descent earlier as it is done with an AT altitude constraint at BEVOL

A dynamic and "closed" route, with recruise level followed by an idle descent, is then more fuel efficient and comfortable for the crew than an "open" route (vectoring).

The negative impact of vectoring on fuel burn is due to the fact that the flight crew can't optimize the descent because they do not know neither the distance nor the speed schedule to rejoin ODILO. Hence, knowing the exact lateral extension (the closed route) is the best but not the only way to optimize the descent. It may not be necessary as long as the distance to go and speed schedule and/or the arrival time planned by the AMAN are provided to the flight crew and the FMS has a way to process this information, such as the Permanent Resume Trajectory for instance.

4.2.17 OBJ-PJ.01.03-V2-VALP-RTS-018 Results

Description:

To assess the operational feasibility, from a controller's perspective, to provide "When ready descend" clearances in E-TMA

Success criteria:

- The proposed working method permit the controller to perform their task

- The information about aircraft descent intentions available for the ATCO permit to facilitate the use of optimised profiles from TOD
- The controllers can monitor the flights executing an optimised descent as easily and safely as usual
- No additional tactical interventions in comparison with the reference
- Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
- Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
- The ATCO is as much in control of the situation as with the baseline (situation awareness, monitoring possibilities, anticipation capacity, fall-back capability)

Conclusion:

The controllers consider that the TOD Information, provided in the EPP data and displayed on their HMI, is not fully reliable, because they are not sure that the flight crew will comply with this information.

From a ground side perspective, and in the context of this exercise, the "when ready descend" procedure was not considered compatible with a high traffic load, or a high traffic complexity. The ATCOs indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and when there is time for a closer monitoring of the traffic.

4.2.18 Results on CTA/RTA operational use in the dynamic attribution of routes context

During this exercise, the CTA/RTA was used as a complement to the dynamic attribution of route. The route was attributed first, associating a route to a TTL thanks to a rough calculation (the assumptions were: fixed average speed, no wind, theoretical vertical profile, standard behaviour). The role of the CTA/RTA used in combination with a route was to account for real life deviations in comparison to the rough assumptions, and make the aircraft respect the Scheduled Time of Arrival over the metering fix precisely, thus refining the sequence.

Although no Validation Objective specifically addressed the CTA/RTA, results concerning the use of this functionality in the dynamic attribution of routes context were collected. These results are reported in A.3.4.17.

4.2.19 OBJ-PJ.01.03-V2-VALP-FTS-001 Results

Description:

Impact in Cost Effectiveness.

Success criterion:

- TMA ATCO is able to handle at least the same number of aircraft movements in its area of responsibility per ATCO hour on duty considering the operational concept under assessment.

Conclusion:

In the reference scenario were registered 89 conflicts in which 131 flights were involved, those flights represent the 20% of the total traffic of the sector during the day. The TMA ATCO on duty of the ESSAE sector had do command 127 level outs

In the solution scenario were registered 62 (30% less) conflicts impacting 104 flights, which represents the 16% of the total traffic of the sector during the day. The TMA ATCO on duty of the ESSAE sector had to command 83 ROC/RODs

The reduction in the number of ATCO interventions is reduced, since there’s no need to manage “false conflicts”, consequently ATCO workload situation is improved compared to the reference scenario.

4.2.20 OBJ-PJ.01.03-V2-VALP-FTS-002 Results

Description:

Impact in Airspace Capacity

Success criterion:

- TMA ATCO is able to handle at least the number of aircraft movements in its area of responsibility considering the operational concept under assessment

Conclusion:

The total traffic TMA increases from 1027 flights in 2012 to 1237 flights in 2025.

Despite the traffic increase, the demand doesn’t surpass sector capacity, despite the traffic increase considered for 2025.

4.2.21 OBJ-PJ.01.03-V2-VALP-FTS-003 Results

Description: Impact in Environment

Success criteria:

- Reduction in fuel burn of aircraft flying an optimised ROC/ROD,
- Reduction of CO_2 emissions from flying more optimised climb and descent profiles,

- Reduce the number of tactical level offs.

Conclusion:

Despite of the results obtained, the limitations that raised up during the data analysis with the IMPACT tool, as addressed in section 4.3.1, did not allow to assess flight efficiency indicator properly.

The fuel burn decreases a 0,083% when aircraft are cleared with an optimised ROC/ROD instead of a level off, despite of this small difference between both procedures it seems that the solution scenario shows a potential improvement in fuel efficiency.

It was observed that the fuel burn is higher in in arrivals than in departures, this occurs because the number of commanded RODs/ level off is higher than the number of commanded ROCs/ level offs (67 ROD against 16 ROCs).

When comparing the reference and solution scenarios, the fuel burn consumption decreases a 0,64% in arrivals and increases a 0,67% in departures. Despite of the fuel burn increase in the solution scenario for departure operations, the difference against the reference scenario is not very high and the overall fuel burn for arrivals and departures shows a slight improvement.

In the reference scenario 127 level offs were commanded to avoid aircraft crossings, on the other hand when considering the solution scenario, no tactical level outs were needed to solve aircraft crossings.

4.3 Confidence in Validation Results

4.3.1 Limitations of Validation Results

EXE. 01-03B.010:

Regarding the ground side:

- Experimentation did not feature wind. This is a significant limitation, as wind may have an influence on the AMAN's stability, on the difficulty for the controllers to anticipate the conflict situations, on the accuracy of information provided by the EPP data, but also on the potential interest of EPP data (provided it is sufficiently accurate and reliable).
- Four controllers participated in the validation exercises: two with an E-TMA experience (among which one with an experience on the sector chosen for the exercise), and two with an En-route experience. This small number is of course a limitation.
- Owing to the maturity level of the concept (start of V2 phase), it was decided to evaluate the concept in a simplified environment: the crossing traffic was not represented, the flows to other airports (flows to Paris CDG airport, LFPG, but also to other smaller airports in the area) were not represented.
- Owing to the maturity level of the concept (start of V2 phase), it was decided to focus on nominal cases. Thus, non-nominal conditions were not considered.

Regarding airborne side:

- As explained in previous part, regarding Thales results, noise data are not available but fuel data are. However, various factors make it difficult to conclude about fuel savings. The lack of reproducibility and determinism of the simulations due to human factor is representative of real life but prevent from performing a quantitative analysis. A larger sample would be required to provide relevant numbers about fuel and noise and perform a complete statistical analysis. From the Human Factors point of view, a larger sample of pilots would also be required to draw conclusions instead of tendencies. A set of three pilots could not be perceived as representative of the population of pilots.
- Another HF limitation identified about the experimentation (on Thales side) is the lack of reference run for the second session, and even for each traffic conditions, as well as the fact that some runs where not duplicated to account for internal variations of perception and ratings with one pilot. Indeed, although several runs were repeated up to three times in session 2, the ATCO guidance was different from one run to another, leading to a heterogeneous set of data not directly comparable.
- In addition, due to the fact that Thales flight models (the Flight Management with the PRT and the Dassault Falcon business jet) are research-based ones, some limitations are introduced. Robustness is not equivalent to the one of the products in flight. For instance, in some scenarios, some mode engagements (such as ALT ACQ) do not occur as expected and the pilots had to react and find a workaround to continue the descent in representative conditions.

- It also should be noted that the ADS-C contract was at a very high periodic rate that would not be possible in "real" life as it would saturate the bandwidth in the context of worldwide traffic permanently growing and actual datalink performances. So, the EPP should be further evaluated using its event based report instead of being based on a periodic report.
- Added to this is the required use of portable cockpit simulation but with associated limitations. Thales pilots pinpointed that the single side "PC screen" cockpit with limited interaction means (pushbuttons, dials, etc.) led to higher workload ratings than what would be expected in a standard cockpit simulator.
- Such issues might have some second order impacts on fuel, time and workload analysis. As Thales VSIB simulator, Airbus PAS@ATM is a Research & Development tool. Even if PAS@ATM has been fully validated with regards to A330 behaviour, fuel data have to be considered as a trend. Also, noise data are not available and this topic needs to be investigated in Wave 2 to complete the maturity of the solution.
- In addition, auto load of CPDLC messages is not available on PAS@ATM simulators. This limitation is almost an added value for the benefit of the solution as both method have been used, auto load on Thales side and manual implementation of CPDLC message on Airbus side.
- The cockpit simulators did not feature any TCAS HMI. Air France pilots involved mentioned that, in operation, the TCAS HMI is also used to understand the rationale behind ATC orders and could be helpful for pilots in some specific cases. These conditions were met in the exercise when evaluating RTA in dense traffic, at this moment (only) Air France pilots involved would have looked to TCAS screen.

EXE. 01-03B.020:

Regarding the environmental assessment

The level of confidence in the flight efficiency indicators, fuel consumption and CO2 emissions, obtained from the IMPACT tool is low, because it was detected that IMPACT needs some specific data input such as thrust engine or flaps configuration in the assessment of the consumption profiles, that RAMS Plus was not able to provide.

4.3.2 Quality of Validation Results

EXE. 01-03B.010:

Regarding the ground side:

The experts and controllers felt that a much longer training would have been necessary to get used to the new CWP and its tools, and to the new operating method. An improvement was noticed all along the experimentation and until the last day.

The AMAN behaviour was satisfactory for the measured ETMA sector, but its update was not possible for the TMA and the MOLBA feeder controller. The consequence is that the traffic was not synchronised between ODILO and MOLBA IAFs. It does not affect the results of the ETMA, but it affects severely the flight profiles in the TMA sector.

The flights behaviour simulated by DSNA were updated for this simulation where the flight profile realism was judged important. The result was satisfactory, but the training of the pilots was impacted by these late changes, implying a significant number of errors.

Regarding airborne side:

- **Flight efficiency**

Various factors impact flight efficiency results quality and analysis.

First, it has to be noted that, according to controllers expertise, the vertical profile observed on the Thales baseline flight does not represent the reality of the sector, as the aircraft are normally cleared for descent later, around AMB. Hence, the results of this analysis have to be considered as a comparison between a geometric descent starting at BEVOL as calculated with nowadays FMS, and a situation where the FMS has calculated a new TOD to reach an idle path, resulting in a profile closer to current operations.

The realism of the TMA profiles is highly impacted by the fact that only one controller was in charge of piloting all TMA sectors and that the MOLBA flow was not managed correctly. Hence, the aircraft profiles often look less optimised than in today's operations.

The wind was not simulated.

Then, the representativeness is not complete and that necessary leads to some gaps with real life conditions. As an example, according to controllers and experts, the only baseline flight recorded on Thales simulator started its descent earlier than in current operations. As the expected benefits in terms of fuel are slight, savings are not easy to identify as the uncertainty and benefits are the same order of magnitude. However, even if an absolute analysis is not realistic, relative measurements might be done in this kind of exercise to establish some trends and practices that favour flight efficiency.

On Airbus side, a questionnaire has been filled by pilot's to gather their feelings and feedbacks and extract tendencies about flight efficiency recovery assessment.

Even if limitations on the RTS exercise exist (detailed in previous chapter), globally, pilots using PAS@ATM were comfortable to give a qualitative assessment of the concept based on benefits tendencies identified during the simulated flights.

4.3.3 Significance of Validation Results

EXE. 01-03B.010:

Regarding the ground side:

Seven runs of 50 minutes were performed for each of the two groups of participants involved in the exercise. For each run, quantitative and qualitative data were collected: debriefing notes, questionnaires and recorded data.

However, owing to the maturity level of the concept (start of V2 phase), it was decided to focus on qualitative results. It was then decided to give the priority to the observation of solution scenarios and thus to perform only one baseline. The implication of this choice is that the feedbacks on the solution are rich, but the counterpart is that it is delicate to make precise comparison between the solution and baseline scenarios and thus the quantitative results significance is highly limited.

The vertical profile of the baseline Thales flight follows approximately a continuous descent from BEVOL to ODILO which doesn't correspond to what is done today on this sector. Thus, the comparison between the baseline and the scenario fuel efficiency does not represent a gain compared to today's operations but with what would have occurred if the flight had followed the profile calculated by the FMS.

The baseline was the first run of the first session, which entailed biases linked to a lack of practical training on the CWP. Moreover, the number of participants and experimental runs was too small to provide any statistical significance.

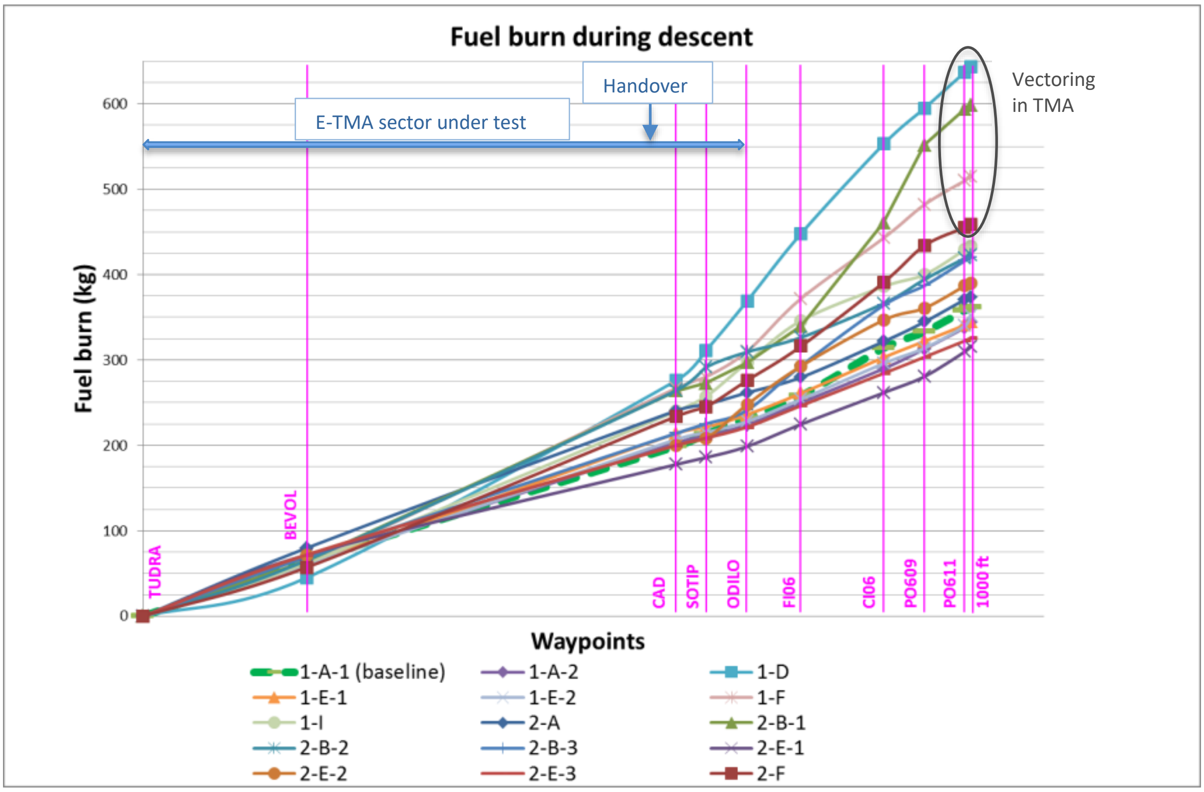
Nevertheless, qualitative analysis remained possible, allowing to get results with some operational significance. It must be noted that the working method was fine-tuned by the controllers during the first session.

Regarding airborne side:

- **Significance of Flight efficiency results**

As described previously, various factors make it difficult to conclude about flight efficiency.

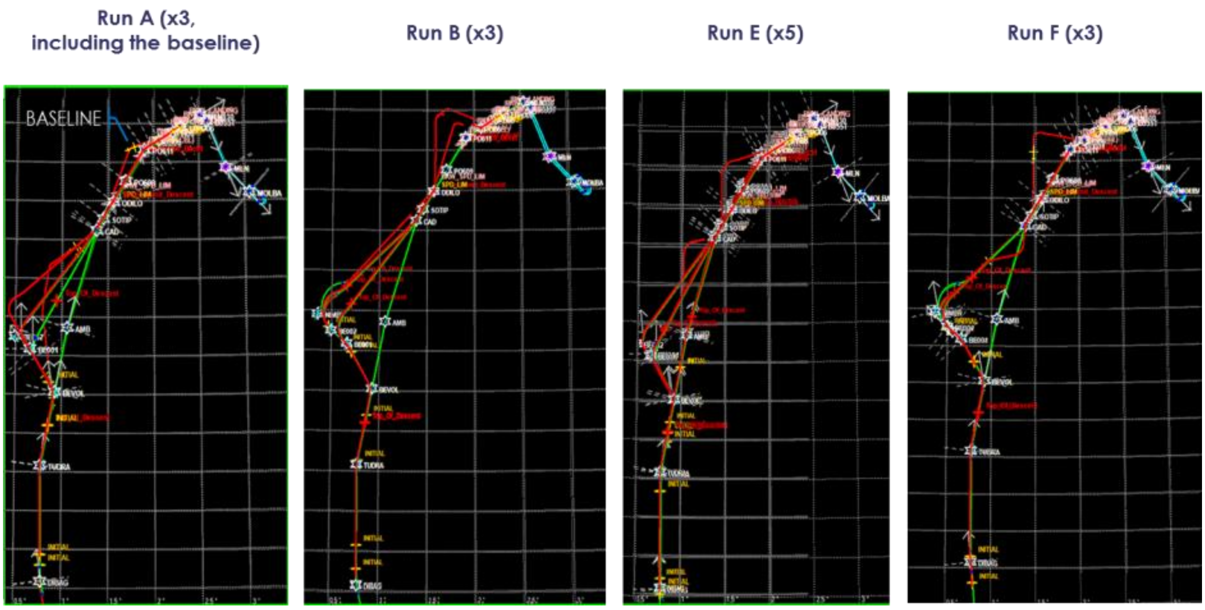
The fuel efficiency is difficult to evaluate mainly because of the sample size. Only 15 flights were run, allocated to 5 traffic conditions: 7 flights in the first session, and 8 flights in the second session. Hence, the number of results is not sufficient to draw a quantitative conclusion but qualitative analysis can be performed and some recommendations clearly appear (cf. Part 5).



Dispersion on fuel burnt by THALES aircraft between TUDRA and 1000ft

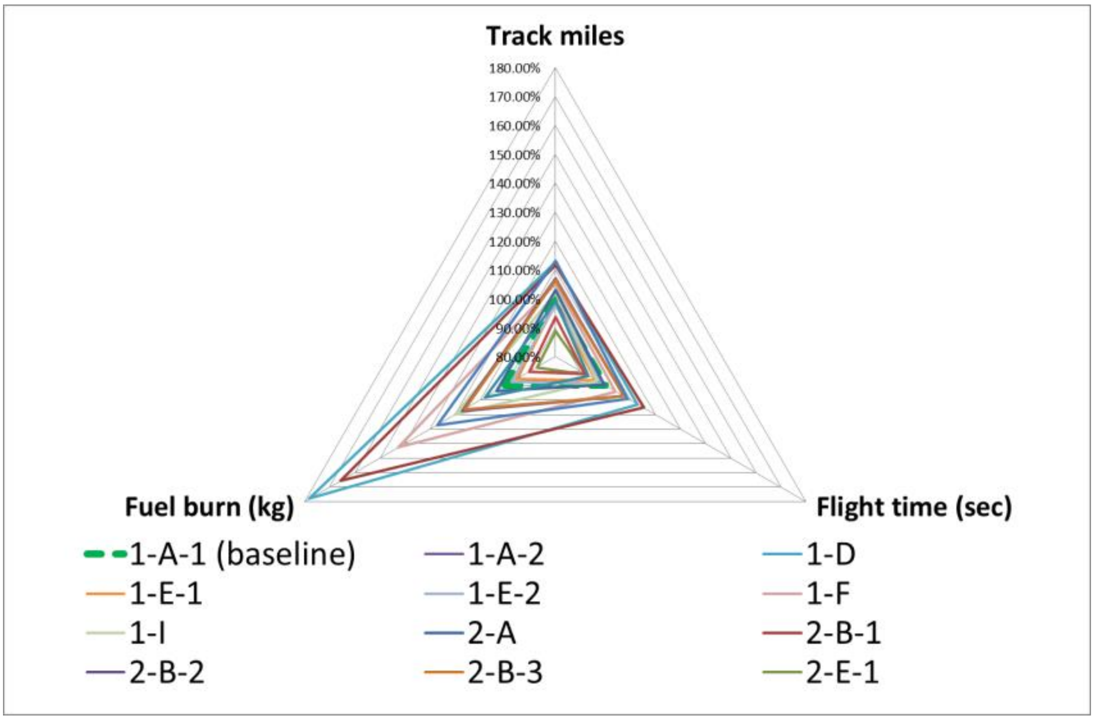
Finally, these two sessions include only one baseline flight (RUN A during session 1) that was run without any new capability, at the beginning of the sessions, that means with very few training and experience on the new tools, specifically on ground side.

Regarding the significance and the relevance of the flight results, an important dispersion was observed even on a same scenario, in the same traffic conditions.



Lateral variability observed on THALES flights

As the system is not fully automatic but there are humans in the loop, each action might introduce some variability and impact fuel consumption depending on the timing, the human reaction, etc. This is representative of real life and the five different [pilots / controllers] combinations that have been tested led necessarily to different results. Another human factor that might impact the results is the probable lack of training of the controllers at the beginning of the experimentation, and the time required to assimilate the concept and the working methods. A progressive skills improvement was observed during the experimentations.



Dispersion on Flight efficiency (synthesis on THALES flights)

As a conclusion on fuel efficiency results, and as shown on the above three figures, an important variability was observed, due to experimental limitations, human operators behaviour and traffic conditions (delay to be absorbed). For this reason, the significance of quantitative results obtained on fuel efficiency is limited. However, a qualitative results analysis was possible, which will have to be confirmed with quantitative (preferably statistical) results in further studies.

On Airbus side, we must also admit that 26 simulated flights were not enough to provide statistics on environmental benefits due to lateral divergences observed because of lateral separation needs.

But, in line with solution goals and maturity objectives, pilots have been in position, with validated performance simulators, to validate environmental benefits tendencies identified in session. These qualitative statements (confirming Thales figures) complies with solution targets.

5 Conclusions and recommendations

5.1 Conclusions

Regarding both aircraft and ground points of view, the experimentations allowed to evaluate solution maturity, representative technical and operational integration into an ATM environment, identify hard points and clarify the concept. Technical and operational feasibility have been evaluated and partly demonstrated from both points of view, including the interaction of the aircraft with the ATC environment.

The realism of the ATC situation in the TMA sector was not sufficient to assess the impact of the concept on this sector. Conversely, this lack of realism of the TMA may have impacted the sector under test as no request came from the TMA and no action on the sequence either. The validity of the following conclusions is nevertheless not questioned by this limitation.

5.1.1 Conclusions on SESAR Solution maturity

Air/ground intentions sharing (ADS-C/EPP)

First item evaluated was the EPP. Its use by the ground is transparent for the crew without any impact on their workload, and solution can be judged mature on board as it contains much more trajectory information than necessary. However, depending on the real need and the planned usage on the ground, the EPP definition might need to evolve, specifically in vectored situations and for use cases involving the Permanent Resume Trajectory capability.

The ATCO or ground system in charge of the EPP analysis must clearly have the necessary information on how the EPP is computed on-board, specifically in selected modes, to use it efficiently and avoid any misunderstanding.

Dynamic attribution of routes

Second item evaluated was the dynamic route attribution. The concept of route attribution to limit current radar vectoring operations has been judged satisfactory by the pilots. The improvement of energy management is a consequence of clearances that do not change much after route attribution, which provides a more predictable trajectory. So if route attribution helps no further change, it is really profitable from the airborne point of view. Air France pilots involved also stated that this anticipated awareness to the crew is really helpful for managing aircraft energy. Furthermore, with alternative routes coded in the Navigation Data Base of the FM Software, pilots acting on PAS@ATM simulators reported the concept is decreasing their workload. However, during those evaluations, speed reductions and sometimes radar vectors have been ordered in addition to route attribution, which reduces the benefits.

Two ways of working are possible to insert a new route, Thales aircraft experimented the CPDLC route clearance method. But using the CPDLC UM#266 message has to be evaluated against the method that consists in loading a procedure from the navigation database, experimented by Airbus, which offers the advantage to permit late change, and thus would be more flexible operationally.

Depending on the context of occurrence, one method can be easier and faster than the other. But in both cases, pilots prefer having the route in the navigation database as a STAR ENRTE TRANS. It will also clarify the way to define the route by voice when it has been sent by CPDLC, without being published nor displayed on the mail box.

Thales pilots' reported that CPDLC route clearance (UM#266) to receive and insert a new "part" of descent procedure (even a new complete STAR) will probably need more evaluations. For instance, the ATCOs tried a few times to give a late route clearance whereas the use of this message implies that the uplink arrives soon enough before BEVOL, otherwise the flight crew cannot insert this message (due to the very nature and structure of the message or because they do not have the time). During the experimentations, the initial route was always on time and early enough, but sometimes the ATCOs tried to change it later by another one longer. That was not possible with the UM#266 message once the aircraft had sequenced BEVOL.

Additionally, Thales pilots reported that they need some time to check the new route in the SEC FPLN, more than if the new route was part of the navigation database. This is partially due to the fact that the CPDLC message is so shortened that it does not carry any constraint information for instance. This discrepancy between the CPDLC and SEC FPLN messages makes the pilot spend more time to validate the new route. ATCOs must consider this in their work; for instance, they cannot expect a pilot to respond instantly to their proposition, nor expect a positive response if they submit their route proposal too late.

On PAS@ATM simulators, an update of the FM Software Navigation Data Base has been done prior to the exercise to add all routes (BEVOL0, BEVOL1, BEVOL2, BEVOL3 and BEVOL4) of the concept. Even if almost all AIRBUS aircraft have auto load capability of CPDLC messages, PAS@ATM simulators can only receive and send CPDLC free text messages. We took advantage of this limitation to investigate both methods to dynamically attribute alternative routes, by CPDLC free text messages, and confirmation by voice.

Of course, all pilots confirm the preferable method is to use CPDLC message to avoid additional workload to confirm order reception and implementation on board but they reported the voice method feasible because of easy wording and limited number of alternative routes used in the concept.

One pilot acting on PAS@ATM simulator (featuring routes in Navigation Data Base) stated that one change of alternative route is acceptable from a workload point of view thanks to CPDLC methodology (provided the alternative route has previously been implemented in the Navigation Data Base).

During the second session of the exercise, Air France pilots involved mentioned the possibility to use "STAND BY" CPDLC messages (not implemented in the exercise) allowing ATC to know that the message is under implementation on board (following pilot action on the DCDU) and that the pilot needs time to check the new alternative route received. Pilot recommendation is to implement such messages for further investigation of the concept and so record the average time needed for the pilot to check and activate the new flight plan in the FM Software.

The use of the Requested Time of Arrival function to refine and adapt the speed profile and comply with the Time To Lose on the attributed route was evaluated on AIRBUS PAS@ATM and VSIB simulators. RTA has been evaluated and used as soon as possible, either by voice ATC request or, thanks to CPDLC messages. As a reminder, the transmission of CTA/RTA CPDLC messages was not implemented on the simulation platform. Prefer pilot way of working is off course by CPDLC to avoid increased workload associated to needed confirmation communication. But they reported the voice method feasible because of the simplified network used to evaluate the context. Due to simple wording and limited number of alternative routes used in the concept, confirmation wording messages (for RTA with associated alternative route name) were easily understandable. That's why, in the frame of the experiment, with the simplified network concept evaluated, RTA voice ATC instruction were judged acceptable by the pilots.

Pilots sometimes had issues with RTA when new ATC order were received (speed instruction) but it has been judged manageable as soon as ATC confirm or cancel RTA in the speed instruction message (from airborne point of view, RTA is by default erased by any new ATC instruction).

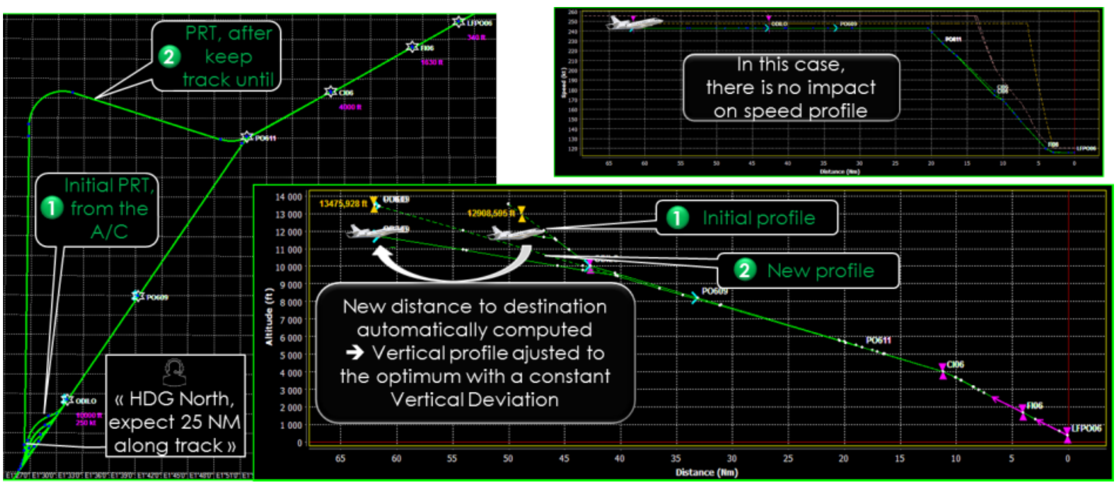
Also, laboratory test pilots confirmed that one change of RTA is acceptable.

Setting RTA in the Flight Management software takes time, one request from the pilots was that, as soon as feasible, ATC's try to anticipate requests to pilots.

In conclusion, the concept of dynamic attribution of route has been judged efficient from airborne point of view. The only open item is the consequences of alternative routes multiplication in the Navigation Data Base with regards to memory space limitations. This limitation will need to be further investigated with Navigation Data Base providers. Concerning the RTA use, pilots recognized, even if RTA is useful to recover flight efficiency as FM Software is proposing an optimised descent in terms of aircraft performance, during the feedbacks sessions, that RTA could be difficult to use in high density traffic to ensure lateral separation of mixed fleet without ATC speed instruction.

Permanent Resume Trajectory

Finally, last item evaluated, on Thales aircraft only, was the Permanent Resume Trajectory prototype. It has been evaluated and the functionality is really promising. Complementary to the dynamic attribution of route method, vectoring will be used, and PRT is a solution to permanently assist the crew when vectored. It provides a clear assumption of the trajectory to rejoin the flight plan, on which situation awareness is enhanced and clear thanks to FMS predictions. It helps to fly an optimized and fuel efficient profile in HDG mode (lateral selected mode) thanks to an adapted vertical reference.



Vertical reference profile adaptation thanks to the Permanent Resume Trajectory

Manual adjustments of the Permanent Resume Trajectory on-board, such as the “Capture AT” or the “Keep Track Until” appear to be essential. It is preferable that the ATCO provides the pilot on-board with some information about his/her intent, which has been done efficiently during the evaluations. Even if this information is not provided by the ATCO, the PRT functionality could help by taking advantage of pilots’ experience on a specific airport for instance. Then, it enabled to well anticipate the future trajectory and to optimize the aircraft energy management as shown below.

Superimposition of the initial PRT with the DIRECT TO trajectory

However, the Keep Track Until interaction that has been prototyped is quite complex and not completely adapted, particularly due to the use of the KCCU wheel to dynamically and finely tune the virtual turning point along the active track. Both Thales pilots have verbally reported that this functionality would gain with the transient display of the distance value (and/or the time) while setting it via the KCCU wheel. This would save them some mental workload and provide more accuracy. Moreover, when the controller provides the distance, the pilot might be busy and some seconds or minutes might elapse before he is able to tune the distance on the interactive navigation display. This increases the mental workload, and might be replaced in the future by another kind of information. For instance, the STA-FF might be used on-board to compute automatically the virtual turning point that will meet the controller expectations. It can then be imagined an air/ground loopback thanks to an upgraded version of the EPP.

Conclusion from a Human Factors perspective

From the Human Factors perspective, both Thales pilots reported being satisfied with the new functionalities introduced with the experiment. The slight tendency to an increase of the workload is hard to specifically attribute to any of the novelties, but it is probably the result of the use of the PRT which has proved its interest and added value in situation awareness, but has also raised the fact that pilots need to be trained and get acquainted to it before it unveils its full potential.

All pilots who used AIRBUS PAS@ATM simulators were, from a Human Factor point of view, comfortable with the concept. Improvements of procedures experimented during the exercise seems to decrease pilot workload. This trend is difficult to evaluate but, within alternatives routes coded in FMS data bases, no additional workload for the crew has been identified during the experiment and the anticipated awareness received by the crew clearly eases aircraft energy management creating this tendency to globally lighten crew workload.

5.1.2 Conclusions on concept clarification

- **Capacity**

In this initialisation of V2 phase, as agreed when PJ01-03B solution was created, it has been decided that the goal of RTS will be to maintain the current capacity to assess PJ01-03B concept. For wave 2, goal will be to assess increase of capacity feasibility within PJ01-03B concept by evaluating concept efficiency on other TMA.

- **Safety & Security**

PJ01-03B concept was deployed only on Paris ORLY TMA only for initialising V2 phase, based on current ATCO management strategy relying on already certified procedures with already certified ATCO and airborne functions. That the reasons why, PJ01-03B concept has no impact on safety and security assessment.

- **Flight profile optimization in descent (efficiency & predictability)**

First, it has to be noticed that the solution has been tested on a scenario with a route designed for the experimentation. This route has been derived from existing procedures available at Paris Orly airport. The STAR chosen was AMB6E, the VIA was ODI4A and the approach was the ILS06. Based on these procedures, a constraint at BEVOL was added at FL280 to match the Letter of Agreement. Even if not in the navigation database, it is realistic as it corresponds to the real delivery conditions between En route and E-TMA sectors. The other constraints were deleted between BEVOL and CI06 except the ones at ODILO, FL100 and 250 kts, that correspond to the delivery conditions between the E-TMA and the TMA. It has been done to facilitate Continuous Descent Operations by keeping the minimum but realistic constraints, enabling the aircraft to compute and fly an optimized profile whatever its performances are, Airbus A330 or Dassault Falcon 7X.

Then, to cope with these constraints, specifically the one at BEVOL which leads to anticipate the Top of Descent and reduce the fuel efficiency, some adapted operational methods have been identified such as re-cruising.

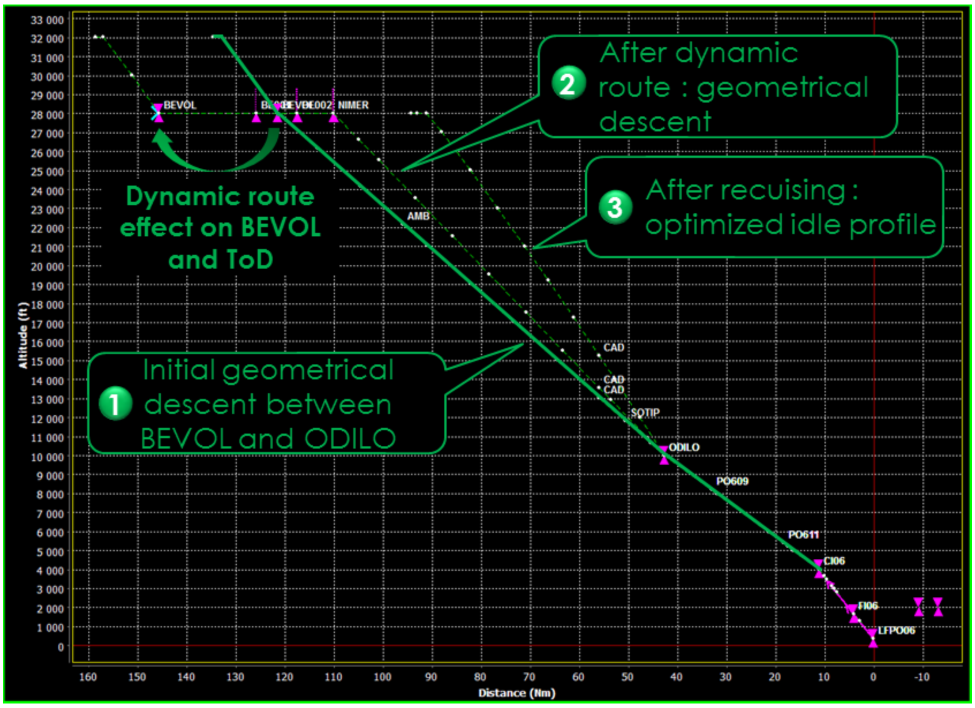
Once a dynamic route is attributed to an aircraft, the distance to the destination is increased (indeed, the attributed route is meant to make the aircraft lose time for sequencing needs and replace a vectoring instruction). However, when the aircraft is in descent flight phase, the way the profile is computed is based on norms and standards that require staying on a geometrical slope between two successive constraints. However, this computation is no more optimal when this slope is shallow compared to an idle slope.

Hence, it is preferable to stay higher longer, and therefore to add some constraints on the dynamic route points (after BEVOL at FL280). Keeping the aircraft higher on a level-off before descending in IDLE (partial CDA in the table below) is better than doing a complete CDA with shallow path, as shown on the next table.

	Route Cost Table (in fuel kg)	
	No constraint	AT 280
BEVOL0	0	/
BEVOL1	42	22
BEVOL2	98	60
BEVOL3	173	132
BEVOL4	247	191

Dynamic route cost evaluation: full CDA (no constraint) vs partial CDA (AT 280)

Additionally, to increase the flight efficiency, it is preferable to change the cruise flight level from FL320 to FL280 when established at FL280. This re-cruising operation triggers a re-computation of the theoretical descent profile which is used as a reference for aircraft guidance. The FMS will then consider differently the constraint at FL280 (at CRZ FL) and build an idle path to reach ODILO at FL100 from the FL280. This idle path preceded by a level-off is much more efficient than starting the descent after the last AT OR ABOVE of the dynamic route. Indeed, a shallow path leads to thrust increase all along the geometrical slope, and hence, to fuel consumption increase.



From initial route to dynamic route optimized by re-cruising operation

From a ground side perspective, and in the context of this exercise, the “when ready descend” procedure was not considered compatible with a high traffic load, or a high traffic complexity. The ATCO indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and when there is time for a closer monitoring of the traffic. This fact could explain why the ATCO did not use information on aircraft intentions provided by the EPP: when the traffic was low controllers did not need this information to clear the aircraft to descend when ready. On the other hand, when the traffic was high, the controller did not use this procedure. An insufficient training time with regard to the concept’s novelty and to the procedural changes may have contributed to this negative result.

However, even though the “When ready descend” procedure cannot always be used, improvements allowing optimized flight profile calculation as described here above can provide benefits, depending on the traffic density and complexity.

- **Dynamic attribution of routes**

The ATCO considered that in the context of this exercise, it was feasible to use the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation. The sequence and the delays proposed by the AMAN allowed the controllers to attribute routes to absorb the delays and build a stable strategy. Nevertheless, they reported that the sequence should be stabilized earlier than during the exercise runs, in order to avoid late changes which are difficult to manage and increase the workload. The issues associated with an early sequence stabilization have to be further investigated.

The dynamic attribution of routes concept implies that the strategy is decided in advance, and so if a change occurs in the executive phase, both controllers have to be aware of the modifications. The need to ensure both controllers’ awareness regarding the sequence must be considered when designing the HMI and the working method.

During this exercise, the CTA/RTA was used as a complement to the dynamic attribution of route, allowing the ATCO to give a CTA/RTA to make the aircraft respect the Scheduled Time of Arrival over the metering fix precisely. The controllers reported that the behaviour of aircraft flying to a CTA was not easy to anticipate and thus led to an important monitoring activity, to make sure there would be no loss of separation. As a consequence, when using CTA, controllers will need a support to assist them in this monitoring activity (published speed constraints allowing to maintain the aircraft’s speed in a reasonable range, monitoring tool, …).

Time information seems to make more sense for the controllers when it is considered in relation with another value. For instance, the ETO on the IAF can be compared to the preceding aircraft ETO or to the aircraft STA-FF. The EPP ETO on the IAF was compared to the STA-FF computed by the AMAN (with its own Trajectory Predictor), thus allowing to monitor precisely that the sequencing was unfolding correctly.

