Step 1 AMAN + Point Merge Validation Report

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Abstract

This document is the Validation Report for the Operational Focus Area (OFA) 04.01.03, "AMAN + Point Merge" validated by Project 5.6.7 in STEP1 through two series of live trials performed in the Paris ACC environment in June and November / December 2012 (exercise EXE-05.06.07-VP-427). This exercise was initially foreseen for SESAR Release 1.

This version is the final version for approval.

The final version of the Validation Report contains all the results of the live trials performed for the exercise EXE-05.06.07-VP-427, including conclusions from all the ANSPs involved in the exercise (DSNA, MUAC and Belgocontrol), as well as the results of the simulations performed in preparation of this exercise at EUROCONTROL Experimental Centre early 2011.

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Executive summary

This document reports the main outcomes resulting from the DSNA V3 validation exercise EXE-05.06.07-VP-427 executed in the context of Operational Focus Area (OFA) 04.01.03, "AMAN + Point Merge" based on the concept set out in the P05.06.07 STEP1 "AMAN + Point Merge" OSED .
The validation was performed through two series of live trials performed in the Paris ACC environment respectively in June and November/December 2012.

Validation activities have investigated the main benefits expected from the implementation of a Point Merge System in Extended TMA (E-TMA) coupled with the use of an Arrival Manager (AMAN) namely:

1. An increase in **safety** resulting from a more structured airspace, which influences positively controller and pilot situational awareness;
2. A reduction in the controller workload, due to the reduction in frequency usage, that could allow to increase **capacity**;
3. The improvement in trajectory prediction and the reduction in the number of open loops which will have a positive impact on **predictability**;
4. The increased use of the FMS and the increased number of CDOs that will lead to a reduction of fuel consumption which in turn will have a positive impact on **flight efficiency** and **environmental sustainability**.

Two different Point Merge Structures have been designed for North-East and North-West arrivals. The June trials operated only the North-West Point Merge Structure, while November / December trials experimented both simultaneously.

The two series of live trials went on as planned. All partners, ANSPs and Airspace Users, cooperated to reach the necessary level of preparation for the exercise. The temporary procedures were approved by NSAs and published in due time, implemented by aircraft operators, and proper training was conducted for Air Traffic Controllers.

The objective of Point Merge in high density environment and complex E-TMA sectors is to replace radar vectoring by a more efficient traffic synchronisation mechanism in order to provide a simpler technique, with less communication workload, more understandable, easier to collectively predict traffic.

The overall objective of the project was reached. **Workability of the concept was proven**. The reduction of controller workload was demonstrated, and the **potential for a safe increase** of capacity is drawn as the main conclusion. The exercise was carried out in the current ATM environment, which confirms that no additional requirement is necessary either on the ground or on the aircraft side, both for equipment's and personnel.

The experimental implementation was well received by Controllers and Pilots, increasing situation awareness and predictability. The TMA controllers considered the arrival flows were delivered in better conditions than usual, and it was globally felt that the system increased the capability to manually optimise the sequence. It was also confirmed that those improvements are obtained while overall flight efficiency remains stable.

These findings confirm the main conclusions from the early real time simulations undertaken in the project. Furthermore, these two approaches are complementary in respect to traffic configuration: while the live trials mainly experienced situations of airport congestion with the need for global Arrival Management, the real time simulations focused on very high traffic in one specific arrival flow, addressing the sector capacity topic.

The live trials also were also beneficial in raising some issues that will need to be considered for further consolidation of the concept or for the definition of guidelines for implementation.

A generic risk resides in the way these new procedures are handled through existing regulations. For the tentative design, the longest possible Point Merge trajectories were published as standard STARs, while they shall be seldom used. This leads the aircraft operators to carry extra fuel, and disturbs FMS calculations of Estimated Time of Arrival. This issue does not appear for TMA Point Merge procedures, as they are part of the SIAs, and do not follow the same rules. This matter should be addressed both through alternative publication options, and through revision of regulations to cope with this new concept.

The other conclusion relates to local implementation. The North-West system used for the two series of trials performed ideally, and integrated perfectly in the existing network. On the other hand, the design experimented for the North-East system, while delivering the expected results, revealed some limitations.

This second system was designed as high and large as possible in order to evaluate maximum benefits. This positioned the procedures close to the limits of the sector, and induced modifications in the interfaces with feeder sectors. These modifications appeared to be problematic for both Belgocontrol and Maastricht centres, creating upstream complications and increased coordinations, even with the low winter traffic.

Furthermore, it was felt on the PMS side that one transfer point was too close to the procedure to allow perfect control of entries in the system.

Pilots as well as controllers also considered the fact that the procedures were only opened at specific periods in the trial days as a complication that is only bearable for experimental conditions.

The overall conclusion of the exercise is that Point Merge System in Extended TMA coupled with AMAN is a solution ready to deploy that brings substantial capacity and safety benefits, but it requires particular attention to local implementation.

1 Introduction

1.1 Purpose of the document

This document reports the main outcomes resulting from the DSNA V3 validation exercise EXE-05.06.07-VP-427 executed in the context of Operational Focus Area (OFA) 04.01.03, "AMAN + Point Merge" based on the concept set out in the P05.06.07 STEP1 "AMAN + Point Merge" OSED .

The validation was performed through two series of live trials performed in the Paris ACC environment respectively in June and November 2012.

This VALR describes the results of validation exercise EXE-05.06.07-VP-427 defined in the P05.06.07 STEP1 "AMAN + Point Merge" VALP ([15]) and how they have been conducted.

1.2 Intended readership

Participants in the following related SESAR projects can be interested in this Validation Report:

- P05.02 and P06.02 as coordinating federating projects (Coordination and consolidation of operational concept definition and validation)
- P06.03 (Integration and pre-operational validation)
- P06.07.02 A-SMGCS Routing and Planning functions as a close cooperation with 06.08.04 is required to analyse how to improve the integration between DMAN and A-SMGCS Routing and Planning functions
- Technical projects from WP12
    - P12.04.04 – The outcomes of both validation exercises have to be taken into account by the technical projects for future prototypes development.

1.3 Structure of the document

Chapter 1 Introduction - describes the purpose and scope of the document, the intended audience, and gives an explanation of the abbreviations and acronyms used throughout the document.

Chapter 2 Context of the Validation – summarizes the main topics concerning with the validation activities including a brief description of the operational concept under assessment on the basis of what and taking into account what has been defined in the Validation Plan [15] in terms of:

- Expected outcomes related to the defined validation objectives and to the identified indicators and metrics,
- Established validation scenarios,
- Methods and techniques used to perform the exercises and to collect both quantitative and qualitative data to be analysed after the simulation,
- Dependent exercises in order to see if different objectives have been addressed and how.

Chapter 3 Conduct of Validation Exercise – provides the details about all the preparatory and execution activities required to conduct the concerned validation exercises. Any deviations from what has been defined in the Validation Plan for V2 [15] is reported.

Chapter 4 Exercises Results – summarizes the main exercises results.

Chapter 5 Conclusions and recommendations – reports the main common conclusions and recommendations derived from the results.

Chapter 6 Validation Exercises reports – details the results for each of the exercise.

Chapter 7 References – lists all the applicable and reference documents.

Appendix A Safety Assessment Plan – describes the result of the activities conducted according to the Safety assessment process.

Appendix B Human Performance Assessment Plan – describes the result of the activities conducted according to the Human Performance (HP) assessment process.

1.4 Glossary of terms

A list of the important terminology and acronyms used in this document is presented below; they are taken, when available, from the SESAR ATM Lexicon (See [5].) In case of any difference between the definitions provided here and the SESAR Lexicon, the SESAR Lexicon should be taken as the authority. Definitions under refinement are included here and will be submitted to the Lexicon when they are mature and agreed across the Programme.

Term	Definition
Arrival Management Service	Arrival Management Service is provided through procedures used to establish sequences and related times e.g. as planned by an arrival manager.
Arrival Manager (AMAN)	An AMAN is a planning system to improve arrival flows at one or more airports by calculating the optimised approach / landing sequence and Target Landing Times (TLDT) and where needed times for specific fixes for each flight, taking multiple constraints and preferences into account.
Extended TMA (E-TMA)	The E-TMA corresponds to ACC terminal sector(s) (between Top Of Descent (ToD) and the Initial Approach Fix (IAF)) which make(s) the transition between the En-Route and the TMA sectors, which encompass the Approach airspace (between IAF and Final Approach Fix (FAF) or transfer to the Tower). In the present document, arrival management starts in E-TMA to feed TMA entry points.
Merge Point	The merge point (merging point) is the point where traffic merges.
Point Merge	The Point Merge is the procedure.

1.5 Acronyms and Terminology

A list of the important terminology and acronyms used in this document is presented below; they are taken, when available, from the SESAR ATM Lexicon [5]. In case of any difference between the definitions provided here and the SESAR Lexicon, the SESAR Lexicon shall be taken as the authority. Definitions under refinement are included here and will be submitted to the Lexicon when they are mature and agreed across the Programme.

Term	Definition
ACC	Area Control Centre
AIP	Aeronautical Information Publication
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
APP	Approach Centre / Control
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
BAC	Belgian Air Component

Term	Definition
CDA	Continuous Descent Approach
CDG	Paris Charles De Gaulle airport
CDO	Continuous Descent Operation
CTA	Controlled Time of Arrival
DOD	Detailed Operational Description
DSNA	Direction des Services de la Navigation Aérienne
DSR	Directorate SESAR and Research
EEC	EUROCONTROL Experimental Centre
E-OCVM	European Operational Concept Validation Methodology
E-TMA	Extended Terminal Manoeuvring Area
EUROCONTROL	European Organisation for the Safety of Air Navigation
FABEC	Functional Airspace Block Europe Central
FL	Flight Level, unit of altitude (expressed in 100's of feet)
FMS	Flight Management System
HMI	Human-Machine Interface
IAF	Initial Approach Fix
KPA	Key Performance Area
KPI	Key Performance Indicator
MISO	Méthodologie d'Intervention sur les Systèmes Opérationnels (Intervention Methodology on operational systems)
MUAC	Maastricht Upper Area Control Centre
NATS	National Air Traffic Services
ODP	Optimised Descent Profile
OFA	Operational Focus Area
OI	Operational Improvement
OSED	Operational Service Environment Description
PIR	Project Initiation Report
PMS	Point Merge system

Term	Definition
P-RNAV	Precision Area Navigation
RDA	Runway Delay Allocation
RDPS	Radar Data Processing System
R/T	Radio Telephony
RTA	Required Time of Arrival
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
STAR	Standard Terminal Arrival Route
STARS	Standard Approach Procedures
SUT	System Under Test
TMA	Terminal Manoeuvring Area
V1, V2… V7	Concept Lifecycle Model Phases V1 to V7

2 Context of the Validation

2.1 Concept Overview

Project 05.06.07 aims at providing an integrated and progressive approach towards TMA queue management support tools. Within the overall queue management concept, this project mainly addresses the concept of how integrated sequence building and optimisation of arrivals will improve the overall arrival management process, both in terms of aircraft operations/efficiency and general TMA operations ([15]).

In the context of this validation, TMA includes the ACC terminal sectors, namely Extended TMA, in which arrival management is initiated to feed TMA entry points. The E-TMA makes the transition between the En-Route (Brussels ACC - MUAC) and the approach TMA sectors, which encompass the Approach airspace (between IAF and Final Approach Fix or transfer to the Tower). The E-TMA consists of the Paris AP and TE sectors augmented with the newly defined CBWV (T2) and CBWV (T3) extending into the Brussels UIR and FIR (currently Brussels ACC and MUAC AOR).

The goal of this V3 validation exercise is to contribute to the 'AMAN + Point Merge' Operational Focus Area (OFA) by investigating the ability to support CDO in high density traffic environment through the use of an AMAN and Point-Merge System in the Paris ACC Extended TMA, Brussels ACC and MUAC. The use of the PMS should:

- increase ATC Capacity through a decrease of ATCO's workload and use of standard procedures;
- standardise ATCOs' methodologies with a 4D Predictable trajectory potential;
- provide a better Predictability as a clear contract between ATCOs and Pilots (Target Time of Arrival at the Merge Point) should allow flight optimisation;
- improve Flight Efficiency.

Two live trials were performed in the framework of EXE-05.06.07-VP-427 consisting in experimenting a new way of sequencing inbound traffic north-east and north-west of Paris: existing STAR (Standard Terminal Arrival Routes) were modified in order to implement new arrival trajectories known as "Point Merge". Airspace limits and transfer procedures from MUAC and Brussels ACC were also be modified for the trials.

The first live trial concerned the implementation of one E-TMA Point Merge system for Northwest arrivals of the CDG airport, coupled to the use of the MAESTRO AMAN in Paris-ACC and at the approach of the Paris CDG Airport, being fed from Brest and London ACC.

The second live trial concerned the implementation of two E-TMA Point Merge systems for Northwest and Northeast arrivals of the CDG airport, coupled to the use of the MAESTRO AMAN in Paris-ACC and at the approach of the Paris CDG Airport, being fed from EUROCONTROL Maastricht UAC and Belgocontrol Brussels ACC, London ACC and Brest ACC.

Table 1 below gives a summary of EXE-05.06.07-VP-427.

Validation Exercise ID and Title	**EXE-05.06.07-VP-427: Live Trials in En-Route, E-TMA and TMA on the use of Point Merge combined with AMAN**
Leading organization	DSNA
Validation exercise objectives	E-TMA validation objectives: • OBJ-05.06.07-VALP-0427.0100 • OBJ-05.06.07-VALP-0427.0200 • OBJ-05.06.07-VALP-0427.0300 • OBJ-05.06.07-VALP-0427.0400 • OBJ-05.06.07-VALP-0427.0500

	• OBJ-05.06.07-VALP-0427.0600 En-Route validation objectives: • OBJ-05.06.07-VALP-0427.1100 • OBJ-05.06.07-VALP-0427.1200 • OBJ-05.06.07-VALP-0427.1300
Rationale	To evaluate in real traffic conditions the efficiency of E-TMA Point Merge system coupled to the use of the AMAN in the sequencing of arrival flows.
Supporting DOD / Operational Scenario / Use Case	05.02 STEP 1 DOD • Sub-scenario 6: Implement ENR/E-TMA in H/H environment, ground solution. • Sub-scenario 9: Plan/optimise with AMAN in H/H environment, AMAN + Point Merge OSED Use case: Parallel legs Point Merge with level-off and multiple levels
OFA addressed	04.01.03 AMAN + Point Merge
OI steps addressed	TS-0102 Basic Arrival Management Supporting TMA Improvements (incl. CDA, P-RNAV)
Applicable Operational Context	E-TMA.
Expected results per KPA	• Increased ATC sectors' arrival capacity through reduction of ATCO workload including reduction of frequency load. • Increased arrival flight efficiency. • Improved trajectory predictability. • Improved safety through improved IAF delivery conditions and better situation awareness. • Improved Environmental sustainability
Validation Technique	Live Trials
Dependent Validation Exercises	N/A

Table 1: Concept Overview

2.2 Summary of Validation Exercise/s

2.2.1 Summary of Expected Exercise/s outcomes

The stakeholders' expectations addressed in V3 were as follows:

Airlines & Pilots:

- At least maintain safety.
- Improved Predictability.
- Acceptable Cost/Benefit Ratio.
- Acceptable impact on airline operations (Increased flexibility whilst in the planning and tactical phases).
- Reduced fuel burn and consequently an improved environmental impact.
- Ease cockpit operations or acceptable impact on cockpit operations.

- Visibility on improved performances as above at the level of individual flights.

ANSPs:

- Acceptable impact on each ANSP's system procurement plans (more standardise methodology leading to reduction of workload and more efficient handling of traffic), airspace design planning, and e.g. procedure definition and planning / publication, etc.
- Signs of potential for improvement in terms of capacity, cost effectiveness, predictability.
- At least maintain safety.

ATCOs:

- Ease ATC operations, or acceptable impact on ATC operations, including e.g. adherence to AMAN advisories in upstream/en-route airspace, interaction of traffic metering objectives and separation objectives, etc.
- Visibility on improved performances for the whole traffic flow.

2.2.2 Benefit mechanisms investigated

The benefit mechanisms were developed in the P05.06.07 Validation Plan [15] for exercise EXE-05.06.07-VP-427. The main impacted areas to be addressed by the Point Merge + AMAN concept are the following: safety, capacity, predictability, efficiency and environment as illustrated in below.

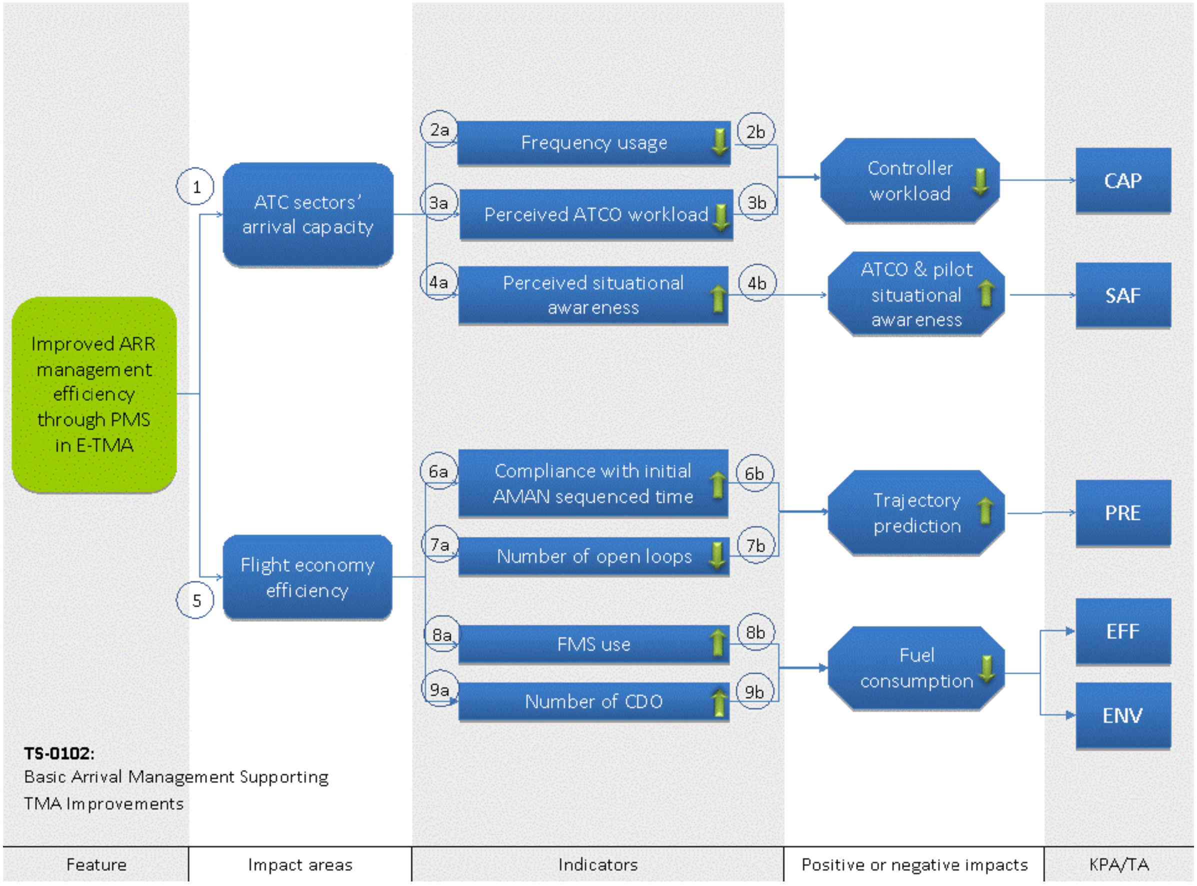


Figure 1: PMS Benefit Mechanisms Diagram in the E-TMA sectors

2.2.3 Summary of Validation Objectives and success criteria

The main goal of the Live Trials was to assess the capacity and efficiency of the Point Merge + AMAN system. The validation objectives linked to the success criteria, validation scenarios and operational requirements are presented in Table 2 below.