5.1.3 Conclusions on technical feasibility

- **EPP and ToD sharing**

For the experimentation, the ADS-C contract was at a very high periodic rate (possible over a direct network connection) defined at 20 seconds in order to always provide a representative EPP to the ATCO. In real operations, it would not be possible as it will saturate the bandwidth in the context of worldwide traffic permanently growing and actual datalink performances. So, the EPP should be further evaluated using its event based report instead of being based on a periodic report. This is feasible and adapted to a “Flight Plan Change” event, which will permit to send an EPP when the dynamic route is taken into account by the Flight Management System.

From an airborne point of view, the EPP use is seamless and does not disturb the classic way of working.

- **Dynamic route attribution**

From a ground perspective it is technically feasible to dynamically attribute routes using AMAN functionalities and an improved coordination tool between sectors.

Dynamic route attribution is clearly feasible from an airborne point of view. It is all the more true, that the current standards are compliant with the CPDLC message as used on THALES flights during the experimentations, through the UM#266 route clearance message.

Nevertheless, as explained before, using CPDLC route clearance message should be challenged with on-board FMS navigation database STAR loading method which will imply creation of “N” additional path extension STARs.

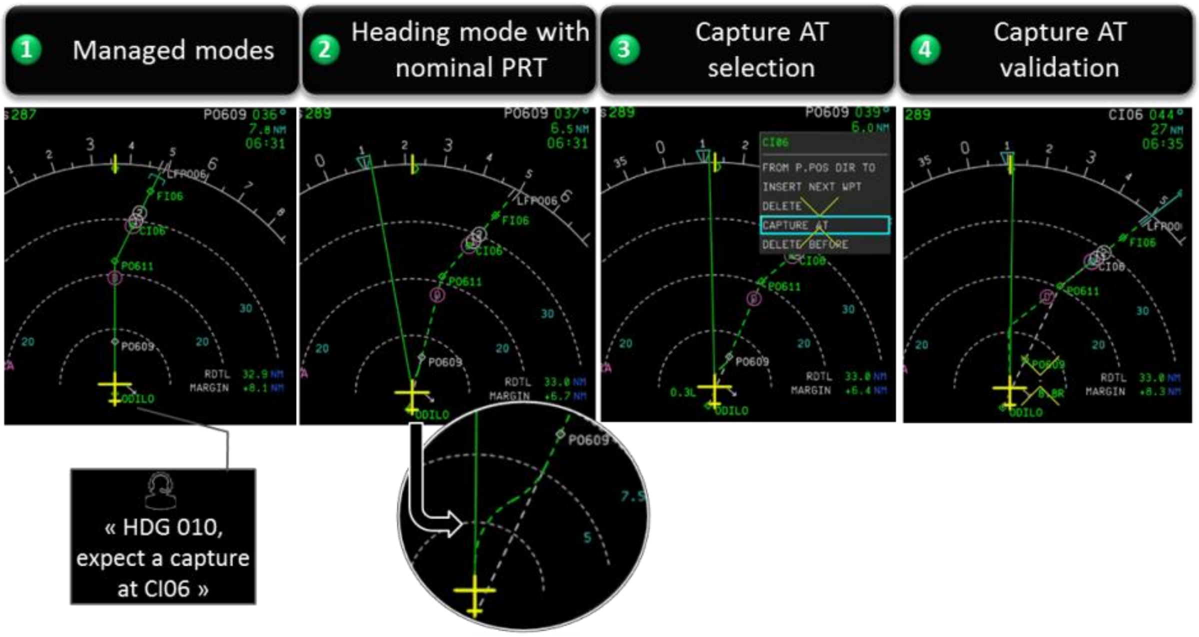
For AIRBUS aircraft, Dynamic route attribution methodology is technically feasible on board without any FM Software update, with the limitation on the Navigation Data base update needed. Implementation of alternative routes in Navigation Data Base is a strong wish from the pilots having evaluated the concept but is has to be further studied to make sure it will be compliant with database capacity in a worldwide context.

- **Permanent Resume Trajectory**

PRT is perceived as a valuable function to help the pilot manage the A/C energy, especially in Descent and Approach phases. These experimentations confirmed the need for training for the PRT, but also that it provides precious information for the pilot when taken in charge by the ATC laterally.

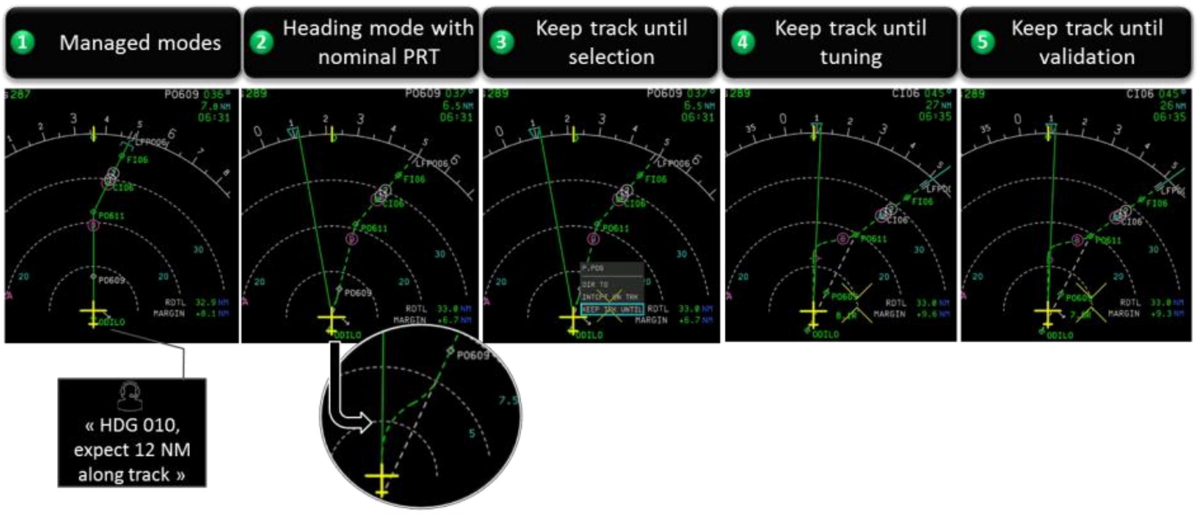
The feasibility is clearly confirmed even if some interactions need to be further studied.

Whereas the “Capture AT” manual adjustment seems to be quite mature to permit a capture on a certain leg, the “Keep Track Until” manual adjustment is not fully satisfactory and needs to be further studied.



“Capture AT” manual adjustment sequence

Indeed, between the controller instruction and the pilot input on the interactive Navigation Display, the elapsed time might induce a bias and increases the mental workload. Moreover, the input is discrete and linked to the Navigation Display range that might not be adapted to the value provided by the ATCO.



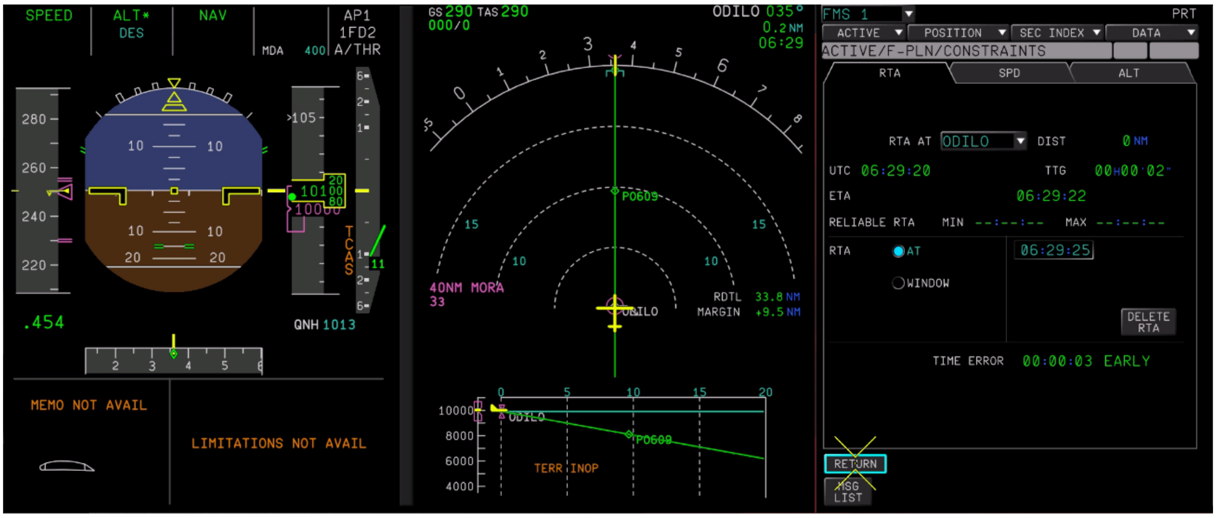
“Keep Track Until” manual adjustment sequence

5.1.4 Conclusions on performance assessments

Regarding airborne side:

- **Predictability**

It can be noted that on Thales flights, each time a RTA has been ordered and not cancelled by a lateral instruction, a speed instruction, a direct, etc..., it has been respected within 10 seconds and ensured to cross the Feeder Fix at the expected STA-FF provided by the AMAN. When a RTA is given, the speed is automatically managed by the system and adapted to arrive at the expected waypoint at the required time.



RTA example on Thales flight at 06:29:25, with a TIME ERROR equal to 3 seconds

The CTA/RTA fix was ODILO IAF. As in current operations, the AMAN was set to implement a delay sharing between E-TMA and TMA. In current operations, speed instructions and/or vectors can be instructed in E-TMA to absorb the part of the delay allocated to the E-TMA. This can be followed by speed instructions and/or vectors in TMA to absorb the part of the delay allocated to the TMA. In the solution scenario, route attribution associated to CTA/RTA allow to absorb the delay allocated to the E-TMA.

However, the pilots expected that this RTA instruction on ODILO would permit to follow the flight plan downstream. Partly because of the delay sharing method, there were frequent radar vectoring manoeuvres after ODILO, to still lose some time in TMA. As pilots generally ignore ATC ways of working, Thales pilots reported that they were surprised to be impacted downstream after an important time loss upstream, and a RTA respected at ODILO. PRT is then really useful on-board to manage the aircraft energy efficiently during these terminal traffic adjustments. It must be noted that the realism of the ATC situation in the TMA sector was not satisfactory for several reasons: as the TMA sector was not under test, only one ATCO was piloting all aircraft in the TMA, and the flow MOLBA was not fully compliant with the AMAN suggestions.

On Airbus PAS@ATM simulators, RTA has been evaluated and used as soon as possible (about 90% of the flights simulated). Five RTA have been missed and part of the others have been cancelled by a new ATC instruction (mostly speed advisory).

For the RTA achieved, the accuracy of the time given was around 1 second, perfectly in line with the specification of the function.

Generally, RTA have been missed and/or cancelled because aircraft have been vectored or received a speed instruction. One time during the experiment (as it could occur in operation), RTA has been missed: an aircraft received a level off instruction for strategic separation and then was on above flight plan situation. Consequently, the aircraft could not decelerate enough to meet the targeted speed associated to ODILO RTA.

Pilots acting on PAS@ATM simulators during the experiment, admitted that these situations of aircraft over energy management in the RTA context are sometimes difficult to solve.

Considering the ”when ready descend” procedure:

The ATCO used this procedure only in low traffic conditions when there is no risk of conflict, so in this context, the safety and the situation awareness were maintained at a high level and the workload was not significantly impacted.

Considering the “dynamic attribution of routes” procedure:

The workload, the situation awareness and the safety were maintained at an acceptable level. Nevertheless, the ATCO reported that the monitoring task was sometimes demanding and generated an additional workload. Some proposals have been already envisaged to facilitate and improve the monitoring activity (see the recommendation section).

Considering the PRT

Solution has been evaluated as a unique global solution. For all solution runs, the TOD sharing, the arrival branches and the PRT have been used which prevent from identifying separately the benefits linked by each item. Even if fuel savings provided by PRT cannot be isolated, vectoring has mainly been used in TMA sector and thus, PRT and TOD sharing/arrival branches were not used together in the same part of the flights. Fuel diagram included in section 4.3.3. illustrates that fuel consumption dispersion increases after CAD, point at which arrival branches converge at. It proves that vectoring has a major impact on flight efficiency. As the PRT helps the crew to optimize this part of the flight, it surely provides some benefits that should be refined in the next phase if needed. However, quantification is not easy to perform as it is closely related to the pilot experience and way of working.

5.2 Recommendations

5.2.1 Recommendations for next phase

Training

- When assessing such a new concept involving several major novelties (airspace design, procedures, link with AMAN, on-board new features, CPDLC, CTA/RTA), training is a key factor. As a consequence a sufficient training time must be foreseen (even if this lets less time for the validation runs)

Environment

- Wind must be simulated to validate this concept, as wind may have an influence on the AMAN's stability, on the difficulty for the controllers to anticipate the conflict situations, on the accuracy of information provided by the EPP data, but also on the potential interest of EPP data (provided it is sufficiently accurate and reliable). A sufficient level of wind simulation's realism will be needed.

"When ready descend" procedure.

The following technical improvements should be considered:

- EPP information displayed on the HMI must be clearly visible,
- The nature of the information displayed on the HMI must be clear: in the case of "raw" EPP data as was the case in this exercise, the nature of this information must be clear for the controller
- It is recommended to simulate crossing traffic flying at a lower level than the main flows descending in E-TMA, in order to assess the acceptability of "When ready descend" clearances.

The following points have to be further investigated:

- It is recommended to provide the controller with a conflict detection tool or a "what-if" probe to assess the "When ready descend" clearance,
- Provide time information as Time to Lose instead of absolute value.

Dynamic attribution of routes procedure.

The following points should be considered:

- EPP uncertainty, in particular discrepancies between the FMS hypotheses and the ground expectations, especially about speed, may impact the dynamic route attribution consistency and disturb the controllers' activity. The EPP data contain information which may solve this issue: the necessary analysis cannot be done by the controllers as the workload is too high, but should be done automatically by the ground system. This point should also be investigated in the next phase for the ROC/ROD concept in particular regarding the reduction of the conflict threshold.

- Evaluate the benefit of an earlier stabilization of the sequence to confirm that it avoids late changes and thus help the ATCO to manage their traffic. This can be done by changing the AMAN settings or by encouraging the ATCO to do so in the working method.

- Provide a “what if” tool giving the remaining time to lose depending on the alternative route chosen to confirm that it could help with the route choice.
- Improve the sequencing manager HMI to clearly display the sequence performed by the executive controller.
- It is recommended to provide the ATCO with a conflict detection tool to assess if and how it could help the ATCO to monitor aircraft flying to a CTA.
- For the next validation, it is recommended to assess the concept with a mixed traffic (CTA, non-CTA aircraft; EPP, non-EPP) to evaluate the feasibility to manage this traffic.
- It is recommended to fully simulate and evaluate the TMA to better assess the concept. It is also recommended to improve the realism of the feeding sectors.

Types of speed constraints

Speed constraints AT (and possibly AT OR ABOVE) should be added to on-board systems that only manage AT OR BELOW constraints. Indeed, the controller expects the aircraft to be AT (or close to) the speed prescribed in the LoA when the flight is handed over. On the other side, if the NavDB shows there is a speed constraint on the IAF or on a waypoint just upstream the IAF (used as a “handover” waypoint by the ATC), then the FMS will consider the aircraft has to cross the waypoint AT OR BELOW the prescribed speed, which may surprise the controller. Speed constraints AT (and possibly AT OR ABOVE) will also provide complete confidence in the time constraint capability that is not restrictive enough with regards to aircraft speed and might lead to temporary separation issues. During the experimentations, the ATCO reported that they were not confident in using the RTA capability as it does not ensure the separation all along the aircraft trajectory but only on the waypoint constrained in time.

Permanent Resume Trajectory

Based on the fact that vectoring will remain one of the possibilities to manage the traffic, the Permanent Resume Trajectory needs to be further studied and associated air/ground interactions should be refined (phraseology, parameters, etc.). Indeed, during the experimentations, as shown below, most of the THALES flights have been vectored for separation or sequencing reasons, mostly in TMA when energy management is crucial. In these situations, the PRT helps to define a closed route on-board, and then enable to fly an optimized and fuel efficient profile, and to stabilize and land safely.

Session	Run	Track miles percentage in HDG mode
1	A	80%
	D	24%
	E	20%
	F	16%
	E	0%
	I	23%
	A	0%
2	A	40%
	B	61%
	E	0%
	B	22%
	E	29%
	B	26%
	E	0%
	F	29%

Track miles percentage in HDG (selected) mode (mainly in TMA) on THALES flights between TUDRA and 1000 ft

The Permanent Resume Trajectory might evolve to consider AMAN STA-FF and compute automatically the turning point, without using the "Keep track until" capability which is not totally satisfactory with the current HMI design.

In the next phase and if needed, PRT fuel savings should be assessed though dedicated scenarios, without any coupling with other capabilities (arrival branches, TOD sharing, etc.) to be able to identify the related benefits that have not been clearly quantified for the moment.

To some extent, PRT algorithms may benefit from contextual information of the surrounding traffic the ATCO has to manage in order to provide better contextualized trajectories.

Route network design

The baseline taken into account in this experimentation is a situation where the ATCO vectors the aircraft to achieve the delay absorption requested by the AMAN, implying that the FMS is unable to optimise the flight on this open loop, and the pilot cannot perform a recompute and recalculate an optimised TOD. The solution scenario was a full closed loop situation that permits to optimise the flight's vertical profile but implies a heavy change in the ATCO's working method and new tools to support the new concept. Another option would be to evaluate if the flight optimisation would be possible thanks to an hybrid solution where the flight is given direct routings, passing from a closed loop to another one (as in PMS operations). The recruise procedure that permits to improve flight efficiency in this experimentation could be possible in this lighter scenario, reducing the cost of the solution. This should be evaluated in later validation activities.

CTA/RTA

The benefit of using CTA/RTA in the context of dynamic attribution of routes was not fully covered by this experimentation and should be assessed in further studies, focusing on workload, situational awareness and full efficiency.

5.2.2 Recommendations for updating ATM Master Plan Level 2

No recommendation for updating the SESAR solution definition, nor the associated OI steps, nor the associated enablers, was identified.

5.2.3 Recommendations on regulation and standardisation initiatives

Regarding airborne side:

Regarding the Top of Descent, the "when ready descend" instruction has been experimented in E-TMA (after a re-cruise procedure) during the exercise, thanks to EPP capability to provide the ToD from the FMS to the ground. It should be applied when possible for the ATCO as it certainly contributes to flight efficiency from pilots' point of view. They identified easily by comparing PAS@ATM simulators performance and FM Software predictions during the experiment, that the first aircraft of the sequence, generally not receiving speed advisory, had the best flight efficiency with the lowest quantity of fuel burned. Their recommendation to ATCO will be to let the speed of the Aircraft under the hands of the crew when possible.

Dynamic route should be sent early enough for different reasons. First, when the message UM#266 is used, the route must be loaded into the FMS before reaching the path extension point. Then, it impacts the position of the Top of Descent, and thus the energy management strategy that needs to be anticipated by the crew, ideally before the descent briefing. If the dynamic routes are coded in the Navigation Data Base, concept methodology was fine from pilot point of view. To cope with these delays and diversion, pilots recommended to use the “STAND BY” message to notify ATCO the crew is implementing the instruction received.

Regarding dynamic route design, the points shall not be too close to permit a correct trajectory computation by the FMS and reach the “time to lose” objective. Based on the tests performed for the experimentation preparation, 8 nautical miles seem to be sufficient. These investigations will surely explain the reason of “flight cut” due to short radius turn on alternatives routes seen during the experiment (and highlighted in paragraph 4.2.8).

Additionally, in order to always fly the most optimized profile, even when an altitude constraint leads to an early descent, the on-board system should propose to the crew the point where an idle path permits to reach the next constraint. Hence, not flying a shallow path reduces the global thrust and thus the fuel consumption, by staying higher longer. Even if it is not really intuitive, this partial CDA definition with a high level-off is more efficient than complete CDA that includes a slope that is not steep enough to fit aircraft performances.

Moreover, the EPP might need some evolutions to be compatible with new functions such as the Permanent Resume Trajectory. It could be a great support for the ATCOs in his/her tasks, in order to increase predictability through better air/ground intentions sharing. This would enable more and more transparency and lead to optimized operations. For instance, the controller reported that it could help to have the aircraft flyable PRT trajectory displayed on the ground side, which would be possible if the PRT virtual turning point was included in the EPP for instance. Maybe also the format of the EPP should evolve to meet ATCO needs, ATCO requirements for EPP report format should be well investigated prior to further investigate the concept.

For further investigation of the concept, a more operational methodology for EPP data sharing should be investigated, maybe a process “on demand” (to not overload communications).

Pilots also recommended to use CPDLC processes as soon as possible as it decreases their workload (avoiding to confirm ATCO instructions by voice) and errors and/or incomprehension with ATCO

6 References

6.1 Applicable Documents

Content Integration

[1] B.04.01 D138 EATMA Guidance Material

- EATMA Community pages

[2] SESAR ATM Lexicon

Content Development

- B4.2 D106 Transition Concept of Operations SESAR 2020

System and Service Development

- 08.01.01 D52: SWIM Foundation v2
- 08.01.01 D49: SWIM Compliance Criteria
- 08.01.03 D47: AIRM v4.1.0
- 08.03.10 D45: ISRM Foundation v00.08.00
- B.04.03 D102 SESAR Working Method on Services
- B.04.03 D128 ADD SESAR1
- B.04.05 Common Service Foundation Method

Performance Management

- B.04.01 D108 SESAR 2020 Transition Performance Framework
- B.04.01 D42 SESAR2020 Transition Validation
- B.05 D86 Guidance on KPIs and Data Collection support to SESAR 2020 transition.
- 16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model
- 16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA
- Method to assess cost of European ATM improvements and technologies, EUROCONTROL (2014)
- ATM Cost Breakdown Structure_ed02_2014
- Standard Inputs for EUROCONTROL Cost Benefit Analyses

- 16.06.06_D26-08 ATM CBA Quality Checklist
- 16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

Validation

- 03.00 D16 WP3 Engineering methodology
- Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects

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

System Engineering

- SESAR Requirements and V&V guidelines

Safety

- SESAR, Safety Reference Material, Edition 4.0, April 2016
- SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016
- SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015
- SESAR, Resilience Engineering Guidance, May 2016

Human Performance

- 16.06.05 D 27 HP Reference Material D27
- 16.04.02 D04 e-HP Repository - Release note

Environment Assessment

- SESAR, Environment Reference Material, alias, “Environmental impact assessment as part of the global SESAR validation”, Project 16.06.03, Deliverable D26, 2014.
- ICAO CAEP – “Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes” document, Doc 10031.

Security

- 16.06.02 D103 SESAR Security Ref Material Level
- 16.06.02 D137 Minimum Set of Security Controls (MSSCs).
- 16.06.02 D131 Security Database Application (CTRL_S)

6.2 Reference Documents

- ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[2]

[4] D3.4.020 - PJ01-03B - Initial VALP - Part I V00_00_07

2

Appendix A Validation Exercise EXE. 01-03B.010 report (DSNA)

A.1 Summary of the Validation EXE. 01-03B.010 Plan

A.1.1 Validation EXE. 01-03B.010 description, scope

- **Scope**

This exercise was a human-in-the-loop real-time simulation at ongoing V2 maturity level.

The objective of this exercise was the validation of concept elements, defined in (OSED ref), aiming at facilitating optimised profiles of descent. It focused on arrivals in E-TMA. It addressed AOM-0702-B "Advanced Continuous Descent Operations" and AOM-0806 "Dynamic Management of Terminal Airspace Routes and Transition".

The validation was performed using a platform composed of the following components:

- A prototype provided by DSNA called IODA, featuring an EC/PC position (radar image) and a Sequencing Manager position which is a set of different HMIs intended for ATCOs,
- A traffic generator tool provided by DSNA called Rejeu,
- Airbus prototype (PAS@ATM) which simulated an aircraft during the experimentations,
- Thales Avionics' prototype (VSIB) which simulated an aircraft during the experimentations including the new Permanent Resume Trajectory capability,
- An AMAN (Arrival MANager), providing IODA sequencing positions with the arrival sequence and the delays meant to be resorb for each flight,
- PPIT, a DSNA tool designed for the pseudo pilot positions.

The goals of the validation exercise was to study whether new procedures could be performed by the controllers to improve Continuous Descent Operations; the objective being to enhance flight efficiency during this phase.

As a means of reaching those goals, we have focused the assessment on different topics as facilitating optimized profiles from TOD, dynamically assigned routes and vectoring

For each of them, the following high-level objectives have been elicited:

- Evaluate the HMI usability as a support to new procedures,
- Assess the working methods related to the use of new functions,
- To assess the operational feasibility from a controller's and flight crew's perspective,
- To assess the acceptability from a controller's and flight crew's perspective,

To assess whether the workload and the situation awareness were maintained at an acceptable level.

General description

- **Environment information**

The E-TMA environment was inspired by the OT sector of Paris ACC, which manages arrivals to Paris Orly airport (LFPO) from the west and south-west. The corresponding STARs are described in the picture below:

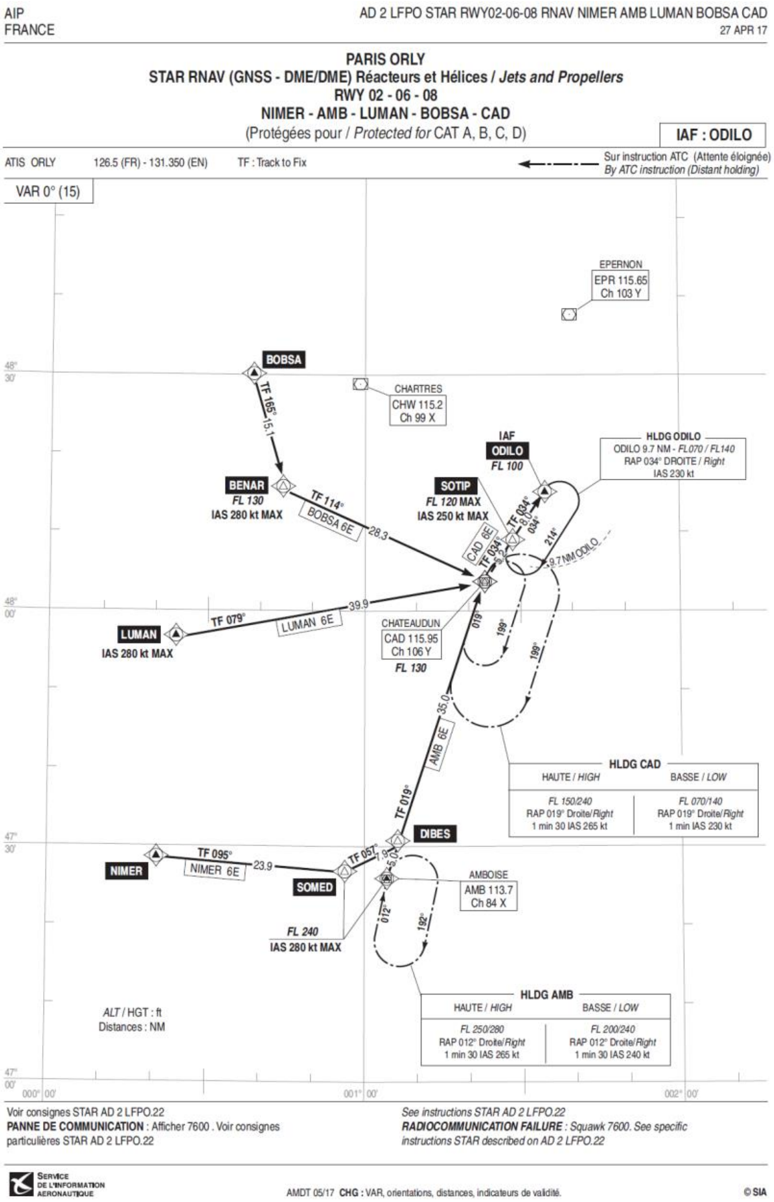


Figure 1 : The E-TMA environment

For the needs of the scenarios, the STARs have been modified so that, in the solution scenario, the E-TMA ATCOs could allocated the appropriate route to the aircraft, depending on the time to lose in the sector. Each STAR has been drawn in order to be 1 minute longer than the previous one, at 250 kts and if the aircraft arrives at FL 280. After thinking about the specific needs associated with the concept to be evaluated, a design work was performed, in several steps. This work led to the route structure shown in the picture below (the design converged towards a structure looking like a PMS structure, but it is not meant to be used as a PMS). Its advantage is that the flows coming from West and South arrive strategically separated and that the crossing points are easily identified by the ATCOs. Furthermore, once the aircraft have turned direct to CAD, the ATCO could easily monitor the sequence.

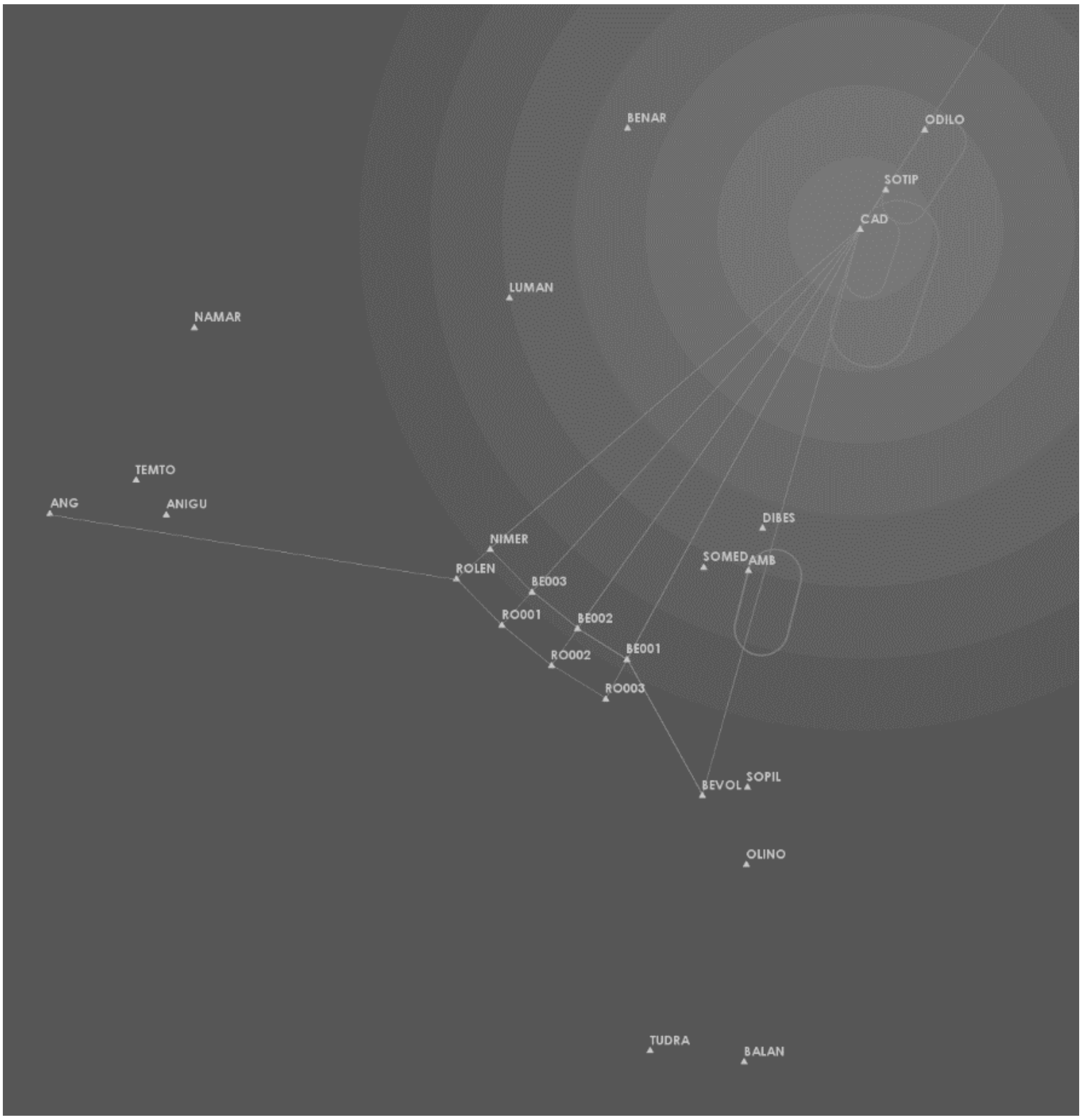


Figure 2: STARs used during the experimentation for E-TMA sector

The LOA between OT and upstream sectors is that the aircraft are handed over (before ANG by Brest ACC on the west and before BEVOL by Bordeaux ACC from the south-west) at FL 280, 10 NM between them and no catch up. The LOA with the downstream sector is that they are handed over on ODILO at FL100, 8 NM between them, 250 kts. A metering fix has been set in the AMAN so that the aircraft are sequenced on ODILO at 90s.

Only arrivals to LFPO airport enter this sector, and a few aircraft in transit, passing through the sector.

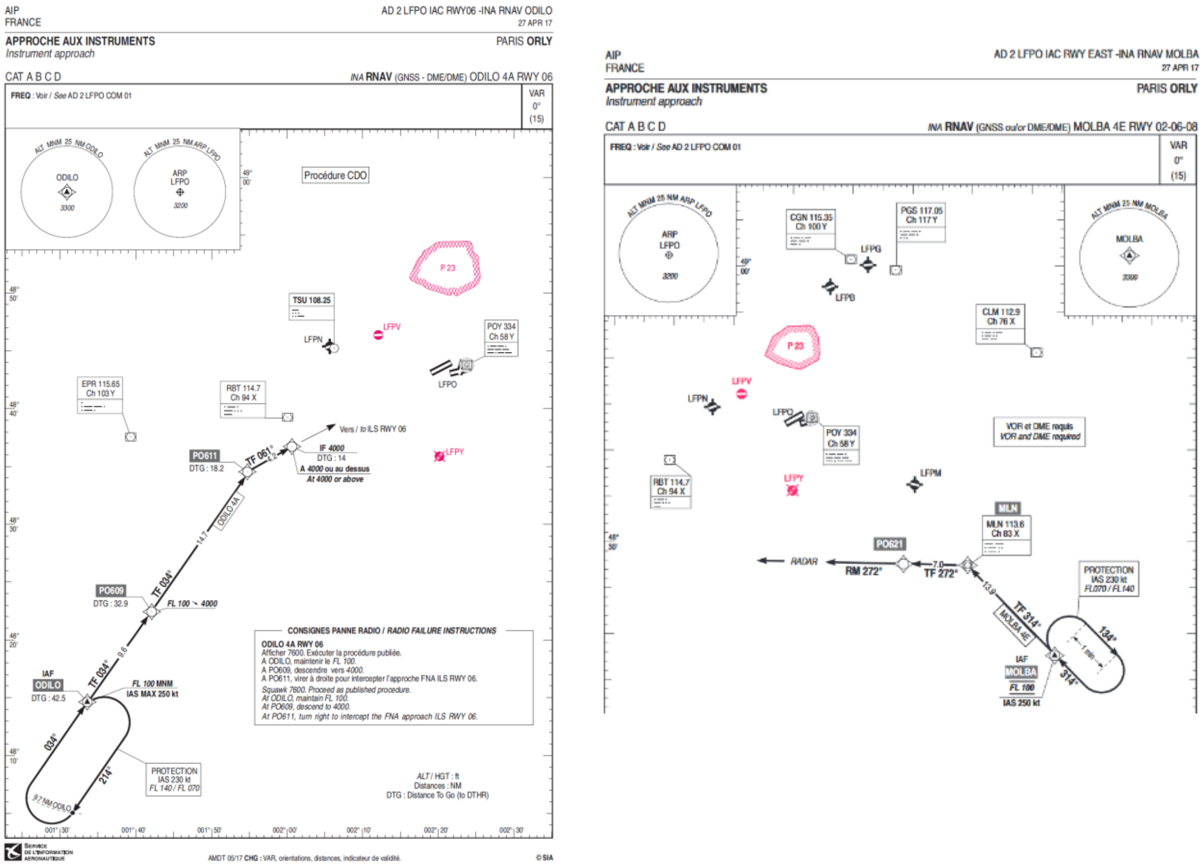


Figure 3: TMA environment

The TMA environment was inspired by Paris Orly (LFPO) TMA, QFU 06. Flows of traffic arrived from ODILO and MOLBA IAFs.The approach procedures have been modified so that the standard routes to the runway are closed routes (see figure below).

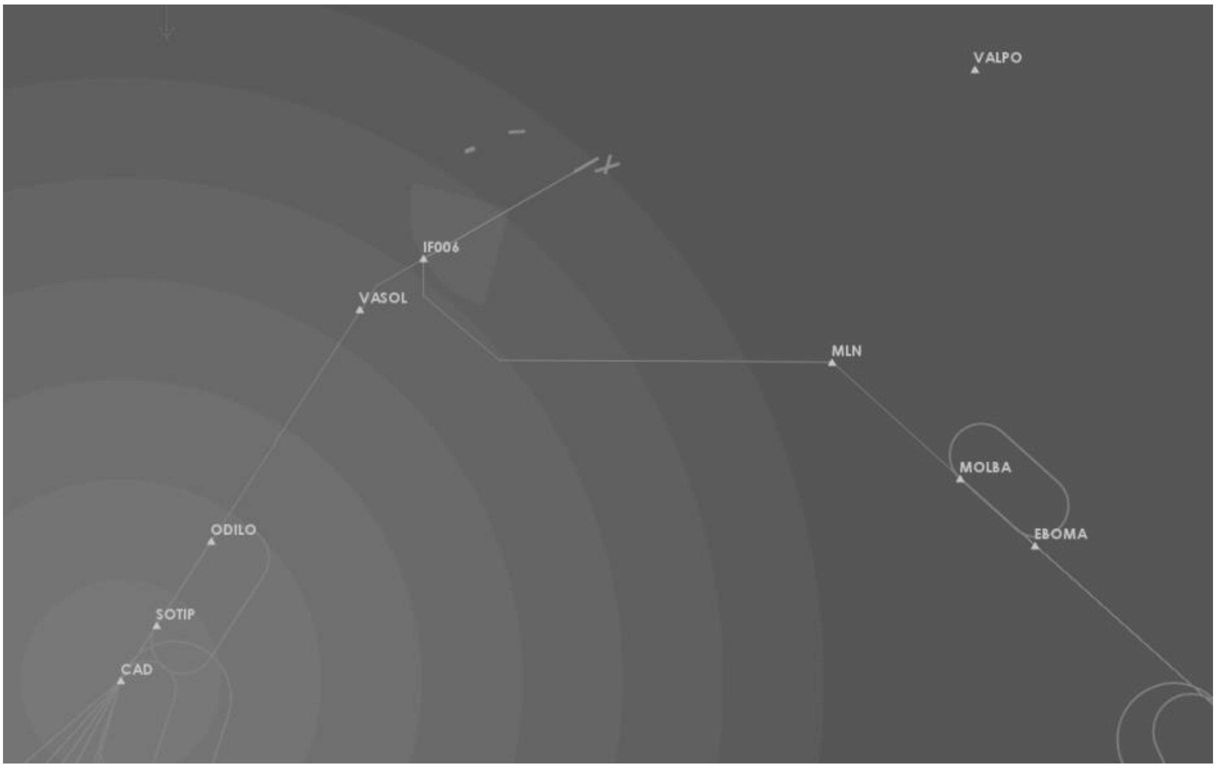


Figure 4: Stars used during the experimentation for the TMA sector

The AMAN settings have been modified so that most of the delay was absorbed in E-TMA, and a speed reduction on the procedures should have been sufficient to achieve the sequence.

- **Sectors**

Five sectors were simulated in this RTS:

- The E-TMA sector sequencing the traffic on ODILO IAF; it was the only sector tested,
- The E-TMA sector sequencing the traffic on MOLBA IAF. Its role was to improve the realm by generating delay on the tested sector, and in TMA,
- Two sectors in Paris Orly TMA (INI and ITM), merging the flows arriving via ODILO and MOLBA. These sectors were not tested but they permitted to have realist data feeding the AMAN and realist flights profiles until the FAF,
- Upstream sector. Only one sector instead of 2 feeding the tested E-TMA sector.

Only the E-TMA tested sector was played by two ATCOs and two pseudo pilots. On other sectors, only on ATCO was in charge of “piloting” generated traffic and delivering clearances to Airbus and Thales flights.

The tested sector was inspired by the real OT/OY sectors. The procedures were changed to support the dynamic attribution of route. These routes were first designed to absorb 1 minute delay at FL 280 and 250kts from each other. Then the decision was taken to extend them a bit to let some more freedom to the ATCO.