Validation Objective ID	Validation Objective	Success Criteria	Validation Scenario	Operational Requirements[1]
OBJ-05.06.07-VALP-0427.0100	Controller workload assessment	• CRT-05.06.07-VALP-0427.0100: Average answer to perceive l workload question is that PMS reduces workload. • CRT-05.06.07-VALP-0427.0110: Frequency usage reduced.	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	REQ-05.06.07-OSED-0200.0020
OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	• CRT-05.06.07-VALP-0427.0200: Better compliance with initial AMAN sequenced time than in baseline. • CRT-05.06.07-VALP-0427.0210: Number of open loops / holdings lower than in baseline. • CRT-05.06.07-VALP-0427.0220: Number of level segments lower than in baseline. • CRT-05.06.07-VALP-0427.0230: Pilots most often obtained a direct to the Merge Point before entering the STAR. • CRT-05.06.07-VALP-0427.0240: Controllers most often proposed the pilots to "descend at discretion" at the exit of the leg toward the Merge Point.	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	REQ-05.06.07-OSED-0200.0030
OBJ-05.06.07-VALP-0427.0300	Metering efficiency assessment	• CRT-05.06.07-VALP-0427.0300: More delay absorbed on the legs rather than in TMA and rather than in vectoring in E-TMA.	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	REQ-05.06.07-OSED-0200.0030
OBJ-05.06.07-VALP-0427.0400	IAF delivery conditions assessment	• CRT-05.06.07-VALP-0427.0400: Aircraft separations and speeds over IAF equal or better than in baseline	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	REQ-05.06.07-OSED-0200.0020
OBJ-05.06.07-VALP-0427.0500	Safety assessment	• CRT-05.06.07-VALP-0427.0500: Level of safety felt by controllers equal or better than in baseline • CRT-05.06.07-VALP-0427.0510: Controllers average answer to situation awareness question is that situation awareness is better than in baseline • CRT-05.06.07-VALP-	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	N/A

[1] The reference to OSED requirements will be updated and aligned on the OSED final version to be issued.

Validation Objective ID	Validation Objective	Success Criteria	Validation Scenario	Operational Requirements[1]
		0427.0520: Pilots' general impression on the PMS procedure about radio communications, simplicity of the procedure, and clarity of the phraseology is globally positive.		
OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	• CRT-05.06.07-VALP-0427.0600: Flight duration equal or better than in baseline • CRT-05.06.07-VALP-0427.0610: Flight distance might be longer than in baseline because aircraft are holding at higher altitude • CRT-05.06.07-VALP-0427.0620: Fuel burn equal or better than in baseline	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	
OBJ-05.06.07-VALP-0427.1100	Controller workload assessment in En-Route	• CRT-05.06.07-VALP-0427.1110: Average answer to perceived workload question is that feeding the E-TMA sectors has no negative impact on E-R controller workload in managing the E-TMA feed • CRT-05.06.07-VALP-0427.1120: Average answer to perceived workload question is that feeding the E-TMA sectors has no negative impact on E-R controller workload in respect to other traffic flows • CRT-05.06.07-VALP-0427.1130: Post analysis of recorded data (depending on outcome of the questionnaire)	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	N/A
OBJ-05.06.07-VALP-0427.1200	Safety assessment En-Route	• CRT-05.06.07-VALP-0427.1210: Level of safety felt by controllers equal or better than in baseline (questionnaire) • CRT-05.06.07-VALP-0427.1220: Controllers average answer to situation awareness question is that situation awareness is better than in baseline (questionnaire) • CRT-05.06.07-VALP-0427.1230: Adequacy of the radio communications failure procedure, simplicity of the procedure	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	N/A
OBJ-05.06.07-VALP-0427.1300	Flight efficiency assessment En-Route	• CRT-05.06.07-VALP-0427.1310: Flight duration equal or better than in baseline • CRT-05.06.07-VALP-	• SCN-05.06.07-VALP-0427.0100 • SCN-05.06.07-VALP-0427.0200	N/A

Validation Objective ID	Validation Objective	Success Criteria	Validation Scenario	Operational Requirements[1]
		0427.1311: Flight distance might be longer than in baseline because aircraft are holding at higher altitude • CRT-05.06.07-VALP-0427.1312: Fuel burn equal or better than in baseline		

Table 2: Summary of validation objectives and success criteria

2.2.3.1 Choice of metrics and indicators

Table 3 and Table 4 below present each validation objective, their related indicator(s) and metrics and the means to collect them respectively for E-TMA and for En-Route.

E-TMA Validation Objective	Indicator	Means
Controller workload reduction	Level of workload felt by controllers	ATCO Questionnaires
	Frequency occupancy	Recordings of the frequency or recordings of controller micro usage
Trajectory Predictability improvement	Compliance with initial AMAN sequenced time	Recordings from AMAN
	Number of open loops / holdings	ATCO Questionnaires or processing of radar data
	Use of FMS optimization	Pilots Questionnaire[2]
	Number of level segments Duration of level of segment (+FL concerned)	ATCO Questionnaires or processing of radar data
Metering efficiency in E-TMA	Ratio of time spent in E-TMA/TMA Time spent on the legs AMAN delay absorbed by E-TMA	Measures based on radar recordings
IAF delivery conditions in E-TMA	Aircraft spacing, FL and speeds over IAF	Measures based on radar recordings
Safety in E-TMA	Level of safety felt by controllers and pilots	ATCO and Pilot Questionnaires
	Situation awareness	ATCO Questionnaires
Flight efficiency in E-TMA	Flight duration	Time spent between the first point and touchdown
	Flight distance	Distance flown between the first point and touchdown
	Fuel burn	Estimation of fuel burn with mathematical model based on radar tracks and aircraft performance models Actual recordings of FMS from Airlines' flights (incl. Air France)

Table 3: EXE-05.06.07-VALP-0427.0100 validation objectives and indicators for E-TMA

[2] It did not seem efficient to directly ask the pilots a general question on whether they used the FMS more than usual with the PMS procedure. The optimization of the FMS use will be deduced from the pilots' answers to more concrete questions on instruction of direct to the Merge Point, flying on the leg, radar vectoring,

En-Route Validation Objective	Indicator	Means
Controller workload assessment in En-Route	Level of workload felt by controllers to feed E-TMA	ATCO Questionnaires
	Level of workload felt by controllers to work other traffic	ATCO Questionnaires
	Level of workload measured by workload modelling tools	SASM, RECALL, TMS analysis
Safety assessment En-Route	Level of safety felt by controllers and pilots	ATCO Questionnaires
	Situation awareness	ATCO Questionnaires
	Adequacy Radio-Comms procedure	Observer expertise and feedback
Flight efficiency En-Route	Flight duration	Time spent between MUAC AoR Entry and MUAC AoR Exit
	Flight distance	Distance flown between MUAC AoR Entry and MUAC AoR Exit
	Fuel burn	Estimation of fuel burn with mathematical model based on radar tracks and aircraft performance models Actual recording of FMS from Airlines' flights (incl. Air France)

Table 4: EXE-05.06.07-VALP-0427.0100 validation objectives and indicators for E-R

2.2.4 Summary of Validation Scenarios

EXE-05.06.07-VALP-0427 used two scenarios:

1. A scenario to be evaluated combining Point Merge with AMAN for NW and NE arrivals (SCN-05.06.07-VALP-0427.0100).
2. A reference (baseline) scenario reflecting today operations (SCN-05.06.07-VALP-0427.0200).

Both scenarios cover nominal and non-nominal situations [16].

2.2.5 Summary of Assumptions

Table 5 below presents the validation assumptions defined for EXE-05.06.07-VALP-0427.

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-05.06.07-427-S1-001	CNS infrastructure	Ground tools/Technology	In Paris ACC, RNAV1 is required to support the implementation of the Point Merge concept in the considered E-TMA environment. And more than 95% of aircraft should be PRNAV approved (i.e. PRNAV equipped and PM procedure loaded in FMS).	Required to set up the Live Trials.	E-TMA	QoS	Expert opinion	N/A	Primary Projects	High
ASS-05.06.07-427-S1-002	Operational system use	Ground tools/Technology	The validation is performed on the operational system (CWP display + AMAN) used in standard operational conditions (no degraded mode).	Required to set up the Live Trials.	E-TMA TMA E-R	All	Expert opinion	N/A	Primary Projects	High
ASS-05.06.07-427-S1-003	Ground system adaptations	Ground tools/Technology	The necessary systems adaptations have been performed in the controlling entities (e.g. new COPs between MUAC and Paris ACC) prior to the trials.	Required to set up the Live Trials.	E-TMA TMA E-R	Interoperability	Expert opinion	N/A	Primary Projects	High
ASS-05.06.07-427-S1-004	Point Merge waypoints display on CWP radar image	Ground tools/Technology	The CWP display has a default setting displaying all the waypoints of the Point Merges.	Required to set up the Live Trials. The Point Merge system should be displayed on the controllers' CWP radar image.	E-TMA TMA E-R	Human Performance Safety QoS	Expert opinion	N/A	Primary Projects	High
ASS-05.06.07-427-S1-005	Point Merge + AMAN configuration	Ground tools/Technology	The Point Merge + AMAN configuration has been done in simulation and validated before being tested in trials.	Required to set up the Live Trials.	E-TMA TMA	Interoperability Safety QoS	Expert opinion	N/A	Primary Projects	High

ASS-05.06.07-427-S1-006	FMS update with Point Merge RNAV procedure	Aircraft Equipage/ Technology	The Point Merge RNAV procedure is loaded in the FMS for equipped aircraft due to fly the new procedure.	Required to set up the Live Trials.	E-TMA	Human Performance QoS Human Performance	Expert opinion	N/A	Primary Projects	High
ASS-05.06.07-427-S1-007	Controllers' training[3]	Human Performance	Additional training is provided to controllers about the changes in procedures.	Required to set up the Live Trials. The controllers have to know the changes in procedures.	E-TMA TMA E-R	Human Performance Safety QoS	Expert opinion	N/A	Primary Projects	High
ASS-05.06.07-427-S1-008	Sequence Manager role	Human Performance	Depending on whether TMA and E-TMA controllers are on the same location and/or on TMA traffic level and complexity, and/or specific Point Merge design considered, there might be one or two SEQ managers, one in TMA and one in E-TMA, to coordinate the global arrival sequence.	Depending on local conditions, there might be a need for someone in the E-TMA to coordinate the arrival flows with the TMA a Sequence Manager to balance the workload within the E-TMA sectors and help balancing the traffic on the runways.	E-TMA TMA	Human Performance QoS	Expert opinion	N/A	Primary Projects	Low

Table 5: Validation Assumptions

[3] No additional training for Pilots was required for both Live Trial sessions, only clear information.

2.2.6 Choice of methods and techniques

Table 6 and Table 7 hereafter summarise the different methods and techniques used for analysing the defined metrics and indicators.

It should be noted that:

- Paris ACC & Paris CDG operational platforms were used for both trials (i.e. June and Nov-Dec.) whereas MUAC & Belgocontrol operational platforms were only used for the Nov-Dec trials.
- June trials only involved measurements in E-TMA whereas Nov-Dec trials also involved measurements in ENR.

Supported Metric / Indicator	Platform / Tool	Method or Technique
• Level of workload felt by controllers • Frequency occupancy • Compliance with initial AMAN sequenced time • Number of open loops / holdings • Use of FMS optimization • Number of level segments • Duration of level off segment (+FL concerned) • Ratio of time spent in E-TMA TMA • Time spent on the legs • AMAN delay absorbed by E-TMA • Aircraft spacing, FL and speeds over IAF • Level of safety felt by controllers and pilots • Situation awareness • Flight duration • Flight distance • Fuel burn	Paris ACC operational platform & Paris CDG operational platform	Live Trials

Table : Methods and Techniques used in E-TMA

Supported Metric / Indicator	Platform / Tool	Method or Technique
• Level of workload felt by controllers to feed E-TMA • Level of workload felt by controllers to work other traffic • Level of workload measured by workload modelling tools • Level of safety felt by controllers and pilots • Situation awareness • Adequacy Radio-Comms procedure • Flight duration • Flight distance • Fuel burn	EUROCONTROL Maastricht UAC operational platform & Belgocontrol Brussels ACC operational platform	Live Trials

Table 7: Methods and Techniques used in En-Route

2.2.7 Validation Exercises List and dependencies

Two live trials were organised to validate the Point Merge system combined with the use of the AMAN:

- June 2012 Live Trials allowed evaluating the implementation of one E-TMA Point Merge system for Northwest traffic to Paris CDG.
- November – December 2012 Live Trials allowed evaluating the implementation of two E-TMA Point Merge systems for Northwest and Northeast traffic to Paris CDG.

Feedback of both Live Trials is described in this report in order to reach a common conclusion.

The Live Trials are dependent:

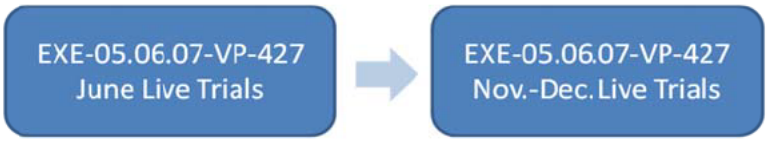


Figure 2: Validation Exercises List and dependencies

3 Conduct of Validation Exercises

3.1 Exercises Preparation

3.1.1 Preliminary exercise preparation: Real-time simulations at EEC

3.1.1.1 Objective

A study was carried out in 2011 at the EUROCONTROL Experimental Centre in preparation for the live trials to be conducted in 2012 at Paris ACC with Paris CDG, Maastricht UAC and Brussels ACC (SJU project 05.06.07, exercise 427).

The objective of the live trials will be to evaluate the use of Point Merge in ACC with AMAN for sequencing Northern arrival flows to Paris CDG.

The objective of the study was to refine and validate design, procedures and working methods, and to perform an initial benefit assessment prior the live trials.

3.1.1.2 Method

The study consisted of a series of small scale simulations iteratively focussing on NE (AP TE) then NW (TP) ACC arrival sectors prior integrating both with approach positions and an AMAN (MAESTRO). It was conducted over five months (March to July 2011) and involved Paris ACC and Paris CDG controllers (27 in total).

The study was conducted jointly by DSNA (Paris ACC, Paris CDG and DTI) and EUROCONTROL (DSR) with the support of Belgocontrol.

3.1.1.3 Key outcomes

Overall, the outcomes from the sessions were consistent and positive. The iterative process and continuity of participants allowed gradually testing and refining the new route structure and working method, with an efficient participation of the controllers that were fully familiarised and trained. The final design, consistent between NE and NW sectors, relies on a Point Merge to sequence the main arrival flow (LFPG arrivals) and segregated routes for secondary arrival flows. The last session allowed conducting an initial quantitative assessment in a realistic environment with NE (AP/TE) and NW (TP) sectors, Approach North positions and MAESTRO.

In ACC, the main benefits reported by the controllers were confirmed by the objective analysis: easy to learn, comfortable, better task allocation in NE, reduction of workload and communication (Figure 3) and potential for safety and capacity increase (Figure 4). The main limitations were: compatibility with existing delivery conditions by upstream sectors in NE and potential interactions with overflights in NW.

In Approach, the general feedback was positive with potentially an improvement of the situation compared to today due to a better awareness/view of the sequence and a better adherence to AMAN advisories in ACC, with positive impact in terms of delivery conditions.

In terms of flight efficiency, the results showed that LFPG arrivals flew an equivalent distance and time (Figure 5) while maintained at higher altitude (Figure 6) with more predictable trajectories (Figure 7 and Figure 8).

Note: The results presented are from the last session and were collected over 6 measured runs (2 Baseline and 4 Point Merge performed in both Westerly and Easterly runway configuration) of 1h each.

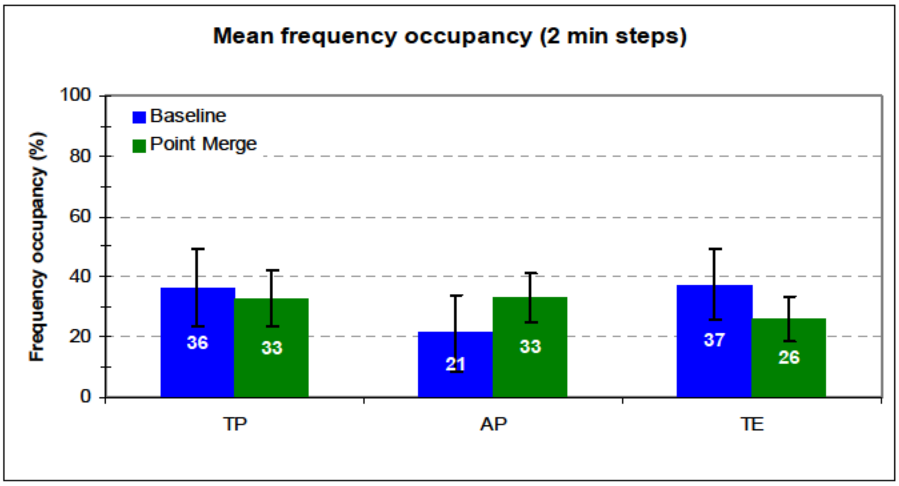


Figure 3: Mean frequency occupancy in ACC sectors.