Regarding the STARs used:

- An aircraft arriving via BEVOL could be cleared on the STARs BEVOL 0,1, 2, 3 or BEVOL4,
- An aircraft arriving via ROLEN could be cleared on the STARs ROLEN 1, 2, or ROLEN3.

- **Traffic**

The properties of the traffic used during the experimentation were the following:

- The traffic was only composed of flows arriving at to Orly airport, via two IAFs: MOLBA and ODILO,
- Few propeller aircraft were integrated to the traffic,
- For technical limitations, all aircraft were EPP and RTA equipped although in certain runs, the use of RTA was forbidden.

The number of aircraft simulated accord the runs is the following:

Run	Number of aircraft « ODILO »	Number of aircraft « MOLBA »
A	19 jet aircraft / 1 Propeller aircraft	5 jet aircraft
D	12 jet aircraft / 2 Propeller aircraft	7 jet aircraft / 1 Propeller aircraft
E	17 j jet aircraft / 1 Propeller aircraft	4 jet aircraft / 1 Propeller aircraft
F	13 jet aircraft / 2 Propeller aircraft	8 jet aircraft / 1 Propeller aircraft
I	19 jet aircraft / 1 Propeller aircraft	5 jet aircraft
J	14 jet aircraft / 3 Propeller aircraft	5 jet aircraft / 2 Propeller aircraft

Figure 5: number of aircraft simulated as function of the run

- **Realism**

Regarding the realism:

- The tested sector was simplified: constraints linked to military area and surrounding approaches were hidden,
- The wind was not simulated,
- Only traffic bound to Orly was played: no Roissy aircraft, and no crossing aircraft,
- Response time was not taken into account for aircraft simulated.

▪ **Specific description**

- **AMAN**

The AMAN used in this RTS is the same as the one used in Paris area, but in a later version not implemented in operational centers yet. For this reason, this AMAN was not set as precisely as it would be in an operational version. It implied some abnormal behaviors that could have been fixed by an operational expertise that was not fully available for the exercise preparation. Moreover, the traffic generated appeared sometimes accelerating and stabilizing few minutes later, leading to an unstable sequence for these aircraft until the speed got stable. The following behaviors have been noticed:

- Propeller aircraft first calculation was wrong (around 10 minutes error) but updated and correct 1 minute later,
- The sequence looked correct to the ATCO 3 to 4 minutes before the entry of the sector. Earlier, the calculations of aircraft ETO were unstable. The decision was taken to ask to the ATCOs to allocate routes a bit late, only few minutes before handover (which was after the TOD).

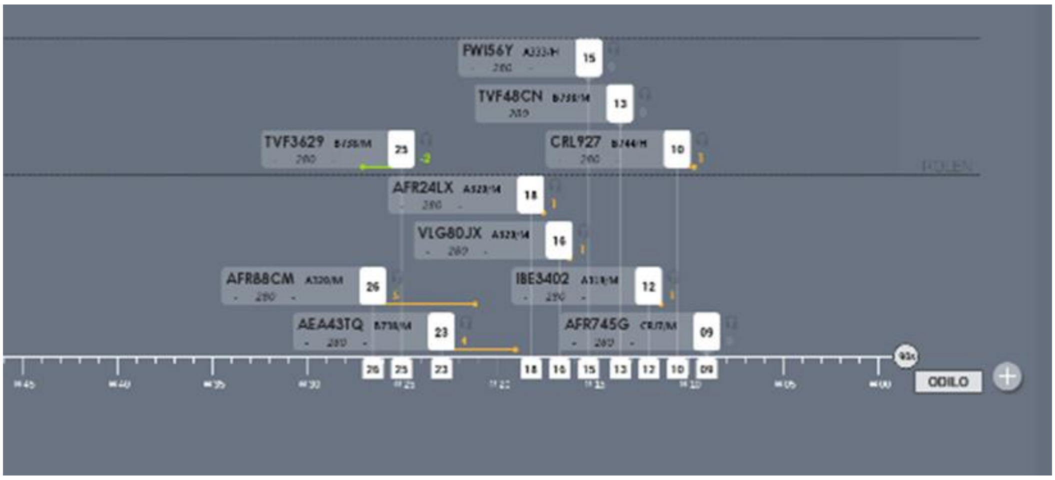


Figure 6 : screen shot of IODA platform with AMAN integrated

In this RTS, the AMAN was integrated to the IODA platform. The ATCOs interacted with IODA to update the sequence (move or swap flights). Then they could read the results of AMAN calculation: the STA-

FF, time at which the AMAN considers the aircraft should fly over the IAF. IODA then displayed the time to loose: the difference between the time the aircraft is currently supposed to fly over the IAF (given by the EPP) and the STA-FF.

It has to be noted that the AMAN is not fed with the EPP to calculate the ETO and deduce the STA-FF: it uses its own trajectory predictor to assess the ETO, then builds the sequence by comparing the ETOs of all aircraft, and then finds the STA-FF for each of them.

Anyway, the calculation of the TTL based on the EPP implied a new way of reading this information: first, this data was more accurate. Then, when the ATCO gave a clearance, the impact was seen on the TTL immediately (once the EPP was updated): for example, the time loosed by the allocation of route. The limitation of this way of calculating the TTL is that the information was not relevant when the aircraft were vectored, but it was updated once a direct on a closed loop was given.

- **DTG tool**

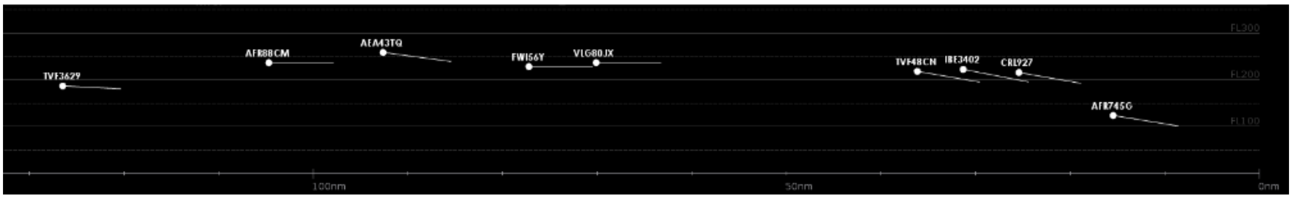


Figure 7 : screen shot of DTG tool displayed on IODA platform

The executive controller could open a window called Distance To Go tool. The first option of this tool displayed a straight line whose origin was ODILO (the IAF). The aircraft were disposed on this line regarding their distance to go to ODILO. (The distance took the length of the allocated route into account). The second option added a second dimension were the aircraft were placed according to their current flight level. The limitation of this tool is that the information provided was not relevant during vectoring. Another is that, for technical limitation, only the traffic generated by DSNA was displayed: Airbus and Thales flights were not available on the tool. It has to be noted that it was developed for the needs of the executive controller.

- **Flight list**

N°	CALLSIGN	ETA-FF	STA-FF	CTA
0	CRL985	05:58:00	05:58:25	
0	AFR74YJ	05:53:00	05:53:00	
0	AFR793	05:46:00	05:46:00	
0	HOP60HO	06:00:00	06:00:00	
0	HOP40WT	05:51:00	05:51:00	
0	TJT01SQ	06:04:00	06:04:00	
0	HOP20DG	06:08:00	06:08:00	
0	AFR019	05:38:00	05:38:00	
0	AFR74GR	05:42:00	05:42:00	
0	AFR73WQ	05:31:00	05:31:00	
0	HOP10NL	05:33:00	05:33:00	
0	HOP71VY	06:14:00	06:14:00	
0	AFR74AC	06:11:00	06:11:00	
0	AFR61BC	06:02:00	06:01:50	
0	AFR74XB	05:55:00	05:55:00	
0	FWI511	05:29:00	05:29:00	
0	AFR73GA	05:57:00	05:57:00	
0	AFR62MP	06:06:00	06:06:20	
0	EZY43AG	06:17:00	06:17:00	

Figure 8: flight list displayed on IODA platform

Another window available for the executive controller was the flight list. All the flights of the sector were disposed in the order of the AMAN sequence. It then displayed its ETO on ODILO IAF (given by the EPP), the STA-FF (given by the AMAN) and the RTA when the ATCO decided to allocate one.

When the ATCO clicked on the RTA button, the time contained in the STA-FF column was passed in the RTA column.

In the second session, a simple alert option was available and alerted the controller:

- When the STA-FF differed from the RTA, meaning that the sequence had changed because of an automatic update or a human action,
- When the EPP differed from the RTA, meaning that the RTA procedure could be under « unable » status (or, generally in the case of this experiment, that the pseudo pilot made a mistake on its HMI).

- **Regarding the use of the RTA**

In the concept of PJ01.03b, the RTA is used to achieve the sequence as calculated by the AMAN. The use of RTA intervenes after the allocation of route which is the main possibility for the controller when it comes to delay absorption. Then, the RTA should only cope with maximum 30 seconds (alternative routes are design to absorb delay with a 1 minute step). Then the update on vertical profile or a modification of route (direct or vectoring) and the uncertainty on wind forecast may also lead to a target speed adjustment.

For example, if an aircraft arrives at 300 kts and has 4 minutes to lose, here are the steps of the concept:

- An hypothesis is proposed that the aircraft can lose 1 minute by a speed reduction to 250 kts on the shortest STAR,
- More minutes can be lost by allocating the third STAR,
- Then, the RTA should allow the aircraft to pass less than 10 seconds from the STA-FF.

- **EPP information displayed**

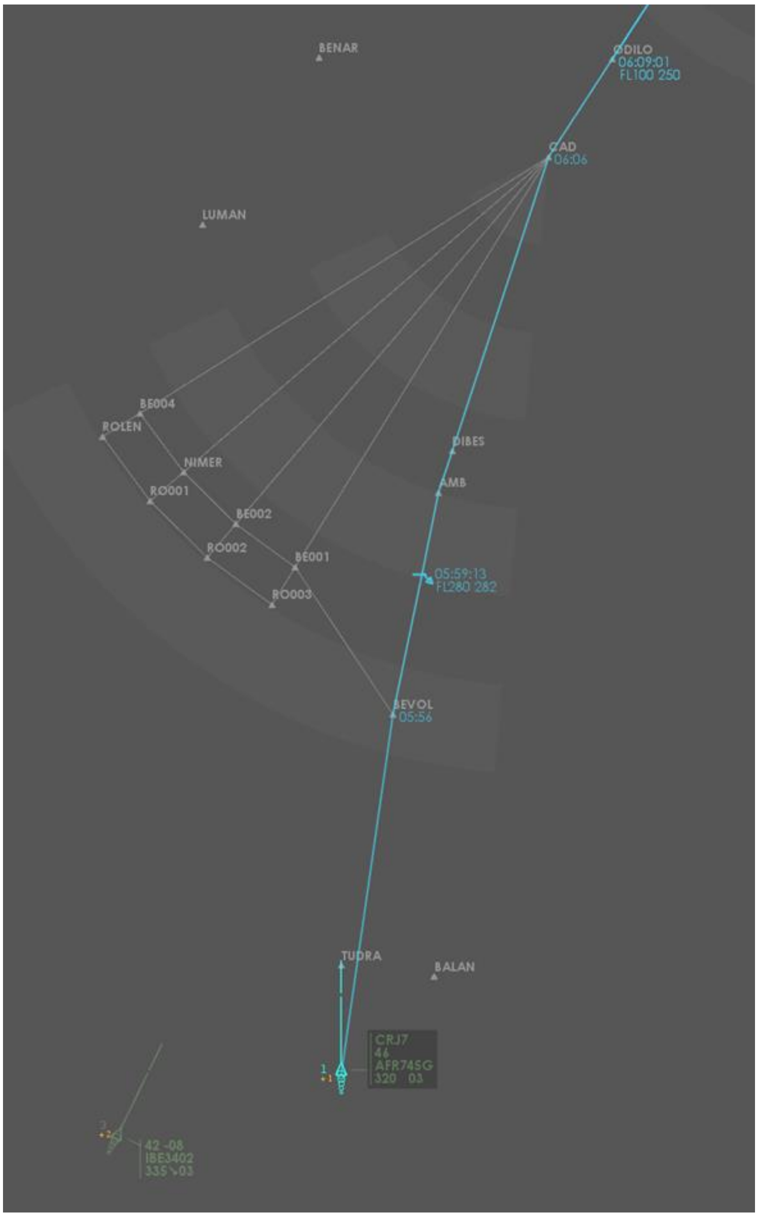


Figure 9: EPP displayed on the radar screen

On the radar screen, the ATCO can monitor some EPP information descending from aircraft. The route expected by the FMS is displayed on the radar and information on FL, speed and ETO is given on several waypoint (ROLEN, BEVOL, CAD and ODILO). The TOD was although displayed.

Note that the TOD is considered to be the point where the aircraft leaves its cruise FL. In our scenarios, the aircraft have already started their descent and will level off in E-TMA at FL 280 (for jet aircraft). On the FMS, a new TOD will only be calculated if the pilot intentionally performs a “ recruise” action on its FMS. However, the traffic generated by DSNA systematically showed a TOD from FL 280.

A.1.2 Summary of Validation Exercise PJ.01-03B -VALP-V2-01 Validation Objectives and success criteria

SESAR Solution Validation Objective	SESAR Solution Success criteria	Coverage and comments on the coverage of SESAR Solution Validation Objective in Exercise 001	Exercise Validation Objective	Exercise Success criteria
OBJ-PJ.01.03-V2-VALP-RTS-001	CRT- PJ.01.03-V2-VALP-RTS-001-001	Fully covered	CRT- PJ.01.03-V2-VALP-RTS-001-001	CRT- PJ.01.03-V2-VALP-RTS-001-001
//	CRT- PJ.01.03-V2-VALP-RTS-001-002	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-001-002
//	CRT- PJ.01.03-V2-VALP-RTS-001-003	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-001-003
//	CRT- PJ.01.03-V2-VALP-RTS-001-004	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-001-004
OBJ-PJ.01.03-V2-VALP-RTS-002	CRT-PJ.01.03-V2-VALP-RTS-002-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-002	CRT-PJ.01.03-V2-VALP-RTS-002-001
//	CRT-PJ.01.03-V2-VALP-RTS-002-002	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-002-002
//	CRT-PJ.01.03-V2-VALP-RTS-002-003	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-002-003

OBJ-PJ.01.03-V2-VALP-RTS-005	CRT-PJ.01.03-V2-VALP-RTS-005-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-005	CRT-PJ.01.03-V2-VALP-RTS-005-001
//	CRT-PJ.01.03-V2-VALP-RTS-005-002	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-005-002
OBJ-PJ.01.03-V2-VALP-RTS-006	CRT-PJ.01.03-V2-VALP-RTS-006-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-006	CRT-PJ.01.03-V2-VALP-RTS-006-001
//	CRT-PJ.01.03-V2-VALP-RTS-006-002	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-006-002
//	CRT-PJ.01.03-V2-VALP-RTS-006-003	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-006-003
//	CRT- PJ.01.03-V2-VALP-RTS-006-004		//	CRT- PJ.01.03-V2-VALP-RTS-002-004
OBJ-PJ.01.03-V2-VALP-RTS-007	CRT- PJ.01.03-V2-VALP-RTS-007-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-007	CRT- PJ.01.03-V2-VALP-RTS-007-001
//	CRT- PJ.01.03-V2-VALP-RTS-007-002	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-007-002
//	CRT- PJ.01.03-V2-VALP-RTS-007-003	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-007-003
//	CRT- PJ.01.03-V2-VALP-RTS-007-004	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-007-004
//	CRT- PJ.01.03-V2-VALP-RTS-007-005	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-007-005
OBJ-PJ.01.03-V2-VALP-RTS-008	CRT-PJ.01.03-V2-VALP-RTS-008-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-008	CRT-PJ.01.03-V2-VALP-RTS-008-001

//	CRT-PJ.01.03-V2-VALP-RTS-008-002	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-008-002
OBJ-PJ.01.03-V2-VALP-RTS-009	CRT-PJ.01.03-V2-VALP-RTS-009-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-009	CRT-PJ.01.03-V2-VALP-RTS-009-001
//	CRT-PJ.01.03-V2-VALP-RTS-009-002	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-009-002
//	CRT-PJ.01.03-V2-VALP-RTS-009-003	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-009-003
//	CRT-PJ.01.03-V2-VALP-RTS-009-004	Fully covered	//	CRT-PJ.01.03-V2-VALP-RTS-009-004
OBJ-PJ.01.03-V2-VALP-RTS-013	CRT- PJ.01.03-V2-VALP-RTS-013-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-013	CRT- PJ.01.03-V2-VALP-RTS-013-001
//	CRT- PJ.01.03-V2-VALP-RTS-013-002	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-013-002
OBJ-PJ.01.03-V2-VALP-RTS-014	CRT- PJ.01.03-V2-VALP-RTS-014-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-014	CRT- PJ.01.03-V2-VALP-RTS-014-001
//	CRT- PJ.01.03-V2-VALP-RTS-014-002	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-014-002
OBJ-PJ.01.03-V2-VALP-RTS-015	CRT- PJ.01.03-V2-VALP-RTS-015-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-015	CRT- PJ.01.03-V2-VALP-RTS-015-001
//	CRT- PJ01.03-V2-VALP-015-002	Fully covered	//	CRT- PJ01.03-V2-VALP-015-002
OBJ-PJ.01.03-V2-VALP-RTS-018	CRT- PJ.01.03-V2-VALP-RTS-018-001	Fully covered	OBJ-PJ.01.03-V2-VALP-RTS-018	CRT- PJ.01.03-V2-VALP-RTS-018-001

//	CRT- PJ.01.03-V2-VALP-RTS-018-002	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-018-002
//	CRT- PJ.01.03-V2-VALP-RTS-018-003	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-018-003
//	CRT- PJ.01.03-V2-VALP-RTS-018-004	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-018-004
//	CRT- PJ.01.03-V2-VALP-RTS-018-005	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-018-005
//	CRT- PJ.01.03-V2-VALP-RTS-018-006	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-018-006
//	CRT- PJ.01.03-V2-VALP-RTS-018-007	Fully covered	//	CRT- PJ.01.03-V2-VALP-RTS-018-007

A.1.3 Summary of Validation Exercise #01 Validation scenarios

[…]

Reference scenario

The reference scenarios correspond to the current methodologies and procedures used by the controllers during the aircraft descent phase. The analyses focused on three different topics, each one implying several considerations:

- General considerations for the provision of “When ready descend” clearances in E-TMA”:
  - The ATCO had the possibility to use a display of the EPP report on his/her CWP to check the aircraft’s 4D trajectory predictions. No specific coordination was necessary to allow an aircraft to descend when ready
  - The en route ATCO followed the current working method and complied with the handover flight level prescribed in the LOA.
- General considerations for “dynamically assigned routes”:
  - the baseline used the current published STARs: no specific coordination was necessary

- The ground controller did not have the possibility to give CTA to aircraft
- The TMA sector sequencer ATCO had the responsibility to update the AMAN sequence.
- The E-TMA sector executive controller vectored the aircraft to absorb the AMAN delay

Solution scenario

The solution scenario focussed on three specifics topics as facilitating optimized profiles from TOD, dynamically assigned routes and vectoring coupled.

- **"When ready descend"**

- General considerations :

The E-TMA EC could display the EPP data, including the TOD, on his/her radar display.

- Specific considerations
  - Some information contained in the EPP may be used by ATC tools to increase their precision or display useful information to the ATCO
  - A specific tool was available to perform the electronic coordination between sectors

- **"Dynamically assigned routes"**

- General considerations :

Controllers with the help of information given by E-AMAN services were aware if they needed the aircraft either to gain time or to lose time in E-TMA/En-route; if necessary they could assign alternative route to be compliant. Once the E-TMA controllers has chosen the route, controller gave the instruction to the flight crew. It has to be noted that it could be provided to the aircraft either by En-route controllers or by E-TMA controllers (both conditions were assessed during the experimentation).

- Specific considerations :
  - With the help of information given by E-AMAN services a system could proposed an alternative route to the ATCO
  - The ATCO was allowed to use a display of the EPP report on his/her CWP to check the 4D trajectory foreseen by the aircraft.

- Controllers had the possibility to use CTA to impose time constraint on a defined metering point to some aircraft (it has to be noted that controllers will be able to identify which aircraft are able to follow a CTA)
- The ETMA planning controller had the new responsibility to update the AMAN sequence

- **Simulation and schedule**

Two groups of two controllers participated in two three day sessions.

Depending on the run, controllers will have the possibility to display EPP, to provide alternative STAR and to check whether aircraft is able to follow a CTA. For each Run, AMAN will be available.

The schedule of a session is presented hereafter:

First Day	
[redacted]	
09:30 12:00	**BRIEFING EXPERIMENTATION**
	HMI TRAINING
12:00 14:00	**LUNCH**
14:00 14:50	**RUN "TRAINING"**
14:50 15:20	**DEBRIEF**
15:20 16:10	**RUN "TRAINING"**
16:10 16:40	**DEBRIEF**

16:40 17:20	RUN "TRAINING"

Second day				
	Run	STAR	CTA	ATCO
09:00	Arrival	Arrival	Arrival	Arrival
09:30 10:20	RUN A	ONE STAR	NOK	A/B
10:20 10:50	QUESTIONNAIRE AND DEBRIEF			
10:50 11:40	RUN D	SEVERAL STARS	NOK	B/A
11:40 12:10	QUESTIONNAIRE AND DEBRIEF			
12:10 13:30	LUNCH			
13:30 14:20	RUN E	SEVERAL STARS	OK	A/B
14:20 14:50	QUESTIONNAIRE AND DEBRIEF			
14:50 15:40	RUN F	SEVERAL STARS	NOK	B/A
15:40 16:10	QUESTIONNAIRE AND DEBRIEF			

Third day				
	Run	STAR	CTA	ATCO
09:00	Arrival	Arrival	Arrival	Arrival
09:30 10:20	RUN E	ONE STAR	NOK	A/B
10:20 10:50	QUESTIONNAIRE AND DEBRIEF			
10:50 11:40	RUN I	SEVERAL STARS	NOK	B/A
11:40 12:10	QUESTIONNAIRE AND DEBRIEF			
12:10 13:30	LUNCH			
13:30 14:20	RUN A	SEVERAL STARS	OK	A/B
14:20 14:50	QUESTIONNAIRE AND DEBRIEF			
16:10 17:10	FINAL DEBRIEF AND QUESTIONNAIRE			

A.1.4 Summary of Validation Exercise PJ.01-03B -VALP-V2-01 Validation Assumptions

No specific validation assumptions are applicable to this validation exercise.

A.2 Deviation from the planned activities

The deviations from the planned activities were the following:

- As the “Descent when ready” from the cruise FL use case was not assessed, the validation objectives “OBJ-PJ.01.03-V2-VALP-RTS-003” and OBJ-PJ.01.03-V2-VALP-RTS-004” were not assessed. The new objective “OBJ-PJ.01.03-V2-VALP-RTS-018” was created to address this procedure in E-TMA only,
- Due to technical limitations, all aircraft were EPP and RTA equipped although in certain runs, the ATCOs were asked not to instruct CTAs,
- Due to technical limitations, no speed advisory tool was available.

A.3 Validation Exercise PJ.01-03B -VALP-V2-01 Results

A.3.1 Summary of Validation Exercise EXE. 01-03B.010 Results

- *OK: Validation objective achieves the expectations (exercise results achieve success criteria)*
- *NOK: Validation objective does not achieve the expectations (exercise results do not achieve success criteria).*
- *Partially OK: Validation objective achieves the expectations to a certain extent. The reasons why the validation objective is not fully achieved shall be clearly recorded in Table below*

Validation Exercise EXE. 01-03B.010 Validation Objective ID	Validation Exercise EXE. 01-03B.010 Validation Objective Title	Validation Exercise EXE. 01-03B.010 Success Criterion ID	Validation Exercise EXE. 01-03B.010 Success Criterion	Sub-operating environment	EXE.01-03B.010 Validation Results	Validation Exercise EXE. 01-03B.010 Validation success criterion Status	Validation Exercise EXE. 01-03B.010 Validation Objective Status
OBJ-PJ.01.03-V2-VALP-RTS-001		CRT-PJ.01.03-V2-VALP-RTS-001-002	Controllers indicate that they can easily identify the status of the operation on board		Controllers confirmed that they were able to identify the status of the operation on board the aircraft	OK	OK

			the aircraft (when relevant : flight mode, CTA, …)				
		CRT-PJ.01.03-V2-VALP-RTS-001-004	Controllers confirm that they can easily identify the constraints given to an aircraft (e.g speed)		Controllers confirmed that they were able to understand which clearances have been given to aircraft	OK	
		CRT-PJ.01.03-V2-VALP-RTS-001-005	Controllers indicate that the experimental conditions allowed them to assess the concept to an acceptable way		Controllers indicated that the HMI and the experimental condition were enough relevant to assess the concept.	OK	
OBJ-PJ.01.03-V2-VALP-RTS-002	To evaluate if the ATCO’s HMI is suitable for him/her to assess the provision of“When ready descend” clearances in E-TMA”	CRT-PJ.01.03-V2-VALP-RTS-002-001	Controllers confirm that tools available on the CWP allow them to perform their tasks in the case they provide “When ready descend” clearances in E-TMA”		Information on aircraft intentions provided by EPP are globally considered as useful and facilitated the provision of ”when ready descend” clearances	OK	OK

		CRT-PJ.01.03-V2-VALP-RTS-002-002	Controllers confirm that they can easily use data about aircraft's intentions"		Globally controllers assessed positively this point but they indicated that information regarding the TOD and the planned speed were not enough visible	OK	
OBJ-PJ.01.03-V2-VALP-RTS-005	To assess how the priority given to capacity impacts the ability to accept to provide "When ready descend" clearances in E-TMA.	CRT-PJ.01.03-V2-VALP-RTS-005-001	Controllers and experts indicate that the management of traffic (sequencing and priority given to capacity) still allows to facilitate optimized profiles for sufficient amount of flights		They indicated that there is an impact of letting aircraft descend when ready (on their preferred profile) on airspace capacity.	NOK	Partially OK
		CRT-PJ.01.03-V2-VALP-RTS-005-002	Controllers and experts indicate that controllers' workload is maintained at an acceptable level optimised profiles are facilitated, compared to the baseline		Controllers globally considered that managing a traffic with aircraft cleared "to descend when ready" did not noticeably increased their workload compared to usual traffic management	OK	
		CRT-PJ.01.03-V2-VALP-	Controllers confirm that tools		Controllers indicated that the HMI was enough efficient to	OK	OK

		RTS-006-001	available on the CWP allow them to choose alternative routes in an efficient way		manage alternative route.		
		CRT-PJ.01.03-V2-VALP-RTS-006-002	Controllers confirm that they are able to easily identify which route has been given to aircraft		No issue have been identified	OK	
OBJ-PJ.01.03-V2-VALP-RTS-006	To evaluate if the ATCO's HMI is suitable for him/her to use "dynamic	CRT-PJ.01.03-V2-VALP-RTS-006-003	Controllers and experts confirm that routes can be sent to the aircraft in an efficient manner		sequencing manger could easily fill in the system the route chosen	OK	
		CRT-PJ.01.03-V2-VALP-RTS-006-004	Controllers confirm that tool permits to make efficient coordination with different sectors		Controllers confirmed that tool available to make coordination with different sectors was efficient, they were aware when the adjacent position replied positively or negatively to a request	OK	
		CRT-PJ.01.03-V2-VALP-RTS-007-001	The proposed working method permits the controller		Controllers indicated that the working method was efficient to attribute a route to absorb a delay and allowed them to manage the traffic when one or several aircraft	OK	O

			to perform their task		followed a dynamically attributed route. Nevertheless, some controllers reported that the working method have been refined during the first simulations;	
OBJ-PJ.01.03-V2-VALP-RTS-007	To assess the operational feasibility of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions	CRT-PJ.01.03-V2-VALP-RTS-007-002	The information given by E-AMAN services permit to the ATCO to easily attribute a route		Controllers indicated that time to lose provided by the system was not the only criterion used to attribute a route. Indeed, we observed during the experimentation that controllers performed a lot of coordination either to confirm the sequence proposed by the system or to change this sequence.	OK
		CRT-PJ.01.03-V2-VALP-RTS-007-003	Controllers and experts confirm that information given by E-AMAN does not change too many times and allows to build a stable strategy early enough		Regarding the sequence proposed by AMAN, controllers considered that it was enough stable to permit to build stable strategy and allowed them to attribute a route to absorb the delay. Nevertheless, during debriefings controllers indicated that this sequence should be stabilized a little before than during the experimentation, in the aim to avoid late change	OK
		CRT-PJ.01.03-V2-VALP-RTS-007-004	It is feasible for the controllers to monitor the		Controllers indicated that they could monitor the traffic when routes were dynamically attributed to aircraft.	OK

			execution of alternative route		One specific difficulty have been highlighted during the simulation, when both aircraft coming from ROLLEN and BEVOL left at the same moment the arc of the circle composing the routes.		
		CRT-PJ.01.03-V2-VALP-RTS-008-001	When, in nominal conditions, the new method application must be interrupted while in progress, the ATCO can revert to the current method (based on vectoring), with no decrease of the safety level, keeping the workload at an acceptable level, and with no impact on the sequencing task.		Controllers indicated that globally reverting to the vectoring method did not decrease their safety level and did not increase their workload to an unacceptable level. Globally, they concluded that the both methods vectoring and dynamic attribution of routes, could be used in a consistent way.	OK	OK
		CRT-PJ.01.03-V2-VALP-RTS-008-002	When, in nominal conditions, the new method application		Controllers considered that they could revert to the current method based on vectoring when the dynamic attribution of routes	OK	

OBJ-PJ.01.03-V2-VALP-RTS-008	To assess the operational feasibility, from a controller's perspective, of facilitating optimised profiles from		is not possible, the ATCO can use the current method (based on vectoring), with no impact on safety, and reasonable impact on workload and on the sequencing task.		either fails or is no more adapted to the situation.		
OBJ-PJ.01.03-V2-VALP-RTS-009	To assess the acceptability of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective	CRT-PJ.01.03-V2-VALP-RTS-009-001	No additional tactical interventions in comparison with the reference		Controllers indicated that when a flight had to follow a dynamically attributed route, it did not lead to more tactical interventions compared to today's operations.	OK	OK
		CRT-PJ.01.03-V2-VALP-RTS-009-002	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline		They confirmed that their perceived safety level is quite high when they have to manage aircraft flying dynamically attributed routes	OK	
		CRT-PJ.01.03-V2-VALP-RTS-009-003	Controllers and experts indicate that controllers' workload is		The workload was maintained at an acceptable level as well as the situation awareness.	OK	

	in nominal conditions.		maintained at an acceptable level with the tested method compared to the baseline				
		CRT-PJ.01.03-V2-VALP-RTS-009-004	The ATCO is as much in control of the situation as with the baseline (situation awareness, monitoring possibilities, anticipation capacity, fall-back capability)		No issue have been identified concerning this point	OK	
OBJ-PJ.01.03-V2-VALP-RTS-010	Evaluate if the ATCO's HMI is suitable for him/her to use the Permanent Resume Trajectory	CRT-PJ.01.03-V2-VALP-RTS-010-001	Controllers confirm that tools available on the CWP allow them to use the Permanent Resume Trajectory		For technical reasons and time limitations, the prerequisites to address this objective were not available.	Not addressed	Not addressed
OBJ-PJ.01.03-V2-VALP-RTS-011	Assess the operational feasibility of using the Permanent Resume Trajectory	CRT-PJ.01.03-V2-VALP-RTS-011-001	The proposed working method permit the controller to perform their task		The proposed working method was simplified, and only consisted in providing, when possible, the distance along track and/or the waypoint/leg intended for capture after a heading instruction. The objective was to tune	OK	OK

					the trajectory on board in order to make it consistent with the controller intent (anticipate the end of vectoring point / capture initial route point), without significantly impacting his/her workload.		
OBJ-PJ.01.03-V2-VALP-RTS-012	Assess the acceptability of the using Permanent Resume Trajectory	CRT-PJ.01.03-V2-VALP-RTS-012-001	No additional tactical interventions in comparison with the reference		During the evaluation, the use of the Permanent Resume Trajectory never led to additional tactical intervention in comparison with the reference. The ATCOs were not aware whether the PRT was computed / used in the aircraft or not, and so, it did not modify their behaviour nor induce any additional instruction. However, some information such as the end of vectoring point, or the leg to be captured were provided by the ATCOs to the pilot.		
		CRT-PJ.01.03-V2-VALP-RTS-012-002	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline				
		CRT-PJ.01.03-V2-VALP-RTS-012-005	Controllers and experts indicate that no misunderstanding between information and clearances are induced by the use				

			of a "Permanent Resume Trajectory"				
OBJ-PJ.01.03-V2-VALP-RTS-013	Assess the feasibility & acceptability of new operational methods from a pilot point of view	CRT-PJ.01.03-V2-VALP-RTS-013-001	Pilots indicate that they can easily adapt their way of working with PJ01-03B new operational methods proposal		PJ01-03B new operational methods proposal has been judged rather easy and understandable by pilots involved in the experiment because the experimental conditions were enough representative of operational conditions to evaluate the concept: the network of alternatives route created within the concept seems applicable to Paris E-TMA from an airborne side (of course, if approved by ATCO).	OK	OK
		CRT-PJ.01.03-V2-VALP-RTS-013-002	Pilot confirm that new operational methods do not decrease level of safety and are acceptable with regards to their procedures (information's received on time to update FPLN or execute		Pilots' recognized that the concept of dynamic attribution of route allows anticipation of aircraft Energy management and so eases management of deceleration, even more with Continuous Descent Approach FMS function, through a better situation awareness which contributes to reinforce safety.	OK	OK

			manoeuver requested)				
OBJ-PJ.01.03-V2-VALP-RTS-014	Evaluate how ADS-C (EPP) data can facilitate CDO operations	CRT-PJ.01.03-V2-VALP-RTS-014-001	Issues linked with EPP uncertainty are assessed by both pilots and controllers		The exercise allowed to address issues linked with EPP uncertainty. In particular discrepancies between the FMS hypotheses and the ground expectations, especially about speed, may impact the dynamic route attribution consistency and disturb the controllers' activity. The EPP data contain information which may solve this issue: the necessary analysis cannot be done by the controllers, but could be done automatically by the ground system.	NOK	NOK
OBJ-PJ.01.03-V2-VALP-RTS-015	Evaluate pilot workload with new operational method	CRT-PJ.01.03-V2-VALP-RTS-015-001	Pilots assess and confirm increase of workload is acceptable with regards to increase of flight efficiency		EPP and dynamic routes allocation functionalities are either transparent for the pilot (EPP) or equivalent to changing the STAR on the ARRIVAL FMS page. Furthermore, no added task or uncertainties was identified by concept implementation.	OK	OK
		CRT-PJ01.03-V2-VALP-RTS-015-002	Pilots confirm that workload associated to new operational methods does not		No pilot reported that PJ01-03B new operational methods proposal could jeopardize the safety of the flight because a trend of self-rated mental workload reduction has been	OK	OK

			decrease safety.		identified during the experiment.		
OBJ-PJ.01.03-V2-VALP-RTS-016	Identify traffic condition limitations with regards to CDO optimization	CRT-PJ.01.03-V2-VALP-RTS-016-001	PJ01-03B team assesses and confirms from which level of traffic, controllers can't authorized CDO optimization		From a ground side perspective, and in the context of this exercise, the "when ready descend" procedure was not considered compatible with a high traffic load, or a high traffic complexity. The ATCOs indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and when there is time for a closer monitoring of the traffic.		
OBJ-PJ.01.03-V2-VALP-RTS-017	Identify new operational method noise impact and fuel efficiency	CRT-PJ.01.03-V2-VALP-RTS-017-001	PJ01-03B team evaluate theoretical noise impact of new operational method in comparison to current operational method (if data available)		Regarding airborne simulators results, noise data are not directly available. However, dynamic route attribution eases CDO and "recruising" procedure enables to stay higher longer on a closed path, and therefore, reduces global noise footprint on ground.	Not addressed	Not addressed
		CRT-PJ.01.03-V2-VALP-RTS-017-002	PJ01-03B team evaluate theoretical fuel efficiency of new operational method in comparison		Even if a quantitative analysis is not relevant due to experiment limitations, a trend of fuel efficiency has been identified. A dynamic and "closed" route, with recruise level followed by an idle	Partially OK	Not addressed

			to current operational method (if data available)		descent, is then more fuel efficient and comfortable for the crew than an “open” route (vectoring).		
OBJ-PJ.01.03-V2-VALP-RTS-018	To assess the operational feasibility, from a controller’s perspective, to provide “When ready descend”	CRT-PJ.01.03-V2-VALP-RTS-018-001	The proposed working method permit the controller to perform their task		The proposed working method was judged as relevant	OK	OK
		CRT-PJ.01.03-V2-VALP-RTS-018-002	The informatio n about aircraft descent intentions available for the ATCO permit to facilitate the use of optimised profiles from TOD		Information on aircraft intentions provided by EPP are globally considered as useful and facilitated the provision of “Descend when ready” clearances. Nevertheless, the relevance of the TOD information has been questioned during the debriefings. Indeed, controllers considered that when they give a clearance “descent when ready”, the pilot has the possibility to start the descent when he wants following the TOD or not (new TOD or other reasons).	OK	
		CRT-PJ.01.03-V2-VALP-RTS-018-003	The controllers can monitor the flights executing an optimised descent as easily and		Globally, controllers considered that it was feasible to manage the traffic in an efficient way when flight were cleared to descend when ready but the procedure is judged as not easy to follow because it leads to an activity of	OK	

clearances in E-TMA		safely as usual		monitoring too important	
	CRT-PJ.01.03-V2-VALP-RTS-018-004	No additional tactical interventions in comparison with the reference			OK
	CRT-PJ.01.03-V2-VALP-RTS-018-005	Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline			OK
	CRT-PJ.01.03-V2-VALP-RTS-018-006	Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline			OK
	CRT-PJ.01.03-V2-VALP-RTS-018-007	The ATCO is as much in control of the situation as with the			OK

			baseline (situation awareness, monitoring possibilities , anticipation capacity, fall-back capability)				

Table 5: Validation Results for Exercise 1

[...]

A.3.2 Analysis of Exercise PJ.01-03B -VALP-V2-01 Results per workload and situation awareness “ground side”

[...]

The workload and the situation awareness of the controllers were assessed during each run. The objective was to highlight potential variations as function of the conditions and the working position.

- **Workload**

The controllers’ workload was assessed through a tool called ISA (Instantaneous Self-Assessment). Every 3 minutes, during each run, the ATCOs were requested to provide an information about their perceived workload. This provided time-based subjective on-line ratings related to changing task demands.

Figure 10: ISA interface.

ISA uses a four buttons keypad to assess the workload, from the blue one representing a very low workload to the red one representing an excessive workload.

- ISA ATCO workload assessment according to the runs

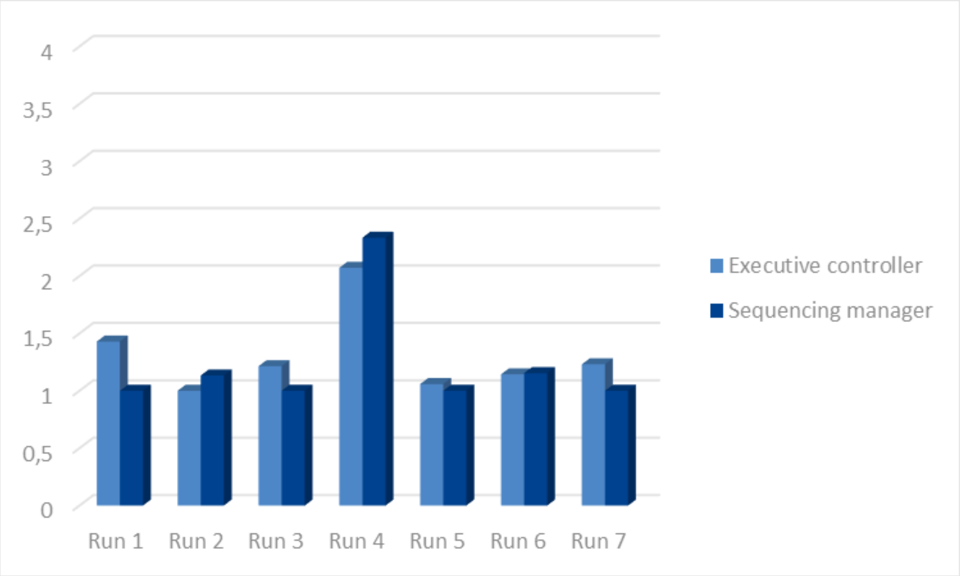


Figure 11: ISA ATCO workload assessment according the runs

Globally, the scores are low whatever the run and the assessed position (executive or sequencer). The higher score, reaching 2.3, describes the workload rated by the sequencing manager in the run 4. These results indicate that the workload is maintained at an acceptable level and is similar for both positions assessed (executive or sequencer). During the debriefing, the controllers said that the traffic level for the Run 4 was too high. Further analysis is needed to determine if this traffic level is not realistic or if this traffic level challenges the concept under evaluation.

- ATCO workload assessment using ISA for the reference and the solution scenario

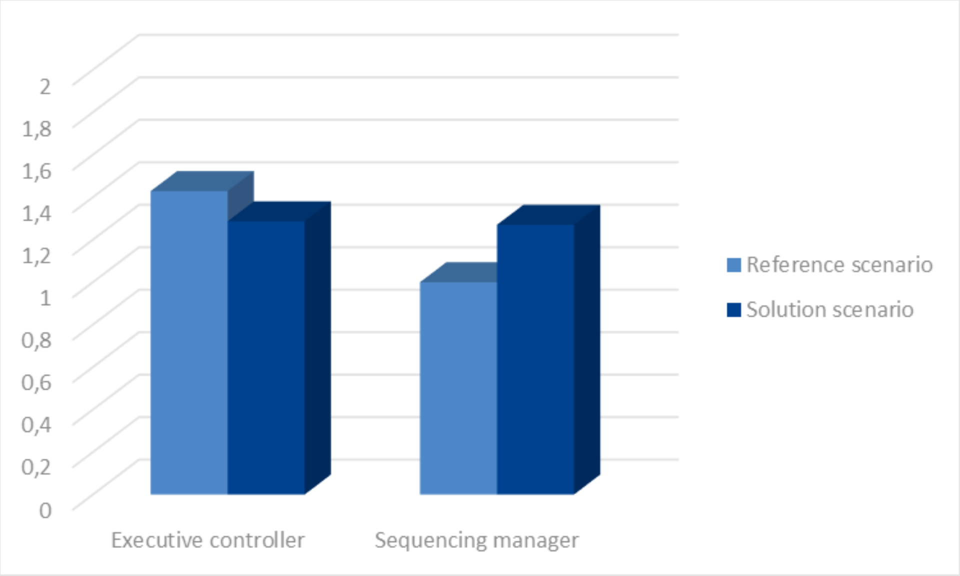


Figure 12: ATCO workload assessment using ISA for the reference and the solution scenario

The score for the condition "reference scenario" was obtained by analysing the RUN 1 whereas runs 2, 3, 4, 5, 6 and 7 scores were averaged to obtain the score of the "solution scenario". These results show that an operational method based on a dynamic attribution of routes seems not to increase the executive controller's workload. On the contrary, a slight workload increase can be observed on the sequencing manager's side for the solution scenario. This result is coherent because in the solution scenario the sequencer had to decide which route to attribute and then coordinate with the upstream sector: he/she did not have to perform this task in the reference scenario.

- ATCO workload assessment using ISA for the solution scenarios according to the level of equipment

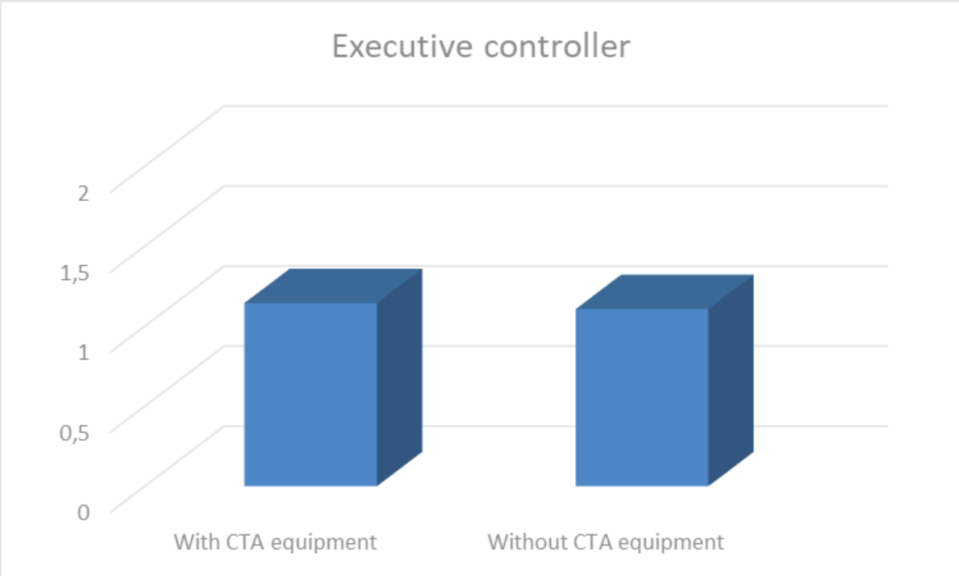


Figure 13: ATCO workload assessment using ISA for the solution scenarios according to the level of equipment (RTA versus without RTA capability)

During the runs 4, 5, 6 and 7, executive controllers had the possibility to give CTA to aircraft. Runs 4, 5, 6 and 7 scores were averaged to obtain the score of the condition "with CTA equipment". The scores of run 2 and 3 were averaged to obtain the score of the condition "without CTA equipment". It can be observed that the scores are identical whatever the aircraft's level of equipment. This suggests that the possibility to manage the traffic using CTA does not lead to a significant decrease of workload. This result is coherent with those obtained during the debriefing and questionnaire where controllers indicated that the monitoring task was more important when aircraft were flying to a CTA.

Conclusion: it must be noted that the ATCOs are not familiar with the use of CTA and that the training may have been insufficient on this point. However For example, the ATCOs felt that they had to monitor the aircraft flying to a CTA very closely because they didn't control their speed

- **Situation awareness**

The situation awareness was assessed by a standardised questionnaire called China Lakes. At the end of each run, the controllers filled the questionnaire. A high score corresponds to a good situation awareness assessed by the controllers, the score is from 1 to 10.

- ATCOs' situation awareness assessment

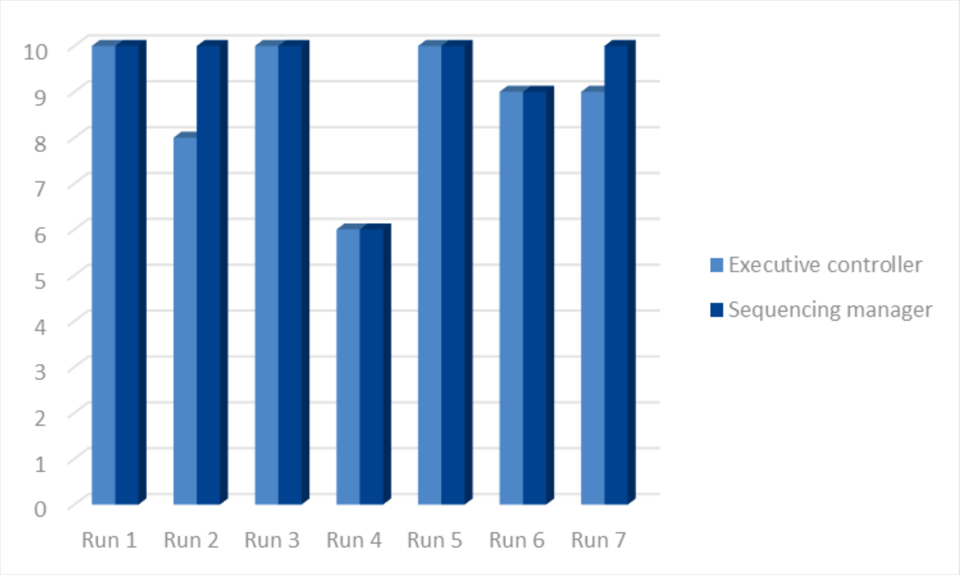


Figure 14: ATCOs' situation awareness assessment using China Lakes scale

Results indicate that the Situation Awareness was considered as good for all the runs, but Run 4. The score obtained are more or less similar for the executive controller and the sequencer. The lower score was obtained for the Run 4, with a sample featuring too high traffic conditions.

- ATCOs' situation awareness for the reference and the solution scenario

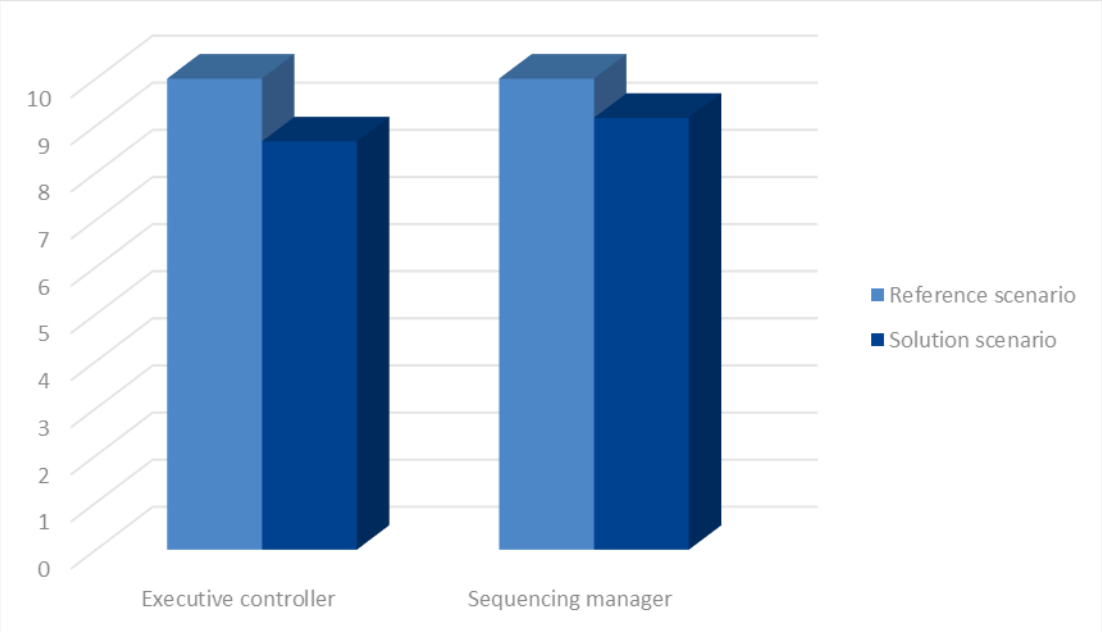


Figure 15: ATCOs' situation awareness assessment using China Lakes scale for the reference and the solution scenario

The score for the condition “reference scenario” was obtained by analysing the Run 1. The runs 2, 3, 4, 5, 6 and 7 scores were averaged to obtain the score of the solution scenario. A slight decrease for both controllers (EC and sequencing manager) can be observed for the solution scenario, but the difference is not considered to be significant. Overall, the controllers deemed that the situation awareness was maintained with the solution scenario.

The controllers were not familiar with the new working method and functionalities, which may have impacted the results.

- ATCO situation awareness for the solution scenarios according to the level of equipment

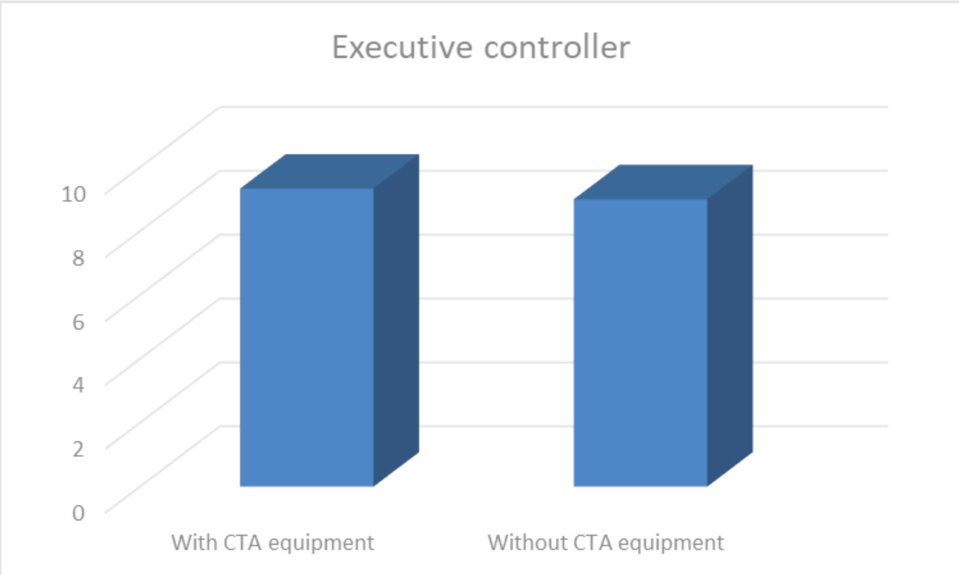


Figure 16: ATCOs’ situation awareness assessment using China Lakes scale for the solution scenario according the level of equipment (RTA versus without RTA capability)

During the runs 4, 5, 6 and 7, executive controllers had the possibility to give CTA to aircraft. Runs 4, 5, 6 and 7 scores were averaged to obtain the score of the condition “with CTA equipment”. The scores of runs 2 and 3 were averaged to obtain the score of the condition “without CTA equipment”. It can be observed that the scores are high and similar whatever the aircraft’s level of equipment. According to those results, it seems that the use of CTA does not significantly impact the situation awareness.

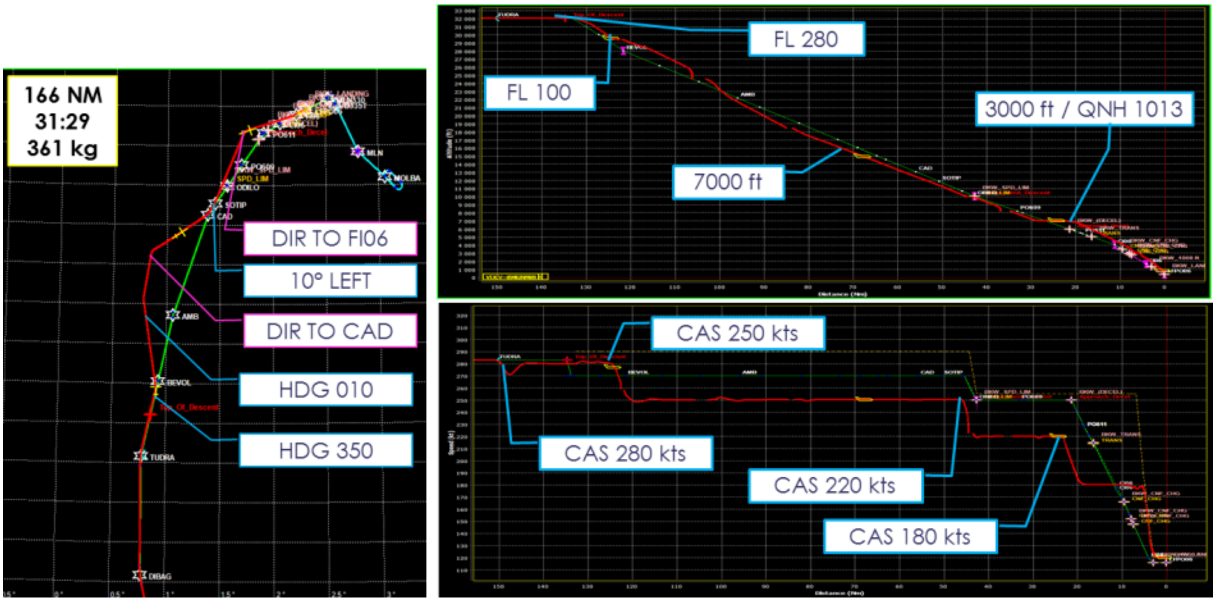
A.3.3 Analysis of Exercise PJ.01-03B -VALP-V2-01 Results per workload and situation awareness “airborne side”

- **Session 1 summary :**

Session	Scenarios	Time at DIBAG	Pilot	E-TMA Controllers	ODILO air flow	MOLBA air flow
1	A (BASELINE)	06:02	1	A / B	19 jets / 1 props	5 jets
	D	06:11	1	A / B	12 jets / 2 props	7 jets / 1 prop
	E	06:01	1	A / B	17 jets / 1 prop	4 jets / 1 prop
	F	06:09	1	A / B	13 jets / 2 props	8 jets / 1 prop
	E	06:01	1	A / B	17 jets / 1 prop	4 jets / 1 prop
	I	05:57	2	A / B	19 jets / 1 props	5 jets
	A	06:02	1	A / B	19 jets / 1 props	5 jets

- **Flight 1 : run A (baseline)**

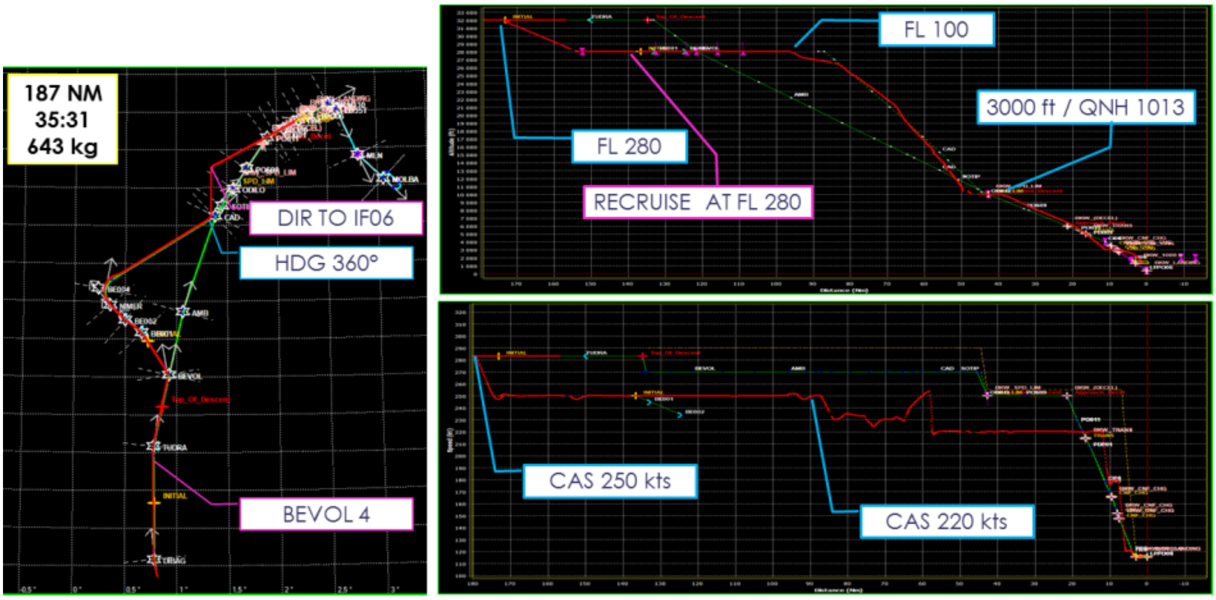
Flight simulations results:



The results in terms of workload are the following (NASA TLX):

- **Flight 2 : run D**

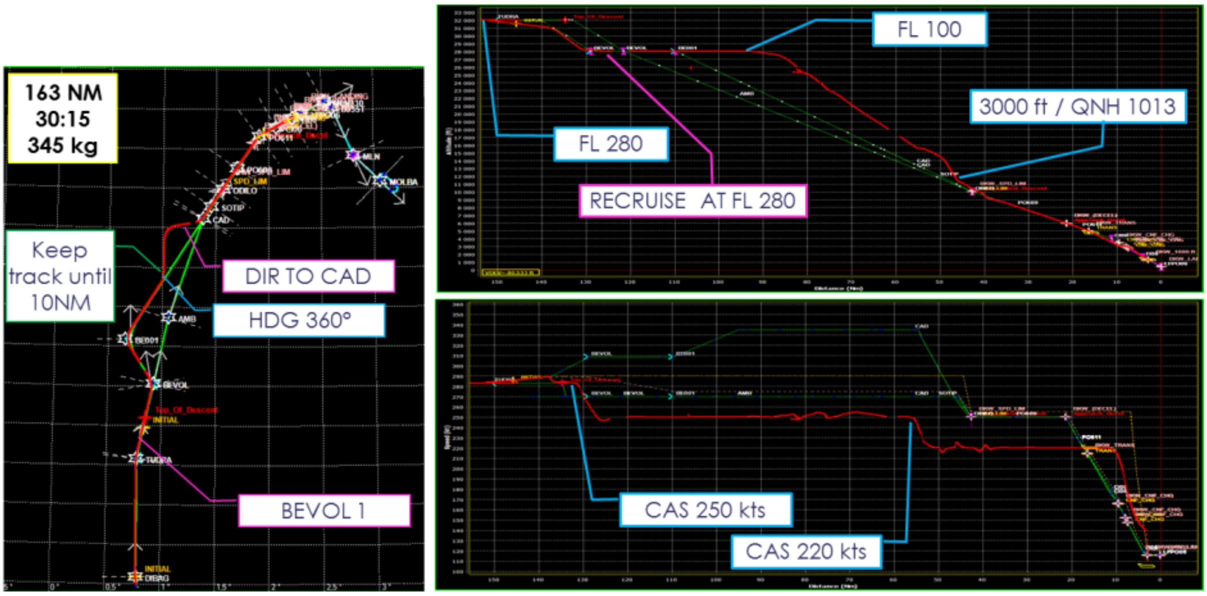
Flight simulations results:



The results in terms of workload are the following (NASA TLX):

- **Flight 3 : run E**

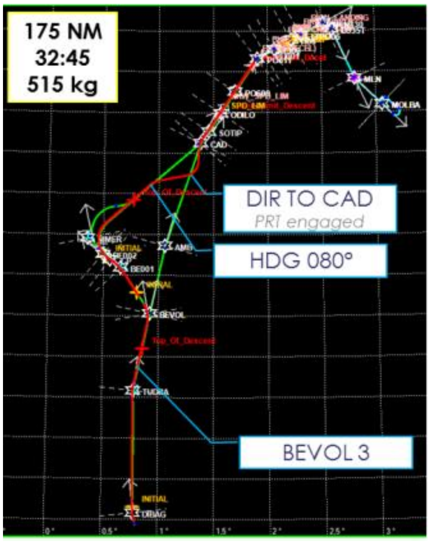
Flight simulations results:

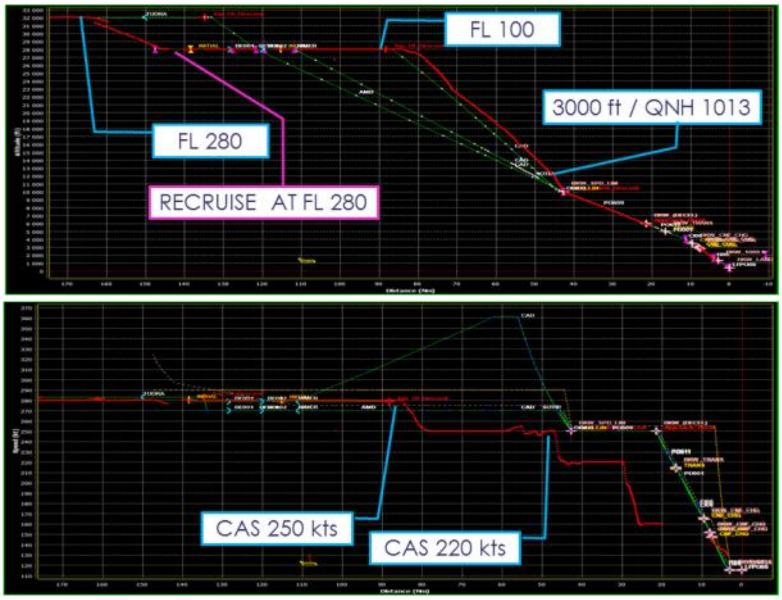


The results in terms of workload are the following (NASA TLX):

- **Flight 4 : run F**

Flight simulations results:

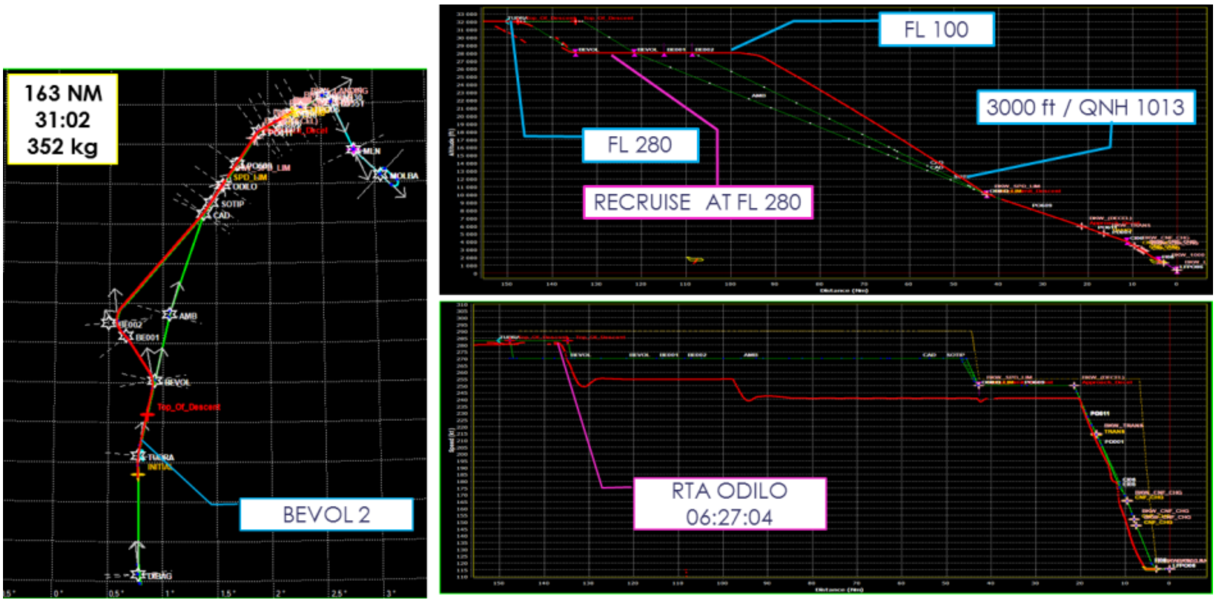




The results in terms of workload are the following (NASA TLX):

- **Flight 5 : run E**

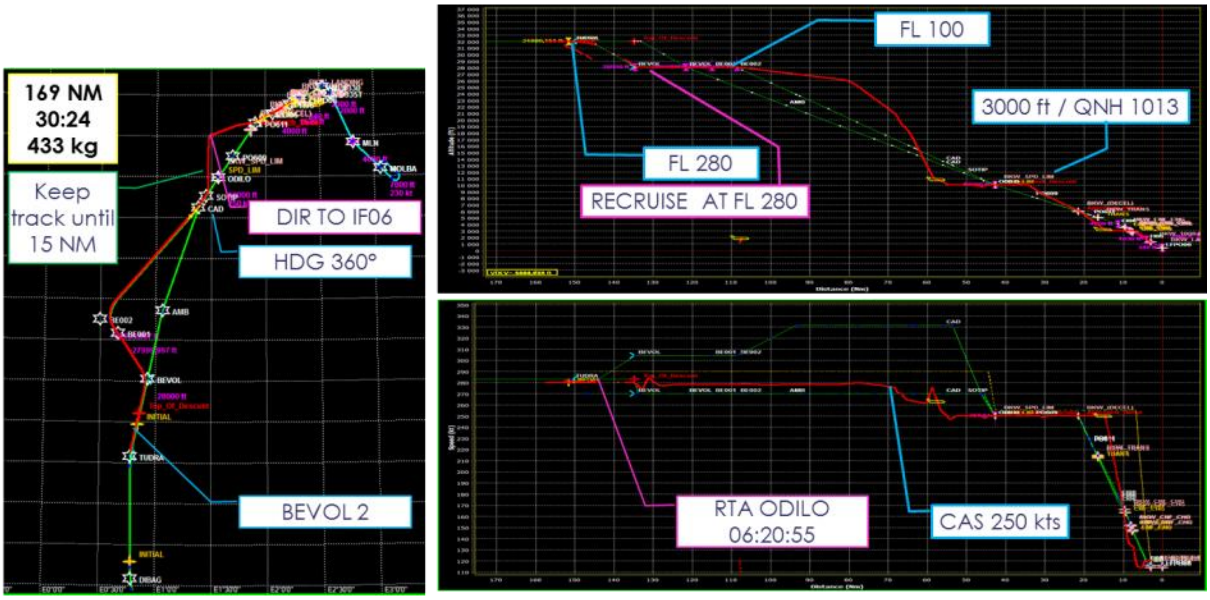
Flight simulations results:



The results in terms of workload are the following (NASA TLX):

- **Flight 6 : run I**

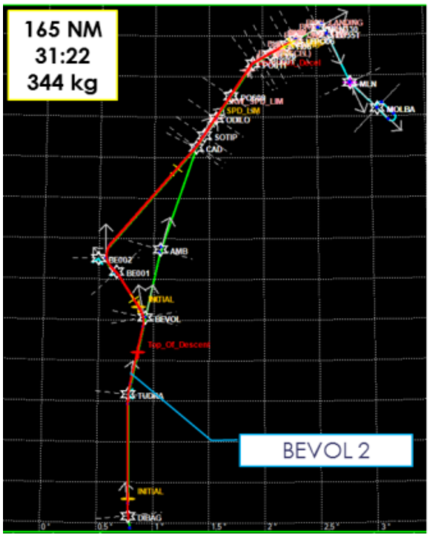
Flight simulations results:

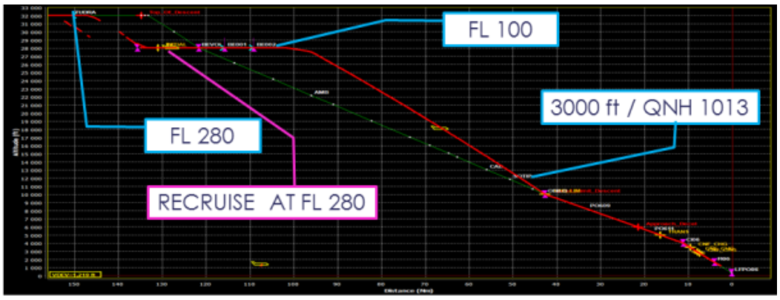


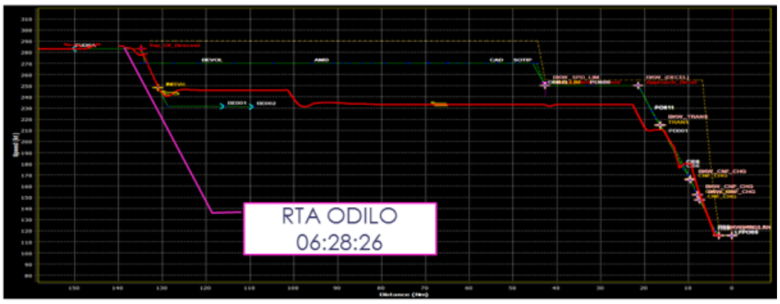
The results in terms of workload are the following (NASA TLX):

- **Flight 7 : run A**

Flight simulations results:







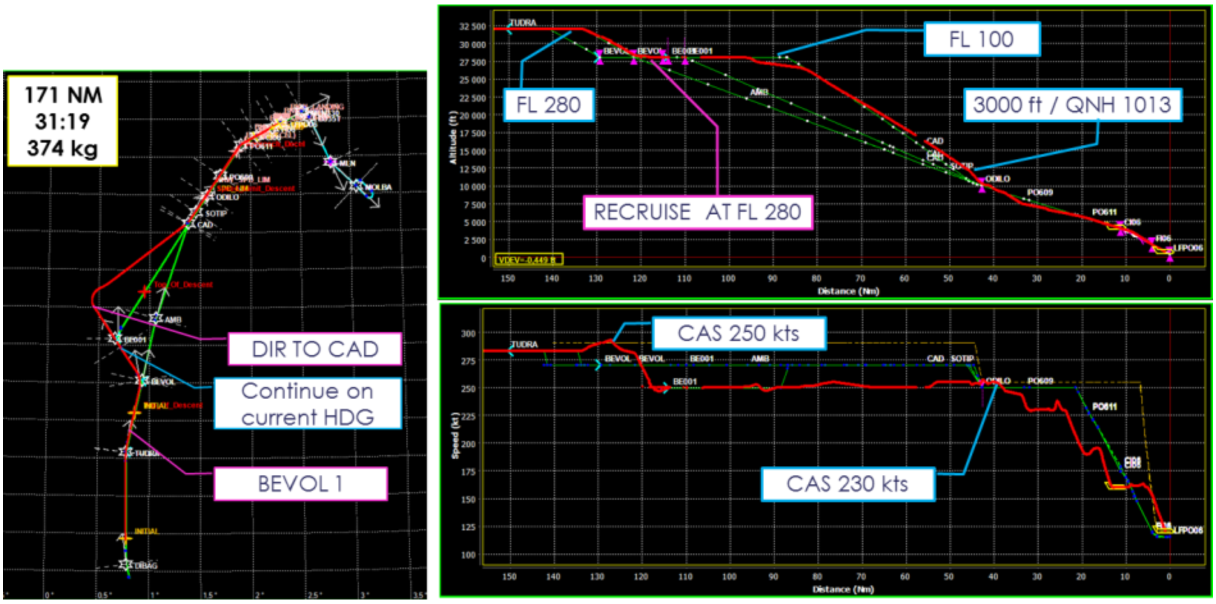
The results in terms of workload are the following (NASA TLX):

- **Session 2 summary :**

Session	Scenarios	Time at DIBAG	Pilot	E-TMA Controllers	ODILO air flow	MOLBA air flow
2	A	06:02	3	C / D	19 jets / 1 props	5 jets
	B	06:14	3	C / D	13 jets / 2 props	8 jets / 1 prop
	E	06:01	3	C / D	17 jets / 1 prop	4 jets / 1 prop
	B	06:14	3	C / D	13 jets / 2 props	8 jets / 1 prop
	E	06:01	3	A / D	17 jets / 1 prop	4 jets / 1 prop
	B	06:14	3	A / D	13 jets / 2 props	8 jets / 1 prop
	E	06:01	3	E / D	17 jets / 1 prop	4 jets / 1 prop
	F	06:09	3	E / D	13 jets / 2 prop	8 jets / 1 prop

- **Flight 1 : run A**

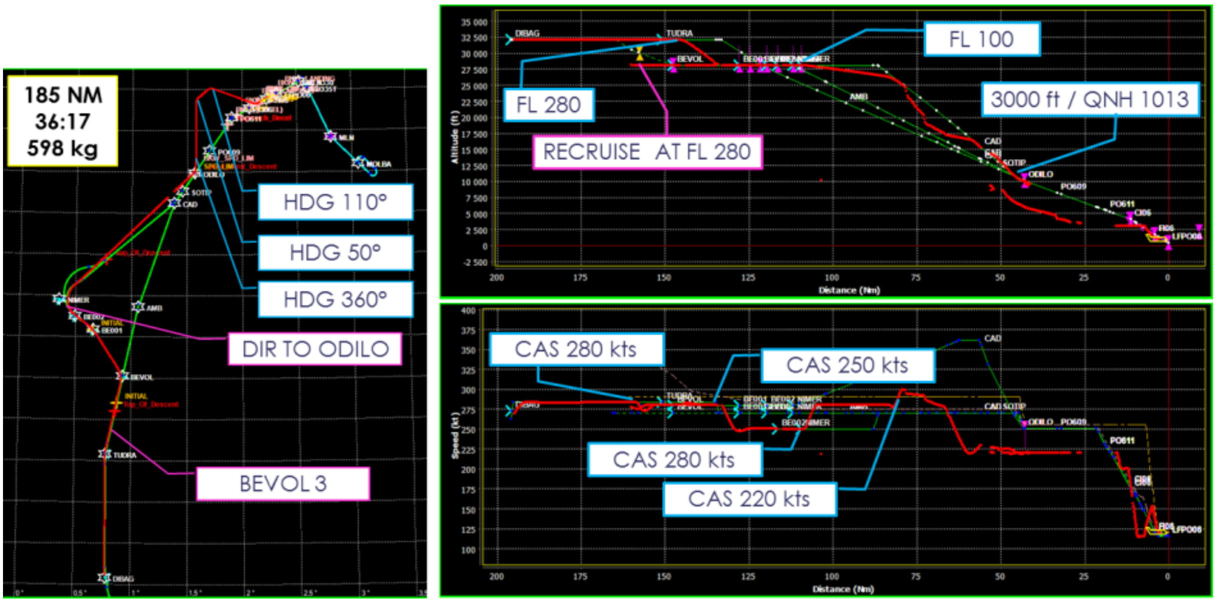
Flight simulations results:



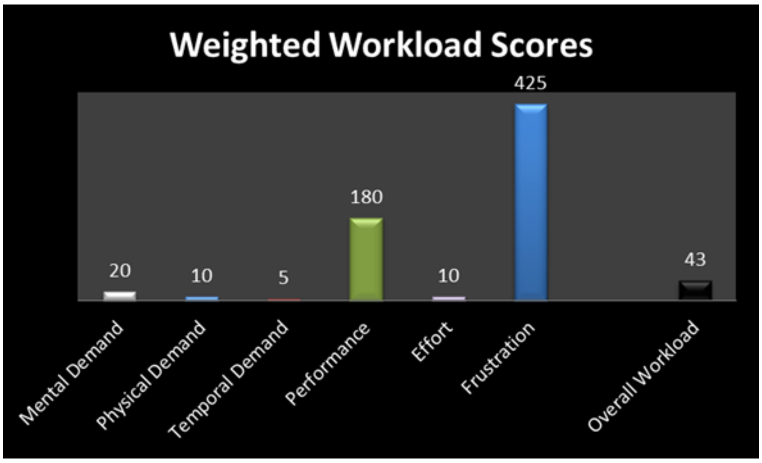
The results in terms of workload are the following (NASA TLX):

- **Flight 2 : run B**

Flight simulations results:

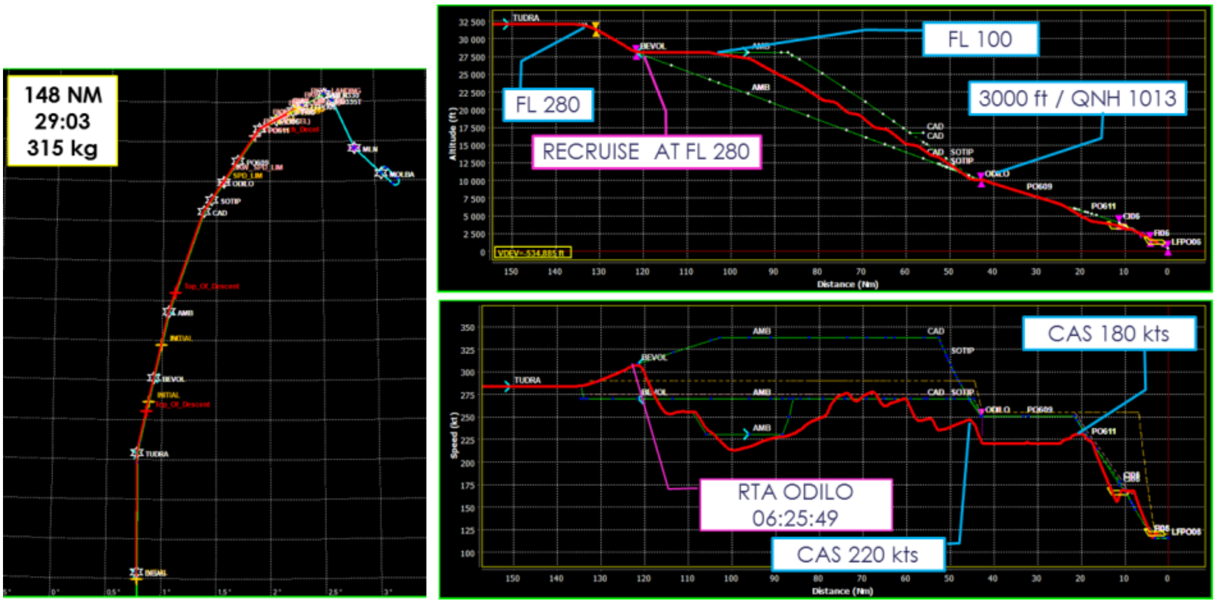


The results in terms of workload are the following (NASA TLX):