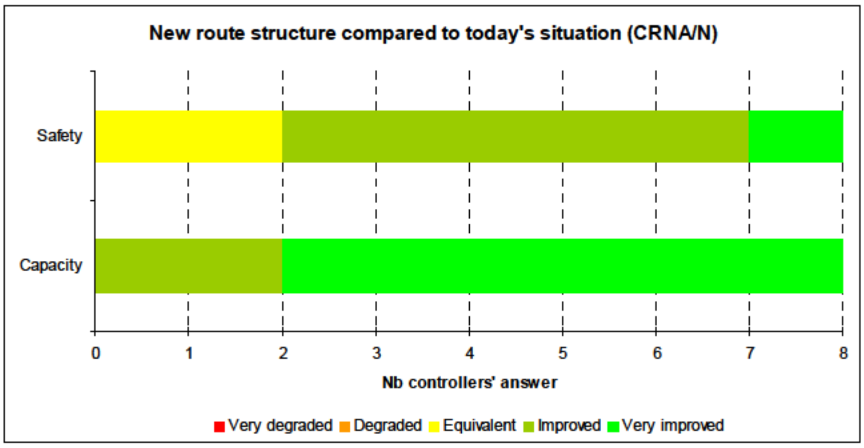


Figure 4: ACC controllers' ratings regarding safety and capacity compared to today's situation.

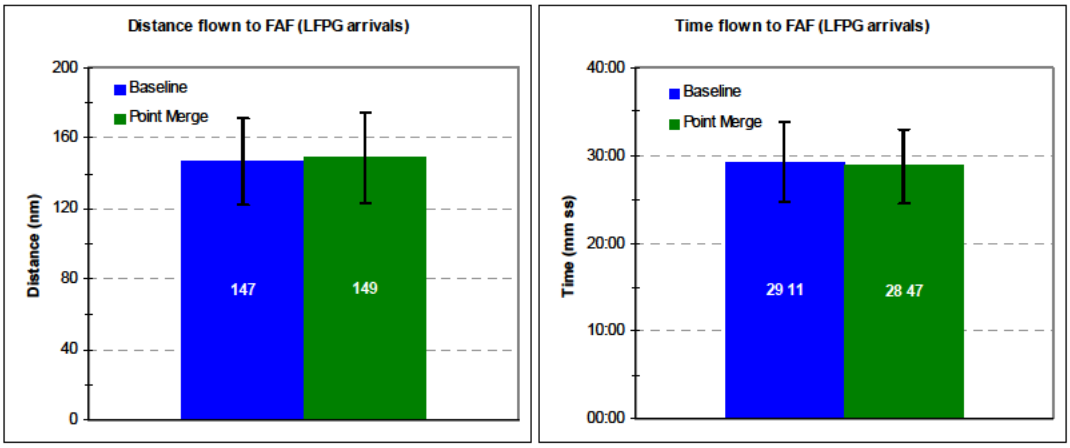


Figure 5: Distance and time flown in ACC+APP (LFPG arrivals).

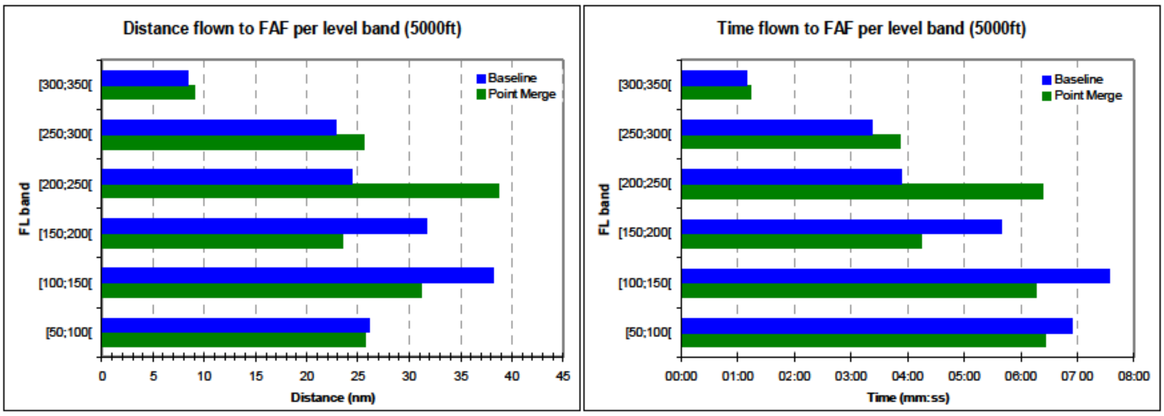


Figure 6: Distance and time flown per level band (LFPG arrivals).

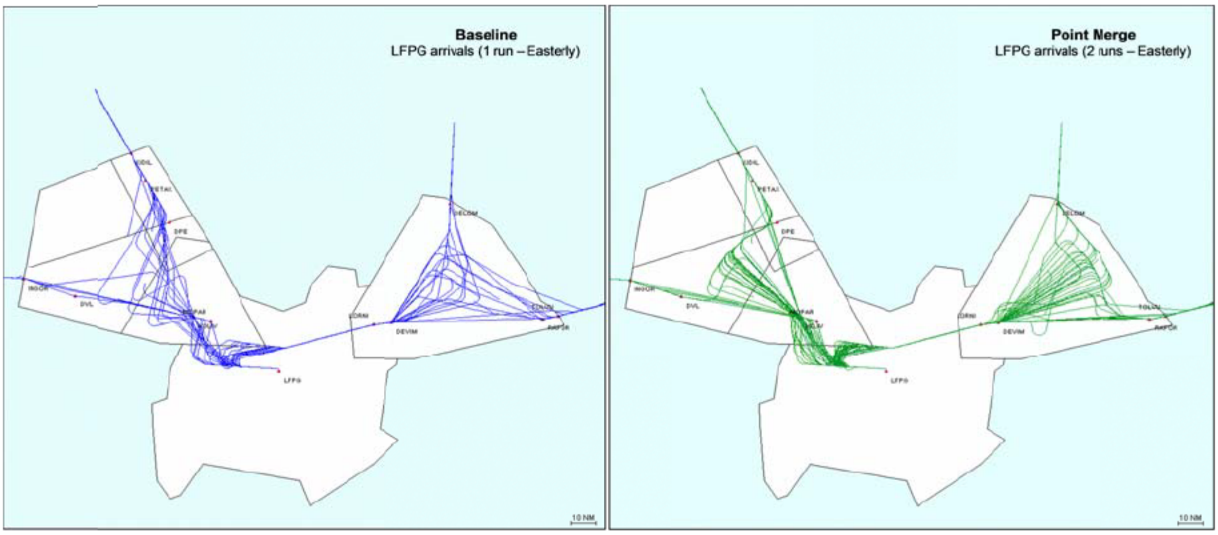


Figure 7: Flown trajectories in Baseline (left) and with Point Merge (right) in Easterly configuration (LFPG arrivals).

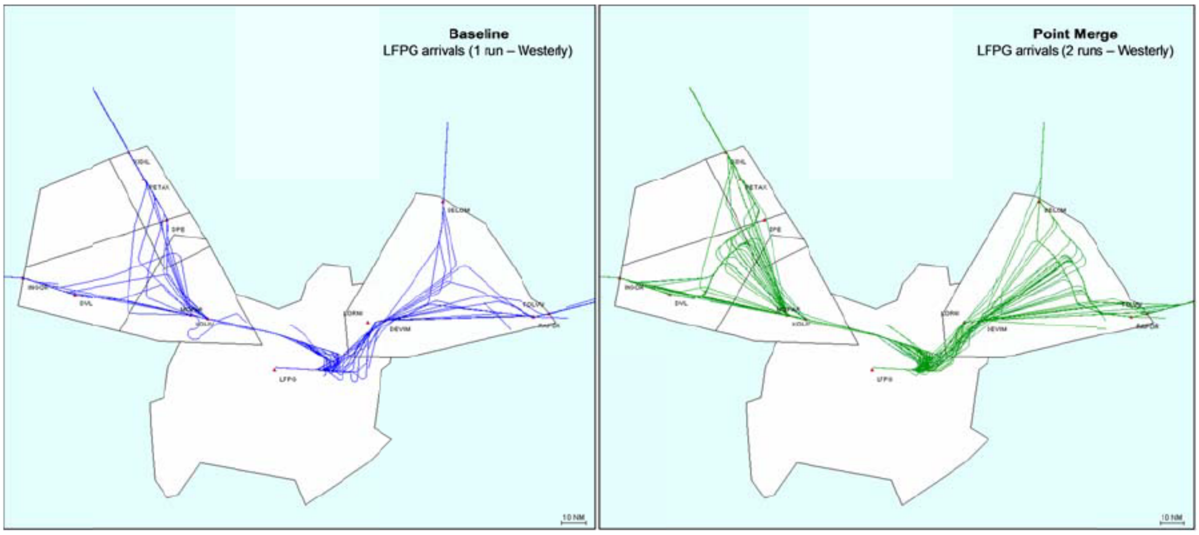


Figure 8: Flown trajectories in Baseline (left) and with Point Merge (right) in Westerly configuration (LFPG arrivals).

3.1.2 Life trials exercise preparation

The preparation of each validation exercise is detailed in the V3 Validation Plan [15] and in sections 6.1.2.1 and 6.2.2.1 of this document.

3.2 Exercises Execution

June 2012 Live Trials took place in Paris ACC and Paris CDG and had the duration of eight days, between the 18th and 23rd of June 2012.

November- December 2012 Live Trials took place in Paris ACC, Paris CDG, EUROCONTROL Maastricht UAC and Belgocontrol Brussels ACC and were held four Saturdays, between the 17th of November and the 8th of December 2012.

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
Exercise #1	EXE-05.06.07-VP-427-June 2012 trials	18/06/2012	23/06/2012	25/06/2012	18/02/2013
Exercise #2	EXE-05.06.07-VP-427-November/December 2012 trials	17/11/2012	08/12/2012	19/11/2012	18/02/2013

Table 8: Exercises execution/analysis dates

3.3 Deviations from the planned activities

3.3.1 Deviations with respect to the Validation Strategy

There were no deviations with respect to the Validation Strategy for none of the validation exercises.

3.3.2 Deviations with respect to the Validation Plan

The deviation with respect to the Validation Plan of each validation exercise is detailed in sections 6.1.2.3 and 6.2.2.3 of this document.

<u>June and November – December Live Trials</u>

- Measures of aircraft speeds and FL over IAF were not performed.
- Measures (number, duration and FL) of level off segment were not performed.
- Measures were not performed for those criteria:
  - CRT-05.06.07-VALP-0427.0230 Pilots most often obtained a direct to the Merge Point before entering the SAR.
  - CRT-05.06.07-VALP-0427.0240 Controllers most often proposed the pilots to “descend at discretion” at the exit of the leg toward the Merge Point

<u>In addition for November - December Live Trials</u>

- Measures were not performed for those criteria:
  - CRT-05.06.07-VALP-0427.0620 Fuel burn equal or better than in Baseline

4 Exercises Results

4.1 Summary of Exercises Results

This section details the outcomes of EXE-05.06.07-VP-427 for each validation objective defined in the Validation Plan [15]. A summary is presented in the following table, including the related success criteria. These outcomes take into account the results from June and November-December exercises. Any deviations with respect to the targets are illustrated as well on the basis of the following status:

- OK – It means that the validation objective has been met. In other words, the exercise results achieve the defined success criteria
- NOK – It means that the validation objective has not been met. In other word, the exercise results haven't satisfied the defined success criteria.
- N/A means that the exercise did not produce results for the considered criterion

An analysis of each result is provided in the corresponding section 4.2, as well as in sections 6.1.3.2 and 6.2.3.2.

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-05.06.07-VP-427	**OBJ-05.06.07-VALP-0427.0100**	Controller workload assessment	**CRT-05.06.07-VALP-0427.0100**	Average answer to perceived workload question is that PMS reduces workload.	In the E-TMA, the workload was perceived as either reduced or equal with the Point Merge (PM). In the TMA, the PM was considered has having no impact on workload.	**OK**
EXE-05.06.07-VP-427	**OBJ-05.06.07-VALP-0427.0100**	Controller workload assessment	**CRT-05.06.07-VALP-0427.0110**	Frequency usage reduced.	Frequency occupancy in APTE sector was lower during Point Merge days. Frequency occupancy in TP sector was very close to Baseline but more information was given by controllers to pilots.	**OK**
EXE-05.06.07-VP-427	**OBJ-05.06.07-VALP-0427.0200**	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0200**	Better compliance with initial AMAN sequenced time than in baseline	The respect of the initial AMAN sequenced time was equivalent or better than in baseline.	**OK**
EXE-05.06.07-VP-427	**OBJ-05.06.07-VALP-0427.0200**	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0210**	Number of open loops / holdings lower than in baseline	The number of open loops / holdings was lower than in baseline.	**OK**

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	CRT-05.06.07-VALP-0427.0220	Number of level segments lower than in baseline	The number of level segments lower than in baseline.	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0300	Metering efficiency assessment	CRT-05.06.07-VALP-0427.0300	More delay absorbed on the legs rather than in TMA and rather than in vectoring in E-TMA.	All delay in ACC was absorbed on the legs rather than in vectoring. In June, more delay absorbed (on the legs) in E-TMA rather than in TMA. In November-December delay in TMA was equivalent.	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0400	IAF delivery conditions assessment	CRT-05.06.07-VALP-0427.0400	Aircraft separations and speeds over IAF equal or better than in baseline	Aircraft spacing over delivery points during peak traffic are similar to Baseline	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0500	Safety assessment	CRT-05.06.07-VALP-0427.0500	Level of safety felt by controllers equal or better than in baseline	The level of safety felt by E-TMA and TMA controllers was rated as better or at least the same than in baseline	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0500	Safety assessment	CRT-05.06.07-VALP-0427.0510	Controllers average answer to situation awareness question is that situation awareness is better than in baseline	A majority of E-TMA and TMA controllers reported that situation awareness was better than in baseline.	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0500	Safety assessment	CRT-05.06.07-VALP-0427.0520	Pilots' general impression on the PMS procedure about radio communications, simplicity of the procedure, and clarity of the phraseology is globally positive.	From 52 Pilots' feedbacks, all found no change or improvement compared to the baseline.	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	CRT-05.06.07-VALP-0427.0600	Flight duration equal or better than in baseline	From entry point of Paris ACC to the RWY, flight duration was equivalent. For the arrival flights from the West, if no time to loose, Flight duration in Paris ACC was equivalent, as well	OK

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					as fuel consumption.	
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	CRT-05.06.07-VALP-0427.0610	Flight distance might be longer than in baseline because aircraft are holding at higher altitude	From entry point of Paris ACC to the RWY, flight distance was equivalent. For the arrival flights from the West, if no time to loose, distance flown in Paris ACC was slightly higher (+2Nm with Point Merge)	OK
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	CRT-05.06.07-VALP-0427.0620	Fuel burn equal or better than in baseline	For the arrival flights from the West, if flights had time to loose, fuel was equivalent. (for June's trials)	OK (for June's trials)

Table 9: DSNA EXE-05.06.07-VP-427– Summary of validation exercises results

4.1.1 Results on concept clarification

The issue of fuel calculation was raised. The coding of the entire route in the FMS leads to an overestimate of fuel carriage and thus to extra fuel consumption. The coding of the entire route in the FMS also results in a wrong Estimated Time of Arrival as in most cases the aircraft did not fly the leg and proceed direct to the Merge Point.

The use of the Point Merge procedure combined with the AMAN saved E-TMA controllers' mental resources. This allowed them to improve the service provide to the pilots, notably by informing them on the expected time to fly on the legs.

During the trials, some confusion sometimes occurred regarding the provision of new information to the pilots (e.g. time to lose on the legs). A new phraseology has to be defined for the E-TMA controllers to provide the flight crews with the information aimed to improve their flight profile.

4.1.2 Results per KPA

The main results per KPA and KPI that were addressed by EXE-05.06.07-VP-427, as defined in the VALP, are summarized in the table below.

KPAs	KPIs	Results
Capacity	Controllers' perceived workload assessment (questionnaire)	A majority of the participating E-TMA stated that the workload was unchanged to lower. A majority of the participating TMA controllers stated that the workload was unchanged.

KPAs	KPIs	Results
	Frequency usage	Frequency occupancy in APTE sector was lower during Point Merge days. Frequency occupancy in TP sector was very close to Baseline but more information was given by controllers to pilots.
Predictability	Number of open loops / holdings (questionnaire and / or processing of radar data).	Most of the E-TMA controllers stated that they did not have to issue heading clearances due to the Point Merge.
	Number of level segments (questionnaire and / or processing of radar data).	Most of the E-TMA controllers stated that they did not have to issue and monitor intermediary levels due to the Point Merge.
Efficiency	Metering efficiency assessment	All delay in ACC during peak traffic was absorbed on the legs rather than in vectoring. In June, more delay absorbed in E-TMA rather than in TMA. In November-December, delay in TMA was equivalent.
	IAF delivery conditions assessment	The respect of the initial AMAN sequenced time was equivalent or better than in baseline. Aircraft spacing over delivery points during peak traffic was similar to Baseline
	Flight efficiency assessment (flight distance & duration, fuel consumption)	From entry point of Paris ACC to the RWY, flight distance and flight duration was equivalent. For the arrival flights from the West, if no time to loose, flight duration in Paris ACC was equivalent, distance flown was slightly higher (+2Nm with Point Merge), and fuel consumption was equivalent. If flights had time to loose, fuel consumption was equivalent.
Safety	Controllers' perceived safety assessment.	All participating E-TMA and TMA controllers stated that the level of safety was higher than today or at least the same.
	Controllers' situational awareness assessment	E-TMA controllers considered that they had a better situational awareness of the sequencing with the Point Merge than without. A majority of TMA controllers stated that the situational awareness was better with the Point Merge or at least equal.
	Pilots' subjective assessment / radio communications, simplicity of the procedure, clarity of the	Pilots' general impression on the Point Merge procedure about radio communications, simplicity of the procedure, and clarity of the phraseology was globally positive.

KPAs	KPIs	Results
	phraseology	
Environmental sustainability	Fuel burn	For flights coming from the West, fuel consumption was equivalent on the flights analysed.

Table 10: DSNA EXE-05.06.07-VP-427 - Results per KPA

4.1.3 Results impacting regulation and standardisation initiatives

No new regulatory requirements are defined with the use of the Point Merge + AMAN as the Point Merge procedure is a STAR. The current regulation applies. However, the issue of fuel calculation was raised. The coding of the entire route in the FMS leads to an overestimate of fuel carriage and thus to extra fuel consumption. The coding of the entire route in the FMS also results in a wrong Estimated Time of Arrival as in most cases the aircraft did not fly the leg and proceed direct to the Merge Point.

DSNA and the airlines would like to introduce a sentence in the AIP supplements, which basically states:

- Direct (shortest) route should be planned for fuel calculation purpose.
- Longer routes can be actually flown for sequencing purpose and airlines still have to apply the applicable regulation for fuel consumption.

This issue is described in the Meeting minutes of PMS live trials FABEC review meeting #2 [18].

Several options are currently investigated to reduce or even eliminate the issue of fuel carriage. Korea brought the topic to the ICAO. However, no solution is available at the moment of the writing of this report.

4.2 Analysis of Exercises Results

4.2.1.1.1 Operability in ACC

4.2.1.1.1.1 General Feedback

Today, in the Baseline environment, both the E-TMA and the TMA controllers have an AMAN at their disposal which displays the arrival flights per entry point or per runway. The AMAN also provides time to loose / time to gain per arrival flight. In the TMA, the AMAN is used by the SEQ manager to allocate the order of the arrival flights and the spacing. The E-TMA controllers inform the SEQ manager of the flights order when different from the one planned in the AMAN so that the TMA SEQ manager can update the sequence on his/her AMAN. The E-TMA controllers try to absorb the ACC delay before transferring the flights to the TMA. In order to do so, the E-TMA controllers pre-regulate the arrival flow. Pre-regulation in the E-TMA can also be requested by the TMA SEQ manager who can ask for a speed reduction and might also provide an Expected Approach Time to be given to the pilot so that s/he can her/himself manage the flight speed.

The feedback from ACC controllers was globally positive. With the Point Merge combined with AMAN, the management of the overall traffic (to LFPG, overflights and peripheral flights) was found easier or at least unchanged. In particular, the ACC controllers found that it was easier to respect the AMAN delays of the arrival traffic to LFPG. They reported that the use of the Point Merge with AMAN improved the quality of the sequencing and of the delivery. Concerning the coordination with LFPG, it was considered as improved as the management of sequence order was facilitated with the Point Merge system. This flexibility in changing the sequence order made it easier for the E-TMA controllers to accommodate requests from the Approach. The reduction in frequency load allowed focusing on the coordination with the Approach and to try and build a sequence perfectly suited to CDG.

In terms of safety, ACC controllers found that it was either improved or at least as safe as today. The Point Merge was considered as easy to use. The aircraft are strategically separated on the legs, which made the traffic less conflicting. The Point Merge with AMAN was considered as more efficient to handle arrivals than radar vectoring, with less workload and more comfort compared to today.

4.2.1.1.1.2 Controller's Activity

The analysis of the frequency occupancy shows that frequency usage was equivalent or lower than in Baseline.

For June live trials, the frequency was slightly more loaded than in Baseline during low traffic and equivalent during high traffic. This result is balanced by the fact that controllers gave more information to pilots as explained in the next section (section 4.2.1.1.1.3).

For November and December live trials, the frequency load was equivalent during low traffic and lower during medium and high traffic compared to Baseline.

4.2.1.1.1.3 Controller's Workload

Overall, ACC controllers stated that their workload was average to very low with the Point Merge and AMAN. The frequency usage was lower than in the baseline. The Point Merge procedure was less demanding than radar vectoring; it saved mental resources, which was used to improve the service provided to the pilots (e.g. time to loose on the leg provided to the flight crews, descent at discretion towards the IAF flight level proposed to the flight crews) and to the Approach (e.g. grouping of aircraft according to their wake turbulence category), and to solve potential conflicts.

4.2.1.1.2 Impact in APP/N

4.2.1.1.2.1 General Feedback

The general feedback from the Approach controllers was globally positive.

Compared to today, APP controllers reported benefits of the Point Merge combined with the AMAN in terms of delivery conditions of the arrival traffic to LFPG and to the other LFP* airfields.

Some controllers reported benefits of the delay absorption strategy with the Point Merge. The aircraft did not have to enter the holding pattern. Regarding the adherence to the AMAN advisories, a few controllers found that there was sometimes too much space between aircraft may be due to strong wind situations and also to the fact that ACC controllers, wanting to relieve the Approach, reduced the total delay to zero by making a longer use of the legs.

They also considered that safety and situational awareness were higher than in the baseline notably due to the respect of the delivery conditions in terms of flight level and speed.

4.2.1.1.2.2 Controller's Activity

The Approach controllers' activity was assessed through their workload. It was rated as equal as today, the Point Merge procedure considered as having no impact on it.

4.2.1.1.3 Performances in ACC + APP/N

4.2.1.1.3.1 Quality of Traffic Delivery

Quality of traffic delivery from ACC to APP/N was equivalent or better than in Baseline. Measures for the analysis of the traffic delivery have been made during peak traffic.

Respect of the initial AMAN sequenced time was equivalent (for November-December live trials) or better (for June live trials) than in Baseline.

Aircraft spacing over delivery waypoints was similar to Baseline.

4.2.1.1.3.2 Flight Efficiency

The different working methods in Baseline and Point Merge are clearly visible on flown trajectories during peak traffic. The use of radar vectoring and holdings is apparent in Baseline whereas the flow of traffic was more order with a contained and predefined dispersion of trajectories with Point Merge.

During peak traffic, aircraft flew equivalent distance and time in ACC+APP. For June live trials, aircraft flew more distance and time in ACC and less distance and time in APP. Delay was moved from TMA to E-TMA, but in total, aircraft flew equivalent distance and time in ACC+APP. For November-December live trials, aircraft flew equivalent distance and time in ACC and in APP. There was no delay moved from TMA to E-TMA.

The analysis of distance and time flown per level band and the analysis of mean descent profiles shows that during peak traffic, aircraft were maintained longer at higher level with Point Merge.

4.2.1.1.4 Flight Crew's Opinion

General Pilots' feedbacks were positives: the Point Merge procedure was easy to fly, the number of radio calls was reduced. The pilots appreciated when E-TMA controllers gave to them the time to loose on the leg. Once arrived on the Point Merge system, it became predictive with a direct or time to loose on the sequencing leg. As with radar vectoring, Point Merge still allowed to change the order of aircraft in the sequence.

There was no safety issue (no Air Safety Reports).

However, flight fuel management during the end part of the flight required changes from the pilots. As the Point Merge procedure is coded in the FMS route, the fuel prediction and the calculated ETA were wrong during all the flight because the aircraft almost never flown the leg and proceeded direct to the Merge Point.

4.2.2 Unexpected Behaviours/Results

Regarding the airlines, as the merge point procedure was coded in the FMS route, the fuel prediction and the calculated ETA were wrong during all the flight because in most cases the aircraft did not fly the arc and proceed direct to the Merge Point.

Based on Belgocontrol feed-back, as described in §4.4.2, the, PM design should avoid the possibility to send traffic from same interface points to different legs depending of the level.

4.3 Confidence in Results of Validation Exercises

4.3.1 Quality of Validation Exercises Results

Both validation exercises unfolded as planned without major problems.

The analysis of the frequency occupancy has a good quality. Indeed, deterioration could have occurred as it was a new procedure which could have required more talk between controllers and pilots. This is even more conclusive that the frequency occupancy was lower than in Baseline.

Wind has an impact on the time flown by aircrafts. That's why time flown indicators should be considered with caution. Distance flown indicators are more comparable from a day to another.

For a same quantity of traffic, there is not same delay. The way that traffic comes into a sector is very important and make days difficult to compare.

4.3.2 Significance of Validation Exercises Results

For November-December live trials, the frequency occupancy has been analysed depending to different values:

- depending to the number of flights in the sector,
- depending to the trajectory extension,
- depending to the number of flights with an important trajectory extension.

Those different comparisons make the result significant. Furthermore, confidence intervals have been calculated and confirm the result.

There is no absolute Baseline because traffic, wind and weather conditions are always quite different and even more than expected in the VALP.

To analyse the respect of the initial AMAN sequenced time and the distance and time flown in ACC+APP, some statistical tests have been performed as measurements on each day in June (only for the analysis of the respect of the initial AMAN sequenced time) and in November and December.

No statistical test was performed from the questionnaires.

As to the operational significance, there was full representativeness of both validation exercises performed as live trials.

4.3.3 Consistency of Validation Exercises Results vs RTS

This section will discuss consistency of live trials measurements versus trends measured during prototyping/RTS sessions at EEC.

Live trials results confirmed trends measured during prototype/RTS sessions at EEC:

- Positive feedback for workload and occupancy frequency for both live trials and RTS.
- All other results were equivalent to Baseline for both live trials and RTS.

Regarding traffic, RTS and live trials were complementary:

- During RTS, sector TE had high traffic so we measured the impact of Point Merge on an congested sector;
- During live trials, LFPG airport was congested so aircrafts were sequenced and had AMAN delay in ACC.

4.4 Other Results

4.4.1 MUAC Results

4.4.1.1 Introduction

MUAC actively participated in the preparation and conduct of the Point Merge trial.

Letter of Agreement (LoA) negotiations took place, leading to an agreed temporary LoA specifically describing the procedures regarding the Merge Point System. An internal safety case was conducted at MUAC. A Preparatory Real Time Simulation was conducted at Maastricht UAC in November 2011. Briefings to controllers were given before the start of the trial.

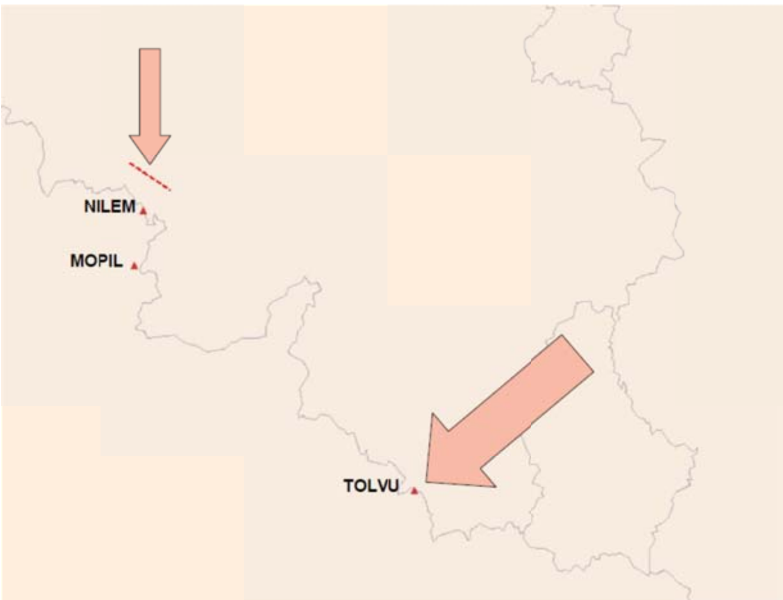
Workload and flight-profile measurements were conducted during the trial and, for comparison purposes, during three Saturdays outside the trial. Questionnaires were filled by controllers and analysed.

The following paragraphs describe the findings after the trial with some figures and analyses as well as the overall opinion and feelings of the controllers involved in Maastricht. In order to ensure a better understanding of these findings the relevant traffic streams and Letter of Agreement constraints are first explained.

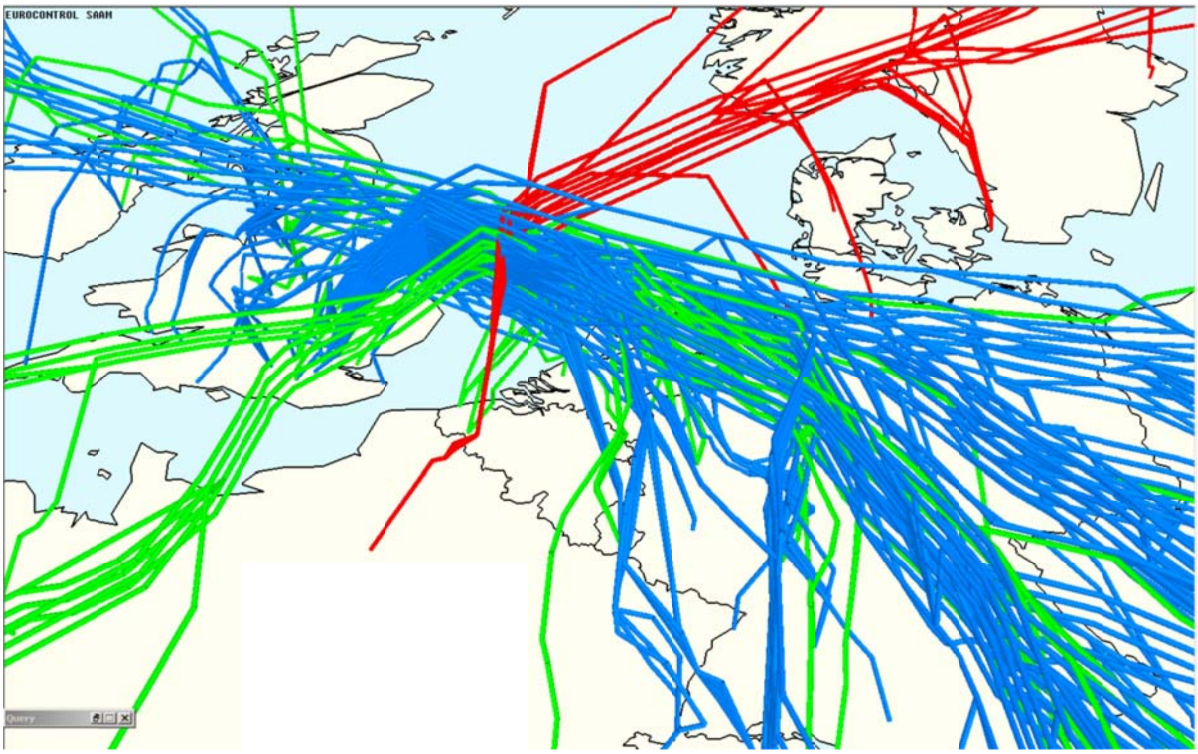
4.4.1.2 Description of the Merge Point interface

Maastricht UAC is feeding traffic towards the Paris airports from the northeast and from the north.

The traffic from the northeast crosses the DIK traffic hotspot over Luxembourg and is then transferred to Paris ACC over TOLVU at FL310 maximum. This transfer condition remained unaltered during the Live Trial.



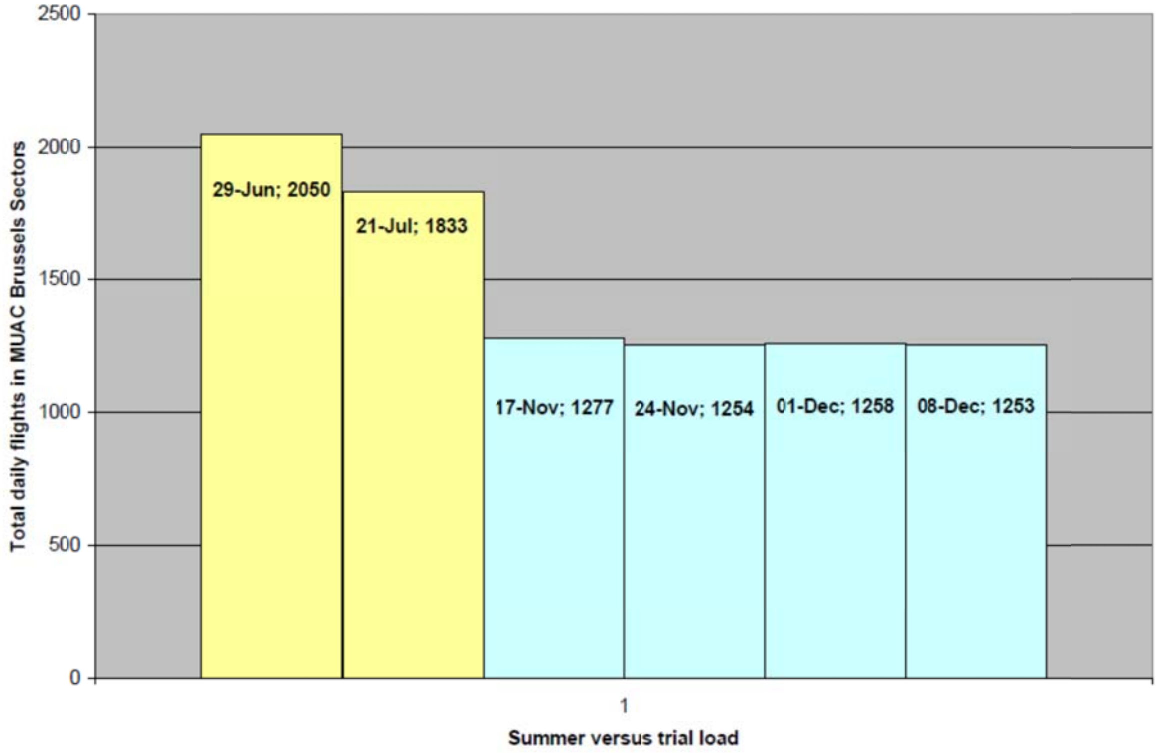
The traffic from the north is normally transferred to Paris towards MOPIL, descending to FL250. In case of simultaneous arrivals, MUAC can also use FL260 and FL270 as transfer levels. The traffic is handed over to Paris ACC at the red dotted line on the picture. This line is situated 10 NM south of the UM150 ATS Route, which holds a busy west to east traffic flow. During the trial, the transfer conditions were changed, and MUAC had to deliver the traffic over NILEM at FL250 maximum (or FL260, after coordination, in case of two simultaneous arrivals). This more stringent transfer constraint was necessary to ensure the vertical separation between the two opposite outer arcs. As a result, MUAC controllers had to descent the Paris arrivals earlier (the distance between MOPIL and NILEM is 8.05 NM). Moreover, the crossing with the busy eastbound flow became more complicated. This crossing, which is a major workload factor, is illustrated in the picture below. This picture, based on SAAM data from the 29th of June 2012, clearly indicates the interaction between the Paris arrivals from the north, with the extremely dense eastbound flow (in blue) and to a lesser extends the westbound flow (in green).