- **Flight 3 : run E**

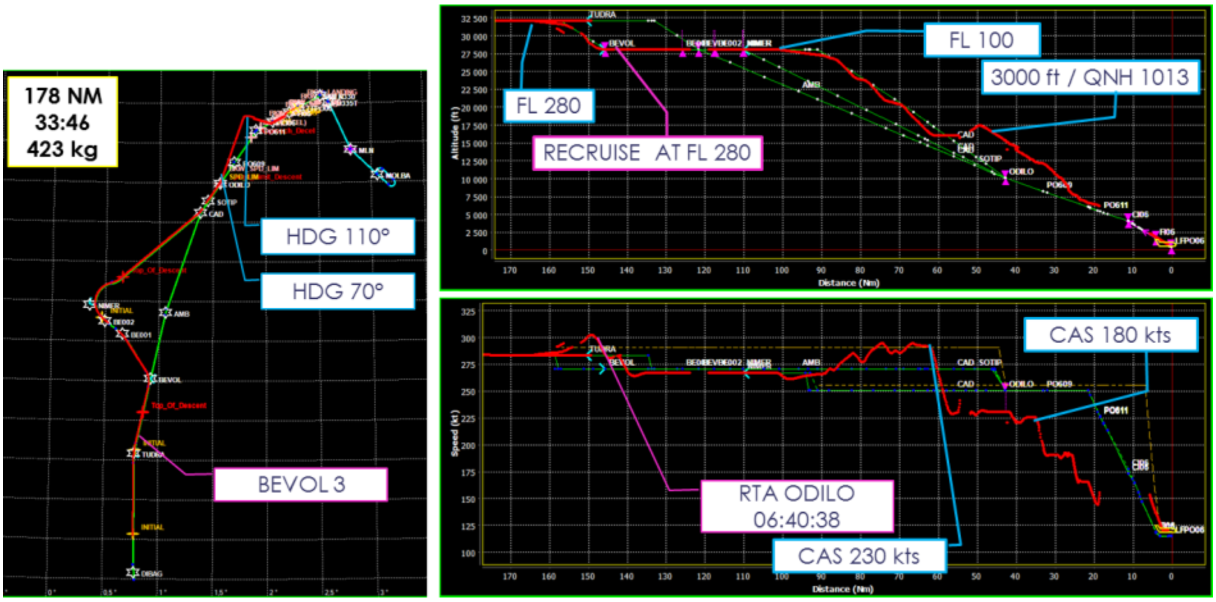
Flight simulations results:



The results in terms of workload are the following (NASA TLX):

- **Flight 4 : run B**

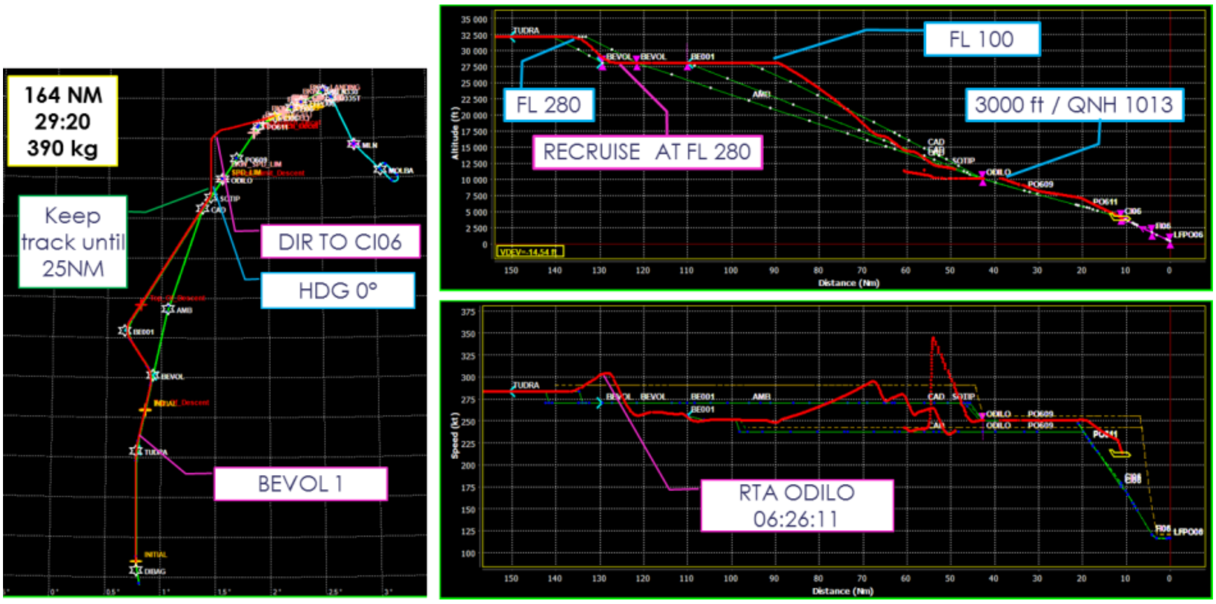
Flight simulations results:



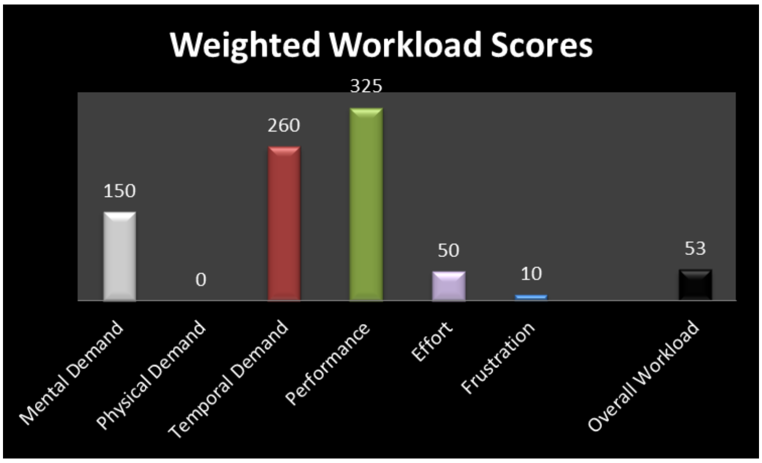
The results in terms of workload are the following (NASA TLX):

- **Flight 5 : run E**

Flight simulations results:

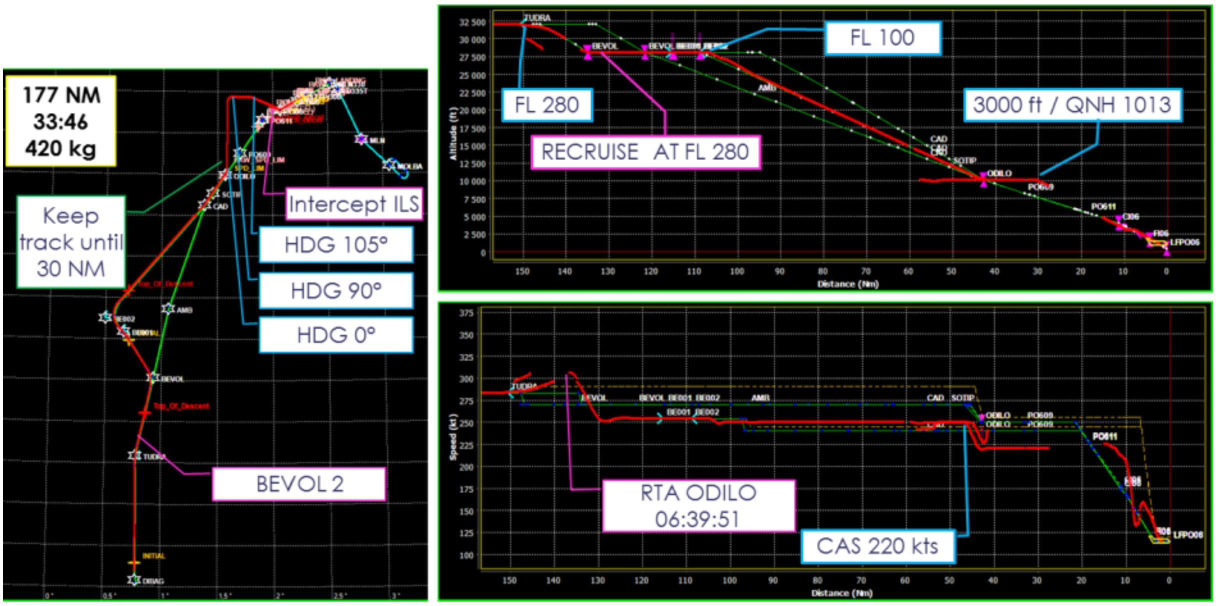


The results in terms of workload are the following (NASA TLX):

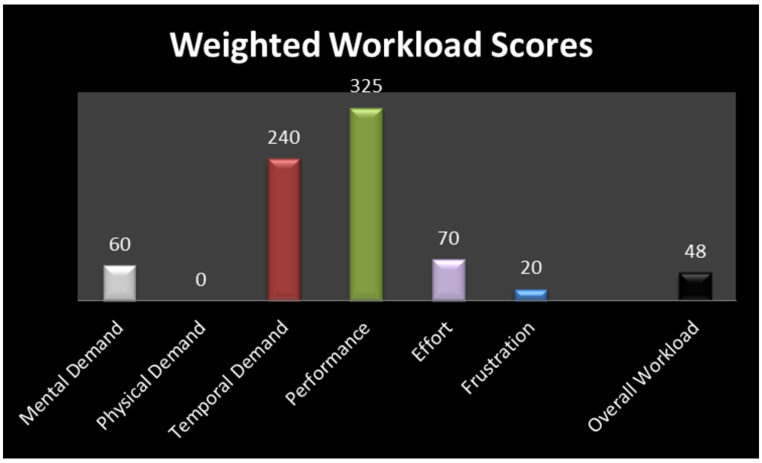


- **Flight 6 : run B**

Flight simulations results:

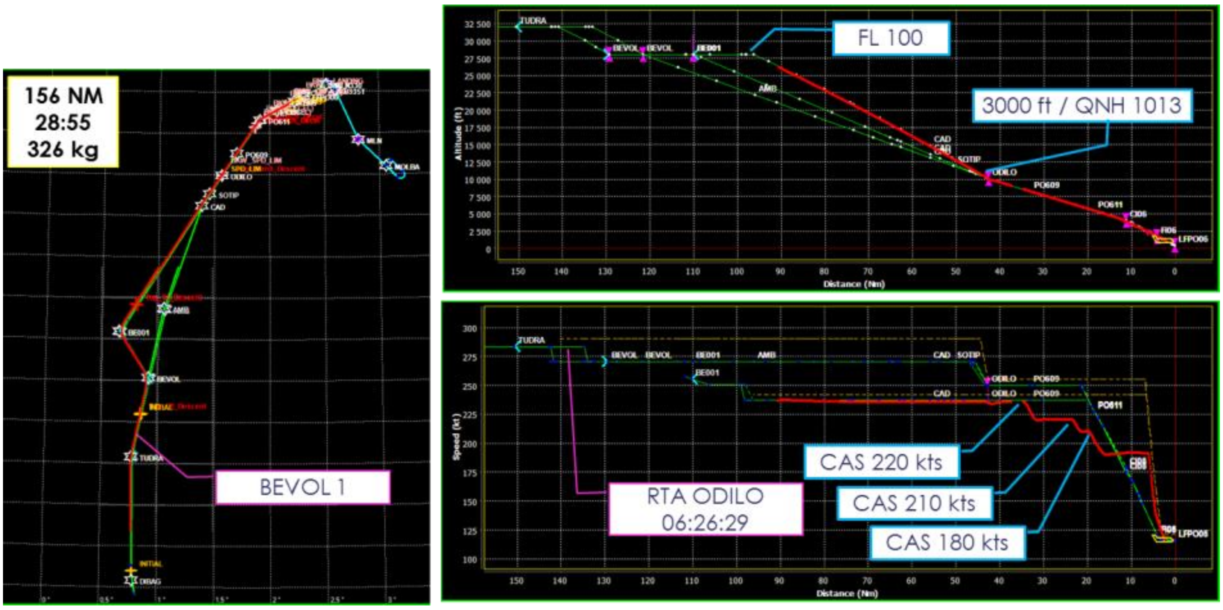


The results in terms of workload are the following (NASA TLX):

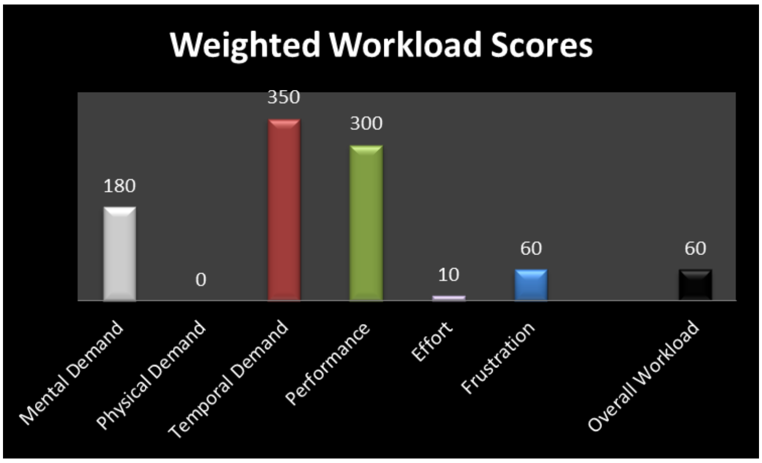


- **Flight 7 : run E**

Flight simulations results:

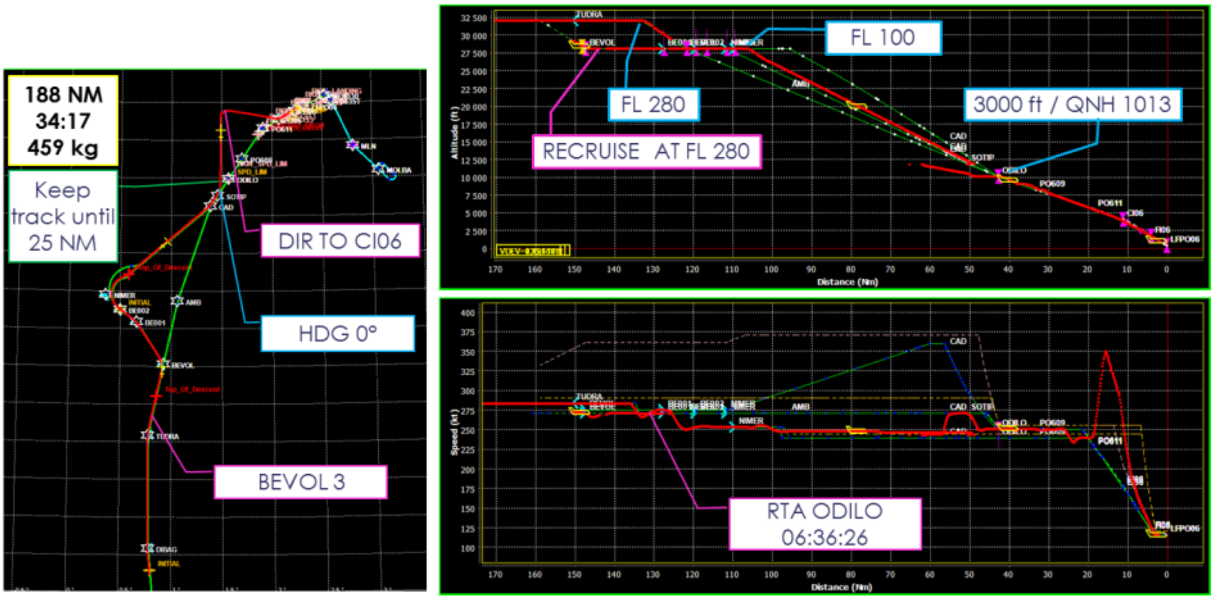


The results in terms of workload are the following (NASA TLX):

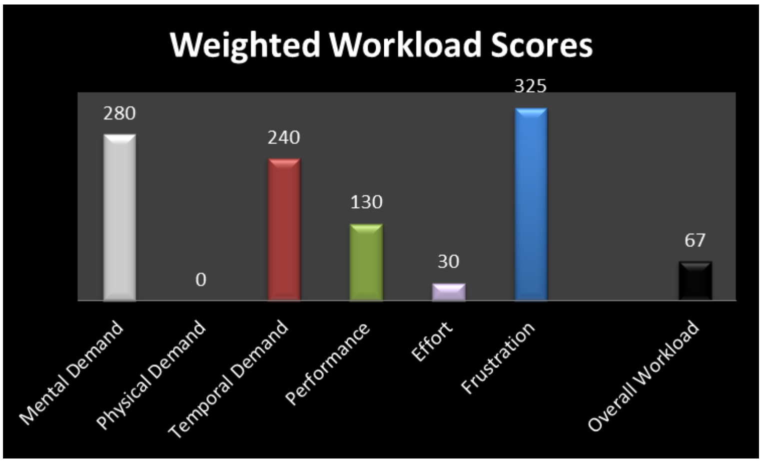


- **Flight 8 : run F**

Flight simulations results:



The results in terms of workload are the following (NASA TLX):



A.3.4 Analysis of EXE. 01-03B.010 Results per Validation objective

A.3.4.1 OBJ-PJ.01.03-V2-VALP-RTS-001 Results

Description:

To evaluate if the ATCO's HMI is suitable for him/her to assess the new concept

Success criteria:

- Controllers indicate that they can easily identify the aircraft equipage (ADS-C, RTA capability, …)
- Controllers indicate that they can easily identify the status of the operation on board the aircraft (when relevant: flight mode, CTA, …)
- Controllers confirm that they are able to easily distinguish information of different nature (FDPS vs ADS-C/EPP)
- Controllers confirm that they can easily identify the constraints given to an aircraft (e.g speed)
- Controllers indicate that the experimental conditions allowed them to assess the concept in an acceptable way

Analysis:

The controllers indicated that the HMI and the experimental conditions were sufficient to assess the concept. The vertical profiles and the behaviour of aircraft were considered as acceptable and controllers confirmed that they were able to understand which clearances had been given to aircraft.

They considered that although the absence of wind in the simulations was a strong limitation, they were able to evaluate the concept. They nonetheless indicated that it will be necessary to include wind for further investigations.

The controllers had to cope with several limitations:

- They had to find solutions to manage the consequences of the PAS@ATM aircraft's unexpected behaviour (see …).
- The rate of descent was not available for both PAS@ATM aircraft (ADS-B message incomplete), which complicated their tasks

- One controller also indicated that waypoints were missing in the simulated environment. In the current operational practice, controllers can use these waypoints to provide Direct To instructions to vectored aircraft. The absence of these waypoints in the simulated environment impacted the reference scenario, but it is difficult to evaluate the extent of this impact.
- The IAS was not available on the radar (no enriched mode S implemented)

Conclusion:

Despite missing information on the ATCO's HMI, this HMI was suitable for the controllers to assess the new concept.

A.3.4.2 OBJ-PJ.01.03-V2-VALP-RTS-002 Results

Description:

To evaluate if the ATCO's HMI is suitable for him/her to assess the possibility to provide «when ready descend" clearances in E-TMA.

Success criteria:

- Controllers confirm that tools available on the CWP allow them to perform their tasks in the case they provide "When ready descend" clearances in E-TMA"
- Controllers confirm that they can easily use data about aircraft's intentions

Analysis:

The implementation choice made about the ADS-C/EPP use in this exercise was to simply present information on the ATCO's HMI. When the aircraft's route was displayed, the aircraft's ETA, FL and speed previsions from the EPP data were displayed on each waypoint or pseudo-waypoint (TOD for example). This basic implementation allowed to address one simple way to use the EPP data. It is not supposed to be the best, nor the preferred use, but it was the only implementation possible for this exercise.

Information on aircraft intentions provided by the EPP data are globally considered as usable. They were supposed to facilitate the provision of "When ready descend" clearances. However, the controllers did not use the TOD information, or marginally. The reason is not fully clear, but there may be a mix of different reasons:

- Controllers found that the EPP information displayed on the HMI was not visible enough, especially the TOD and the foreseen speed,

- ETA information on the different waypoints was judged as identifiable enough. However, it was not much used, because even in current operations the controllers do not use time information on waypoints for tactical actions.
- if the traffic was low, the controller doesn't need this information to instruct a descend when ready; if the traffic was high, the controller didn't have time to take it into account.

Conclusion:

The possibility to provide "When ready descend" clearances in E-TMA was assessed and controllers said they could instruct such clearances. However, the EPP information displayed on the ATCO's HMI (TOD, ETO, FL, speed), although usable, was not much used. Indeed, the controllers did not feel the need to use "raw" EPP data displayed on their HMI, mainly because there was no such need in their working method. This result is dependent on the conditions of this exercise, but it gives an indication that a simple display of "raw" EPP data is not sufficient to bring useful information to the ATCO.

A.3.4.3 OBJ-PJ.01.03-V2-VALP-RTS-005 Results

Description:

To assess how the priority given to capacity impacts the provision of "When ready descend clearances" in E-TMA

Success criteria:

- Controllers and experts indicate that the management of traffic (sequencing and priority given to capacity) still allows to facilitate optimized profiles for sufficient amount of flights
- Controllers and experts indicate that controllers' workload is maintained at an acceptable level optimised profiles are facilitated, compared to the baseline

Analysis:

Although the controllers globally considered that using "When ready descend" clearances did not noticeably increase their workload compared to usual traffic management, they indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and time for a closer monitoring of the aircraft following this clearance. It must be noted that no conflict detection tool was available, and no "what-if" probe either.

Conclusion:

In the context of this exercise, "When ready descend" clearances were not considered compatible with a high traffic load, or a high traffic complexity.

An insufficient training time with regard to the concept's novelty and to the procedural changes may have contributed to this negative result, as well as the lack of tools to compensate for less control on the start of descent.

A.3.4.4 OBJ-PJ.01.03-V2-VALP-RTS-006 Results

Description:

To evaluate if the ATCO's HMI is suitable for him/her to dynamically attribute E-TMA routes.

Success criteria:

- Controllers confirm that the tools available on the CWP allow them to choose alternative routes in an efficient way
- Controllers confirm that they are able to easily identify which route has been given to aircraft
- Controllers and experts confirm that routes can be sent to the aircraft in an efficient manner
- Controllers confirm that the coordination tool permits to make efficient coordinations with different sectors

Analysis:

The controllers indicated that the HMI was adapted to the dynamic attribution of routes. The sequencing manager could easily fill in the system with the chosen route. Difficulties linked with the HMI occurred in the cases when the executive controller had to attribute a route (which happened when the previously attributed route did no longer match the delay to be absorbed). When a flight was very near to a route intersection, the menu dedicated to route attribution on the radar screen was sometimes hidden by the label and could not be opened. Except for this case, the menu was judged as efficient.

The controllers confirmed that the coordination tool was efficient. They were aware when the upstream position replied positively or negatively to a request.

Once the flight crew had loaded the route in the FMS, the update of the EPP available on the radar screen allowed the controllers to check that the flight crew had correctly followed the instruction. However, due to the delay between the route selection and the EPP update on the radar screen, this check could not be performed systematically. It has to be noted that the update of the EPP data was immediate when the controller gave an alternative route to the traffic generator aircraft, which is not realistic, whereas this update could take more than one-minute for the PAS@ATM and VSIB aircraft, which is more realistic. The controllers indicated that displaying obsolete EPP information on the radar screen for a short time was acceptable, provided an HMI feedback notified that an update was ongoing. Further studies will have to address how to deal with the EPP update delay.

A point about coordinations was discussed during debriefings. Sometimes, a coordination was refused by the upstream position without operational justification. It happened when the flight was handed over to the next sector before the coordination could be addressed by the upstream sector. The coordination was subsequently automatically cancelled and refused. Further investigations are needed to define an efficient working method which could solve this kind of issue.

Conclusion:

The ATCO's HMI was suitable for him/her to dynamically attribute E-TMA routes, despite a defect on the EC's HMI in a specific situation.

The working methods must take into account the EPP update delay. A coordination with PJ18-02a is needed, to ensure this point is fully addressed and consider PJ18-02a work's outputs.

It is recommended that further work address more completely handover occurring during the dynamic attribution of route's process, to anticipate gaps, especially concerning coordinations.

A.3.4.5 OBJ-PJ.01.03-V2-VALP-RTS-007 Results

Description:

To assess the operational feasibility of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.

Success criteria:

- The proposed working method permit the controller to perform their task
- The information given by E-AMAN services permit to the ATCO to easily attribute a route
- Controllers and experts confirm that information given by E-AMAN does not change too many times and allows to build a stable strategy early enough
- It is feasible for the controllers to monitor the execution of alternative route
- It is feasible for the controllers to deal with several levels of equipage

Analysis:

The controllers indicated that the working method was efficient to attribute a route to absorb a delay and allowed them to manage the traffic when one or several aircraft followed a dynamically attributed route. The choice of the sequence induced more discussion between the sequencing manager and the executive controller than expected: the planning controller often wanted the executive controller approval before validating the order.

The controllers considered that although the sequence proposed by the AMAN was not always stable, they could build a stable strategy and attribute routes to absorb the delays. Nevertheless, during debriefings controllers indicated that the sequence should be stabilized a little before than during the exercise runs, in order to avoid late changes which are not easy to manage and increase the workload. Note that this point was identified but the moment of the stabilization was constrained by technical limitations, like some abnormal behaviour of aircraft during the end of the cruise phase. It has to be noted that the platform let the possibility to stabilize manually each flight

Due to technical limitations, the metering fix was positioned at ODILO IAF. This setting raised issues, because the routes concretely merge at CAD waypoint, which is 13 nautical miles upstream from

ODILO. They also reported that a “what if” tool giving the remaining time to lose depending on the alternative route chosen, could help with the route choice.

The sequencing manager reported that it is important to be aware about changes performed by the executive. Regarding this last point, the sequencing manager stated that he had some difficulties to correctly see the label displayed on the radar screen when the flight was near the IAF because the label could not be moved easily. For this reason, it was sometimes difficult for the sequencing manager to be fully aware of the sequence performed.

The controllers pointed out that the time to lose information was false when a heading was given to an aircraft. Indeed, the time to lose was calculated from the ETA coming from the EPP data, which is wrong when the aircraft is vectored.

The controllers indicated that they could monitor the traffic when routes were dynamically attributed to aircraft. However, the monitoring task was sometimes demanding and generated an additional workload. This happened when one aircraft arriving from ROLEN and one aircraft arriving from BEVOL had about the same distance to go to CAD. Those flights were separated when entering the sector (because coming from different flows), but their routes were merging at CAD. They were expected to be separated at CAD, thanks to actions on their speed profile (either thanks to speed instructions or to a CTA). As a consequence, the EC had to closely monitor that the CTA or speed adjustments were efficient and allowed to keep the aircraft separated and to respect the handover conditions. This is a limitation of the working method proposed for the solution scenario: nowadays, the controller starts by giving speed instruction to have an homogenous flow of traffic, then he adjusts when necessary by stretching the path of the aircraft thanks to vectoring, implying that two aircraft shouldn’t have the same distance to go at the same time. In the solution scenario and with the working method that was proposed, this case could occur leading to an increase of the monitoring activity. This could have been avoided if the sequencing manager could monitor the distance to go that would result from the route attribution.

In the figure below, the aircraft are too close to each other. The sequence can be achieved by the ATCO thanks to speed instructions or a CTA, but it will induce an increase in workload.

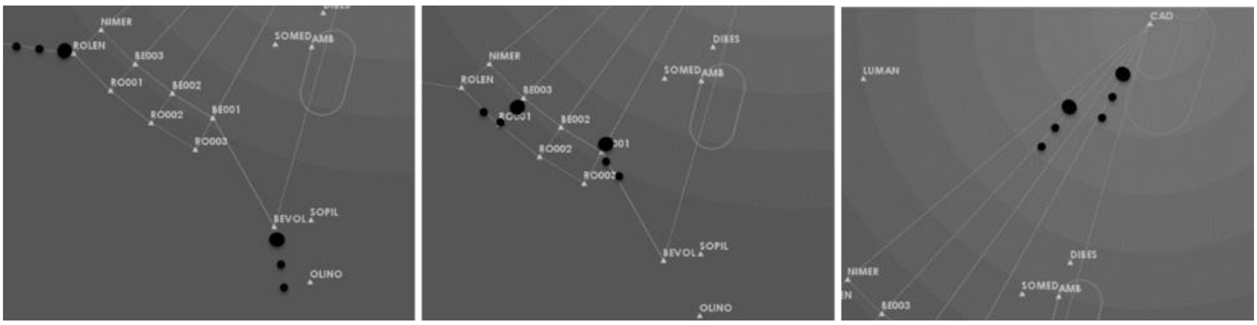


Figure 17 : sequence where aircraft are too close to each other

Thanks to a tool, the planning controller could have anticipated the case described above and eventually, attribute a longer path to the second aircraft (see figure below).

Figure 18: Example of "Distance to go" tool

Conclusion:

During this exercise, it was feasible to use the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.

It was possible to use the sequence and the delays proposed by the AMAN to build a stable strategy and attribute routes to absorb the delays. However an earlier stabilization of the sequence would be worth investigating. Indeed, the earlier the sequence is stabilized, the more risks there are to have to change it later, with a negative impact on the workload.

The application of the new concept entails a transfer of a part of the controller's activity from the active control task to the monitoring task. Limitations of the available tools and proposed working method may have negatively impacted the monitoring activity during the validation runs. Solutions are already envisaged to deal with this issue such as the "distance to go" tool (see figure 18), ghosts or a conflict detection and resolution tool.

A.3.4.6 OBJ-PJ.01.03-V2-VALP-RTS-008 Results

Description:

To assess the operational feasibility of recovering from a situation where dynamic attribution of route fails or is not sufficient (while still in nominal conditions) and fall back on today's method (based on vectoring).

Success criteria:

- When, in nominal conditions, the new method application must be interrupted while in progress, the ATCO can revert to the current method (based on vectoring), with no decrease of the safety level, keeping the workload at an acceptable level, and with no impact on the sequencing task.
- When, in nominal conditions, the new method application is not possible, the ATCO can use the current method (based on vectoring), with no impact on safety, and reasonable impact on workload and on the sequencing task.

Analysis:

The controllers considered that they could revert to the current method based on vectoring when the dynamic attribution of routes either failed or was no more adapted to the situation. Globally, they indicated that they had to revert to vectoring to make sure that the separation between aircraft would be maintained. One example of such a situation was caused by the unexpected behaviour of the PAS@ATM aircraft when sequencing the BEVOL and the BE00x waypoints (high angle transition between two legs). In this situation the controllers had to give a heading clearance to avoid a catch up with another flight. Although this case was linked with a simulation technical limitation, it was an opportunity to evaluate the use of vectoring as a fallback method. It also happened that the controllers had to use vectoring to make sure of the separation when they deemed that two aircraft belonging to different flows had almost the same distance to go to CAD. Nevertheless, the controllers indicated that globally, reverting to vectoring did not decrease their perceived safety level and that their workload was kept at an acceptable level. They concluded that both methods (dynamic attribution of routes and vectoring), could be used together in a consistent way.

Conclusion:

It is feasible to recover from a situation where dynamic attribution of route either fails or is not sufficient (while still in nominal conditions) and fall back on today's method (based on vectoring). In the context of this exercise, both methods (dynamic attribution of routes and vectoring) could be used together in a consistent way.

A.3.4.7 OBJ-PJ.01.03-V2-VALP-RTS-009 Results

Description:

To assess the acceptability of using the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, from a controller's perspective in nominal conditions.

Success criteria:

- No additional tactical interventions in comparison with the reference
- Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
- Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
- The ATCO is as much in control of the situation as with the baseline (situation awareness, monitoring possibilities, anticipation capacity, fall-back capability)

Analysis:

Controllers indicated that when a flight had to follow a dynamically attributed route, it did not lead to more tactical interventions compared to today's operations. Although their perceived safety level, workload and situation awareness are kept at an acceptable level, there is no strong feeling for the controllers to be as much in control of the situation as with the reference when they have to manage aircraft flying dynamically attributed routes. Indeed, the application of the new concept, when it unfolds nominally, leads to less ATC instructions in E-TMA, but requires more monitoring. This result of course depends on the exercise context (training time, route network, available tools).

Conclusion:

From a controller's perspective, it is acceptable to use the proposed Dynamic attribution of routes method to sequence and merge flows to an airport while ensuring separation, in nominal conditions. However the controllers did not feel as much in control of the situation as with the current procedures and working method. Indeed the new working method substitutes an active control task for a monitoring task.

It is recommended to further evaluate the concept providing the controllers with tools adapted to the activity's changes.

A.3.4.8 OBJ-PJ.01.03-V2-VALP-RTS-010 Results

The objective was to evaluate if the ATCO's HMI is suitable for him/her to use "Permanent Resume Trajectory", through the following criterion.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-010-001: Controllers confirm that tools available on the CWP allow them to use Permanent Resume Trajectory

For technical reasons and time limitations, the prerequisites to address this objective were not available: no ground tool to support the ATCO for anticipating the end of vectoring to pass it to the flight crew, current EPP standards and resulting implementation do not contain the virtual turning point when the aircraft is vectored (see 5.2.3 for a recommendation on this point). It was decided that the scenario would be only to evaluate the PRT from an on-board point of view. From the ground side, it was decided to instruct headings as in today's operations and provide a rough distance on heading generally when it was requested by the pilot (the ATCO acted as if he/she did not know the PRT functionality). The working method did not request the ATCO to check the route on the CWP.

For these reasons this objective was no longer relevant and thus not addressed.

A.3.4.9 OBJ-PJ.01.03-V2-VALP-RTS-0011 Results

The objective was to assess the operational feasibility of using Permanent Resume Trajectory, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-011-001: The proposed working method permit the controller to perform their task

The proposed working method was simplified, and only consisted in providing, when possible, the distance along track and/or the waypoint/leg intended for capture after a heading instruction. The objective was to tune the trajectory on board in order to make it consistent with the controller intent (anticipate the end of vectoring point / capture initial route point), without significantly impacting his/her workload.

A.3.4.10 OBJ-PJ.01.03-V2-VALP-RTS-012 Results

The objective was to assess the acceptability of using Permanent Resume Trajectory, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-012-001: No additional tactical interventions in comparison with the reference

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-012-002: Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-012-005: Controllers and experts indicate that no misunderstanding between information and clearances are induced by the use of a "Permanent Resume Trajectory"

During the evaluation, the use of the Permanent Resume Trajectory never led to additional tactical intervention in comparison with the reference. The ATCOs were not aware whether the PRT was computed / used in the aircraft or not, and so, it did not modify their behaviour nor induce any additional instruction. However, some information such as the end of vectoring point, or the leg to be captured were provided by the ATCOs to the pilot.

A.3.4.11 OBJ-PJ.01.03-V2-VALP-RTS-0013 Results

The objective was to assess the feasibility & acceptability of new operational methods from a pilot point of view, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-013-001: Pilots indicate that they can easily adapt their way of working with PJ01-03B new operational methods proposal
- Success criterion CRT- PJ.01.03-V2-VALP-RTS-013-002: Pilot confirm that new operational methods do not decrease level of safety and are acceptable with regards to their procedures (information's received on time to update FPLN or execute manoeuver requested)

From the flight point of view, route instruction entry into the Thales system was done through the Baseline 2 CPDLC message UM#266 route clearance from the ATCO control HMI to the avionics. This route clearance extends the initial route between a point A (BEVOL in this case) and a point B (ODILO in this case), adding "N" additional waypoints, each allowing a given distance/time extension (BE003 for instance extends by 3 minutes). In the cockpit/avionics, the insertion process involves both the ATC datalink (CATIM) and the FMS products. A message with the key elements of the route instruction (namely start, end points and extension) is first displayed to the pilot in the ATC datalink mail box (CATIM). Then, after review and response to ATC (STANDBY or ACCEPT), the crew is able to load the modified (extended) route into the active flight plan (FMS) from a secondary flight plan. This process has been judged rather easy, understandable regarding the route extension and time and efficient by Thales pilots.

Mail box example

Secondary flight plan on MFD and ND example

However, the use of the UM#266 route clearance message has to be evaluated against procedure loading from the navigation database which offers the advantage to permit late change. Depending on the context of occurrence, one method can be easier and faster than the other. CPDLC or voice depends upon the current communication means with ATC when loading (CPDLC with enroute sector for initial uplink and voice with E-TMA for modification during the experimentation for instance). In both case, pilots prefer having the route in the navigation database as an enroute transition (STAR ENRTE TRANS).

For the benefit of the exercise, on PAS@ATM simulators, Airbus decided to update the Navigation Data Base by adding the alternatives routes defined by the concept (4 new routes, BEVOLX were coded on PAS@ATM). This methodology has been recognized efficient by either laboratory test pilots or Air France pilots involved.

Another point is the way to communicate by voice about a route sent by CPDLC (for a confirmation for instance), the route name (e.g. BEVOL2) is not clear enough if not published on charts and not clearly displayed on the mail box (which is the case when using UM#266). The routes name should be known by anyone involved unambiguously. It might lead to misunderstanding when pilot is not able to clearly associate the route name with a list of waypoints upon voice controller request for modification/adaptation, and so decrease workload associated to alternative route attribution.

However, manual insertion of waypoints to define a new alternative route was also evaluated. Air France pilots involved stated they could implement maximum 3 waypoints if they are already coded in the Navigation Data Base, or only 1 waypoint if it's needed to create it based on coordinates provided by ATC (due to confirmation voice communications needed).

From Thales pilots' point of view, CPDLC route clearance (UM#266), that permits to receive and insert a new "part" of descent procedure (even a new complete STAR), will probably need more evaluations. For instance, ATCOs tried a few times to give a late route clearance without success. The use of this message implies that the uplink arrives soon enough (approximately 5 minutes) before BEVOL, otherwise the pilot does not have the time to insert this message. During the experimentations, the initial route was always on time and early enough. Sometimes the ATC tried to change it later by another one and it was not possible with this method (as the UM#266 is usable only before sequencing the first waypoint of the specified deviation).

With alternative routes implemented in the Navigation Data Base, Air France pilots involved admitted that one change of alternative route (from BEVOL0X to BEVOL0Y) was acceptable from a workload point of view thanks to CPDLC "free text" message. But, again, they confirmed, also during the debriefing sessions, it's comfortable to be informed of ATC intention (route instruction entry) prior to TOD, as played in the exercise, to well anticipate and prepare descent phase, (i.e. to manage aircraft energy).

From pilot's point of view, the experimental conditions were enough representative of operational conditions to evaluate the concept. For Air France pilots involved, the network of alternatives route created within the concept seems applicable to Paris E-TMA from an airborne side (of course, if approved by ATCO).

Moreover, pilots recognized that the concept of dynamic attribution of route allows anticipation of aircraft Energy management and so eases management of deceleration, even more with Continuous Descent Approach FMS function.

Even if, from pilot point of view, shorter routes with low speed are more efficient considering fuel burn, longer routes are acceptable regarding flight efficiency due to "descent when ready" method respecting FMS optimised TOD.

Further investigation will be needed to assess impacts on fuel burn (also because of lateral uncertainties detailed in chapter 4.3.3).

Other investigation requested by some actors of the exercise was to confirm that Navigation Data Bases will not be over loaded by the introduction of alternatives routes (this issue was identified during the conceptual note development process).

From Thales pilots' point of view, using the Permanent Resume Trajectory improved perceived safety level as it enables to display a vertical deviation even in heading mode. This feature helps for anticipation and energy management through a better situation awareness which contributes to reinforce safety.

Both Thales pilots reported that representing the controllers' intent had an added value for them. This trajectory "predictability" obtained thanks to the PRT, coupled with the RDTL (Required Distance To Land), helps them to anticipate future ATC instructions and aircraft limits.

Lateral instructions are still shown as usual with a cyan triangle for the target and a green plain line for the trajectory. The Permanent Trajectory information is provided through a green dashed line, while the flight plan is represented as a white dashed line. During the evaluations, neither Navigation Display nor Vertical Display symbology ever led to any misunderstanding.

Although the PRT function and, thus, its symbology were new for Thales pilots, none of them reported being misled by display items related to PRT and their FPLN.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-013-001: Pilots indicate that they can easily adapt their way of working with PJ01-03B new operational methods proposal

From Thales pilots' point of view, the trajectory predictions sent to ATC (EPP) is transparent as the reply to the ground contract request is fully automatic. Then, no adaptation of the current way of working on board the aircraft is required.

Same feedbacks were received by pilots using Airbus PAS@ATM simulators as EPP (because transparent from Pilot point of view) do not add any workload.

The use of CPDLC route clearance (UM#266) to receive and insert a new "part" of descent procedure (even a new complete STAR) has been judged feasible and acceptable but will probably need more evaluations. In particular, it has to be evaluated against procedure loading from the navigation database which offers the advantage to permit late change. Depending on the context of occurrence, one method can be easier and faster than the other. In both cases, pilots prefer having the route in the navigation database as a STAR ENRTE TRANS. Pilots also reported that they need some time to check the new route in the SEC FPLN, more than if the new route was part of the NavDB.