4.4.1.3 Traffic load

The traffic level worked during the 4 Saturdays was very low. As a comparison there were 1253 flights in the Brussels WEST and EAST sectors on the 08/12 (last PM trial day) of which 288 from west to east (main flow) where as on 29/06 , 2050 flights were counted and 438 from west to east. The table below contains relevant traffic load numbers, as derived from SAAM data (m1 files)

2012	Total transits via MUAC Brussels Sectors	Eastbound flow via MUAC Brussels Sectors	Destination LFPG via MUAC Brussels Sectors	Remarks
29-Jun	2050	438	152	Busiest day in 2012 (Friday)
21-Jul	1833	381	142	4th busiest Saturday in summer 2012
03-Nov	1478	344	114	Comparison day 1
10-Nov	1330	289	118	Comparison day 2
17-Nov	1277	241	127	Trial Day 1
24-Nov	1254	253	115	Trial Day 2
01-Dec	1258	291	126	Trial Day 3
08-Dec	1253	288	130	Trial Day 4



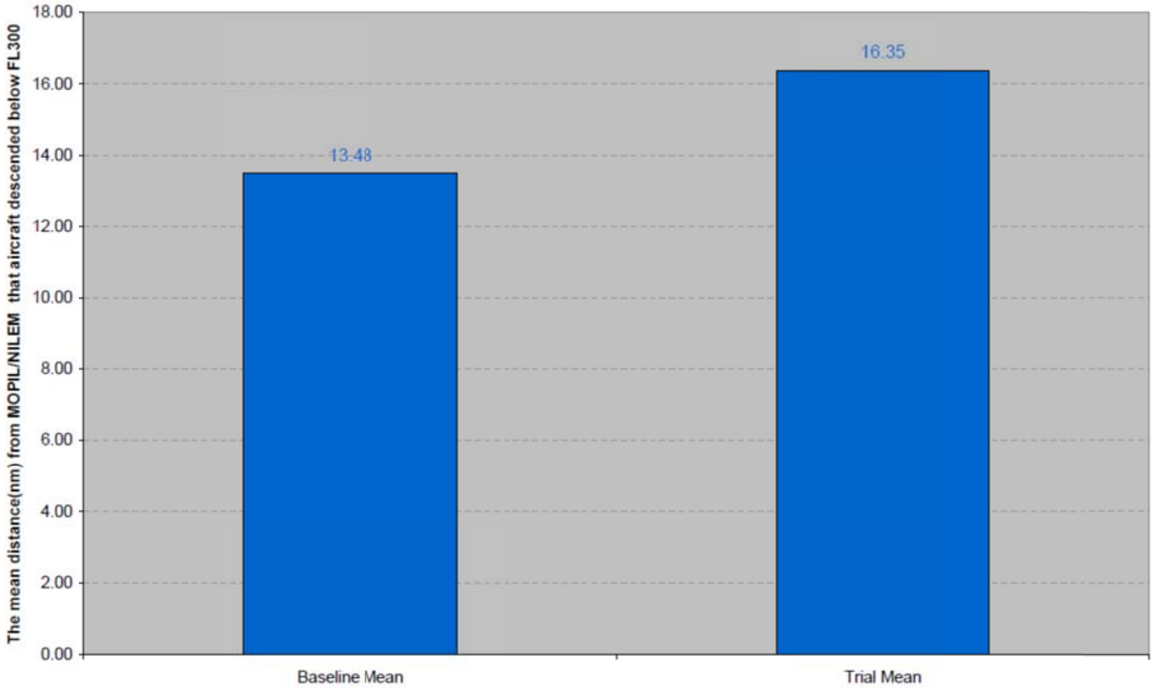
This low level of traffic questions the evaluation of the impact of the Point Merge and the associated constraints due to its specific design and position on the MUAC sectors.

4.4.1.4 Effect on flight profile

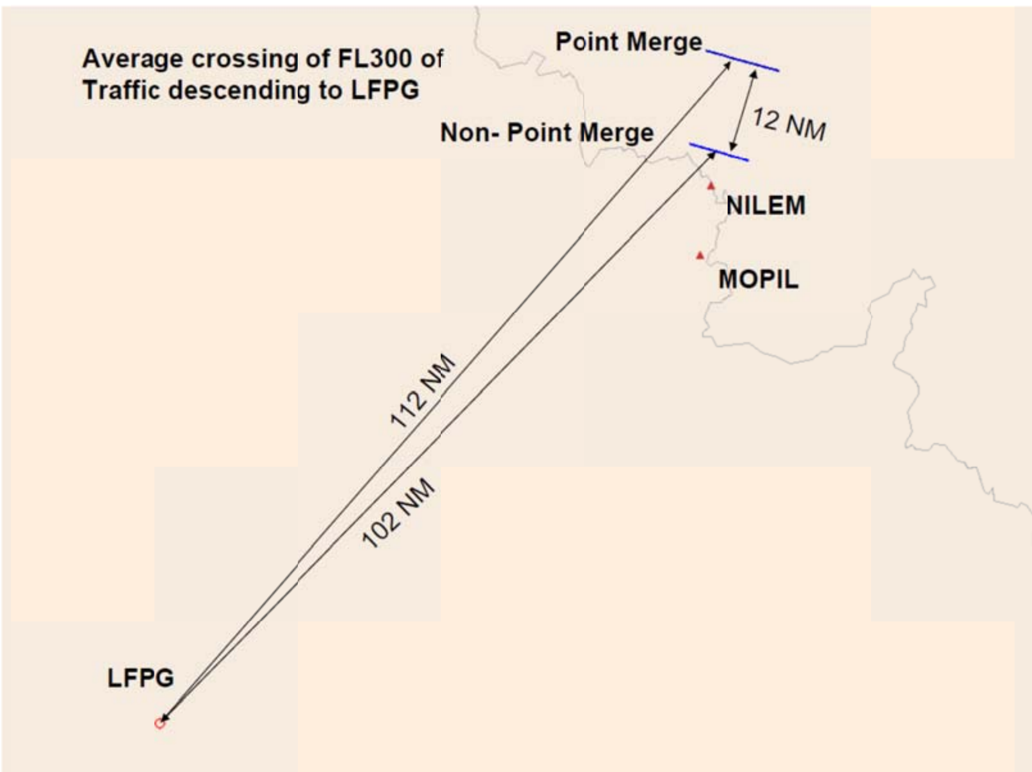
Taking into account the more stringent transfer condition (as described above) the flight profile of traffic via NILEM (Merge Point Live Trial) was compared to Non-Point Merge operations (i.e. traffic via MOPIL). Following days were taken as baseline for comparison: 03 Nov, 10 Nov and 15 Dec.

The live MUAC system records a radar derived 3D profile for each aircraft but only at various points on the route. It does not record the vertical details between points (unless the A/C turns) to keep the storage requirements manageable. An algorithm is used later to derive the vertical profile between two points. Next this derived vertical profile is examined to determine where the aircraft descended below flight level 300. The final step is to calculate the distance from this point to NILEM in the case of the trials or MOPIL for the baselines. This process should return a result accurate to 1/30nm laterally and 20 ft vertically.

As shown in the graph below, the traffic with destination LFPG crossed FL300 on average 13,48 NM North of MOPIL (Non Merge Point) and 16,35 NM North of NILEM (Merge Point).



Taking into account the distance from LFPG to MOPIL and NILEM respectively, this means that during the Live Trial, the Paris arrival flow from the North was descended some 12 NM earlier than during normal operations. This was due to the changed LoA constraints.



It is also expected, that this effect will be aggravated during summer traffic, when the crossing of the eastbound flow will be further complicated by higher traffic loads. This might even necessitate an even earlier descend profile, possibly starting in the MUAC DECO sectors at more than 180 NM from LFPG.

4.4.1.5 Controller Workload

Besides the controllers' feedback, a workload measurement was conducted (ISA measurements). Two Saturdays prior the Live Trial were used as baseline for comparison purposes (03 and 10 Nov).

The ISA measurements were based on inputs that ATCOs were asked to do, every couple of minutes, to give an indication of their perceived workload, where by 1 means very low workload, while 5 means extremely high workload.

The average workload for both Baseline and Trial days is situated between 1 and 2. There is a slightly higher workload perceived during the baseline. This is due to the higher traffic loads on the baseline days (see table above). This can be derived from the fact that the slight workload surplus is observed in the Lux sectors (where no change in transfer condition was imposed), as well as in the West sectors.

	Baseline	Trial
Lux Low.CC	1.8029	1.5095
Lux Low.EC	1.8439	1.5783
West Low.CC	1.6522	1.7223
West Low.EC	1.8281	1.6512

Moreover, the Coordinator Controllers (CC) of the West sectors recorded a slight workload increase for the trial. This corresponds with controller feedback whereby it was stated that the Merge Point did not have a positive workload effect and that it did not reduce the coordination requirements between the involved sectors.

Overall, the reduced traffic levels, typically for wintertime, do not allow making reliable workload assessments. However, it is expected that the more stringent transfer conditions via NILEM would increase the workload for the west sectors in MUAC during the busier summer period.

4.4.1.6 ATCO feedback

The feedback obtained from MUAC controllers that worked during the Live Trial can be summarised as follows:

4.4.1.6.1 Safety

Today's safety levels were maintained during the trials. However the traffic levels were not sufficient to highlight any possible safety issue.

4.4.1.6.2 Workload

The descent profile had to be lowered in the area of NILEM/IDOSO to facilitate Point Merge. This causes an increase in workload for the MUAC controllers. The descent has to be anticipated earlier than to lay and would even in some cases need to be initiated by our upstream sector. Moreover the difficulty to descend this inbound stream is increased by the crossing with a high density west-east stream. The handling of several LFPG arrivals did not appear to create extra workload than today.

4.4.1.6.3 Other remarks

It was also found that the size and the format of the CBWV was forcing our controllers to reroute slow climbing traffic departing Dusseldorf TMA via CIV or IDOSA , creating extra workload and extra mileage .The turns onto the arcs should also be investigated to ensure no unexpected early turns before the CBWV .Finally the handling of LFPG arrivals via RAPOR was felt identical to today.

4.4.1.7 Partial conclusions (MUAC's perspective)

The overall low traffic load during the trial does not allow MUAC to assess in a definite way the impact of the Point Merge on MUAC. However in a busy environment the more stringent constraint in NILEM and the loss of airspace with associated with the creation of the CBWV create a workload issue. These issues seem not to be related to the point merge concept itself but to its height and location (i.e. at the border of 4 different ANSPs), which interferes with other traffic flows in the neighbouring upstream centres.

In summary:

- Low traffic numbers during the trial (compared to summer traffic);
- Transfer conditions between MUAC and Paris ACC had to be adapted to the Merge Point System;
- The flight profile of traffic to Paris was lower than normal (passing FL300 approximately 12 NM earlier;
- The earlier descend complicates the crossing with other streams in MUAC's airspace, and will add to the workload of the upstream controllers (especially in busy summer traffic);
- The airspace structure was also adapted during the trial, with the implementation of a temporary volume of airspace in the Brussels FIR/UIR that was allocated to Paris ACC (referred to as "CBWV");
- Certain flights (i.e. other than Paris arrivals) in the Brussels FIR/UIR had to be re-routed in order to avoid the CBWV;
- There were no noticeable differences with regard to the coordination procedures between Paris ACC and Maastricht UAC.
-

Based on the live trial, together with the earlier Real Time Simulation that was conducted in Maastricht UAC in November 2011, following recommendations can be made:

- The design of Point Merge systems for any airport, or group of airports, must take into account the effects on the overall network and on the impact on upstream flows of traffic, taking into account high traffic demand.
- The availability of AMAN data in upstream centres and sectors can greatly enhance any Point Merge System.

4.4.2 Belgocontrol Results

The Belgocontrol results have been extracted from Belgocontrol report [20]. Please refer to this report for more details.

Belgocontrol conclusions are as follows:

- During the 4 Saturdays of these PMS trials, the traffic load is not deemed high enough to evaluate the impacts. Additionally two Saturdays (17/11 and 01/12) were 'hindered' by LFPG flow restrictions and on the last Saturday, holding procedures were initiated by the Approach unit of LFPG.
- In the live trial, only during the 'peak periods' of LFPG, traffic proceeded on the legs, thus on an average, PMS was used 1Hr in the morning session and 1Hr in the afternoon session, resulting in reserving this CBWV1/2 from 06.00Z till 18.00Z for only 2Hrs effective use.
- In low peak periods, direct routes were requested by Paris ACC. Contrarily to the agreements to have all traffic fly standard (as flight planned) during PMS, this caused not only additional workload but also confusion.
- The current practice during Saturdays is to provide directs to traffic inbound LFPG (i.e. traffic on UM617 is vectored direct avoiding SISGA). Thus, traffic situation changes whereby an

additional 'Hot Spot' is created with the merge of routes UM150, UZ319 and UM617 at SISGA.

- CBWV1 and CBWV2 create additional workload and impact the flight efficiency as departing EBCI traffic needs to be either levelled off or vectored outside the CBWV limits. Additionally, departing 'heavy' traffic from EDDL and EDDK normally on direct route to KOVIN has difficulty to achieve the level constraint (above FL285) in order not to enter CBWV. Therefore some flights are rerouted through LNO.
- The described procedures (in Temporary LoA for the Live Trial) need to be revisited.

Belgocontrol recommendations are as follows:

- This point merge system is designed cross border, the difficulty to estimate whether the traffic proceeds on the PMS legs (high peak) or on direct route (low peak) is very high as this information is not available to the Brussels controllers (e.g. possibility exists that LFPG has a peak arrival in the West whereby traffic arriving via Brussels sectors need to enter PMS without any obvious reasons to the traffic situation in TE/AP sector). Therefore, it is recommended to design the start of the legs points inside the same area of responsibility of the 'PMS handler'.
- 'Cross border PMS' has only benefits during peak arrival periods for LFPG. In order to measure, test and investigate the effects (switch over from normal ops to PMS ops), a RTS has to be organized including all concerned ANSPs with measured sectors.
- PMS procedures should be implemented at the time they are necessary and not during the whole day.

The design of PM in the MOPIL area introduces the following routing for LFPG inbounds:
UY50: DELOM – DELUL from FL225 to FL265
UY63: NILEM – DELUL from FL225 to FL265
UY64: DELOM – MAPOV from FL195 to FL225
UY68: NILEM – MAPOV from FL195 to FL225
Y67: IDOKO –MAPOV below FL195

It means that the same exit points DELOM or NILEM can lead to two different PM legs depending of the level of the last filed flight plan. Since the RFL is often modified during the flight it was then not guaranteed during the live trial that the initial FPL level was going to be maintained at the time of transfer between Brussels ACC and PARIS ACC.

A modified level could lead to two consequences:

- A wrong automatic data exchange (e.g. an ACT is send on the COP DELUL because of current FL240 although the STAR of the filed flight plan is via MAPOV).
- The pilot not disposing of the correct STAR according to his new level (e.g. an initial RFL via DELOM at FL220 means the pilot is provided with the STAR via MAPOV although if FL240 is requested en route, that flight should go via DELUL, a routing not available in the FMS).

This design is leading to confusions for pilots and for ATCOs.
In order to limit confusion and to make sure pilots could follow the PRNAV routing of their FMS, it was decided that Paris ACC would send traffic following the STAR whatever the level of transfer, hence not respecting the leg levels prescribed by the PM design.
The CBWV2 was then lowered to FL195 (instead of the initial FL225) to allow Paris ACC to send traffic below the normal leg levels via DELUL, this leading to climb constraints for EBCI departures.

5 Conclusions and recommendations

As both Live Trials were dependent and their results were based on the same KPAs, a global conclusion could be reached: conclusions and recommendations are presented for both trials in this part.

5.1 Conclusions

Three levels of conclusions have been drawn and presented in this chapter:

- ⇨ Concept generic conclusions: Conclusions on the concept of Point Merge in E-TMA
- ⇨ Local live trials application specific aspects: Conclusions on the specific local implementation of the Point Merge concept in the Paris ACC
- ⇨ Integration of the concept in the network: Conclusions on the integration of Point Merge Structures in the Paris ACC context and local implementation impact on adjacent ACCs (MUAC and Belgocontrol).

5.1.1 Concept Generic aspects

The exercise was run with:

- ⇨ No additional ATFCM restrictions due to the live trials.
- ⇨ No additional requirements for airspace users (aircraft equipment or pilot training)

The conclusions on the Concept in E-TMA (Paris ACC) are as follows:

- ⇨ The objective of Point Merge in high density environment and complex E-TMA sectors is to replace radar vectoring by a more efficient traffic synchronisation mechanism in order to provide a simpler technique, with less communication workload, more understandable, easier to collectively predict traffic. Live trials demonstrate that this concept objective has been reached.
- ⇨ The overall impact on workload
  - ▪ The concept would allow a safe increase of capacity;
  - ▪ The frequency workload decreases.
- ⇨ The overall impact on safety is positive:
  - ▪ E-TMA controllers felt a higher level of safety with the Merge Point
  - ▪ Simplification of controller's tasks, reduction in radio communications and workload
  - ▪ More orderly flow of traffic with a better view of arrival sequence
  - ▪ No air safety report was received from airlines
- ⇨ The overall impact on predictability is positive for ATCO:
  - ▪ In E-TMA, controllers felt more predictability of horizontal trajectories and more efficient time predictability as they can be determined in advance with reduction of workload. They felt an easier adherence to AMAN delay and better monitoring and controlling of delivery conditions to APP.
- ⇨ Positive general pilots' feed back
- ⇨ The concept facilitates the optimisation of the sequence providing more capability to adhere to the AMAN sequence and particular to adapt to any change.
- ⇨ There is no issue reported when the transfer point is far enough from the entry of the sequencing leg. If not, there may be issue in terms of respect of vertical separation and early sequencing.
- ⇨ The two PM Structures design in E-TMA are globally satisfactory:
  - • Number of legs (two or three)
  - • Waypoints defined as fly-by

- Levels defined on the legs, compatible with constraints at IAF
- Routes for other airports in the TMA located on the outer sides of the legs

⇨ Fuel management issue: in terms of predictability, the implementation of the Point Merge in the FMS implied fuelling and ETA estimation issues as the estimation is based on the full leg whereas 90% of flights had Direct-To. Pilots which were delivered a DCT accelerate based on the ETA estimation which is not correct.

⇨ In terms of flight efficiency:

- Fuel is equivalent
- Flight duration is equivalent
- Distance flown in E-TMA (Paris ACC) equivalent

- These results have been measured:
  - By airspace users (in Paris ACC in June Trials)
  - By trial performances: The trajectory extensions flown with the Point Merge are in the standard interval of daily trajectory extensions in Paris ACC. There is no significant improvement or degradation, which is conforming to the concept of Point Merge in E-TMA.

5.1.2 Local live trials application specific aspects

There are two different conclusions depending on localisation and design of Point Merge:

⇨ North West : Smooth integration because no impact on interfaces

- The logic of construction of the North Western Point Merge structure is as followed:
  - The design consisted in only two sequencing legs, located at 35 and 40NM from the Merge Point KOLIV.
  - The design was chosen to optimise the airspace available (airspace delegated to London 10NM further north-west of the legs).
  - The vertical constraints on the legs were compatible with both standard entry conditions (no LoA change between London ACC and Paris ACC or between Paris ACC and Brest ACC) and standard delivery conditions at KOLIV, to CDG APP.
  - The interference with another flow, slow climbing London departures to the south-west couldn't be completely avoided as their route crosses the sequencing legs.

⇨ North East :

- The logic of construction of the North Eastern Point Merge structure is as followed:
  - The Point Merge structure included two main sequencing legs located at 45 and 50NM from the Merge Point DEVIM. The levels to be assigned on the legs were defined according to standard descent profile to reach the levels defined at DEVIM (interface between Paris ACC and CDG APP).
  - A bidirectional third leg was positioned at 40NM from DEVIM for traffic cruising at lower levels than the ones defined on the two other legs.
- For the exercise, to evaluate a higher and larger sequencing leg of PM structure in order to provide the required capacity and better flight efficiency, PM was designed and positioned close to and partly in the Belgian airspace, interfering with other flows of traffic. This proximity resulted in an increase in complexity for Brussels ACC and MUAC to achieve the more stringent transfer conditions that were necessary to ensure that arriving flights enter the PM system at the correct level.

- With interfaces modified, the trials were globally positive. However increased coordination was needed. It will be all the more true with higher period traffic (summer traffic).

5.1.3 Integration of the Concept in the network

In terms of integration of the concept in the network, conclusions are as follows:

- **Workload:**
  - MUAC:
    - Workload with regards to sequencing of traffic did not change during the live trials compared to normal operations.
    - Increase of workload to avoid the CBWV2
    - Increased workload to achieve the Paris/MUAC LOA constraints in force during the live trials, taking into account the crossing of Paris arrivals with other busy streams (e.g. KOK-DIK), this will be aggravated in busy summer time.
  - Belgocontrol:
    - Even with low traffic, there was an increase in coordination.
    - Negative impact of the CBWV (EBCI' departures/Re-routing traffic EDDL – EDDK departures).
    - Hot spot SISGA (additional crossing of flows)
- **Safety**
  - From MUAC:
    - No safety issue experienced during the trials taking into account that these experiences occurred during reduced traffic in area of responsibility of MUAC (winter traffic and only Saturdays). No conclusions can be drawn with regards to week days' situations or summer traffic.
  - Belgocontrol:
    - No safety concern was noted. However if traffic level was higher, possibly safety issues might occur.
- **Predictability:**
  - Recommendation for upstream sectors (from MUAC & Belgocontrol): AMAN data should be transmitted to upstream sectors in order to provide earlier visibility in the Point Merge context.
  - MUAC:
    - No change was experienced with regards to predictability from MUAC point of view; MUAC received occasional requests from Paris ACC regarding sequencing similar to situations without Point Merge. In this respect, it should be noted that MUAC does not dispose of AMAN data from Paris airport.
  - Belgocontrol:
    - Belgocontrol ATCO felt a decreased predictability due to little anticipation of Paris requests (e.g. Direct Traffic to DEVIM).

5.2 Recommendations

5.2.1 Airspace users' feed-back and recommendations

Airspace users' consider that in terms of Point Merge design, the Point Merge structure should be easily integrated into the existing network so as to have no impact in flight preparation

Airspace users' positive feedback on execution of life trials:

- They appreciate to be involved in this project. They appreciate that the ANSP take into account their Users point of view into consideration.

- No additional requirement for aircrews or aircraft equipment.

- They appreciate that ATCOs gave to their Pilots the time to loose on the arc (information not given during the actual situation).

- Pilots appreciate the decrease in fatigue and workload due to the reduction of radio calls.

- **Integration with AMAN**: this method allows for an efficient and early management of arrival constraints (time to be absorbed on the leg during peaks of arrival traffic) thanks to close coordination between Paris ACC and CDG APP.

- As with radar vectoring, Merge Point does not lose the ability to change the order of aircrafts in the sequence.

Airspace users' identified risk to keep in mind on execution of life trials:

- They could be involved earlier, since the beginning of the Design.

- Possible extra fuel (fuel carried) and perhaps loss of payload and wrong ETA (Estimate Time of Arrival)

- Risk of invalidity of flight plans: STAR Point Merge into force only on certain time slots
  - They ask for H24 validity and during complete AIRAC cycle.
- Extra work at the dispatcher generated by the evaluation (~0,5 Mho per day of evaluation)
  - They ask for an H24 validity and during complete AIRAC cycle
  - Review the procedure so that feeding airways are not specific for live trial, but the procedures Merge Point easily integrated into the existing network (done for the 2nd set of Live Trial in Nov./Dec.).

- Risk to flight safety: not selecting the right STAR by the Pilot
  - They ask for an H24 validity and during complete AIRAC cycle
  - Communicate to the Pilot the STAR into force as early as possible
  - Review the naming conventions of points in the procedure Merge Point.

- They believe that if this Merge Point seems appropriate for Paris ACC, it may not be the case for other environment with less strong density convergent flows. "One size doesn't fit all".

5.2.2 Recommendations for the airspace design of Point Merge in E-TMA

The following recommendations have been draft with all partners in the course of a dedicated VALR workshop.

5.2.2.1 Recommendations on Point Merge Design in E-TMA

The main recommendations on Point Merge design in E-TMA are as follows:

- The transfer point should be far enough (depending on local conditions) from the entry of the sequencing leg in order to take into account vertical constraints and early sequencing needs. Particular attention should be paid to the definition of the distance between the transfer point and the entry to the PM. It is all the more sensitive for complex local operations.

- Additionally to the standard design principles, the following elements have been identified:
  - Leg positions could be higher than flight profiles (up to 1000 feet higher)
  - Legs can be entered from any point
  - In order to improve legibility, points of a leg would be specified as a mix of character and number (e.g., Pt1, Pt2, etc.)
  - To avoid crossing flows as much as possible interfering with sequencing legs

5.2.2.2 Recommendations for the airspace users

Recommendations drawn for airspace users are as follows:

- To handle the issue related to possible extra fuel (fuel carried) and perhaps loss of payload and wrong ETA (Estimate Time of Arrival), the airspace users recommend:
  - To work on this issue at a regulatory/legislation level.

  - ANSP could provide regularly statistics per time of arrival of estimated time to fly the last 100Nm.

  - Apply the minimum speed according to the characteristics of the aircraft on standby arcs to minimize fuel consumption (speed on the arc, 260kt, should be considered more like an exception than the common). ATCOs should be able, tactically, to adjust an economically speed (210-240kt).

6 Validation Exercises reports

This chapter provides the validation exercise report for the live trials performed in 2012 at Paris ACC for the validation of the concept of STEP 1 AMAN + Point Merge (Exercise 427 of project 05.06.07).

As defined in the validation plan [15] two different sub-exercises have been identified corresponding to the two trials sessions performed:

- In June 2012: 6 days from Monday 18th June to Saturday 23rd June.
- In November / December 2012: 4 Saturdays from 17th Nov. to 8th Dec.

6.1 Validation EXE-05.06.07-VP-427 - June 2012 trials

This section reports the main results derived from the EXE-05.06.07-VP-427 conducted by DSNA from the 18th to 23rd of June 2012.

6.1.1 Exercise Scope

EXE-05.06.07-VP-427 is a V3 exercise that addresses the use of the **Point Merge + AMAN** in E-TMA as detailed in the Initial OSED [16].

The Point Merge is a systemised method for sequencing arrival flows developed by the EUROCONTROL Experimental Centre. It is designed to replace radar vectoring. Sequencing is achieved with a "direct-to" instruction to the merge point at the appropriate time.

Legs are used to delay aircraft when necessary. To de-conflict simultaneous arrivals upstream each leg, ATC may use different levels on the leg and/or instruct a direct to a point of it.

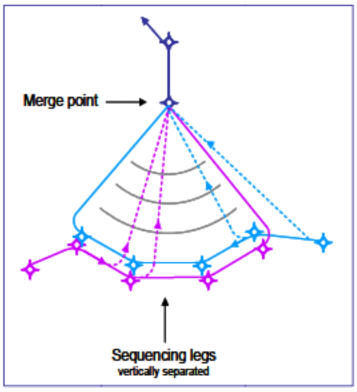


Figure 9: Example of Point Merge with two sequencing legs

The Point Merge with AMAN integration allows for an efficient and early management of arrival constraints (time to be absorbed on the leg during peaks of arrival traffic). It relies on ACC / APP close coordination [17].

EXE-05.06.07-VP-427 live trials planned to assess the use of the Point Merge + AMAN are described in the Point Merge + AMAN Validation Plan [15].

The exercise performed in June 2012 corresponds to the first live trial session aiming at assessing the implementation of the E-TMA Point Merge system for North West traffic to Paris CDG. June exercise addressed the evaluation in real traffic conditions of one E-TMA Point Merge system for Northwest arrivals of the CDG airport, coupled to the use of the MAESTRO AMAN in DSNA Paris-ACC and at the approach of the Paris CDG Airport, being fed from London ACC and Brest ACC.

It is worth noting that this project is called "PANAM" internally at DSNA.

6.1.1.1 STAR procedure

The figure below is the Paris CDG North Western STAR procedure which has been published in AIP and used during Point Merge Trials.

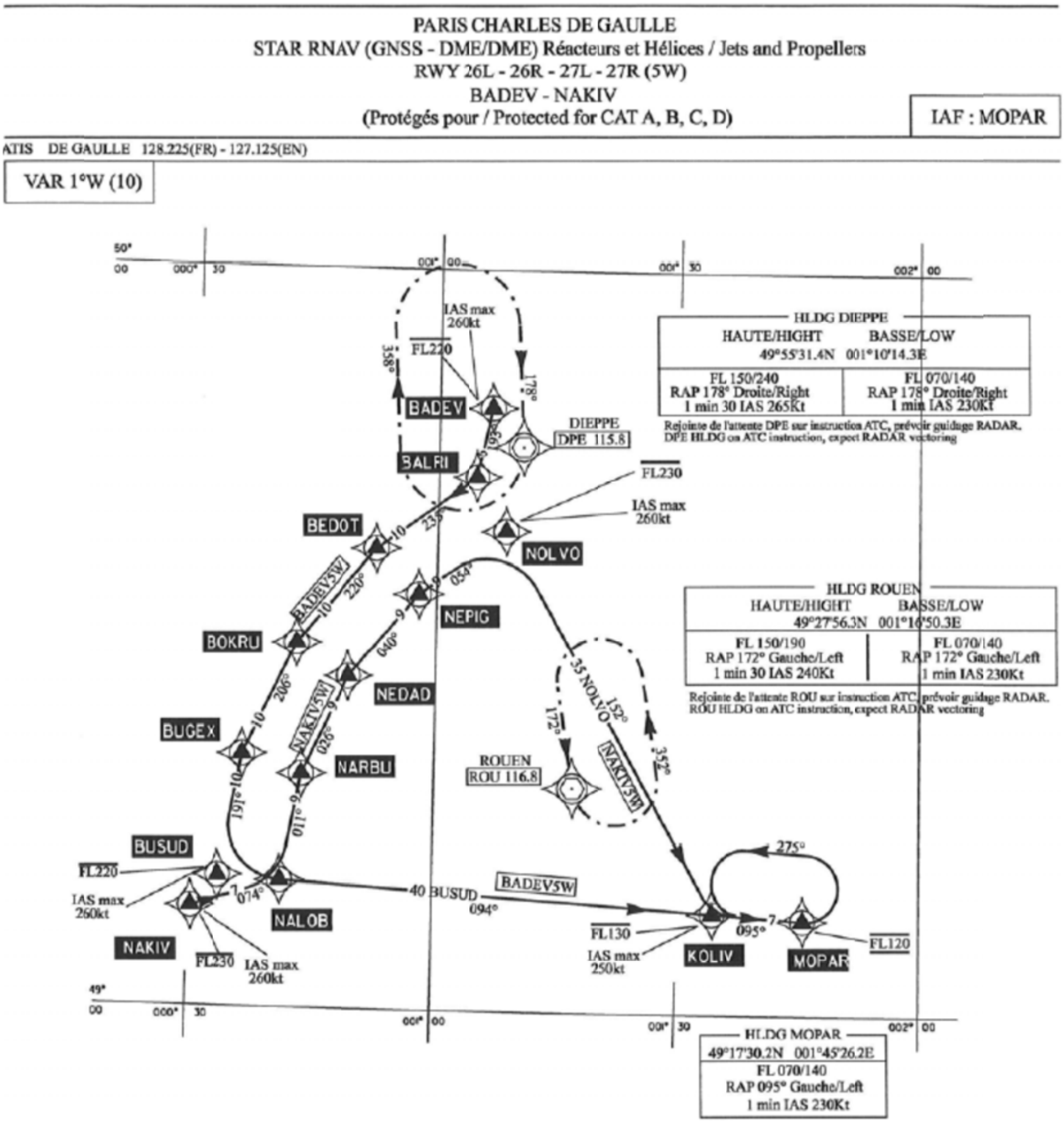


Figure 10: Paris CDG North Western STAR (incl. Point Merge) Procedure facing West

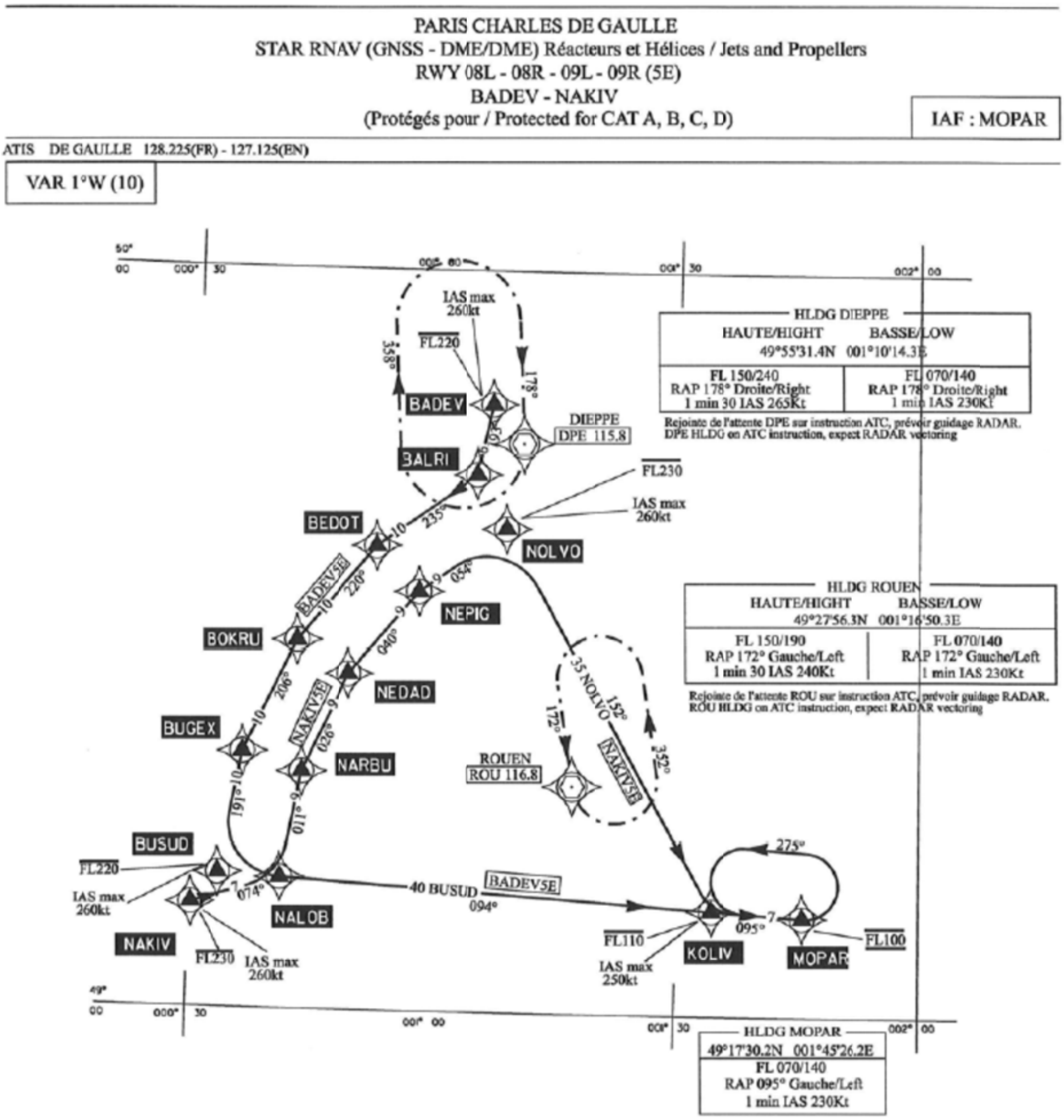


Figure 11: Paris CDG North Western STAR (incl. Point Merge) Procedure facing East

The outer STAR BADEV was defined with a maximum level FL220 while the inner STAR NAKIV was defined with a maximum level FL230. The vertical separation between the two trajectories was maintained by the controllers. They were assigning the levels FL200/210/220 (outer) and FL230/240 (inner) on the legs, depending on the traffic load. In a standard situation (one flight on each leg), the levels assigned are preferably FL220 on the outer leg and FL230 on the inner leg. Other levels were used in case of simultaneous arrivals.

6.1.2 Conduct of Validation Exercise

6.1.2.1 Exercise Preparation

6.1.2.1.1 Preparatory activities

The following main preparatory activities were carried out:

- **Paris ACC Safety Case.**

- **Paris ATCO Training:**
    - Definition of PANAM Training Needs & Objectives
    - Editing PANAM Training booklet
    - Instructor Training
    - Theory training
    - Two sessions of main training
    - ATCO PANAM training certificate deliverable
    - Optional procedure simulation reminder
- **Publication and Communication**
    - ATM procedure (AIS publication announcing the live trials to airlines).
    - ATC procedure (Letter of Agreements, ATC Ops instructions).
- **Information and communication**
    - Large information has been achieved to airlines, ATCO, FABEC, CDM@CDG, SESAR community.
    - Common Pilots/ATCOs communication.
- **Achieving technical & system implementation**
    - *Paris ACC*
        - Prepare and deliver ATC data (RDPS + FDPS + Other systems)
        - Test ATC data between LFFF/LFRR (Paris ACC/Brest ACC)
        - Test ATC data between LFFF/EGLL (Paris ACC/ London Heathrow)
        - Validation with CFMU
        - Control Quality: MISO procedure before operational use
    - *Airlines*
        - Test on FMS data base.
        - Addition of new routes for internal data base.
        - Change of chart for Pilots.
        - Point Merge concept tested before Live Trial on Flight simulator to validate the feasibility, especially with high altitude strong tail wind.
- **Performance Working Group**
    - Trajectory based indicators definition
    - Vocal communications based indicators definition
    - Available data identification
    - Reference trajectories modelling and comparison
- **Questionnaires**
    - The questionnaires (questionnaire LFFF, LFPG, Pilot) have been adapted to the exercise of the Northwest (with a complementary question in the pilot questionnaire on extra fuel for extra planned route).

6.1.2.1.2 Operational environment

The platform used for the live trials was Paris ACC operational platform consisting mainly in a flight data processing system (STPV v.25), a visualization tool (ODS v.6), and Paris Area AMAN (MAESTRO France v.14).

The description of the operational environment that follows is extracted from EUROCONTROL report [19] and adapted where modifications have been made for the live trials.

In the E-TMA (i.e. Paris ACC), the Paris terminal sector TP, in the North West was manned by an executive controller assisted by a planning controller. The TP sector has two or three delivery points (Initial Approach Fixes) depending on the runway configuration: MOPAR, MATID in Easterly runway configuration, plus MOBRO in Westerly runway configuration. All arrival aircraft have to be delivered over those waypoints at 250kts (or 280kts at MOPAR), 8NM spacing (+AMAN constraints) and at specific delivery FLs (see Table 11). TP also handles overflights.