With the alternative routes defined in NDB, the pilots confirm being comfortable with dynamic attribution of route, no impact on pilot workload was identified. Moreover, pilots confirmed a late change is feasible (one time only, if TTL needs to be increased and implies a second attribution of a longer route).

Concerning the use of the Permanent Resume Trajectory, it does not require any specific crew action in a first step. As soon as the heading mode is activated to comply with the controller instruction, the PRT is computed to provide a continuous rejoin trajectory route from the current vectored track and vertical position to rejoin the FPLN. All the predictions provided are based on this explicit assumption, visible on the Navigation and Vertical Displays (ND/VD). This is totally feasible and acceptable.

Then, to adjust and tune this trajectory in order to match the controller intent, three manual adjustments in the avionics have been prototyped: the “Keep Track Until”, the “Capture At” and the “Delete Before” capabilities.

During the evaluations, the “Delete Before”, that aims to clean up certain waypoints in the FMS flight plan when necessary, was not used as it was not necessary in the context of the experimentations.

The “Capture At”, that aims to ensure that the PRT rejoin trajectory will capture a designated leg, has been judged useful and satisfactory. It represents the ATCO expectations when he provides the flight plan waypoint at which the vectored manoeuvre should terminate.

The “Keep Track Until”, that permits to define a distance along the vectored heading instruction before turning to rejoin the flight plan route, was the most widely used capability during these experimentations, probably because the controller briefing focused on this capability. It has been judged rather useful and satisfactory but several points might be further studied. One pilot estimates that it is rather useless if the information is not transmitted in the EPP and useful for the ATCO. He also mentions that the distance along the vectored heading provided by the ATC should be accurate; otherwise he prefers to still consider the worst case as today, based on his own experience.

Both Thales pilots have verbally reported that the KEEP TRACK UNTIL functionality would be easier to use if the distance value (and/or the time) was displayed and tunable while setting graphically on the interactive Navigation Display. This would save them some mental workload and provide more accuracy. The pilots would have preferred to enter the numerical value (e.g. through a numerical value edit box) provided without modifying the EFIS range.

Moreover, as the communication with the ATC might be complicated on frequencies that are already quite busy, even if the value is not provided, the crew would also appreciate to tune the trajectory based on its own experience flying into a specific airport. In this case, the trajectory might not represent the controllers’ intent but it could help the crew to analyse its energetic situation.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-013-002: Pilot confirm that new operational methods do not decrease level of safety and are acceptable with regards to their procedures (information’s received on time to update FPLN or execute manoeuver requested)

All the new operational methods do not decrease the level of safety and are considered acceptable by the pilots. However, according to when the new route message is received, the pilot may not be able to respond quickly if he is already engaged in a demanding task (same as today); the pilot will need to prioritize his activities. Additionally, and as explained before, checking the content of the SEC FPLN before swapping with the ACTIVE FPLN takes some time. Therefore, the pilot may not be able to accept dynamic route modification if they are used as tactical instructions and come too late. Hence, dynamic route attribution is more a strategic operational method than a tactical one as the radar vectoring is.
On Airbus PAS@ATM simulators, pilots recommended to use the CPDLC message “STAND-BY” (as of today, pilot action on DCDU, but not implemented in the RTS exercise) to communicate that the pilot needs time to accept the ATC instruction received.

A.3.4.12 OBJ-PJ.01.03-V2-VALP-RTS-014 Results

The objective was to evaluate how ADS-C (EPP) data can facilitate CDO operations, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-014-001: Issues linked with EPP uncertainty are assessed by both pilots and controllers

From Thales and Airbus pilots' point of view, trajectory predictions sent to ATC (EPP) is transparent as the reply to the ground contract request is fully automatic. However, uncertainty is the one of the FMS predictions and then, is the same for all actors (crew and ATC). Some assumptions linked to speed management, specifically in selected speed mode, might lead to temporary EPP deviations. For instance, when in selected speed in cruise phase, the speed deselection point, which consists in a reversion in managed speed, is located at the Top Of Descent. But when sequencing the ToD still in selected speed, it changes to be the point where a deceleration is required to match the next speed constraint, for instance the speed limit at 250 knots at FL100. This assumption is the system "best guess" and is due to the fact that it does not know when the crew will engage the managed speed. This leads to speed, thus to time predictions discontinuity during the flight, which are visible in the EPP and might impact the dynamic route attribution consistency in particular. To solve this issue, when such reliance is required, the flight crew should either revert to managed speed at the ToD when authorized by the ATCO (pilot might request to switch to the managed speed when sequencing the deselection point on the Navigation Display), or enter the selected descent speed into the FMS, as the new descent speed. The second solution also requires an ATC procedure: the ATCO must provide the required descent speed for traffic management early enough prior to the Top of Descent.

Nonetheless, it has to be noted that the EPP contains the speed information that could be helpful for the ATCOs to identify a discrepancy between the expected speed profile and the one computed by the FMS. When this kind of discrepancy exists, FMS time predictions at the feeder fix should be judged non relevant and should not be used for dynamic route attribution. It is not realistic to assume that the ATCO will have time do this analysis, but it could be done automatically by the ground system.

As long as the use of EPP profile by the ATCOs is transparent to the pilot and does not add more mental charge or uncertainties, which was the case here, it is acceptable from a Human factors point of view on the airborne side.

Conclusion:

The exercise allowed to address issues linked with EPP uncertainty. In particular discrepancies between the FMS hypotheses and the ground expectations, especially about speed, may impact the dynamic route attribution consistency and disturb the controllers' activity.

The EPP data contain information which may solve this issue: the necessary analysis cannot be done by the controllers, but could be done automatically by the ground system.

A.3.4.13 OBJ-PJ.01.03-V2-VALP-RTS-015 Results

The objective was to evaluate pilot workload with new operational method, through the following two criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-015-001: Pilots assess and confirm increase of workload is acceptable with regards to increase of flight efficiency

All pilots reported being rather satisfied with the new functionalities brought in this experiment in terms of flight efficiency. They nonetheless also pinpointed that the cockpit simulated systems on a computer instead of a real cockpit led to higher mental workload ratings than expected. This shows that additional experiment in more realistic environment will be of interest in terms of crew workload impact evaluation.

It is remarkable in the NASA TLX results that there is a clear tendency to observe lower mental workload in runs in which radar vectoring was not used. PRT has proved to be helpful to pilots (especially in terms of situation awareness) but it is a quite complex function that pilots need to become acquainted with by training. The present experiment could be considered as a first encounter with the function thus providing higher levels of mental workload in runs with radar vectoring, even when PRT was used, when compared to runs without radar vectoring. Further experimentations and longer exposure to PRT would be necessary to account for the real impact of PRT on pilots' workload. PRT capability will certainly reduce the mental workload compared to current vectoring operations, as it provides a clear and explicit assumption of the trajectory to be flown.

That said, no pilot reported that the PRT could jeopardize the safety of the flight. Rather, the PRT is perceived as a complex but valuable function to help the pilot manage the A/C energy, especially in Descent and Approach phases, and thus, to improve the safety of the flight in radar vectoring. Previous experimentations with the PRT have underlined the need for training for the PRT, but also that it provides precious information for the pilot when ATC traffic manoeuvres are performed. To some extent, PRT algorithms might benefit from contextual information of the surrounding traffic the ATCO has to manage in order to provide even purposeful and better contextualized trajectories.

EPP and dynamic routes allocation functionalities are either transparent for the pilot (EPP) or equivalent to changing the STAR on the ARRIVAL FMS page. NASA TLX recordings tend to show a reduced self-rated mental workload of the pilots.

All pilots which used Airbus PAS@ATM simulators feel comfortable with anticipated awareness received with dynamic attribution of routes. Furthermore, no added task or uncertainties was identified by concept implementation (as EPP is transparent from pilot point of view and alternative routes available in NDB). Moreover, with Continuous Descent Approach function active, anticipation was judged satisfactory allowing managed mode descent and re-cruising method to optimize the flight until final approach thanks to “descent when ready” method. Also, pilots seems to be comfortable with safety aspects (no impact reported) with these new operational methods.

A trend of fuel burn reduction has been identified on Airbus PAS@ATM simulators, confirming OSED theoretical studies: flying closed routes allows FMS to optimise vertical aircraft path. Further investigations will be needed to confirm this trend trying to decrease lateral uncertainties and evaluate the gain of PJ01-03B procedures with regards to baseline scenario.

- Success criterion CRT- PJ01.03-V2-VALP-RTS-015-002: Pilots confirm that workload associated to new operational methods does not decrease safety.

Since the dynamic route allocation tends to decrease the workload of the pilots, it almost certainly does not degrade the safety of the flight.

Although radar vectoring operations showed a tendency to raise a bit the mental workload of the pilots (with the current level of training), the PRT capability unanimously was perceived as a precious help by the pilots when they are not flying in managed modes. Especially, they consider that their situation awareness was greatly improved.

Taken altogether, these early results and pilots concept evaluations show that safety is not negatively impacted by these new operational functionalities.

A.3.4.14 OBJ-PJ.01.03-V2-VALP-RTS-016 Results

The objective was to identify traffic condition limitations with regards to CDO optimization

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-016-001: PJ01-03B team assesses and confirms from which level of traffic, controllers can't authorized CDO optimization

This objective's results were collected at the same time as OBJ-PJ.01.03-V2-VALP-RTS-018 results. The analysis is provided in A.3.4.16.

Conclusion:

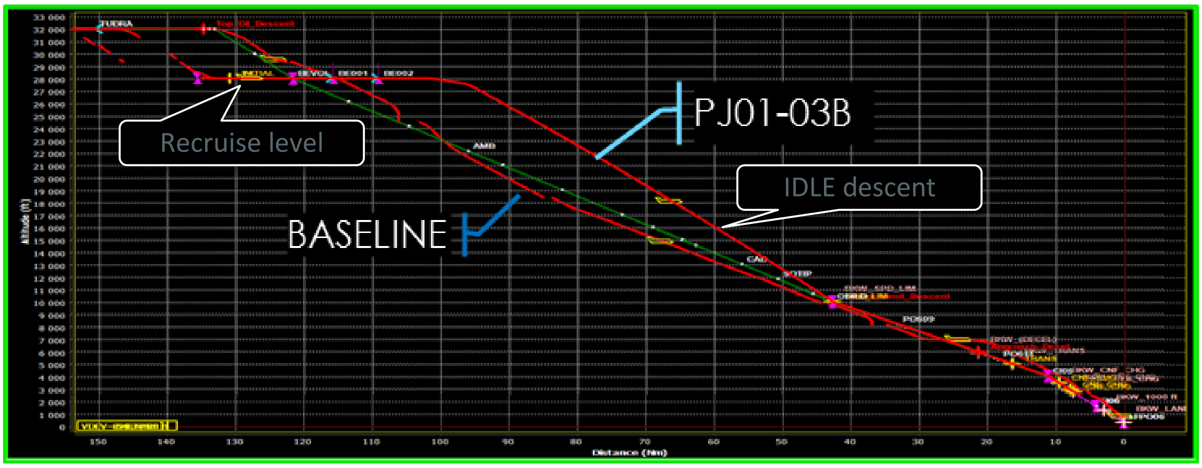
From a ground side perspective, and in the context of this exercise, the "when ready descend" procedure was not considered compatible with a high traffic load, or a high traffic complexity. The ATCOs indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and when there is time for a closer monitoring of the traffic.

A.3.4.15 OBJ-PJ.01.03-V2-VALP-RTS-017 Results

The objective was to identify new operational method noise impact and fuel efficiency, through the following criteria.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-017-001: PJ01-03B team evaluate theoretical noise impact of new operational method in comparison of current operational method (if data available)

Regarding Thales results, noise data are not directly available. However, on Thales flights, dynamic route attribution eases CDO and "recruising" procedure enables to stay higher longer on a closed path, and therefore, reduces global noise footprint on ground. In this case, only the upstream part of the profile is higher due to the constraint at ODILO at FL100.



Session 1 / Run A : THALES altitude profiles comparison between baseline and new concept

This profiles illustrates that partial CDA, including a level-off (recruise level at higher altitude), might be more efficient than full CDA with an early descent, with regards to flight efficiency. It has to be noted that full "early" CDA is not always performed and that ATCOs make the aircraft descend from FL280 later in most of the case.

- Success criterion CRT- PJ.01.03-V2-VALP-RTS-017-002: PJ01-03B team evaluate theoretical fuel efficiency of new operational method in comparison to current operational method (if data available)

Regarding Thales results, even if fuel data are fully available, various factors make it difficult to provide full conclusions about fuel analysis.

First, an important dispersion has been observed even on a same traffic sample, with the same traffic conditions. As the system is not fully automatic, as there are humans in the loop, each action might introduce some variability and impact fuel consumption depending on the timing, the human appreciation and reaction, etc. The five different [pilots / controllers] combinations led necessarily to different results.

Moreover, only few flights have been done with Thales aircraft. First session includes 7 flights, and second session includes 8 flights. This provides a trend, but statistically there are too few samples to draw a full conclusion on fuel consumption. Hence, 15 flights are distributed with 5 traffic conditions.

It has to be noted that, according to controllers' expertise, the vertical profile observed on the Thales baseline flight does not represent the current practice, as the aircraft are normally cleared for descent later, around AMB. Hence, the results of this analysis have to be considered as a comparison between a geometric descent starting at BEVOL which would result from a FL280 constraint at BEVOL and a FL100/250kts constraint at ODILO , and a situation where the FMS has calculated a new TOD to reach an idle path. It must be noted that the vertical profiles achieved in current operations (descent from FL280 around AMB) are closer to the idle path. These two sessions include only one baseline flight (Session 1 / Run A) that has been done without any new capability. The idea was to get a reference without EPP/PRT/UM#266 in order to represent current aircraft operations. All the other runs have been dedicated to the new concepts to maximize the exposure.

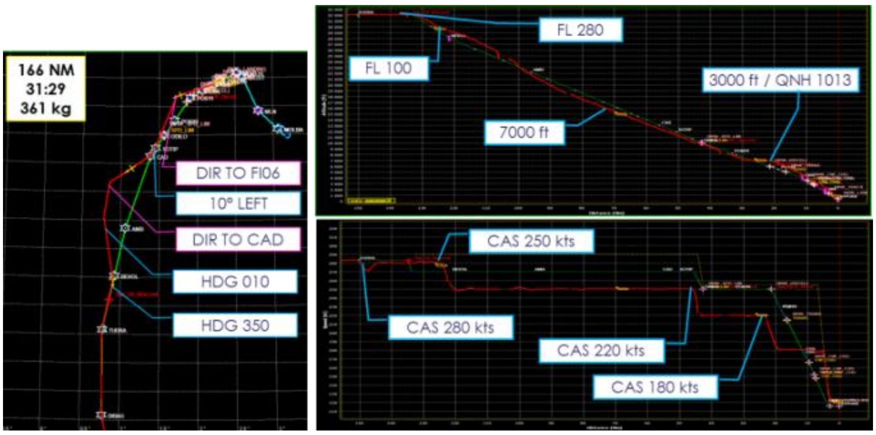
Session	Scenarios	Time at DIBAG waypoint	Pilot	E-TMA Controllers	ODILO air flow	MOLBA air flow

	A (BASELINE)	06:02	1	A / B	19 jets / 1 props	5 jets
	D	06:11	1	A / B	12 jets / 2 props	7 jets / 1 prop
	E	06:01	1	A / B	17 jets / 1 prop	4 jets / 1 prop
1	F	06:09	1	A / B	13 jets / 2 props	8 jets / 1 prop
	E	06:01	1	A / B	17 jets / 1 prop	4 jets / 1 prop
	I	05:57	2	A / B	19 jets / 1 props	5 jets
	A	06:02	1	A / B	19 jets / 1 props	5 jets
	A	06:02	3	C / D	19 jets / 1 props	5 jets
	B	06:14	3	C / D	13 jets / 2 props	8 jets / 1 prop
	E	06:01	3	C / D	17 jets / 1 prop	4 jets / 1 prop
2	B	06:14	3	C / D	13 jets / 2 props	8 jets / 1 prop
	E	06:01	3	A / D	17 jets / 1 prop	4 jets / 1 prop
	B	06:14	3	A / D	13 jets / 2 props	8 jets / 1 prop
	E	06:01	3	E / D	17 jets / 1 prop	4 jets / 1 prop
	F	06:09	3	E / D	13 jets / 2 prop	8 jets / 1 prop

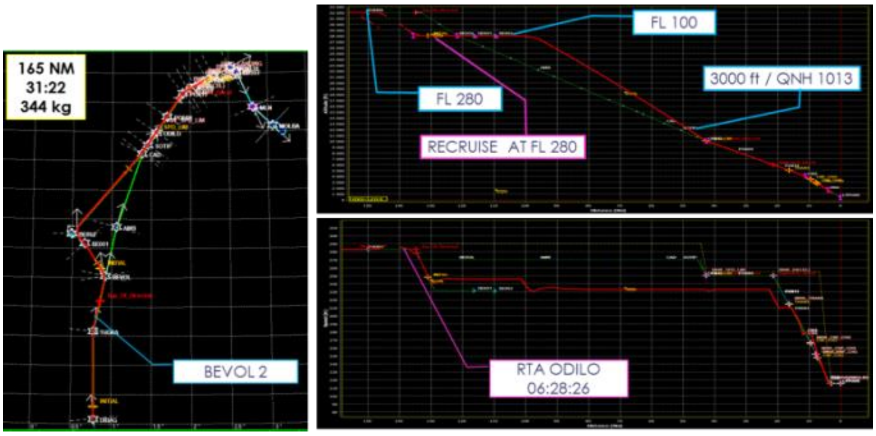
Session variability description for Thales aircraft

However, even if a quantitative analysis is not relevant due to the previously explained factors, the experimentation shows how the concept can improve flight efficiency. Theoretically, a dynamic route coupled with re-cruising operation improves the fuel efficiency compared to a geometrical descent between BEVOL and ODILO. It is clearly more efficient to stay higher longer, at a recruise level and to recompute another top of descent followed by an idle descent segment, instead of starting a geometric descent earlier as it is done with an AT altitude constraint at BEVOL. As said before, this higher profile is closer than what is done on this sector in current operations but this good practice is easier on a closed route, when distance to destination is known on-board. That is why constraints at FL 280 have been defined on the dynamic route after BEVOL. It leads to fuel savings as long as the aircraft is able to descend at idle thrust.

As an example, during the first session and second run A, the dynamic route coupled to a RTA (Required Time of Arrival) at ODILO, including a re-cruising operation, led to a smooth descent profile and reduced slightly the fuel consumption compared to the baseline (first run A).



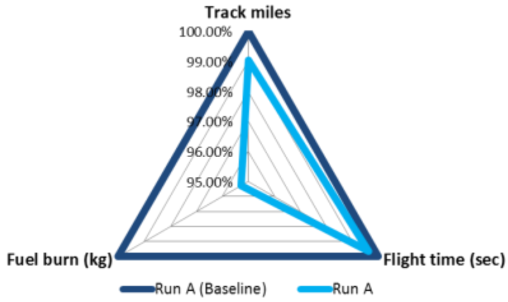
Run A: Baseline lateral, vertical and speed profiles (boxes show ATC clearances)



Run A: New concept lateral, vertical and speed profiles (boxes show ATC clearances)

In this case, track miles (166 vs 165 NM) and flight time (31:29 vs 31:22) between TUDRA and destination are equivalent but fuel burn is reduced by approximately 5% between TUDRA and 1000ft. It shows that the same "time to lose" objective was converted into the same track miles but with different methods. About half of this benefit can be attributed to the part of the flight in the sector under test.

But the flight has been recorded from cruise level to final approach, and on this overall descent profile, the two flights are comparable in terms of distance and flight time .



Run A: Baseline versus new concept flight efficiency comparison

Yet the two runs cannot be fully compared, as the sequence was different between the two runs. Moreover, in the baseline an additional delay was absorbed in the TMA because the time at ODILO was not respected by the ATCO, whereas in the solution run, the delay sharing was better respected. The delivery at ODILO is different. In the baseline, the standard handover condition (FL100, 250kts) is not respected. The reason could be that for human factors and training issue (this is the first run of the session), the Thales flight was too close to the preceding aircraft.

Although not fully satisfying in terms of quantitative results, this case allows to better understand the experimental design necessary to perform a quantitative analysis. Further studies will have :

- to include the TMA sector to evaluate the global benefit and ensure coherent experimental conditions throughout the descent,
- to make sure there is enough baseline and solution data to make a comparison. In particular, the delay to be absorbed in E-TMA and TMA, the speed and altitude of the aircraft on the IAF will have to be comparable between the runs.

A dynamic and "closed" route, with recruise level followed by an idle descent, is then more fuel efficient and comfortable for the crew than an "open" route (vectoring).

A.3.4.16 OBJ-PJ.01.03-V2-VALP-RTS-018 Results

Description:

To assess the operational feasibility, from a controller's perspective, to provide "When ready descend" clearances in E-TMA

Success criteria:

- The proposed working method permit the controller to perform their task
- The information about aircraft descent intentions available for the ATCO permit to facilitate the use of optimised profiles from TOD
- The controllers can monitor the flights executing an optimised descent as easily and safely as usual
- No additional tactical interventions in comparison with the reference
- Controllers and experts indicate that the change does not lead to a deterioration of perceived safety level, compared to the baseline
- Controllers and experts indicate that controllers' workload is maintained at an acceptable level with the tested method compared to the baseline
- The ATCO is as much in control of the situation as with the baseline (situation awareness, monitoring possibilities, anticipation capacity, fall-back capability)

Analysis:

The proposed working method was judged as relevant. As already mentioned, information on aircraft intentions provided by the EPP data are globally considered as usable. Nevertheless, the reliability of the TOD information was questioned during the debriefings. Indeed, the controllers considered that when they clear an aircraft to descend when ready, the flight crew has the possibility to start the descent in accordance with the FMS calculated TOD or not (they may descend before this TOD or after, for any reason). For this reason, the controllers consider that the TOD Information displayed on their HMI is not fully reliable. As a consequence, if there is a risk of conflict (even the smallest one), either they do not use this clearance, or they need to increase the monitoring of the corresponding aircraft, with a negative impact on the workload.

Three controllers considered that it was feasible to manage the traffic in an efficient way when flights were cleared to descend when ready, but one controller said it was not feasible. The three first controllers considered that, during the runs, the situation was maintained safe. Nevertheless, they expressed reservations during the debriefings, explaining that the "When ready descend" procedure led to a too important activity of monitoring. Indeed, controllers often need to put constraints on flights to ensure separation. If they do not, they have to monitor the flights more closely. It has to be noted that constraints do not necessarily prevent the use of "When ready descend" clearances (for example a clearance to an intermediate flight level). However this was not evaluated during this exercise.

Conclusion:

The controllers consider that the TOD Information, provided in the EPP data and displayed on their HMI, is not fully reliable, because they are not sure that the flight crew will comply with this information.

From a ground side perspective, and in the context of this exercise, the "when ready descend" procedure was not considered compatible with a high traffic load, or a high traffic complexity. The ATCOs indicated that they would use this kind of clearance only in low traffic conditions when there is no risk of conflict and when there is time for a closer monitoring of the traffic.

A.3.4.17 Results on CTA/RTA operational use in the dynamic attribution of routes context

During this exercise, the CTA/RTA was used as a complement to the dynamic attribution of route. The route was attributed first, associating a route to a TTL thanks to a rough calculation (the assumptions were: fixed average speed, no wind, theoretical vertical profile, standard behaviour). The working method given to the controllers was: the first minute is absorbable by a speed reduction on the shortest track, then every supplementary minute is absorbed by a route extension. This working method was chosen as it was easy to use and did not need any support tool, although it could be refined with the use of a tool giving pairs of route/ expected speed to absorb the delay. The role of the CTA/RTA used in combination with a route was to account for real life deviations in comparison to the rough assumptions, and make the aircraft respect the Scheduled Time of Arrival over the metering fix precisely, thus refining the sequence.

The controllers indicated that the behaviour of aircraft flying to a CTA was not easy to anticipate and thus led to an important monitoring activity to make sure there would be no loss of separation. One controller said that monitoring aircraft flying to a CTA was possible only in low traffic conditions. Indeed, he considered that if something happened it would be too complicated to give heading or speed clearances to each aircraft that were flying to a CTA.

The need to reduce the workload associated with this monitoring activity and make it easier was expressed during the debriefings. The controllers felt that an information about IAS was missing and would be helpful to assess the effect of the CTA on the speed. The controllers consider that a conflict detection tool is needed to safely monitor aircraft flying to a CTA. They reported that managing a mixed traffic (CTA, non-CTA aircraft) seems complicated, although this condition was not assessed during the experimentation. Further investigation is needed to confirm this feeling. Observations during the experimentation have highlighted the need for sufficient training about the communication between controllers and pilots concerning CTA/RTA clearances. Indeed, as the training was insufficient on this topic, when controllers gave a clearance (heading or speed) to an aircraft already flying to a CTA, it was not clear for the pilot to know whether the aircraft had either to maintain the CTA or to cancel it.

Conversely, when a pilot received a clearance, the capacity of the aircraft to comply with the CTA or not was not clear for the controller (it is important to note that in this exercise CTA were used without application of the i4D concept, i.e. without the controller knowing the ETAmin/ETAmax over the CTA waypoint). However, in the second session, a tool was available on the executive controller HMI to monitor if the ETO provided in the EPP was consistent with the CTA instructed by the controller, but the lack of training does not permit to conclude if this is sufficient.

Due to Airbus PAS@ATM simulators capabilities, RTA has been evaluated and used as soon as possible, either by voice ATC request or thanks to CPDLC messages.

Prefer pilot way of working is of course by CPDLC to avoid increased workload associated to needed confirmation communication.
Pilots sometimes had issues with RTA when new ATC order were received (speed instruction) but it has been judged manageable as soon as ATC confirm or cancel RTA in the speed instruction message (from airborne point of view, RTA is by default erased by any new ATC instruction).

Also, laboratory test pilots confirmed that one change of RTA is acceptable.
Setting RTA in the Flight Management software takes time. One request from the pilots was that, when feasible, controllers try to anticipate requests to pilots.

Air France pilots involved raised a warning about FM software's discrepancies behaviour (RTA implementation is not normed). The impact on lateral separation and associated margin needs to be further investigated.
On the other hand, they appreciate RTA in operations because FM software predictions, and so RTA speed target, are not frozen in OPEN DES mode (FM software consider an immediate return to vertical managed navigation mode and RTA speed targets are continuously updated).

But pilots recognized, during the debriefings, that RTA could be difficult to use in high density traffic to ensure lateral separation of mixed fleet without ATC speed instruction.

A.3.5 Unexpected Behaviours/Results

No unexpected behaviours or results were identified.

A.3.6 Confidence in Results of Validation Exercise 1

1. Level of significance/limitations of Validation Exercise Results

The level of significance or limitations of validation Exercise Results are the same at exercise level and at solution level. See 4.3.1.

2. Quality of Validation Exercises Results

The quality of Validation Exercise Results is the same at exercise level and at solution level. See 4.3.2.

3. Significance of Validation Exercises Results

The significance of Validation Exercise Results is the same at exercise level and at solution level. See 4.3.3.

A.3.7 Conclusions

1. Conclusions on concept clarification

The conclusions on concept clarification are the same at exercise level and at solution level. They are therefore presented in chapter 5.1.2.

2. Conclusions on technical feasibility

The conclusions on technical feasibility are the same at exercise level and at solution level. They are therefore presented in chapter 5.1.3

3. Conclusions on performance assessments

The conclusions on performance assessment are the same at exercise level and at solution level. They are therefore presented in chapter 5.1.4.

A.3.8 Recommendations

The recommendations are the same at exercise level and at solution level. They are therefore presented in chapter 5.2.1

Appendix B Validation Report EXE.01-03B.020

This section provides the Exercise Report for Exercise PJ.01-03B.020

B.1 Summary of the Validation EXE.01-03B.020 Plan

Described in section 5.2 of the VALP [4]

B.1.1 Validation Exercice description scope

This validation exercise has been executed under the scope of EXE-01.03B-02.01. The exercise consists on a Fast Time Simulation on the Stockholm TMA operational environment, aimed to demonstrate the benefits of the conflict resolution though the provision of optimised Rate of Climb and Rate of descent profiles against tactical level offs.

SESAR Solution Validation Objective ID	**EXE-PJ.01-03B-VALP-V2.02.** A-CDO/CCO facilitation through the provision of an optimised ROC/ROD
Leading organization	ENAIRE/INECO
Expected Achievements	Reduce Emissions Reduce fuel burn Ensure the facilitation of CDO/CCO by reducing the number of tactical level offs
Validation Objectives	OBJ-PJ.01.03b-VALP-FTS-0001 OBJ-PJ.01.03b-VALP-FTS-0002 OBJ-PJ.01.03b-VALP-FTS-0003
OI steps addressed	AOM – 0702-B Advanced Continuous Descent Operations AOM0705-B Advanced Continuous Climb Operations.
Enabler	ER APP ATC 120 — Enhance Conflict Detection and Resolution to Use the RBT/RMT
V Phase	V2
Validation Technique	Fast time simulation
KPA/TA Addressed	TMA Capacity Cost Efficiency Environmental Sustainability Flight Efficiency
Validation Platform	RAMS PLUS

Table 6: Summary of Validation Exercises

Exercise Preparation

The Fast Time Simulation was performed with RAMS Plus simulation tool and with the additional support of EUROCONTROL's NEST tool to obtain the traffic sample for the simulation and the Stockholm TMA sector design.

Prior to the execution of the exercise, the modelling of the simulation environment was supported by the feedback of COOPANS' operational experts to:

- Ensure that the design of the approach and departure routes of the validation scenarios was coherent with Stockholm´s TMA procedures.
- Ensure that the simulation traffic sample met the required safety levels of separation, speed climb/descent rate and altitude.

Once the validation scenarios were defined, the simulation experts modelled the approach and departure routes in the simulation platform and configure the tool´s rule base to ensure that the traffic execute the simulated procedures for both, the reference and the solution scenario.

The departure procedures were modelled according to the information available in the AIP while the approach procedures follow the STARs chart provided by COOPANS previously used in other SESAR validation exercises

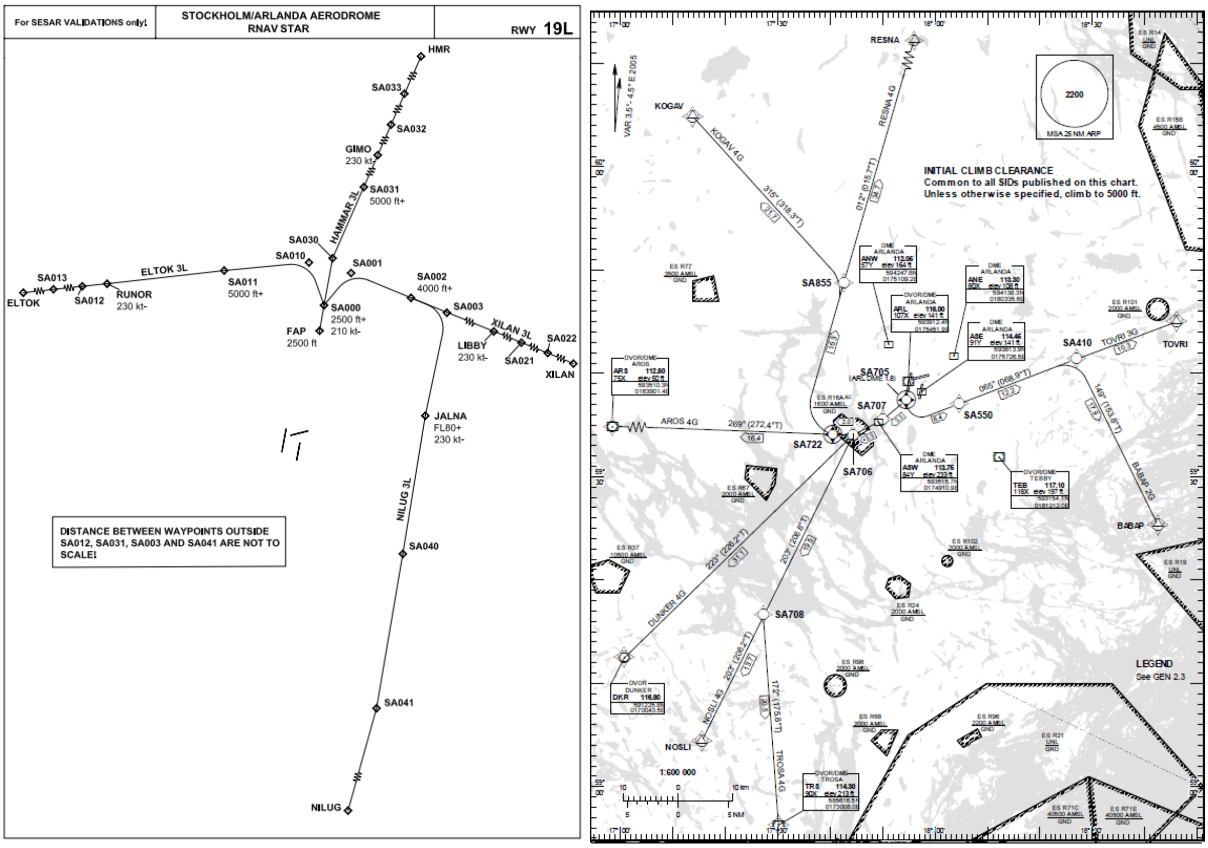


Figure 19: SIDs and STARs charts of Arlanda airport

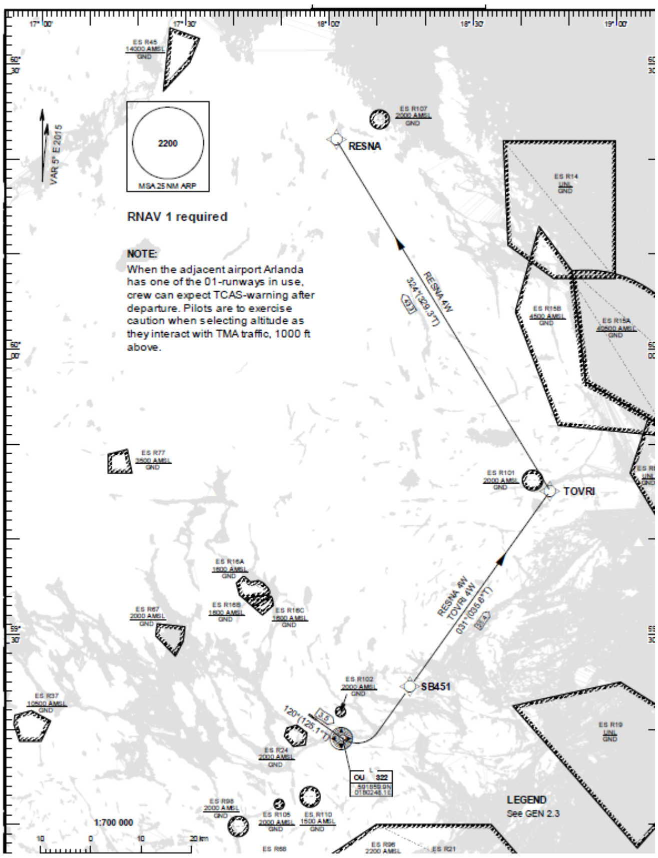


Figure 20: SID charts of Bromma airport

The particular focus of the simulation are departures/arrivals from/to Arlanda airport and departures from Bromma airport. For this exercise, the runway configuration for Arlanda airport that will be simulated are departures on Rwy19R and arrivals on Rwy19L, as they are confirmed to be used during peak traffic periods.

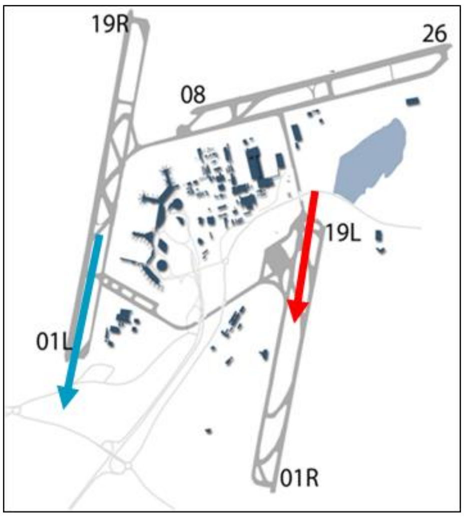


Figure 21: Arlanda RWY Configuration

The airport traffic distribution for each runway is represented in the following figure

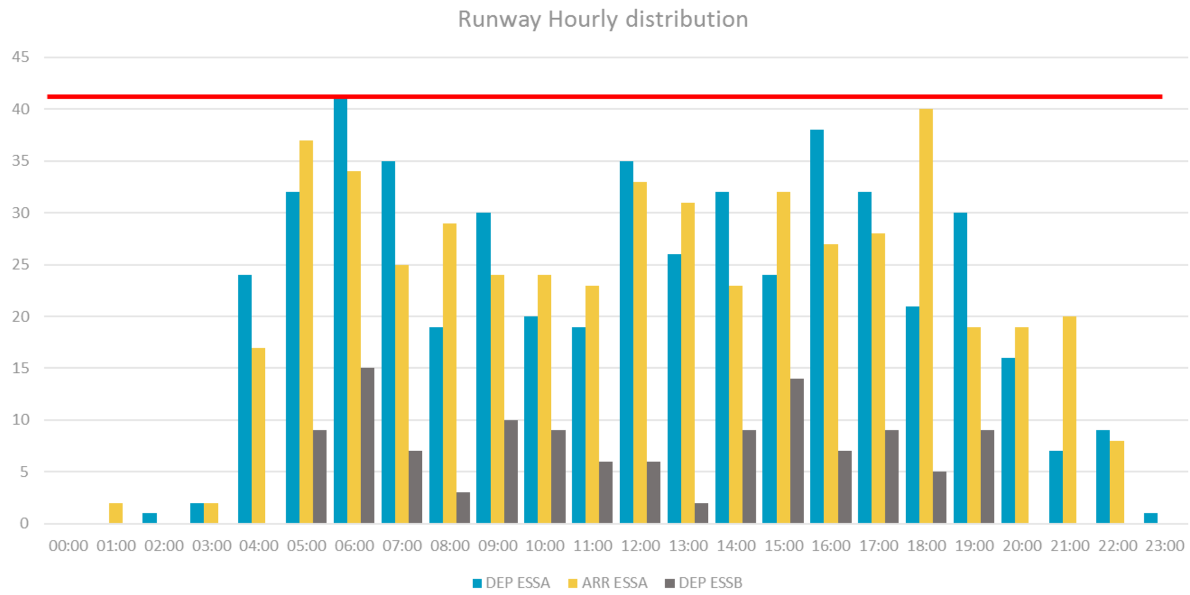


Figure 22: Arlanda and Bromma hourly operations per Runway

The Stockholm TMA is divided in three elementary sectors as shown in the following picture

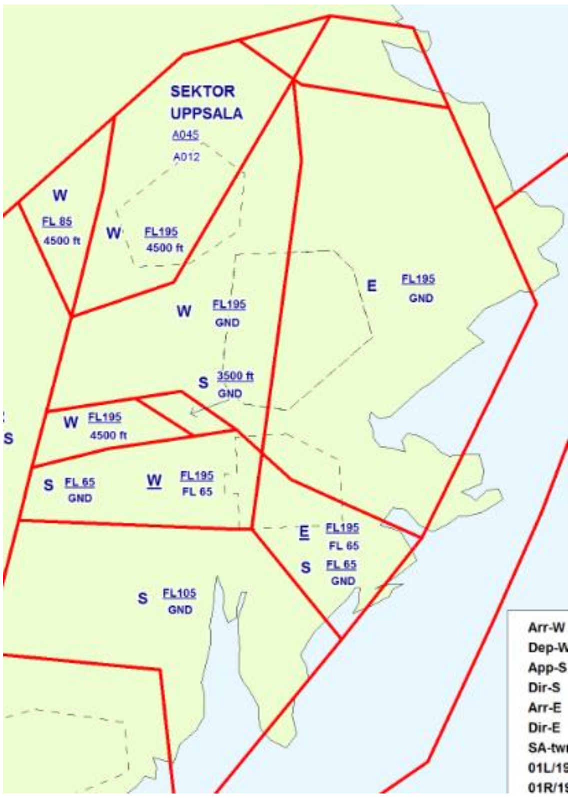


Figure 23: Stockholm TMA Sectorization

In the simulation exercise, the whole traffic of ESSATMA was simulated, though, the main study is focused in the east **sector ESSAE**, where the focus area of conflicts between ESSA and ESSB takes place. This sector encompasses the departures from Arlanda airport (ESSA) through SID TOVRI and SID BABAP, arrivals to Arlanda through STAR NILUG and STAR XILAN, departures from Bromma airport via TOVRI (ESSB).