TP (ACC NW)	
Easterly	**Westerly**
• MOPAR : - PG FL100 - PB/PC/PT FL70 • MATID - OB FL70	• MOPAR : - PG-Jets FL120 - PB/PC/PT FL70 • MOBRO : - PG-Prop./PB FL70 • MATID - OB FL70

Table 11: E-TMA NW: delivery FLs over IAF according to destination airport and runway configuration (from [19])

In the TMA (i.e. Paris CDG), CDG North arrival positions handle LFPG arrivals to the North runway and associated airports (LFPB, LFOB; LFPT and LFPC arrivals from East and South-East). The APP/N positions are:

- SEQ
  - Sequencing and metering CDG and Le Bourget arrival flights; distributing the arrival traffic on CDG runways (i.e. handling the AMAN to optimise the sequence on the runways).
- COOR-INI
  - Ensuring the coordination with TP and TE for the arrivals delivery, and between the INI and the ITM.
- INI/N
  - Receiving traffic from ACC and initiating the arrival sequence to LFPG North runway prior transfer to ITM/N.
  - Controlling North-Eastern and North-Western arrivals to LFPO/PV/PN prior transfer to Orly APP.
- ITM/N
  - Finalising the sequence to LFPG North runway prior transfer to the tower.

The "Point Merge" design in the North-West, developed by DSNA and refined/validated through real-time prototyping sessions carried out with the support of EUROCONTROL, was composed on two elements: a "large" Point Merge for the main arrival flow (LFPG) and segregated routes on both sides leading to each specific IAF for the other arrival flows (LFOB, LFPB, LFPC, LFPT).

- The "large" Point Merge composed of two sequencing legs centred on KOLIV at a distance of 35 and 40NM (see Figure 12). Typical levels assigned by controllers on legs were FL200/210/220 (outer) and FL230/240 (inner) with the option to have flights on each of the legs at cruising level below FL195 (approximately 0,3% of the traffic). The legs were up to 40NM long (delay absorption considerations).

- Routes for other arrival flows were defined with vertical constraints (FL090 or FL110 at PITAV) depending on the runways configuration.

The overflight routes remained unchanged compared to today's situation.

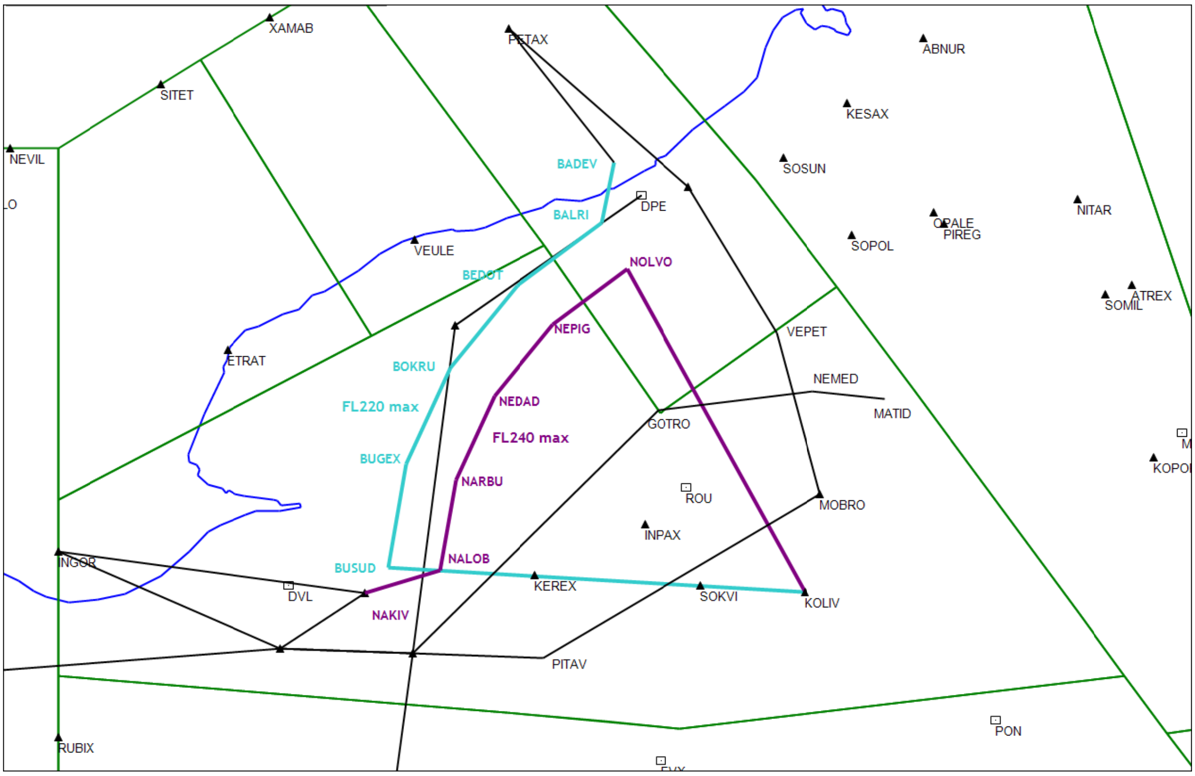


Figure 12: Point Merge in E-TMA TP sector (North-West)

Sector roles and responsibilities for TP sector remained unchanged, TP essentially performing pre-sequencing of North West arrivals (from Brest and London ACC) to Paris Approach, and handling also a few overflights.

The transfer conditions from TP to Paris Approach or from Brest and London ACC to TP were unchanged.

One objective of Point Merge in that particular case of that exercise and airspace is to absorb more delay in E-TMA rather than in TMA. The AMAN delay sharing strategy during Point Merge experimentation was different from that in the baseline The AMAN (MAESTRO) is usually set with a maximum delay absorption capability of 5 minutes in APP. During the Point Merge experimentation, the AMAN was set with a maximum delay of 2 minutes in APP.

6.1.2.2Exercise execution

DSNA performed an implementation of the North West Point Merge during six days in June from 03:30 AM to 12:30 AM (UTC). Globally, the execution of the live trial went well.

Paris ACC TP sector was opened either as a standalone sector or grouped with another sector when the traffic load was low. Usually in current operations, TP sector is grouped with another sector, even during peak traffic.

For the exercise, it has been decided to open the TP sector as a standalone sector whatever the level of traffic, including during peak traffic, in order to focus on the new procedure only. Therefore, in order to obtain a Baseline for the analysis of controllers' activity, the TP sector was opened as a standalone sector during peak traffic the week before the Point Merge experimentation. This sector configuration was chosen for analysis only (measurement and comparison of frequency occupancy) but was not a prerequisite on the operational side.

Except STAR and the fact that the TP sector was opened as a standalone sector, no other system change has been planned; operations remained the same as usual.

The days' schedule was as follows:

Time (UTC)	Location	Action
03:30	PARIS.CDG	New ATIS at CDG airport mentions Point Merge trials
04:00	PARIS.ACC	Paris ACC deputy Supervisor starts shift
04:00	PARIS.ACC	Paris ACC Supervisor coordinates the start of trials to NATS supervisor
04:00	PARIS.ACC	Paris ACC Supervisor coordinates the start of trials to Brest supervisor
04:00	PARIS.ACC	Paris ACC Supervisor coordinates the start of trials to CDG supervisor
04:10	PARIS.CDG	Opening AMAN SEQ position
04:15	PARIS.ACC	Team 1 starts shift
04:15	PARIS.ACC	Paris ACC deputy Supervisor & MP expert brief Team 1
04:25	PARIS.ACC	HPZZ open
04:30	PARIS.ACC	Start of Live trials with Team 1
05:00	PARIS.ACC	TP sector open
06:45	PARIS.ACC	Team 2 taking over Team 1 (Team 2 starts shift)
07:30	PARIS.ACC	TP sector may be collapsed to form a sector operated with 2 controllers if traffic is low
08:15	PARIS.ACC	Team 1 taking over Team 2
10:30	PARIS.ACC	Team 2 taking over Team 1 (end of shift for Team 1)
12:30	PARIS.ACC	Paris ACC supervisor will coordinate the end of trials to NATS supervisor
12:30	PARIS.ACC	Paris ACC supervisor will coordinate the end of trials to Brest supervisor
12:30	PARIS.ACC	Paris ACC supervisor will coordinate the end of trials to CDG supervisor
12:30	PARIS.ACC	ACC Supervisor & MP expert will do a check with APP ATCO & MP expert
12:30	PARIS.ACC	End of Point Merge Trials
12:30	PARIS.ACC	End of shift of Team 2 and Deputy Supervisor

Table 12: Point Merge days' schedule

The project team members were invited in the Paris ACC control room during the hours of operations. A control position was opened displaying TP traffic during all the live trials opening hours.

A show room, prepared to receive all the external observers or attendees, allowed to provide explanations on the current control room operations without interfering.

The execution activities were as follows:

- Observation of the different tasks on the working-positions using the Point Merge and AMAN. Five types of observers were present:
    - The SJUx427 (member of SJU 567 x427 exercise) observers having the task to log all environment events for measurement.
    - The DSNAx427 observers from DSNA, Point Merge Expert, having the task to provide information for on-going operation staff: one in Paris ACC and one in Paris CDG.
    - The SJU-NSA (National Supervisory Authority) observer for safety issues.
    - The SJU-IVT (International Validation Team) observers for procedure validation process.
    - Airlines representatives.

- Controllers on duty during the sessions and pilots having flown to CDG through Paris TP sector during the sessions were asked to fill in a questionnaire.

6.1.2.2.1 Choice of Baseline

To analyse flight efficiency, Paris ACC controllers have established a baseline by choosing days with typical traffic. To analyse controllers' activity, only the week before the experimentation was usable, since it was the only week during which the TP sector was opened as a standalone sector (see 6.1.2.2), as it was during Point Merge.

The table below shows Baseline and Point Merge days, detailing if they were used for the analysis of flight efficiency and/or controllers' activity and detailing the LFPG runway configuration of the day. Each day of the Point Merge experimentation has been used for the analysis of flight efficiency and controllers' activity.

Date	Conditions	LFPG runway configuration	Analysis of flight efficiency	Analysis of controllers' activity
Saturday 26th May	Baseline	Easterly	Used	
Monday 28th May	Baseline	Westerly	Used	
Friday 1st June	Baseline	Westerly	Used	
Tuesday 5th June	Baseline	Easterly	Used	
Monday 11th June	Baseline	Westerly		Used
Tuesday 12th June	Baseline	Westerly	Used	Used
Wednesday 13th June	Baseline	Westerly	Used	Used
Thursday 14th June	Baseline	Easterly	Used	Used
Friday 15th June	Baseline	Westerly	Used	Used
Saturday 16th June	Baseline	Westerly	Used	Used
Monday 18th June	Point Merge	Westerly	Used	Used
Tuesday 19th June	Point Merge	Easterly	Used	Used
Wednesday 20th June	Point Merge	Easterly	Used	Used
Thursday 21st June	Point Merge	Easterly	Used	Used
Friday 22nd June	Point Merge	Westerly	Used	Used
Saturday 23rd June	Point Merge	Westerly	Used	Used

Table 13: Baseline and Point Merge days

Note: In addition to these dates, Air France also used the following ones: 25 May, and 4, 8, 9, 25, 29, 30 June.

It is worth noting that to analyse flight efficiency in APP+ACC, we have to take into consideration the LFPG runway configuration. Results of the analysis of flight efficiency will be detailed in two parts: when the LFPG runway configuration is westerly and when it is easterly. For this kind of analysis, there will be 6 days in westerly Baseline, 3 days in westerly Point Merge, 3 days in easterly Baseline and 3 days in easterly Point Merge. For the analysis of distance and time flown and vertical profile, choice has been made to use the mean of each kind of days (Baseline or Point Merge and westerly or easterly), so the flight efficiency analysis will compare the mean of 6 westerly Baseline days with the mean of 3 westerly Point Merge days.

For the analysis of controllers' activity in the TP sector, the LFPG runway configuration is considered as having no impact.

6 Point Merge days will be compared with 6 Baseline days.

The table below shows traffic levels in LFPG, TP and TE. This is actual traffic:

- From 06:00 to 07:30 AM (UTC):
  - Through sector TP
  - Through sector TP, LFPG arrivals via DPE (North)
  - Through sector TE
  - LFPG arrivals
- During peak P2, the maximum number of LFPG arrivals in one hour:
  - On the North runway
  - On all runway

There are some variations from a day to another and it is difficult to find a perfect Baseline day corresponding to each Point Merge day. However, all of Baseline days is similar to all of Point Merge days. That's why the different analysis performed used mean of those days.

Day	RWY configuration	06:00 to 07:30				Arrivals maximum in one hour	
		TP	TP via DPE to LFPG	TE	LFPG	North RWY	All RWY
26/05/2012	Easterly	34	22	32	96	34	69
28/05/2012	Westerly	33	16	29	95	36	76
01/06/2012	Westerly	28	18	26	94	36	73
05/06/2012	Easterly	22	13	31	93	36	72
11/06/2012	Westerly	29	15	35	97	33	68
12/06/2012	Westerly	30	16	30	96	35	75
13/06/2012	Westerly	27	14	31	94	35	75
14/06/2012	Easterly	23	11	37	89	32	70
15/06/2012	Westerly	27	14	32	95	36	75
16/06/2012	Westerly	32	15	28	98	30	67
18/06/2012	Westerly	25	14	32	94	35	75
19/06/2012	Easterly	30	15	36	93	32	70
20/06/2012	Easterly	24	15	30	95	35	72
21/06/2012	Easterly	32	13	30	94	33	70
22/06/2012	Westerly	26	10	32	98	34	70
23/06/2012	Westerly	33	15	33	99	34	73

Table 14: Actual traffic for Baseline and Point Merge days

6.1.2.2.2 Data collection

Data were collected just after the Point Merge experimentation:

- questionnaires filled in by pilots and controllers,
- processing of radar data (RDPS) of Paris ACC for Baseline days and Point Merge days (trajectories are beginning before legs of Point Merge and ending on LFPG runways),
- recordings of the frequency of the TP sector (week of Point Merge and the week before),
- logs of phone communications of Paris ACC,
- recordings from AMAN,
- wind conditions,
- recordings of sector configurations in ACC (from COURAGE system)
- Flight Data recording (time, localisation, altitude, wind direction/speed, Fuel Flow per engine, ground speed, calibrated airspeed, A/C weight…).

6.1.2.2.3 Hours for analysis

Point Merge Trials were performed from 04:30 AM to 12:30 AM (UTC). But the most interesting for analysis happened during peak traffic which was from 05:20 AM to 07:10 AM (UTC).

6.1.2.3 Deviation from the planned activities

Deviation with respect to the Validation Plan

- Measures of aircraft speeds and FL over IAF were not performed because:

    - Speed contained in radar trajectories is ground speed (which depends on wind conditions). Aircraft speed over IAF would have been interesting in case of indicated air speed (IAS).

- Measures (number, duration and FL) of level off segment were not performed.
- Measures were not performed for those criteria:
    - CRT-05.06.07-VALP-0427.0230 Pilots most often obtained a direct to the Merge Point before entering the STAR.
    - CRT-05.06.07-VALP-0427.0240 Controllers most often proposed the pilots to "descend at discretion" at the exit of the leg toward the Merge Point

6.1.3 Exercise Results

6.1.3.1 Summary of Exercise Results

6.1.3.1.1 Results on concept clarification

6.1.3.1.2 Results on concept clarification are presented in section 4.1.1. Results per KPA

The main results per KPA that were addressed by EXE-05.06.07-VP-427 are summarized in the table below:

KPAs	Validation Objective ID	Validation Objective	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
Capacity	**OBJ-05.06.07-VALP-0427.0100**	Controller workload assessment	**CRT-05.06.07-VALP-0427.0100**	Average answer to perceived workload question is that PMS reduces workload	All the participating E-TMA controllers stated that the workload was unchanged to lower. In TMA, the Point Merge was perceived as having no significant impact on workload.	**OK**
	OBJ-05.06.07-VALP-0427.0100	Controller workload assessment	**CRT-05.06.07-VALP-0427.0110**	Frequency usage reduced.	Frequency occupancy of the TP sector is very close to Baseline but more information was given by controllers to pilot	**OK**
Predictability	**OBJ-05.06.07-VALP-0427.0200**	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0200**	Better compliance with initial AMAN sequenced time than in baseline	Better respect of the initial AMAN sequenced time for Point Merge days compared to other days of June 2012	**OK**
	OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0210**	Number of open loops / holdings lower than in	Most of the E-TMA controllers stated that they did not have to issue	**OK**

KPAs	Validation Objective ID	Validation Objective	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				baseline	heading clearances thanks to the Point Merge. No holding during Point Merge and very few open loops observed.	
	OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0220**	Number of level segments lower than in baseline	Most of the E-TMA controllers stated that they did not have to issue and monitor intermediary levels due to the Point Merge.	**OK**
Efficiency	**OBJ-05.06.07-VALP-0427.0300**	Metering efficiency assessment	**CRT-05.06.07-VALP-0427.0300**	More delay absorbed on the legs rather than in TMA and rather than in vectoring in E-TMA.	More delay was absorbed in E-TMA rather than in TMA. Very few vectoring was performed in E-TMA with Point Merge, all delay in ACC were absorbed on the legs.	**OK**
	OBJ-05.06.07-VALP-0427.0400	IAF delivery conditions assessment	**CRT-05.06.07-VALP-0427.0400**	Aircraft separations and speeds over IAF equal or better than in baseline	Aircraft spacing over delivery point during peak traffic are similar to Baseline	**OK**
	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	**CRT-05.06.07-VALP-0427.0600**	Flight duration equal or better than in baseline	Flight duration in ACC+APP is equal or better than in baseline	**OK** (for flights coming from the West)
	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	**CRT-05.06.07-VALP-0427.0610**	Flight distance might be longer than in baseline because aircraft are holding at higher altitude	Flight distance in ACC+APP is shorter (i.e. from entry point of Paris ACC to the RWY)	**OK** (for flights coming from the West)
Safety	**OBJ-05.06.07-VALP-0427.0500**	Safety assessment	**CRT-05.06.07-VALP-0427.0500**	Level of safety felt by controllers equal or better than in baseline	A majority of the participating E-TMA and TMA controllers stated that the level of safety was better than in baseline.	**OK**
	OBJ-05.06.07-VALP-0427.0500	Safety assessment	**CRT-05.06.07-VALP-0427.0510**	Controllers average answer to situation awareness question is that situation awareness is	E-TMA controllers considered that they had a better situational awareness of the sequencing with the	**OK**

KPAs	Validation Objective ID	Validation Objective	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				better than in baseline	Point Merge than without. A majority of TMA controllers stated that the situational awareness was higher with the Point Merge or at least the same.	
	OBJ-05.06.07-VALP-0427.0500	Safety assessment	CRT-05.06.07-VALP-0427.0520	Pilots' general impression on the PMS procedure about radio communications, simplicity of the procedure, and clarity of the phraseology is globally positive.	Pilots' general impression on the Point Merge procedure about radio communications, simplicity of the procedure, and clarity of the phraseology was globally positive.	OK
Environmental sustainability	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	CRT-05.06.07-VALP-0427.0620	Fuel burn equal or better than in baseline	Fuel consumption is equivalent, for an equivalent time to loose.	OK

Table 15: DSNA EXE-05.06.07-VP-427 - Results per KPA

6.1.3.1.3 Results impacting regulation and standardisation initiatives

Results impacting regulation are presented in section 4.1.3.