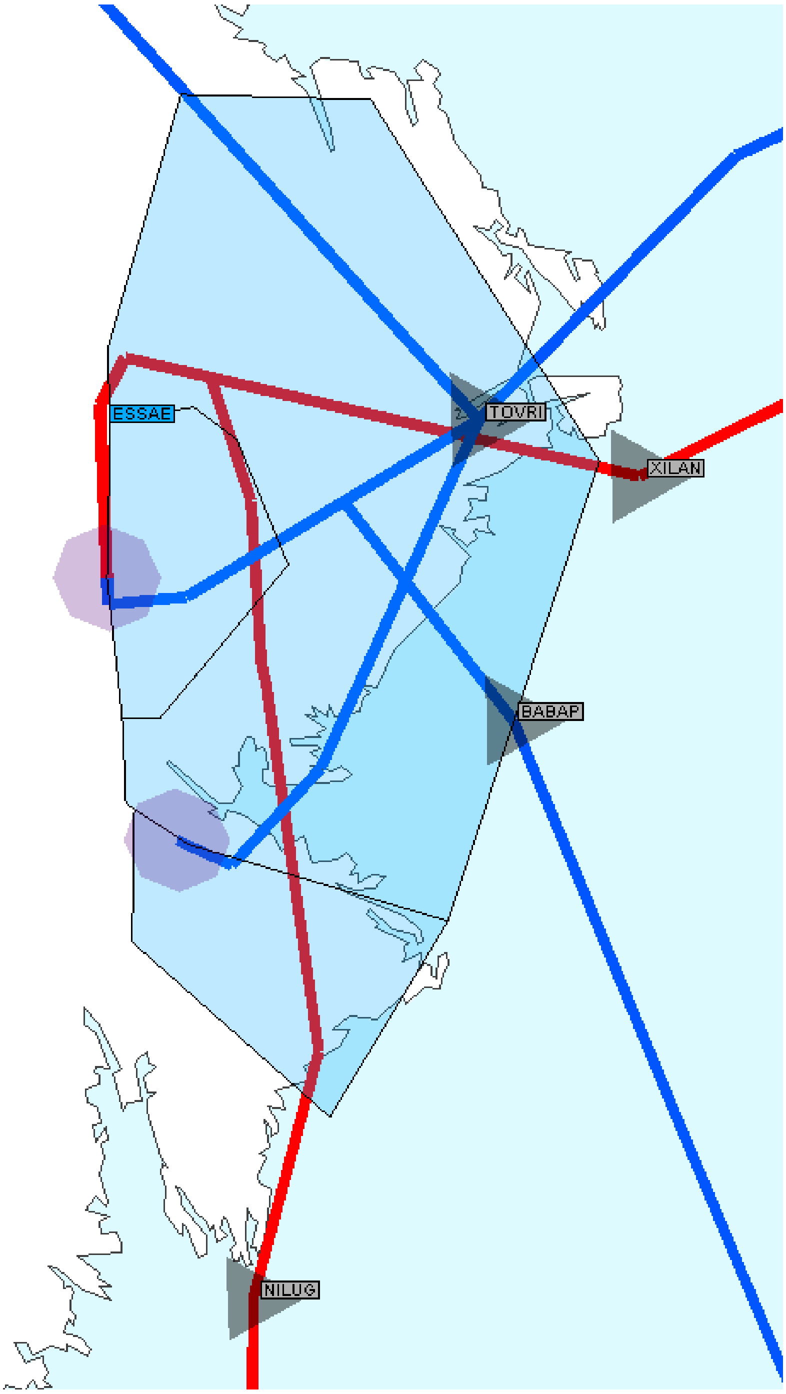


Figure 24: ESSAE sector procedures under study

For the conflict detection it was designed an uncertainty bubble according to operatinal experts indications (minimum required separation + mental safety buffer). This bubble allows that the simulation platform could detect conflicting aircraft crossings and to ensure, that once applied the resolution measures, the conflict disappears.

Reference scenario	Solution Scenario
LATERAL NM = 5 LONGITUDE NM = 5 SEPARATION ABOVE =2000FT SEPARATION BELOW =2000FT	LATERAL NM = 4 LONGITUDE NM = 4 SEPARATION ABOVE =1500FT SEPARATION BELOW =1500FT

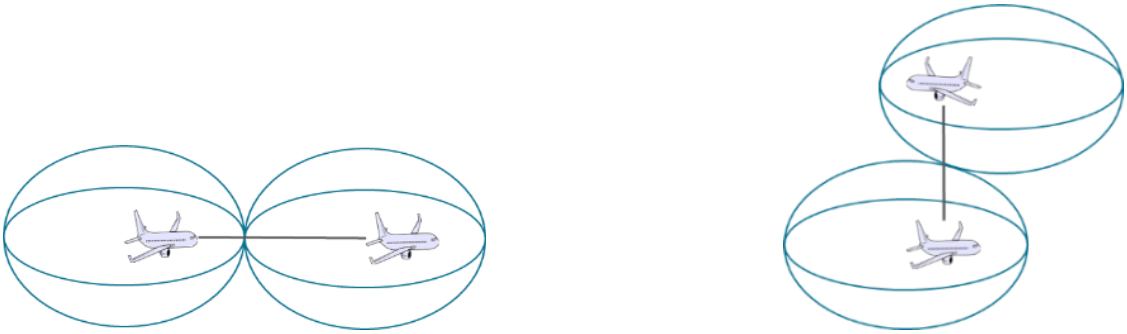


Figure 25: Aircraft separation criteria of the simulation tool

Traffic sample

For the validation exercise, the base traffic sample was chosen for a peak day of 2012 as specified in the operating/sub operating Environment Performance Needs of the EATMA portal. Since the time horizon for SESAR 2020 is 2025, the 2012 traffic required some adaptation to be compliant with current procedures. By applying the annual growth considered for Sweden, according to ECTRL STATFOR (long term) scenario C[3], to the 2012 traffic in Stockholm TMA, the total traffic increases from 1027 flights in 2012 to 1237 flights in 2025 as follows:

[3] **Scenario C:** *Regulated Growth*: Moderate economic growth, with regulation reconciling the environmental, social and economic demands to address the growing global sustainability concerns. This scenario has been constructed as the 'mostlikely' of the four, most closely following the current trends.

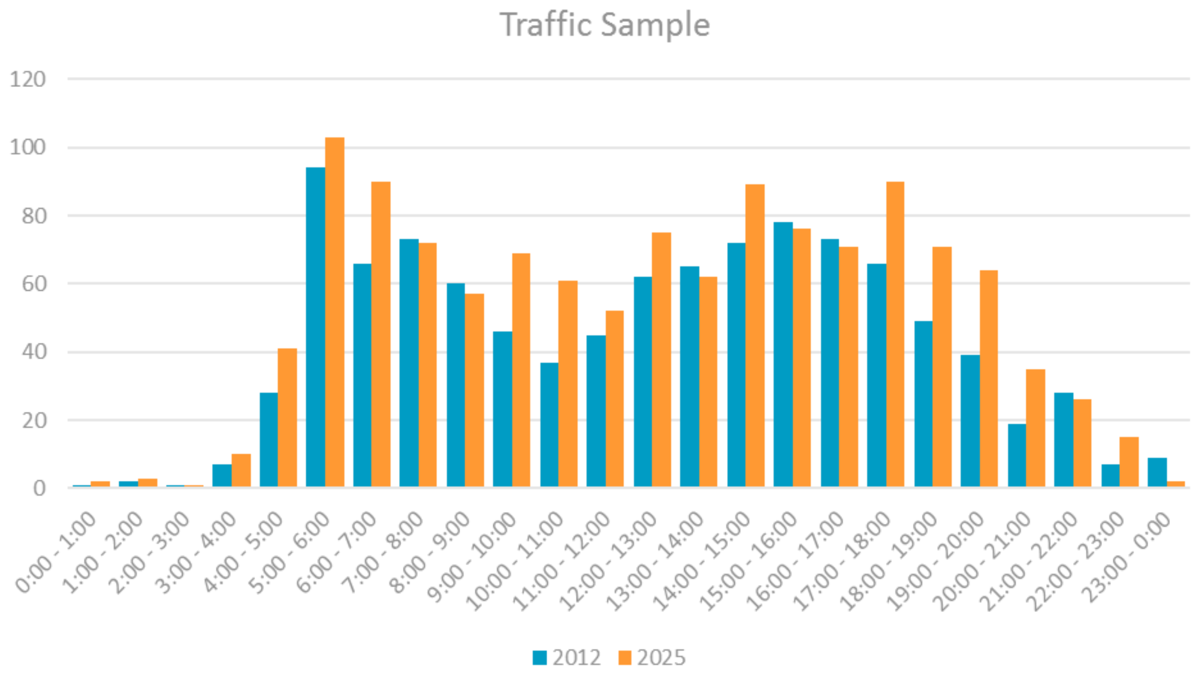


Figure 26: ESSA TMA traffic sample 2012 vs 2025

Exercise Execution

The exercise execution entailed several simulations runs to detect airspace crossings and afterwards to fine tune the climb and descent procedures for the reference and the solution scenarios.

All simulation runs were conducted at INECO premises by RAMS experts and correctly executed.

Platform preparation

RAMS Plus

The tool used for the simulation is RAMS plus. It is a is a gate-to-gate ATC/ATM fast-time simulator tool, which provides decision support in the design, analysis, and planning of ATM systems, from airspace design, capacity, working procedures, & safety concerns, to airport movements, capacity and delay.

RAMS Plus simulates traffic from a macro-to-micro level (gate-to-gate movements), where a single scenario can contain as many flights, sectors, and airports as needed, from a local to global level, to provide insights into the ATM system under study.

Rams Plus was used to model the approach and departure rules and procedures and to execute the validation scenarios. The airspace sectorisation and the traffic sample was obtained and loaded from the NEST Tool.

NEST tool

NEST is a stand-alone desktop application used by the EUROCONTROL Network Manager and national Air Navigation Service Providers (ANSPs) for medium to long-term planning activities.

The nest tool was used to make the traffic prognosis, create the simulation traffic sample, obtain the airspace sectorisation and to analyse the traffic simulated in the RAMS Plus tool in terms of sector entry counts for each scenario.

B.1.2 Summary of Validation Exercise EXE.01-03B.020 Validation Objectives and success criteria

The following table contains a summary of the Validation Exercise objectives by the exercise EXE. 01-03B.020

SESAR Solution Validation Objective	SESAR Solution Success criteria	Coverage and comments on the coverage of SESAR Solution Validation Objective in Exercise 001	Exercise Validation Objective	Exercise Success criteria
OBJ-PJ.01.03b-VALP-FTS-0001	CRT-PJ.01.03b-VALP-FTS-0001-001	Fully covered	OBJ-PJ.01.03b-VALP-FTS-0001	CRT-PJ.01.03b-VALP-FTS-0001-001
OBJ-PJ.01.03b-VALP-FTS-0002	CRT-PJ.01.03b-VALP-FTS-0002-001	Fully covered	OBJ-PJ.01.03b-VALP-FTS-0002	CRT-PJ.01.03b-VALP-FTS-0002-001
OBJ- PJ.01.03b-VALP-FTS-0003	CRT-PJ.01.03b-VALP-FTS-0003-001	Fully covered	OBJ- PJ.01.03b-VALP-FTS-0003	CRT-PJ.01.03b-VALP-FTS-0003-001
OBJ- PJ.01.03b-VALP-FTS-0003	CRT- PJ.01.03b-0003-VALP-FTS-0003-002	Fully covered	OBJ- PJ.01.03b-VALP-FTS-0003	CRT- PJ.01.03b-0003-VALP-FTS-0003-002
OBJ- PJ.01.03b-VALP-FTS-0003	CRT-PJ.01.03b-VALP-FTS -0003-003	Fully covered	OBJ- PJ.01.03b-VALP-FTS-0003	CRT-PJ.01.03b-VALP-FTS -0003-003

Table 7: Summary of Validation Exercise Objectives

B.1.3 Summary of Validation Exercise EXE.01-03B.020 Validation scenarios

Reference

The reference scenario will consider a way of operating at Stockholm TMA where ATCOs are not assisted by an ATC decision support tool and the conflict resolution involves the tactical clearance of level offs to aircraft, to ensure a defined safety buffer of separation. Additionally, aircraft will not be equipped with an EPP that provides accurate trajectory predictions to ATC systems, but a basic AMAN is assumed to be in operation.

Solution

The solution scenario will consider an operational environment where TMA ATCOs have an advisory tool for conflict detection/ATC decision support tool
and the resolution of conflicts takes place through the clearance of optimum ROC/ROD, aimed to improve the facilitation of CDO/CCO.

B.1.4 Summary of Validation Exercise EXE. 01-03B.020 Validation Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-1	Mental /safety buffer	Operational	The mental/safety extra buffer for ATCOS in the reference scenario will be +2NM and +1000ft	FTS modelling criteria	Climb /Descent	CAP CEF	Operational expert	N/A	PJ.01.03b FTS	N/A
ASS-2	Mental /safety buffer	Operational	The mental/safety extra buffer for ATCOS in the solution scenario will be +1NM and +500ft	FTS modelling criteria	Climb /Descent	CAP CEF	Operational Expert	N/A	PJ.01.03b FTS	N/A
ASS-3	Aircraft Speed	Operational	Aircraft speed will be the same as the one downlinked in the EPP (FMS-calculated aircraft speed profile) no matter whether a new ROC is commanded or the current ROC is maintained	FTS modelling criteria	Climb /Descent	ENV(FEFF)	Operational Expert	N/A	PJ.01.03b FTS	N/A

Table 8: Validation Assumptions overview

B.2 Deviation from the planned activities

N/A

B.3 Validation Exercise EXE. 01-03B.020 Results

B.3.1 Summary of Validation Exercise EXE. 01-03B.020 Results

Validation Exercise EXE.01-03B.020 Validation Objective ID	Validation Exercise EXE.01-03B.020 Validation Objective Title	Validation Exercise EXE.01-03B.020 Success Criterion ID	Validation Exercise EXE.01-03B.020 Success Criterion	Sub-operating environment	Exercise EXE.01-03B.020 Validation Results	Validation Exercise EXE.01-03B.020 Validation Objective Status
OBJ-PJ.01.03b-VALP-FTS-0001	Impact in Cost Effectiveness	CRT-PJ.01.03b-VALP-FTS-0001-001CRT-PJ01.03b-VALP-0001-001	TMA ATCO is able to handle at least the same number of aircraft movements in its area of responsibility per ATCO hour on duty considering the operational concept under assessment	Very High Complexity TMA	In the reference scenario were registered 89 conflicts in which 131 flights were involved, those flights represent the 20% of the total traffic of the sector during the day. The TMA ATCO on duty of the ESSAE sector had do command 127 level offs In the solution scenario were registered 62 (30% less) conflicts impacting 104 flights, which represents the 16% of the total traffic of the sector during the day. The TMA	OK

Validation Exercise EXE.01-03B.020 Validation Objective ID	Validation Exercise EXE.01-03B.020 Validation Objective Title	Validation Exercise EXE.01-03B.020 Success Criterion ID	Validation Exercise EXE.01-03B.020 Success Criterion	Sub-operating environment	Exercise EXE.01-03B.020 Validation Results	Validation Exercise EXE.01-03B.020 Validation Objective Status
					ATCO on duty of the ESSAE sector had to command 83 ROC/RODs The reduction in the number of ATCO interventions is reduced, since there's no need to manage "false conflicts", consequently ATCO workload situation is improved compared to the reference scenario.	
OBJ-PJ.01.03b-VALP-FTS-0002OBJ-PJ.01.03b-VALP-0002	Impact in Airspace Capacity	CRT-PJ.01.03b-VALP-FTS-0002-001CRT-PJ01.03b-VALP-0002-001	TMA ATCO is able to handle at least the number of aircraft movements in its area of responsibility considering the operational concept under assessment	Very High Complexity TMA	The total traffic TMA increases from 1027 flights in 2012 to 1237 flights in 2025. Despite the traffic increase, the demand doesn't surpass sector capacity, despite the traffic increase considered for 2025.	OK
OBJ-PJ.01.03b-VALP-FTS-0003OBJ-	Impact in Environment	CRT-PJ.01.03b-VALP-FTS-0003-001	Reduction in fuel burn of aircraft flying an optimised ROC/ROD	Very High Complexity TMA	The fuel burn decreases a 0,083% when aircraft are cleared with an optimized ROC/ROD instead of a level off.	OK

Validation Exercise EXE.01-03B.020 Validation Objective ID	Validation Exercise EXE.01-03B.020 Validation Objective Title	Validation Exercise EXE.01-03B.020 Success Criterion ID	Validation Exercise EXE.01-03B.020 Success Criterion	Sub-operating environment	Exercise EXE.01-03B.020 Validation Results	Validation Exercise EXE.01-03B.020 Validation Objective Status
PJ01.03b-VALP-0003					When comparing the reference and solution scenarios, the fuel burn consumption decreases a 0,64% in arrivals and a 0,67% in departures	
OBJ-PJ.01.03b-VALP-FTS-0003OBJ-PJ01.03b-VALP-0003	Impact in Environment	CRT- PJ.01.03b-0003-VALP-FTS-0003-002	Reduction of CO2 emissions from flying more optimised climb and descent profiles	Very High Complexity TMA	The CO_2 emissions are directly related to the fuel burn, for this reason emissions decrease in the same proportion as the fuel burn (0,083%) when aircraft are cleared with an optimised ROC/ROD instead of a level off.	OK
OBJ-PJ.01.03b-VALP-FTS-0003OBJ-PJ01.03b-VALP-0003	Impact in Environment	CRT-PJ.01.03b-VALP-FTS -0003-003	Reduce the number of tactical level offs	Very High Complexity TMA	In the reference scenario 127 level offs were commanded to avoid aircraft crossings, on the other hand when considering the solution scenario, no tactical level offs were needed to solve aircraft crossings.	OK

Table 9: Validation Results for Exercise EXE. 01-03B.020

B.3.2 Analysis of Exercise EXE. 01-03B.020 Results per Validation objective

1. OBJ-PJ.01.03b-VALP-FTS-0001 - OBJ-PJ.01.03b-VALP-FTS-0002

Validation Objectives OBJ-PJ.01.03b-VALP-FTS-0001 and OBJ-PJ.01.03b-VALP-FTS-0002 are jointly analysed since both are directly related.

Airspace Capacity

The impact in airspace capacity has been analysed as the number of hourly movements per TMA sector. The traffic sample for the reference and solution scenario is the same, but the procedures to solve conflicts are different. The following graphs display the **hourly entry counts per sector** for both, the reference and the solution scenario.

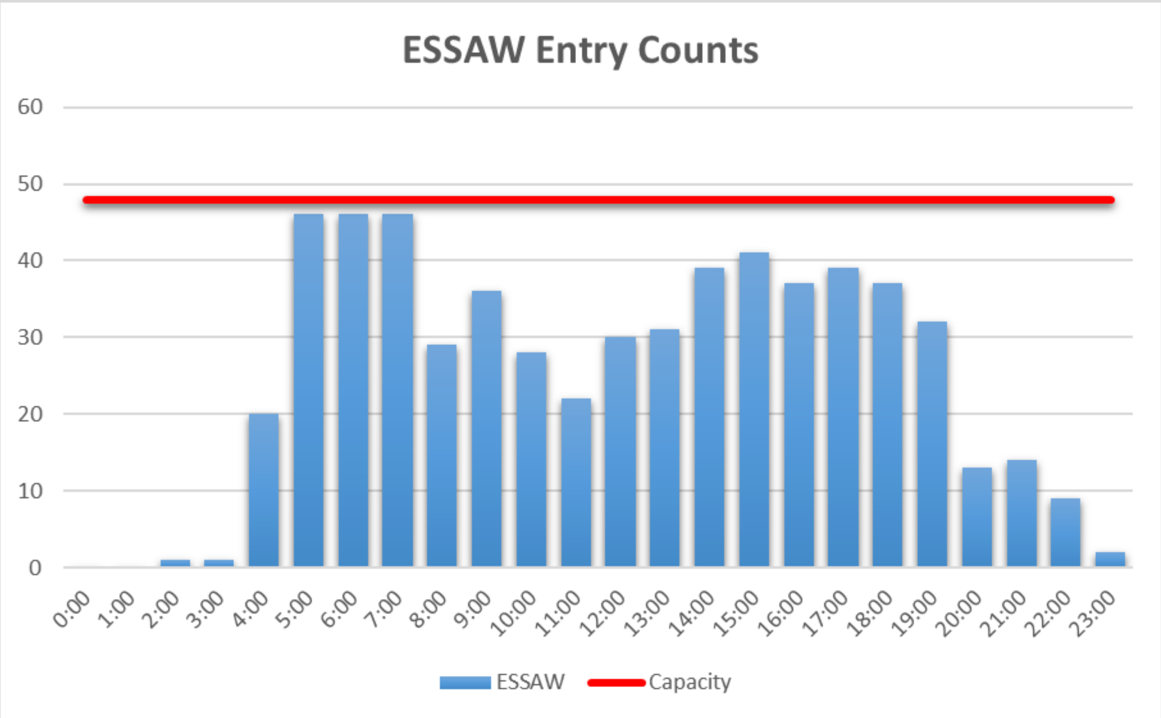


Figure 27: ESSAW sector entry counts

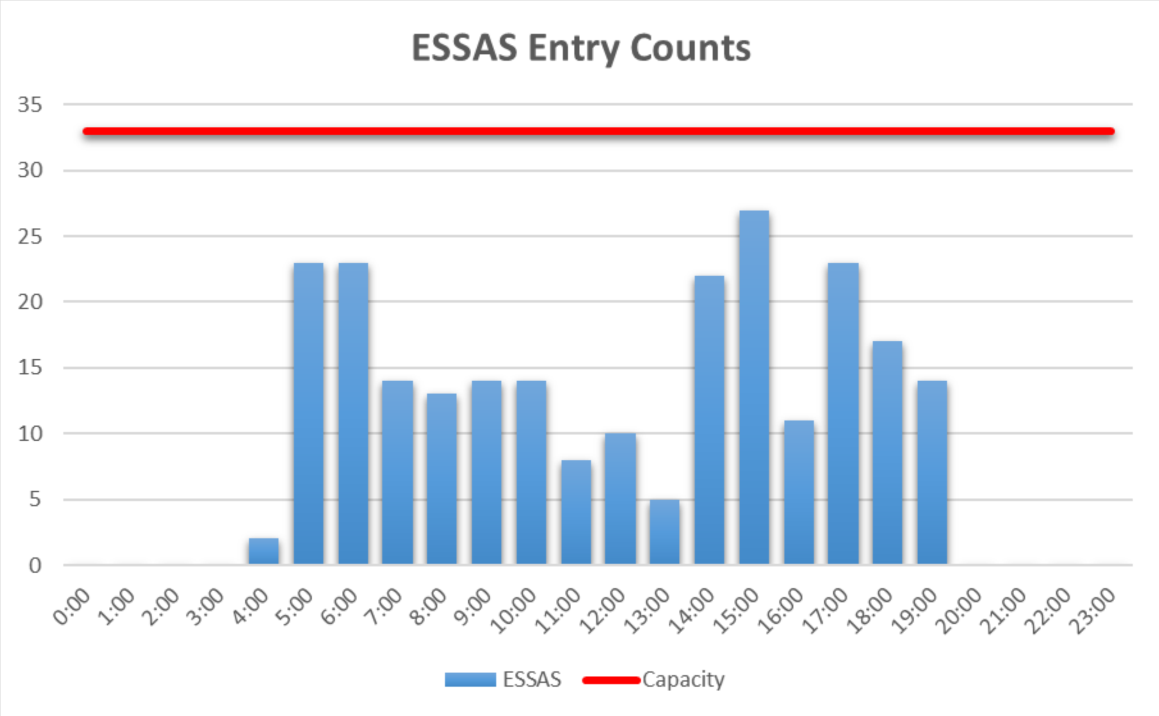


Figure 28: ESSAS sector entry counts

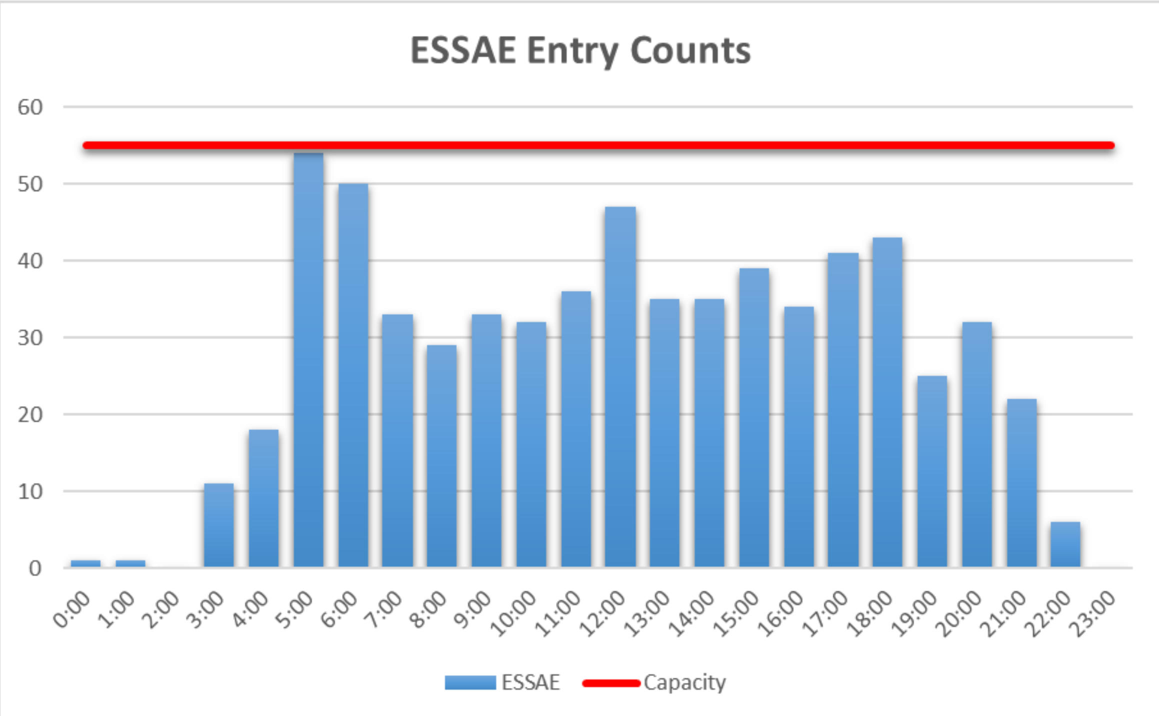


Figure 29: ESSAE sector entry counts

As seen in all graphs, the demand doesn't surpass sector capacity, despite the traffic increase considered for 2025. The busiest period, with 46 movements, is registered between 5:00 and 07:00 for the ESSAW sector and between 5:00 and 6:00 in the ESSAE sector with 54 movements. The ESSAS sector presents an hourly demand below the declared capacity during the whole day of operations analysed.

Cost effectiveness

The impact in cost effectiveness has been measured as the number of entry counts per sector taking into account the perceived impact in ATCO workload due to the management of aircraft conflicts per hour.

Since the main study takes place in the **ESSAE sector**, a more detailed analysis has been made by analysing the number of conflicts resolutions per hour per total operations in the sector.

The traffic distribution per approach and departure procedure and the number of conflicted flights in the ESSAE sector is distributed as follows:

PROCEDURE	TOTAL FLIGHTS	CONFLICTED FLIGHTS
SID BABAP	50	22
SID TOVRI DEPARTING FROM ESSA	57	37
SID TOVRI DEPARTING FORM ESSB	26	3
STAR NILUG	210	56
STAR XILAN	84	16

The flights departing from ESSA airport via SID TOVRI presents the higher number of conflicted flights, representing the 65% of the total traffic of the departure route, due to the crossing with two approach routes (STAR NILUG and STAR XILAN). On the other side, the STAR route NILUG has the 49% of the total traffic of the ESSAE sector, but the number of conflicted flights on this approach route represents the 27% of the total traffic of the STAR.

In the reference scenario were registered 89 conflicts in which 131 flights were involved, those flights represent the 20% of the total traffic of the sector during the day. The TMA ATCO on duty of the ESSAE sector had do command 127 level offs, distributed as shown in the graph (orange bar). The conflicts detected for flights departing from ESSB and aircraft departing from ESSA disappear due to the prior action on aircraft departing from ESSA, therefore no action was needed to solve that conflict.

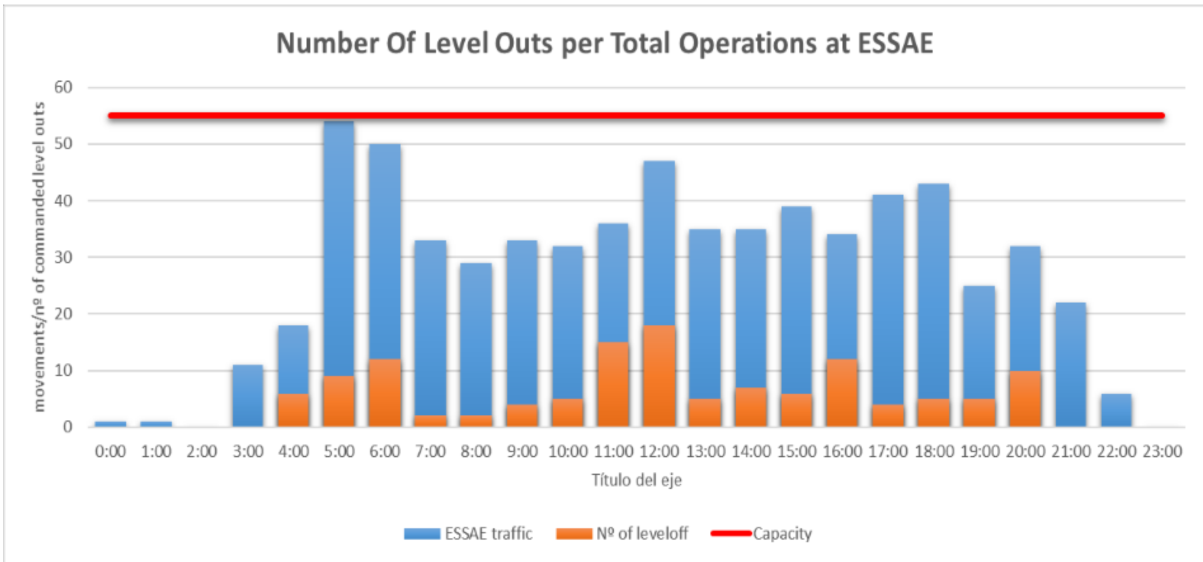


Figure 30: Level off hourly distribution per entry counts at ESSAE sector

In the solution scenario 62 conflicts were registered impacting 104 flights, which represents the 16% of the total traffic of the sector during the day. The TMA ATCO on duty of the ESSAE sector had to command 83 ROCs/RODs, distributed as in the picture below. As for the reference scenario, conflicts between departures from ESSB and departures from ESSA disappear due to the prior action on aircraft departing from ESSA, therefore no action was needed to solve that conflict.

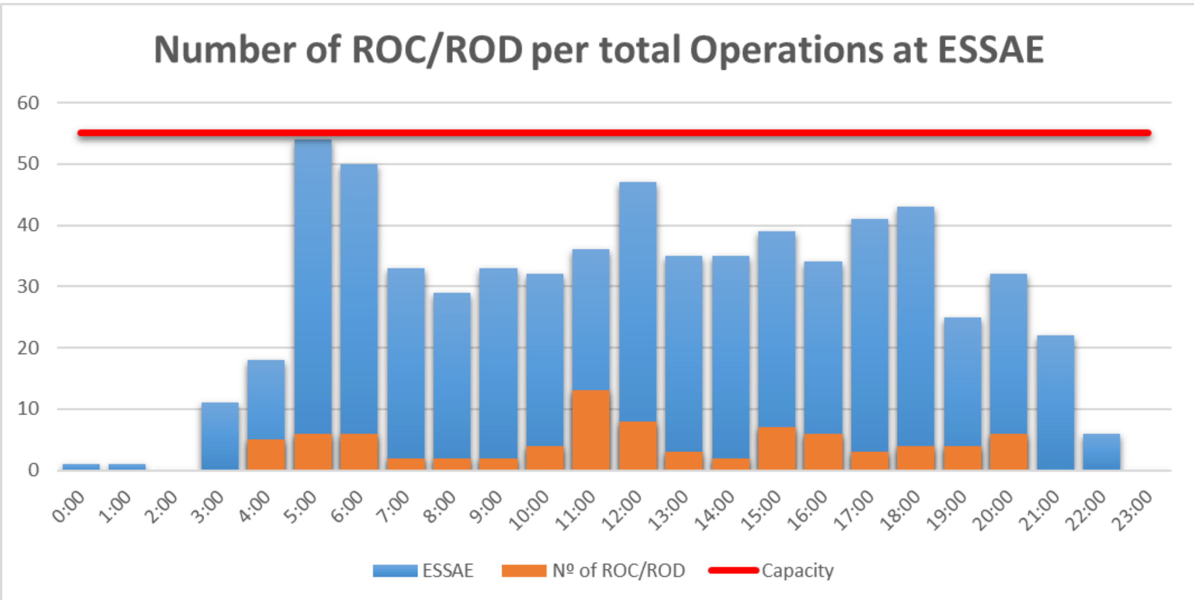


Figure 31: ROC/ROD hourly distribution per entry counts at ESSAE sector

The number of conflicts is reduced in a 30% due to the fact that with a system support tool the accuracy of the conflict detection (smaller safety bubble) is greater than in the reference scenario where such a tool wasn`t available for ATCOs. The reduction in the number of ATCO intervention is therefore also reduced from 127 in the reference scenario to 83 in the solution scenario, since there's no need to manage "false conflicts ", consequently ATCO workload might be reduced. The following graphs compares the number of hourly conflicts to be solved in the reference and the solution scenario

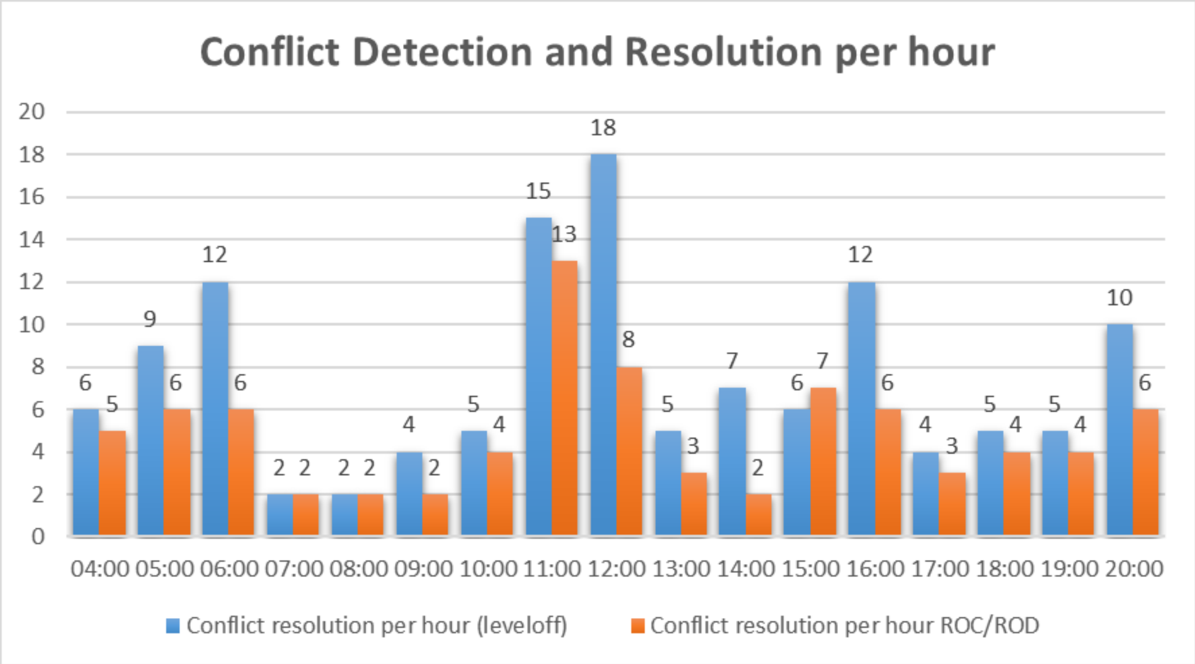


Figure 32: ROC/ROD VS Level off hourly distribution at ESSAE sector

As previously mentioned, the peak hour takes place from 5:00 to 6:00, in this period the number of conflicts is reduced from 9 in the reference scenario to 6 in the solution scenario which contributes to ease the management of the sector demand. In the next hour, the number of conflicts is reduced in a 50% which also contributes to reduce ATCO workload.

In the period from 12:00 to 13:00 the difference in the number of conflicts is more notable between the reference and solution scenario as it is reduced in a 56%. In this period, the demand is below the declared capacity but in the previous hour the number of conflicts has the higher value of the solution scenario which means that conflict resolution has a higher impact on ATCO workload, this reduction in the number of conflicts, again contributes to reduce ATCO workload.

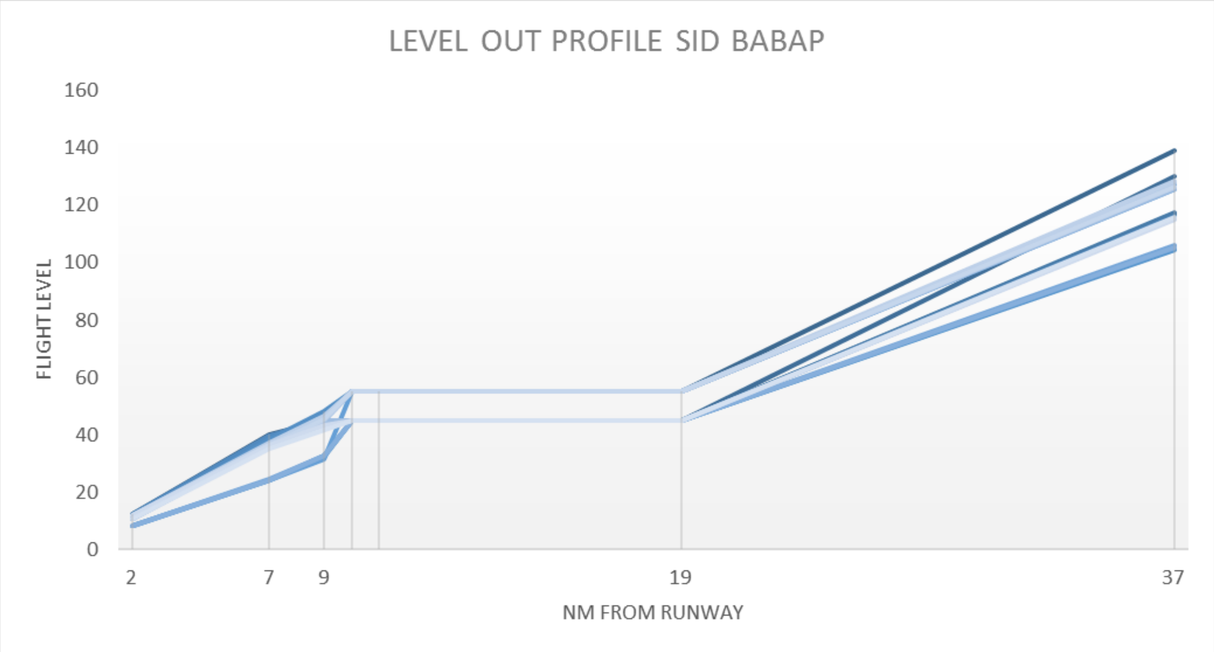
2. OBJ- PJ.01.03b-VALP-FTS-0003

The environmental impact of the approach and departure procedures has been measured in terms of fuel burn and CO2 emissions. The measurement has been done with the IMPACT tool, provided by Eurocontrol, a web-based platform dedicated to multi-airport environmental impact assessments for noise, gaseous and particulate emissions, and local air quality.

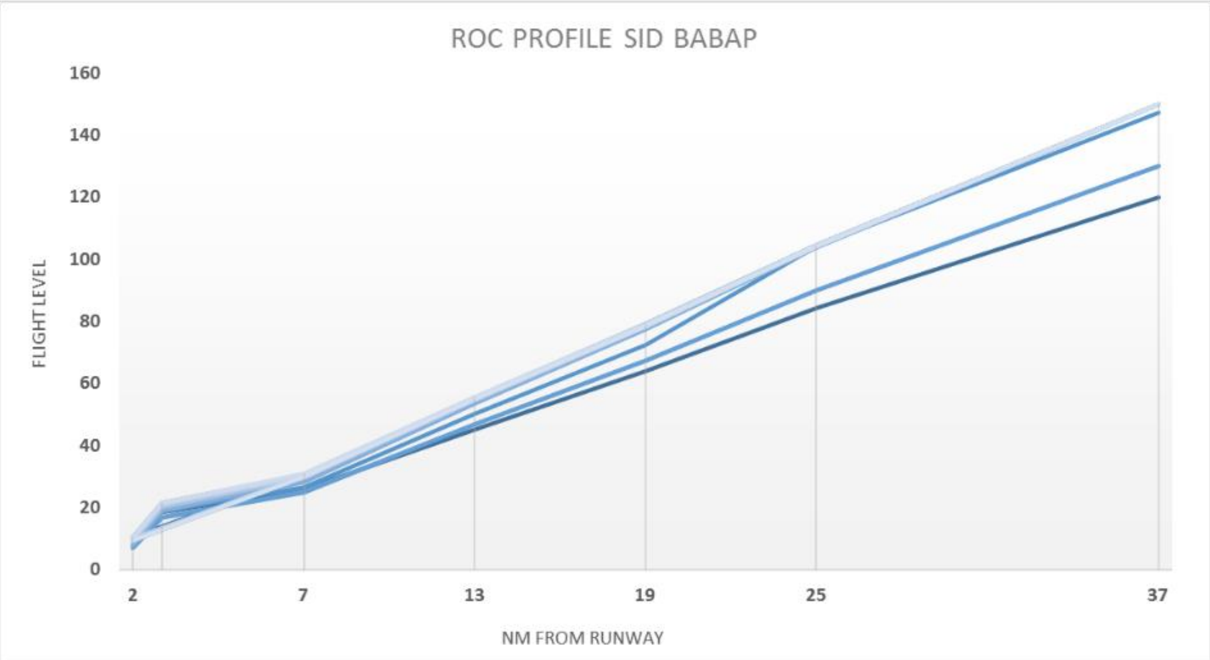
Fuel Burn

The exercise allowed to demonstrate that optimised ROC/RODs allow to fly more continuous profiles than in a level off scenario. This continuity in the trajectory also contributes to save fuel burn. The following graphs show the different flight profiles of the SIDs and STARs under assessment.

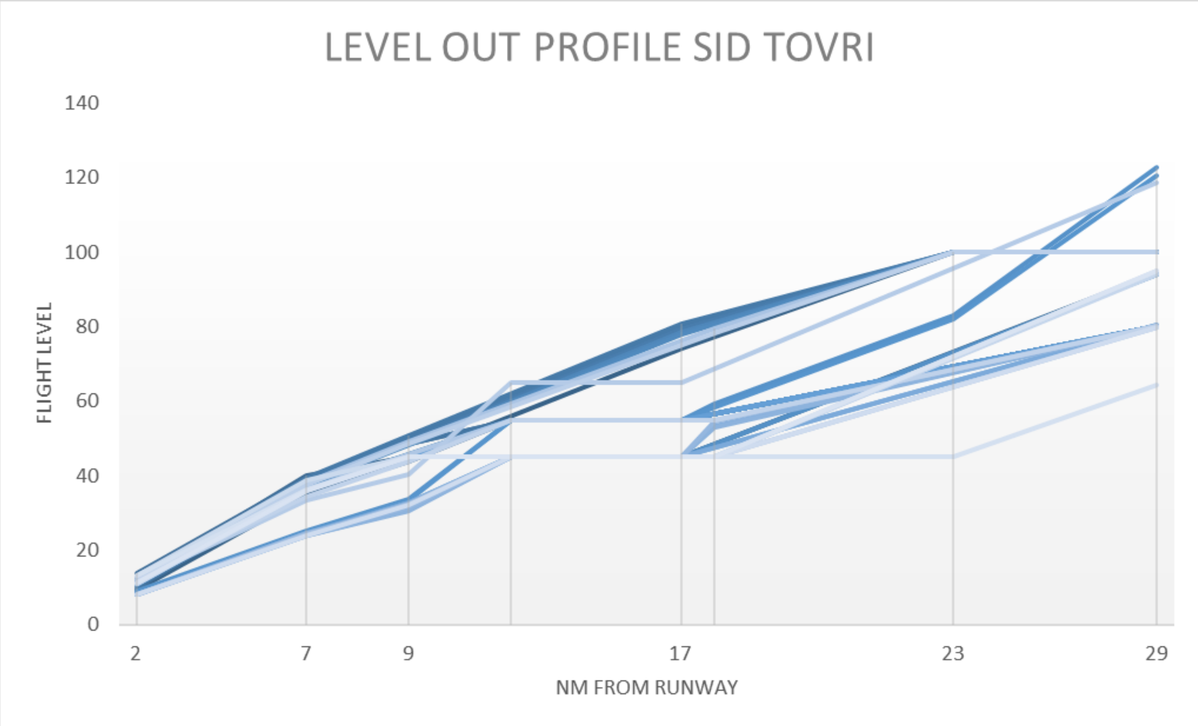
- **SID BABAP**. From the 131 conflicting flights, the traffic through the SID BABAP represents the 17%. The flight profiled of the reference and solution scenario is as follows.



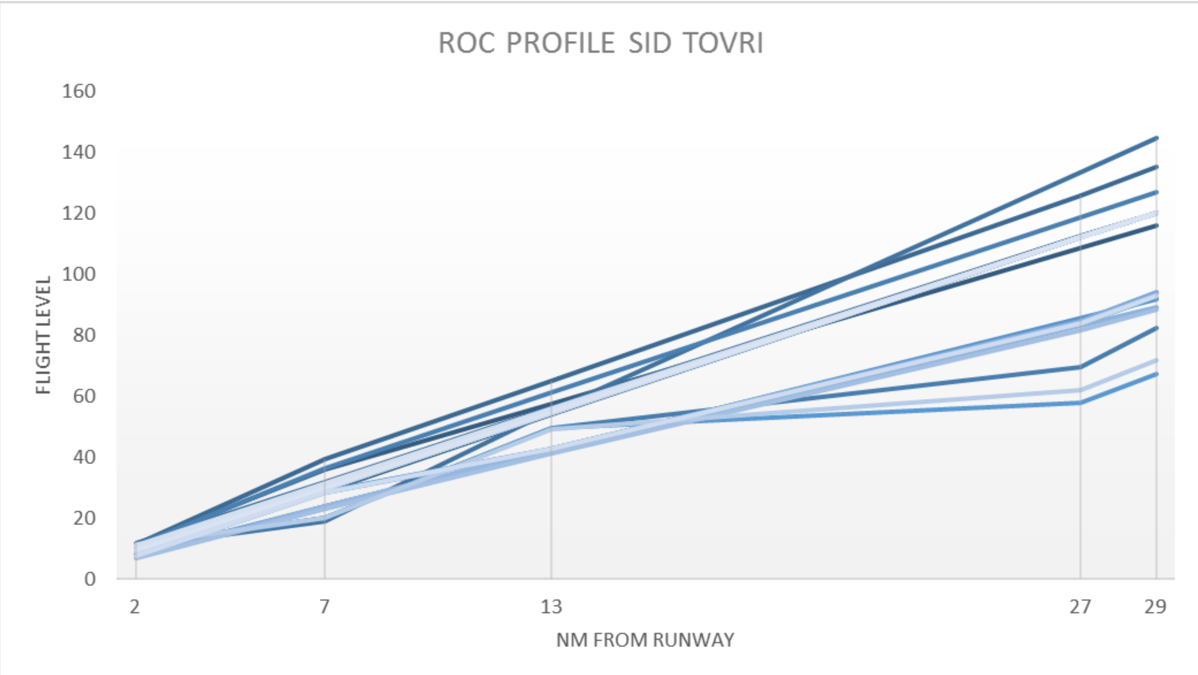
Level offs occur at FL45 and FL55 between 9NM and 19NM from departure to avoid conflicts with aircraft approaching via STAR NILUG.



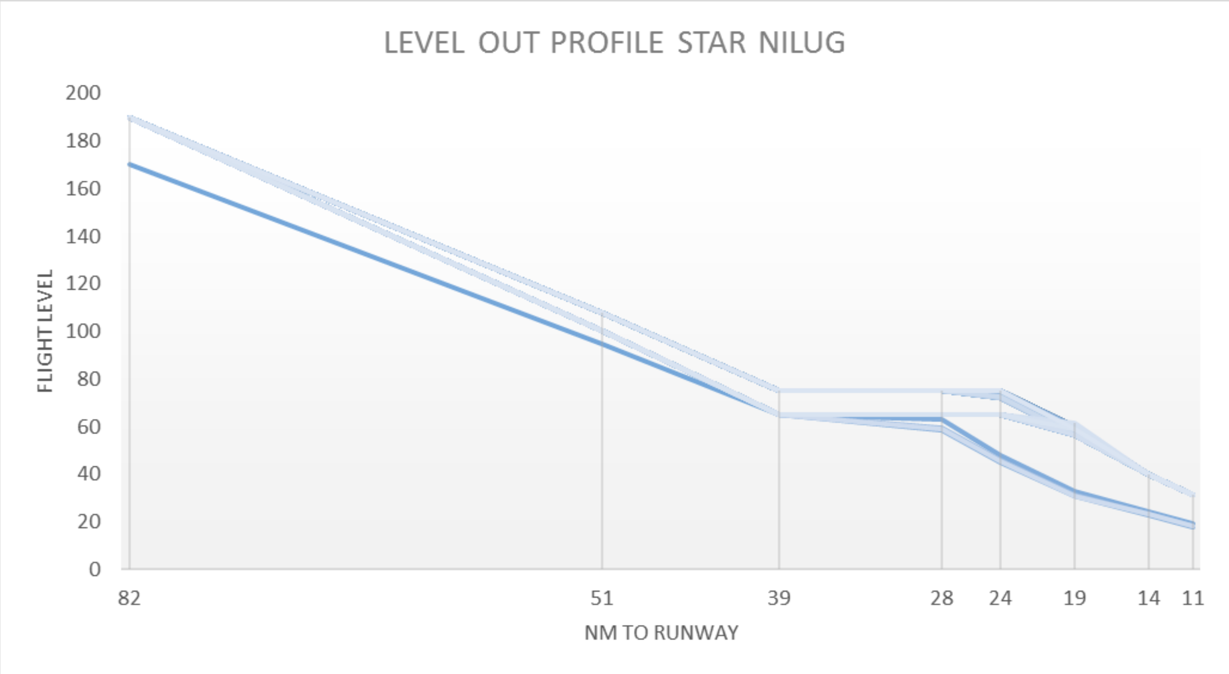
- **SID TOVRI**. From the 131 conflicting flights, the traffic through the SID TOVRI represents the 65%. The flight profiled of the reference and solution scenario is as follows.



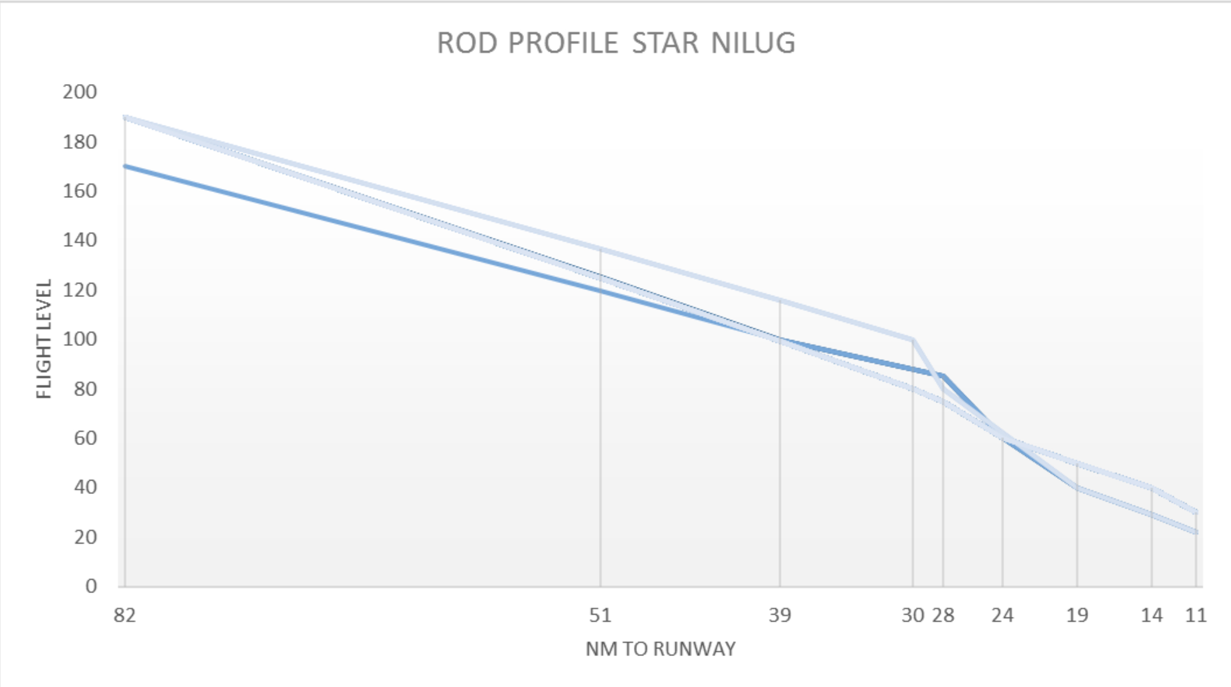
The level offs take place at FL45, FL65 and FL55 to avoid conflicts with aircraft approaching via STAR NILUG and at FL100 to avoid conflicts with aircraft approaching via STAR XILAN.



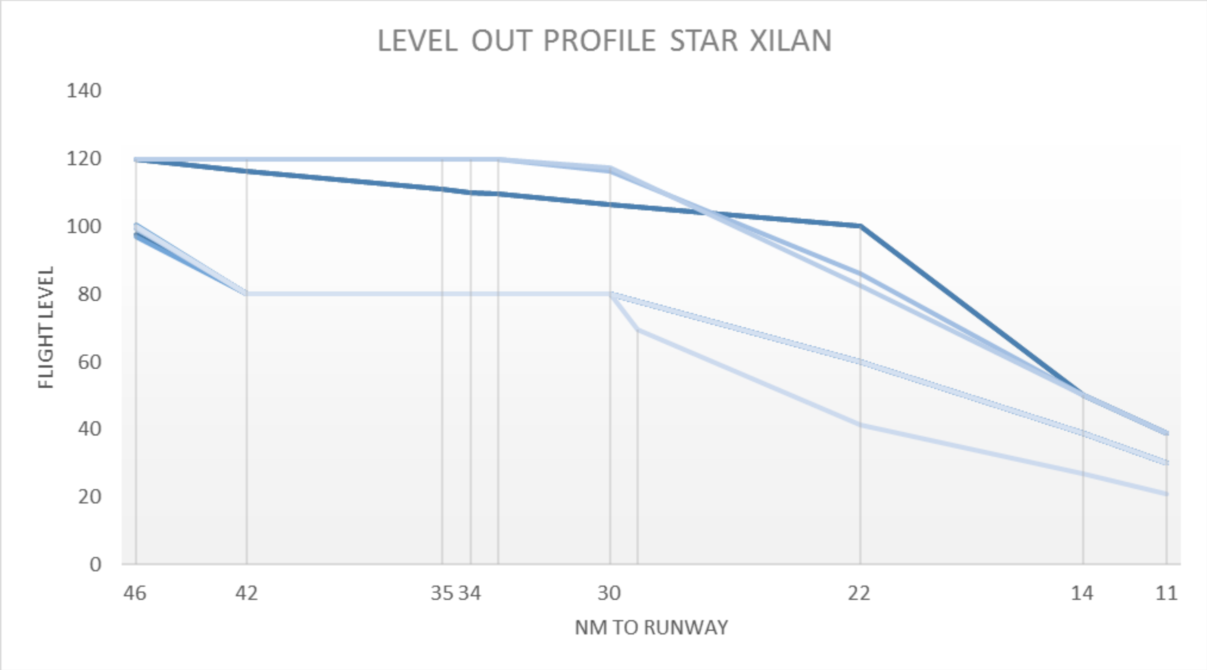
- **STAR NILUG**. From the 131 conflicting flights, the traffic through the STAR TOVRI represents the 27%. The flight profiled of the reference and solution scenario is as follows.



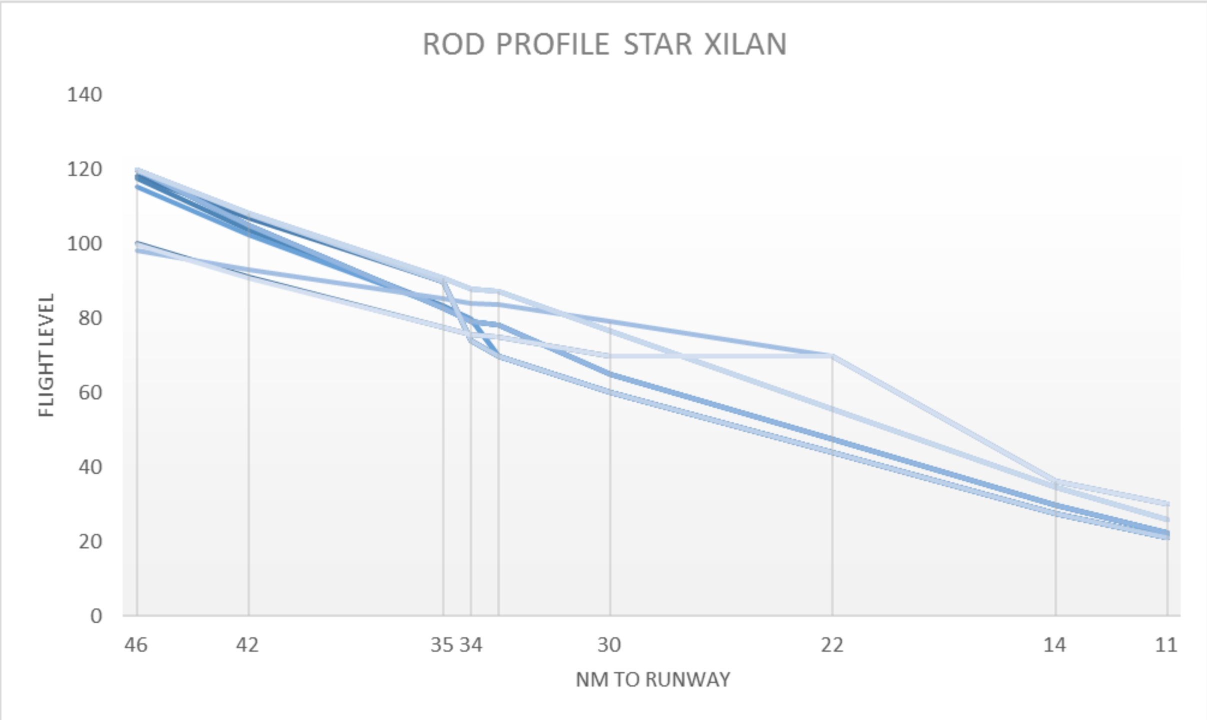
The level offs take place at FL75, and FL65 and between 39NM up to 24NM to airport, in order to avoid conflicts with aircraft departing via SID TOVRI and SID BABAP.



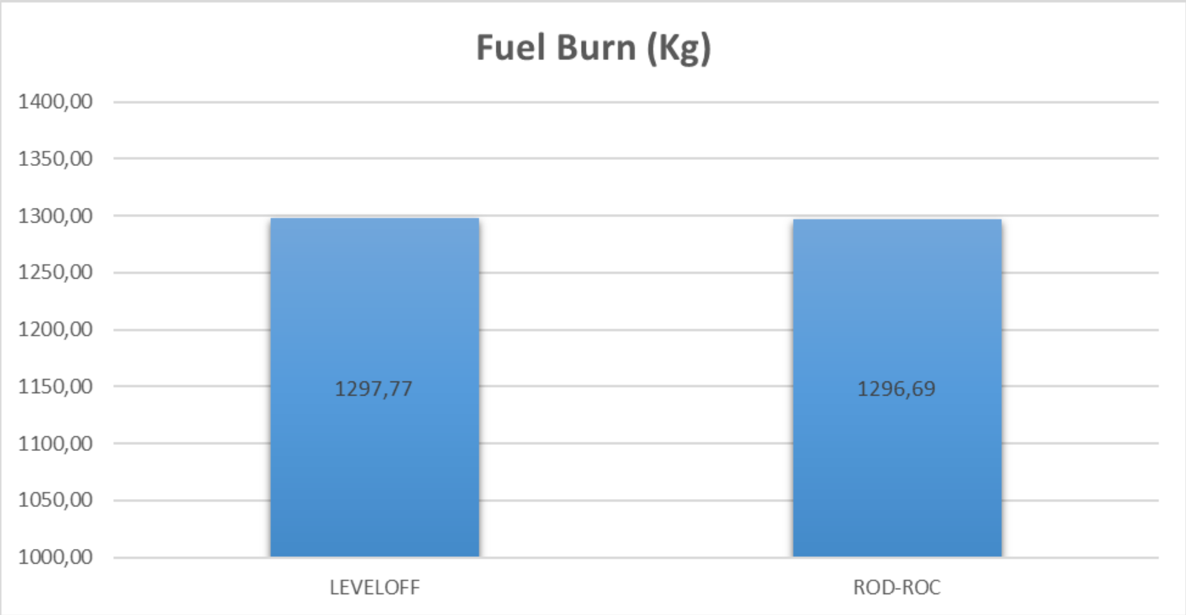
- **STAR XILAN**. From the 131 conflicting flights, the traffic through the STAR XILAN represents the 19%. The flight profiled of the reference and solution scenario is as follows.



The level offs take place at FL120 and FL100 in order to avoid conflicts with aircraft departing from ESSA via SID TOVRI.

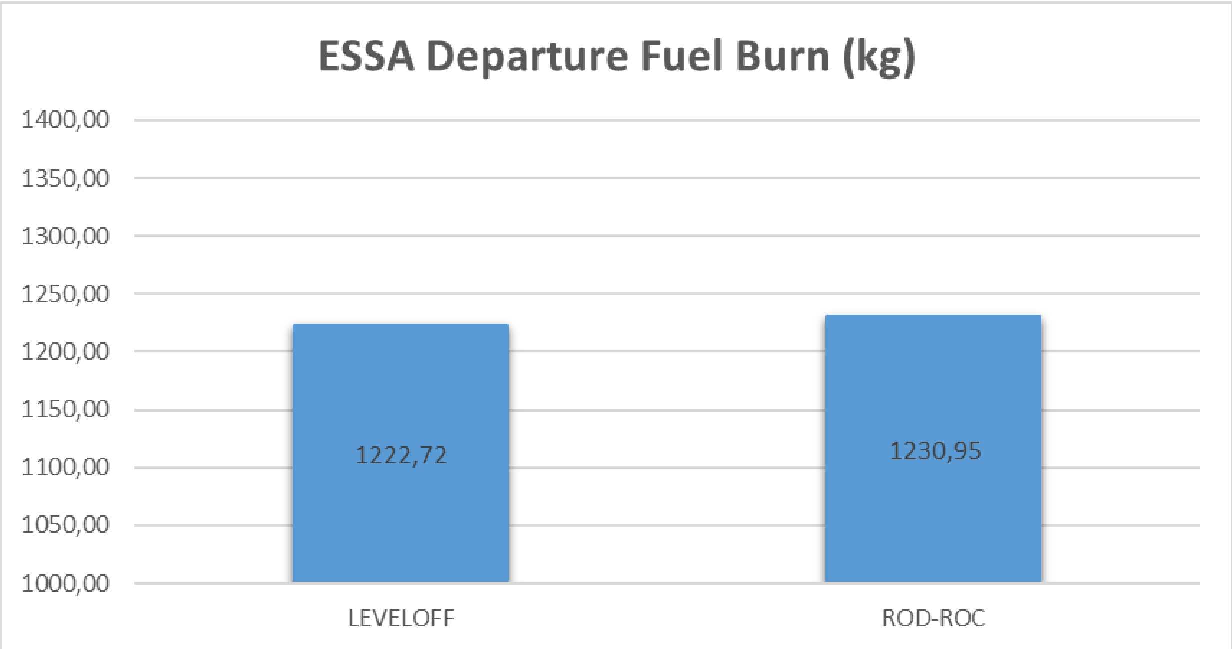


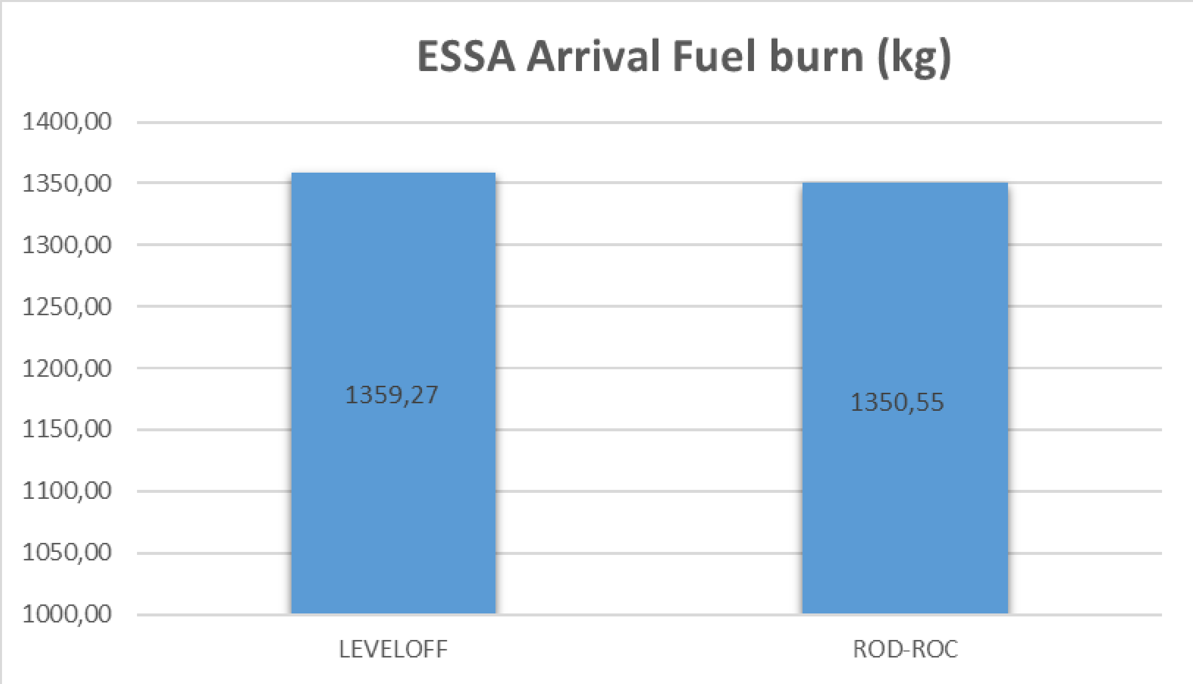
The fuel burn associated to these climb and descent profiles resulted as follows:



The fuel burn decreases a 0,083% when aircraft are cleared with an optimised ROC/ROD instead of a level off, despite of this small difference between both procedures it seems that the solution scenario shows a potential improvement in fuel efficiency.

When analysing more in detail the fuel consumption for arrival and departure procedures, the results obtained were as shown in the following graphs.



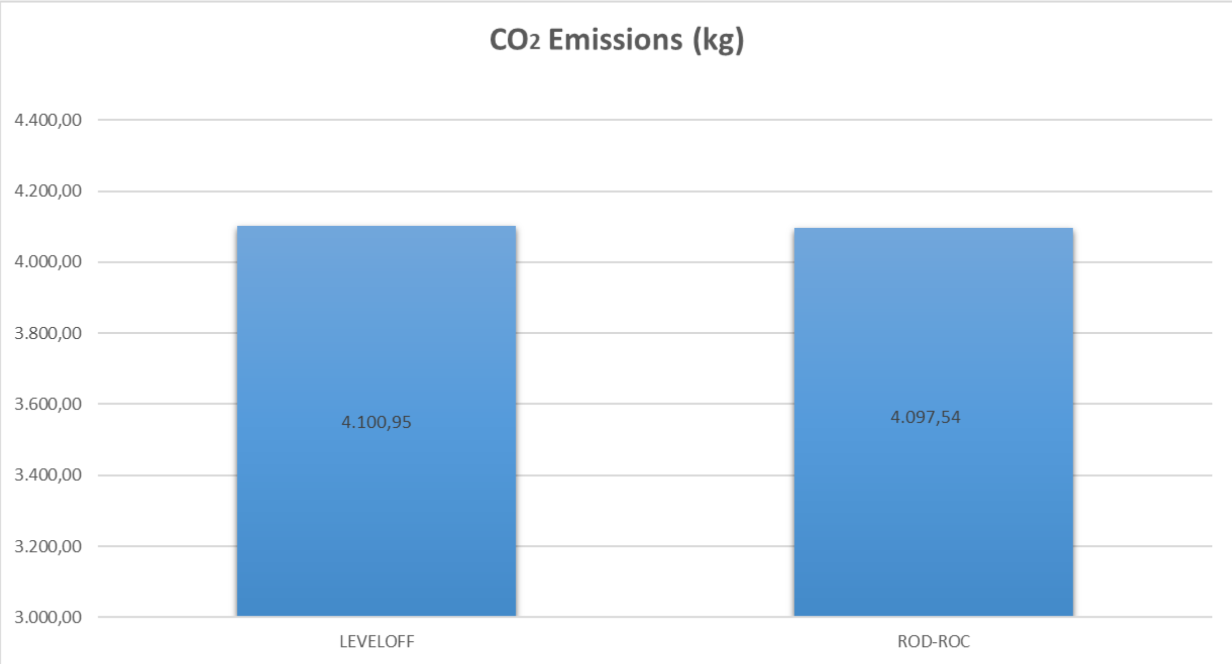


It was observed that the fuel burn is higher in in arrivals than in departures, this occurs because the number of commanded RODs/ level off is higher than the number of commanded ROCs/ level offs (67 ROD against 16 ROCs).

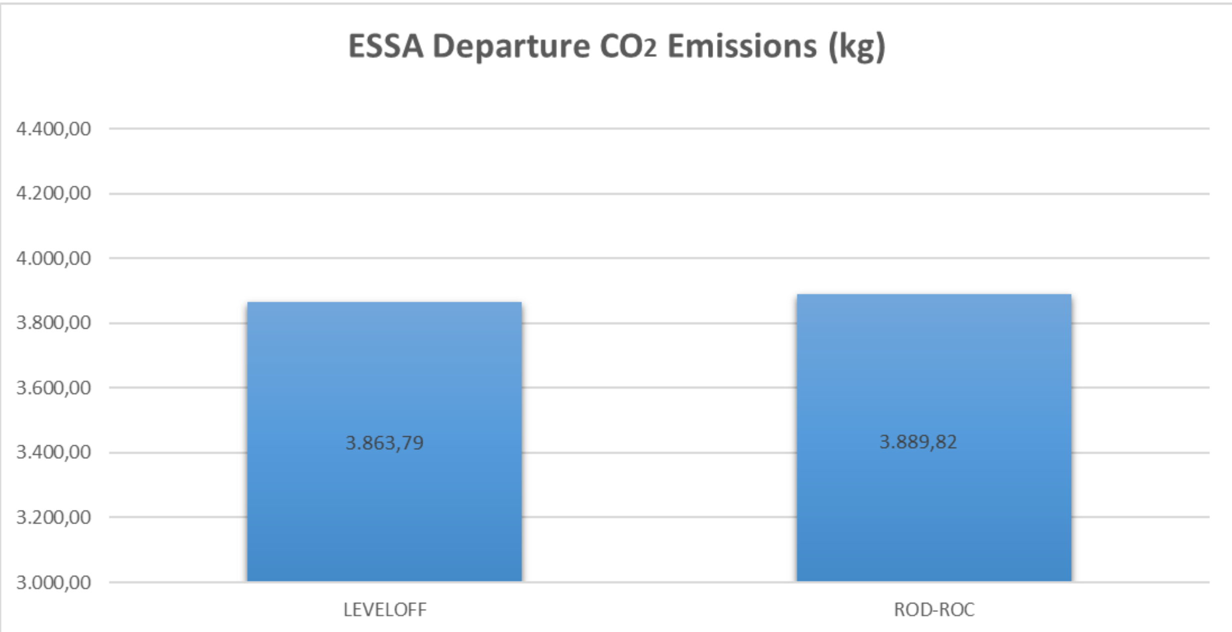
When comparing the reference and solution scenarios, the fuel burn consumption decreases a 0,64% in arrivals and increases a 0,67% in departures. Despite of the fuel burn increase in the solution scenario for departure operations, the difference against the reference scenario is not very high and the overall fuel burn for arrivals and departures shows a slight improvement.

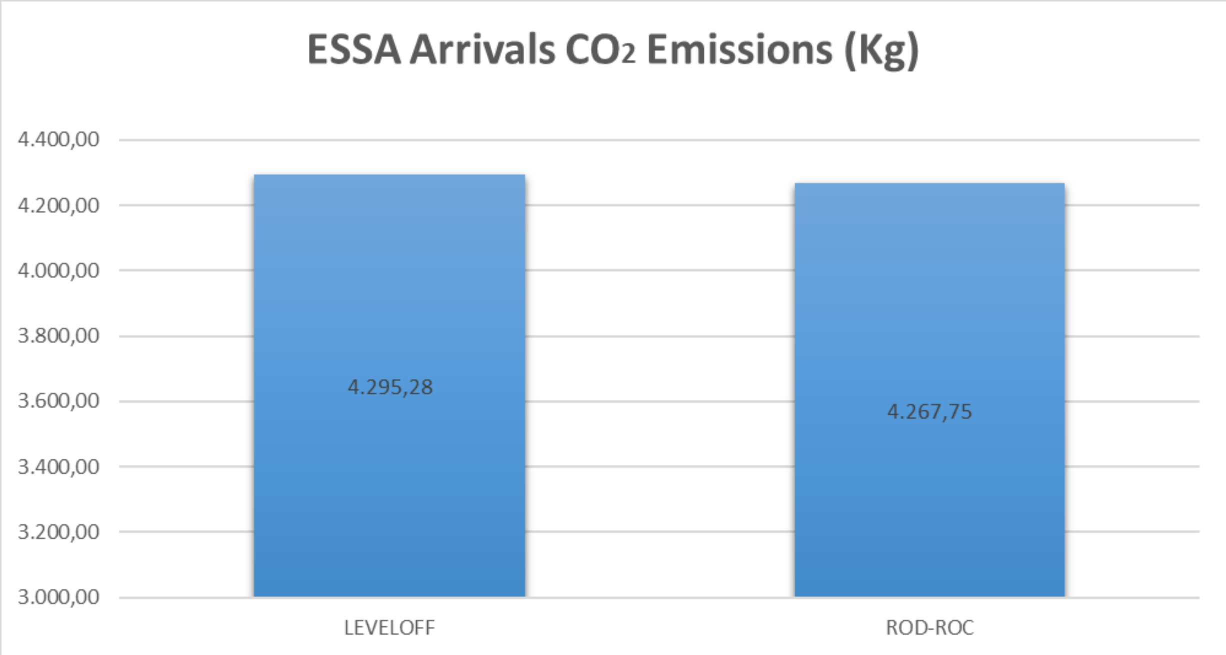
CO_2 Emissions

The CO2 emissions are directly related to the fuel consumption, the results obtained are represented in the following graphs:



The CO_2 emissions decrease a 0,083% when aircraft are cleared with an optimised ROC/ROD instead of a level off. When distinguishing between arrivals and departures the results obtained are as follows





As well as in the fuel burn analysis, the CO_2 emissions are reduced when optimised ROC/ROD are commanded, not only due to the slight improvement in the approach and departure profiles but also due to the reduction in the number of level offs.

Number of tactical Level offs

In the reference scenario 127 level offs were commanded to avoid aircraft crossings, on the other hand when considering the solution scenario, **no tactical level offs were needed**, since the optimised ROC/ROD commanded avoid the detected conflicts ensuring the defined safety levels of separation between aircraft crossings. Additionally, the conflicts detected for the departure flights from ESSB disappear as a result from a previous conflict resolution at both, reference and solution scenarios.

B.3.3 Unexpected Behaviours/Results

The exercise was modelled and executed without unexpected behaviours.

B.3.4 Confidence in Results of Validation Exercise EXE. 01-03B.020

1. Level of significance/limitations of Validation Exercise Results

The validation scenarios have been modelled in accordance to the operational specifications provided by Stockholm's TMA operational experts. The traffic samples were based on operational data from the Stockholm TMA.

The limitations of the FTS impacting the representativeness of the of the exercise results were that the exercise didn't allow to provide statistical values for ATCO's workload, instead of that, a qualitative assessment was based on the number of operations per hour per ATCO on duty in relationship with the impact of the number of conflict resolutions per hour.

The level of confidence in the flight efficiency indicators, fuel consumption and CO2 emissions, obtained from the IMPACT tool is low, because it was detected that IMPACT needs some specific data input such as thrust engine or flaps configuration in the assessment of the consumption profiles, that RAMS Plus was not able to provide.

2. Quality of Validation Exercises Results

Considering that the exercise consisted in a fast time simulation where the detection and resolution of conflicts was executed based on assumptions agreed with operational experts, the simulation provided the necessary results to demonstrate the validation objectives under assessment.

3. Significance of Validation Exercises Results

Statistical significance

The focus of the statistical assessment takes place only at the east sector (ESSAE) of Stockholm's TMA. This sector encompasses 657 operations from the 1237 considered in the traffic sample. In addition, this sector presents three main conflict hotspots that the other sectors do not have. The information provided by the ESSAE sector provided was enough to perform the statistical analysis addressed in the 3.2 section of this ANEX.

Operational significance

The operational significance was addressed by

- Generating of traffic samples based on operational data, using multiple aircraft types and the multiple TMA Entry and Exit points.
- Using a route structure based on the existing Stockholm TMA approach and departure procedures.
- Applying aircraft's separation rules based on an operational safety buffer in accordance to operational experts' requirements.
- Operationally realistic altitude and speed restrictions at Stockholm's TMA.

B.3.5 Conclusions

The aim of this validation exercise is to provide a performance assessment on climb and descent profiles based on the operational concept defined in the OSED, for this reason no conclusions on concept clarification and technical feasibility have been made.

1. Conclusions on performance assessments

TMA Capacity

The FTS study concluded that:

- The traffic increment considered for this validation exercise does not impact negatively the sector capacity of Stockholm's TMA.

Cost Efficiency

The FTS study concluded that:

- The situation regarding ATCO workload improves in the solution scenario due to the reduction in the number of conflicts that ATCOs must manage, caused by the reduction of the bubble of uncertainty. The fact that the conflict is solved by an optimised ROC/ROD or a level off might not reduce the workload but under circumstances of peak traffic can improve the situation.

- The reduction in the mental safety buffer caused that less conflicts were detected by the simulation platform. This safety buffer was defined considering that aircraft trajectory would be better predicted by enhancing the information of the different sources such as AMAN, DMAN, aircraft's FMS etc.

Environment / Fuel Efficiency

The FTS study concluded that:

- Despite it is observed a slight improvement in fuel efficiency and emissions, the trust in the IMPACT tool, regarding the treatment of consumption profiles, is quite low due to the lack of input data that the RAMS tool was not able to provide. For this reason, it is recommended to act cautiously when extrapolating the results obtained.

B.3.6 Recommendations

The following recommendations are derived from FTS:

- The fast time simulation allowed to estimate what the impact in ATCO workload might be, considering the number of entry counts and the number of commanded level offs and optimised ROC/RODs. A more detailed study on this area shall be investigated considering a real time simulation exercise.

- From a human performance perspective, it would help that a monitoring system displays the aircraft's present ROC/ROD as well as the planned/intended ROC/ROD when flying in the ATCOs sector of responsibility.

- Since the results in flight efficiency do not offer a clear benefit of the solution, they should be contrasted with further calculations in later validation stages.

Appendix C SESAR Solution(s) Maturity Assessment

[...]

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