6.1.3.2 Analysis of Exercise Results

The performance indicators measured during EXE-05.06.07-VP-427 are collected in the table below:

Exercise ID	Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0100	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Level of workload felt by controllers	Questionnaire
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0100	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Frequency occupancy	Recordings of the frequency or recordings of controller micro usage
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0200	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Compliance with initial AMAN sequenced time	Recordings from AMAN
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0200	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Number of open loops / holdings	Questionnaire or processing of radar data
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0200	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Use of FMS optimization	Questionnaire
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-	SCN-05.06.07-VALP-	Scenario Solution	Number of level segments	Questionnaire or processing of

Exercise ID	Objective ID	Scenario ID	Scenario Title	PI ID	Measure Value
	0427.0200	0427.0100		Duration of level off segment (+FL concerned)	radar data
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0300	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Ratio of time spent in ETMA/TMA Time spent on the legs AMAN delay absorbed by ETMA	Measures based on radar recordings
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0400	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Aircraft spacing, FL and speeds over IAF	Measures based on radar recordings
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0500	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Level of safety felt by controllers and pilots	ATCO and Pilot questionnaires
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0500	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Situational awareness	ATCO questionnaire
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0600	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Flight duration	Time spent between the first point and touchdown
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0600	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Flight distance	Distance flown between the first point and touchdown
EXE-05.06.07-VP-427	OBJ-05.06.07-VALP-0427.0600	SCN-05.06.07-VALP-0427.0100	Scenario Solution	Fuel burn	Estimation of fuel burn with mathematical model based on radar tracks and aircraft performance models Actual recordings of FMS from Airlines' flights (incl. Air France)

Table 16: Performance Indicators

Regarding the number of answers per question in the controllers' questionnaires:

- In Paris ACC: each controller filled a questionnaire after each day of trial s/he was participating at. There were 27 answers out of 30, some controllers having felt the traffic load too low while they were working to evaluate the procedures..
- In Paris CDG: each controller filled a questionnaire after each day of trial s/he was participating at. Out of the 135 controllers who participated to the trial, 23 filled the questionnaire.

The pilots' questionnaire was filled in by:

- 3 Air Canada pilots.
- 4 Easy Jet pilots.
- 13 Air France pilots.

Note: In the figures presented in the following sections, the number of answers to the questions is sometimes different. This is due to the fact that the controllers and the pilots did not always answer all the questions.

The following sections provide with a general analysis of EXE-05.06.07-VP-427 results.

6.1.3.2.1 Operability in ACC

6.1.3.2.1.1 General Feedback

As illustrated in Figure 13, Figure 14 and Figure 15, the feedback from ACC controllers was very positive. The level of difficulty of the Point Merge + AMAN procedure to manage the overall traffic (to LFPG, overflights and peripheral flights), and to perform the coordination was rated in majority as unchanged to clearly easier. In particular, the ACC controllers found that it was easier to stick to the AMAN delays and to sequence the arrival traffic to LFPG. They found that the use of the Point Merge and AMAN improved the quality of the delivery (more accuracy) and the quality of the sequencing (e.g. grouping of aircraft).

According to the majority of the participating ACC controllers, the safety was either improved or at least as safe as today. The aircraft were strategically separated on the legs, which made the traffic less conflicting. The Point Merge was considered as easy to use. The controllers found that they could better anticipate the traffic and that they were more available for the coordination between the Executive and Planning Controllers. The Point Merge + AMAN were considered as more efficient to handle arrivals than radar vectoring, with less workload and more comfort compared to today.

As illustrated in Figure 13, the use of the AMAN to sequence LFPG arrivals was found very comfortable and efficient when combined with the Point Merge. Indeed, during peaks of arrival, most of the delay was absorbed on the sequencing legs with no need for vectoring.

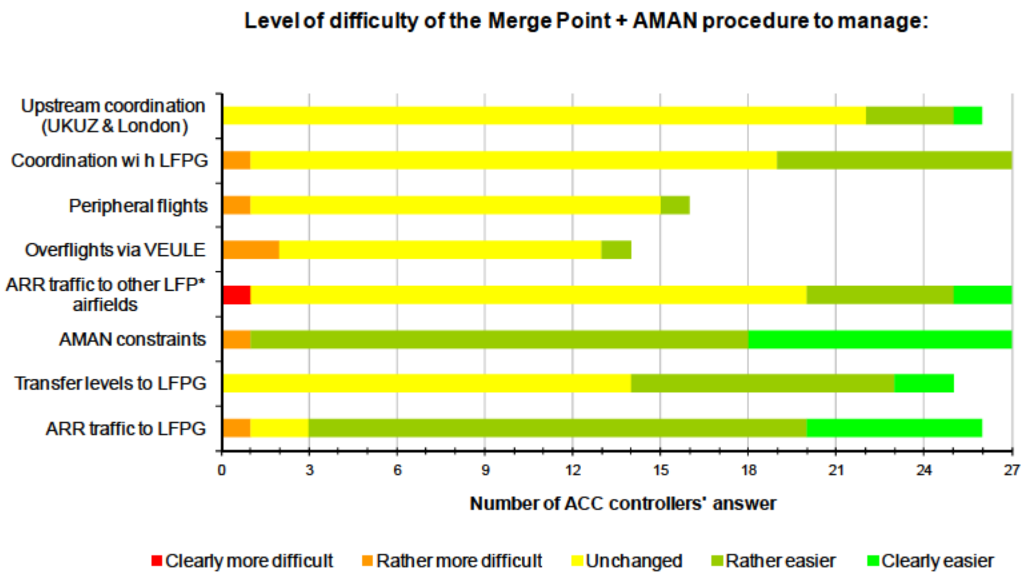


Figure 13: ACC controllers' rating regarding the level of difficulty of the Point Merge + AMAN procedure

Note: No comment was provided that could explain the orange and red ratings visible in Figure 13.

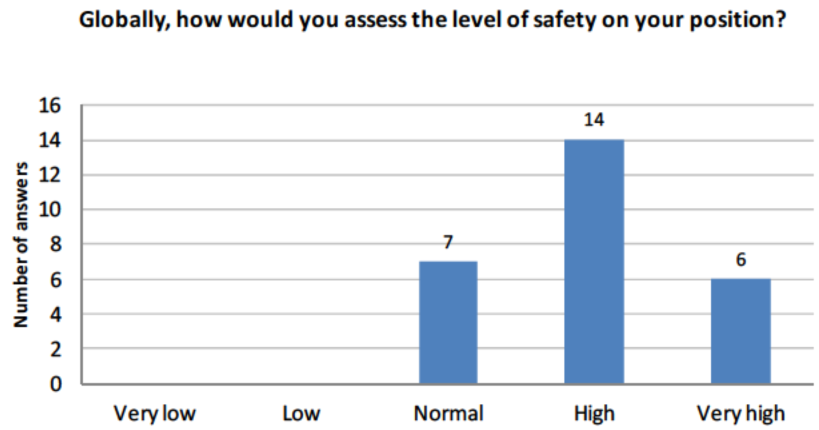


Figure 14: ACC controllers' ratings regarding safety on their control position

Figure 15: ACC controllers' ratings regarding safety compared to today's situation

Note: The negative rating regarding the level of safety compared to usual situation in Figure 15 (i.e. Clearly lower) cannot be explained. No comment was provided by the controller who otherwise gave rather positive feedback to the other questions.

6.1.3.2.1.2 Controller's Activity

The frequency occupancy is calculated over 5 minute ranges every 5 minutes when the TP sector is opened as a standalone sector.

As the traffic is not exactly the same in Baseline and during Point Merge, we analysed the frequency occupancy with the number of flights in the TP sector. This number of flights is an instantaneous number of flights in TP sector, calculated in the middle of the 5 minute ranges during which the frequency occupancy is calculated. To know if a flight is in the TP sector or not, we analysed the trajectory in the radar recordings and calculated when the flight entered and exited the TP sector (geographically).

The analysis of the frequency occupancy shows that:

- During low traffic, the frequency was slightly more loaded with Point Merge than in Baseline;
- During high traffic, the frequency load was equivalent to that of Baseline days.

This result is balanced by the fact that controllers gave more information to pilots as explained in section 6.1.3.2.1.3.

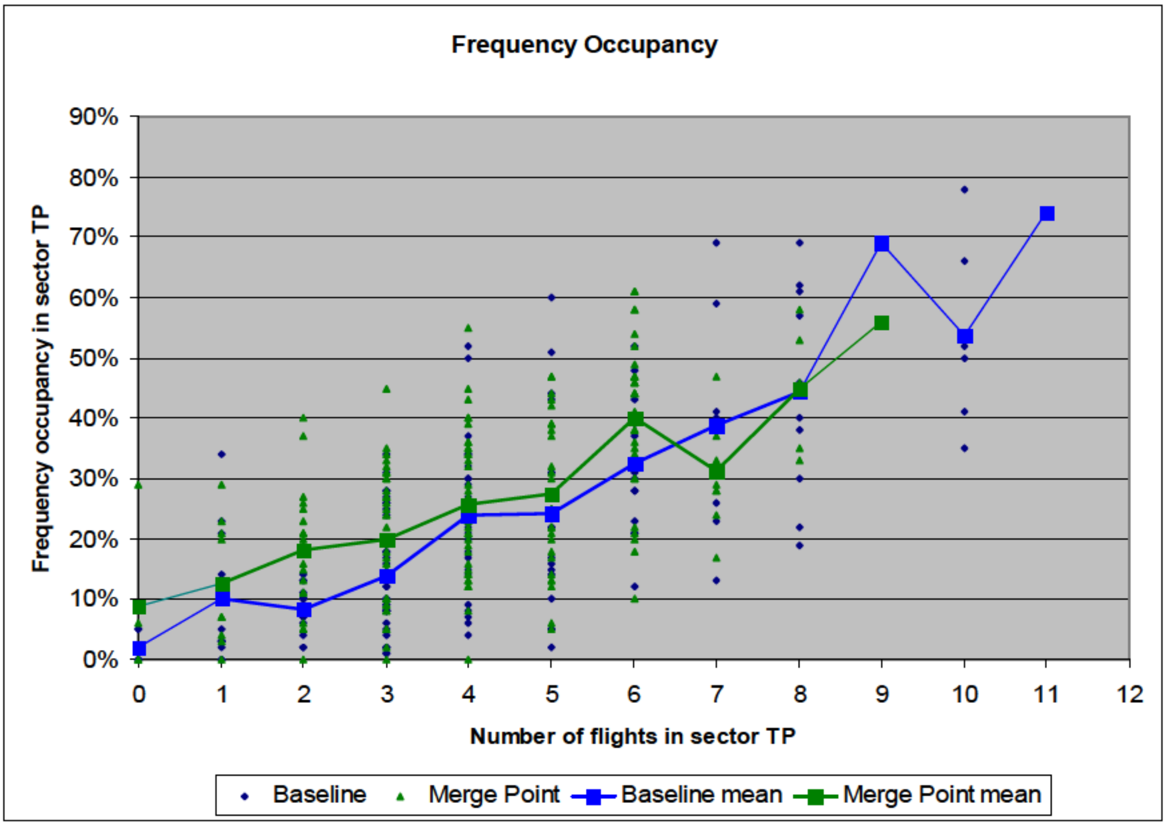


Figure 16: Frequency occupancy in sector TP

The scatter plot below confirms this analysis. The difference with the previous scatter plot is that the number of flights is not an instantaneous number. This is the number of flights in the TP sector weighted with the time spent in the sector during the 5 minute range during which the frequency occupancy is calculated.

The linear regression shows that frequency occupancy is slightly higher with little traffic in case of Point Merge but with higher traffic, the frequency occupancy is equal in both cases (Baseline and Point Merge).

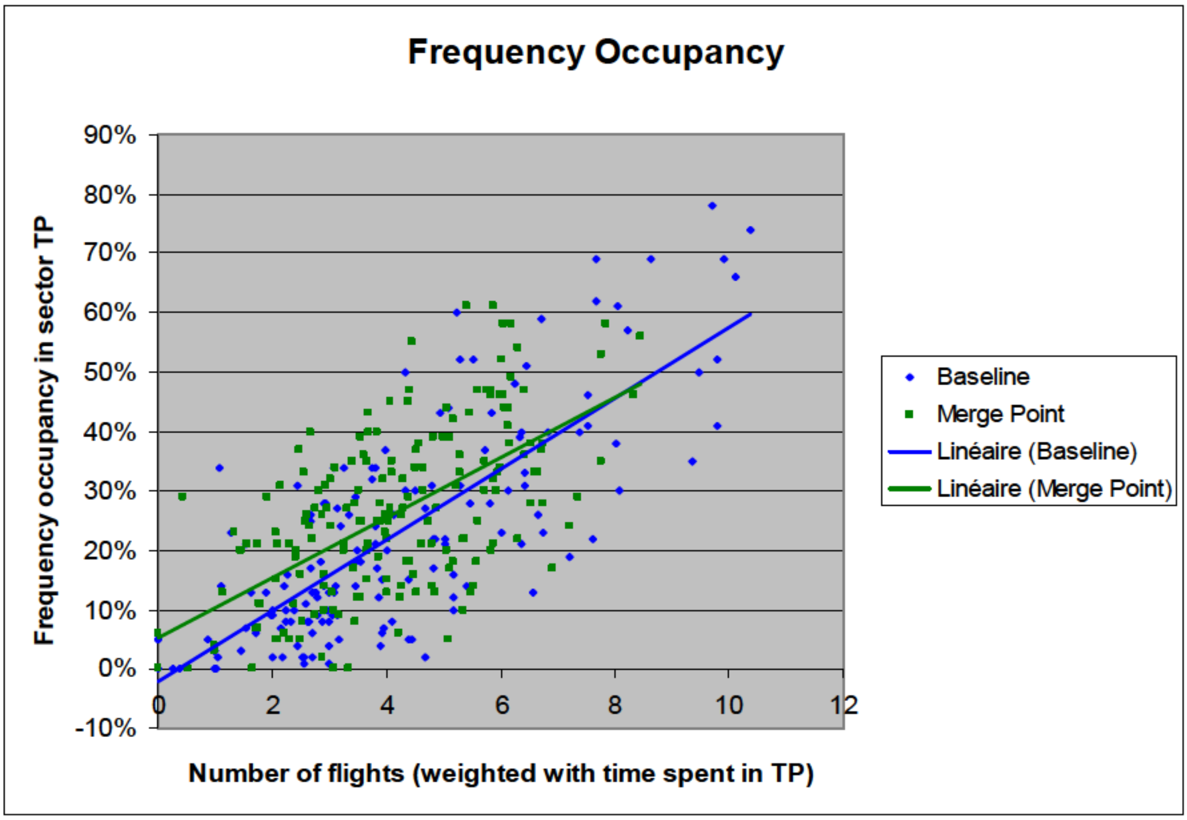


Figure 17: Frequency occupancy in TP with number of flights weighted with time spent in TP

The analysis of phone communications between the TP sector and APP shows that controllers of the TP sector called more the Approach with Point Merge (+2.7%pt) but remained at an acceptable level. An explanation for this increase is that Planning Controllers, having a less demanding task of monitoring surveillance with the Point Merge, had more time to perform a more intensive coordination task with the TMA Sequence Manager to improve the management of the arrival sequence (e.g. group heavy aircraft, better coordinate the spacing in order to respect AMAN delays and the speed constraints for delivery…). This statement is confirmed in section 6.1.3.2.1.3 where related comments are analysed.

Those numbers were calculated during one hour during peak trafic every day (from 06:15 AM to 07:15 AM (UTC)) where the TP sector was opened as a standalone sector (week of the experimentation for Point Merge and the week before for Baseline).

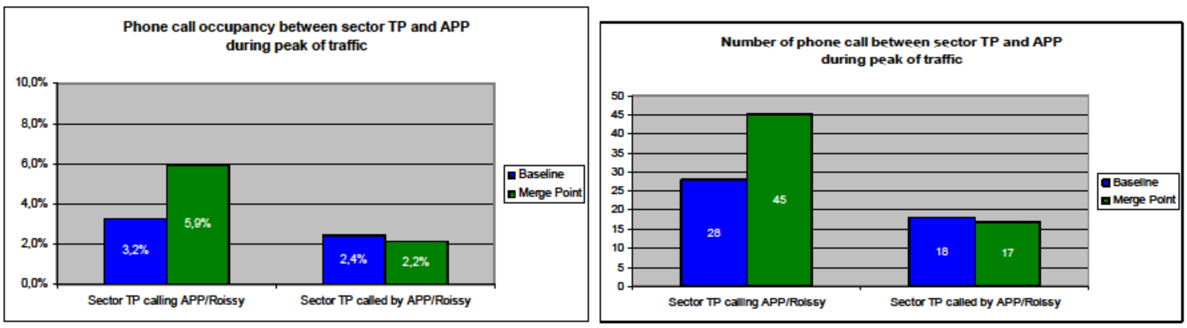


Figure 18: Phone Communication Occupancy with APP

6.1.3.2.1.3 Controller's Workload

Overall, ACC controllers' feedback about their perceived workload was that they were not overloaded. They got the impression that the frequency usage was lower than in the baseline. The aircraft had time to loose on the legs, but the sequencing task was easier due to the Point Merge.

The workload was considered as average to very low with the Point Merge and AMAN. In majority, it was considered as rather unchanged to clearly lower with the Point Merge. Compared to today, the reduction in workload was due to the fact that the arrivals are separated on the legs and the Point Merge and AMAN procedure is easy to apply. The ACC controllers did not have to give headings, or to monitor intermediary levels. The procedure saved mental resources, which was used to improve the service provided to the pilots (e.g. time to loose on the leg provided to the flight crews, descent at discretion towards the IAF flight level proposed to the flight crews) as shown in section 6.1.3.2.1.2 with the analysis of frequency occupancy.

The planning controller's workload proved to be reduced for the main tasks s/he has to perform (coordination and monitoring). This allowed him/her to spend more time coordinating with the Sequence Manager in order to improve the quality of the sequence (precision in spacing and speed according to APP needs).. The analysis of the phone communication logs confirms an increase in coordination. It shows that controllers of the TP sector called more the Approach with Point Merge (Figure 18).

In conclusion, while the Executive Controller's workload seems to be reduced with the use of the Point Merge and AMAN, the Planning Controller's workload seems to be increased due to the coordination task performed with the TMA Sequence Manager to improve the management of the arrival sequence.

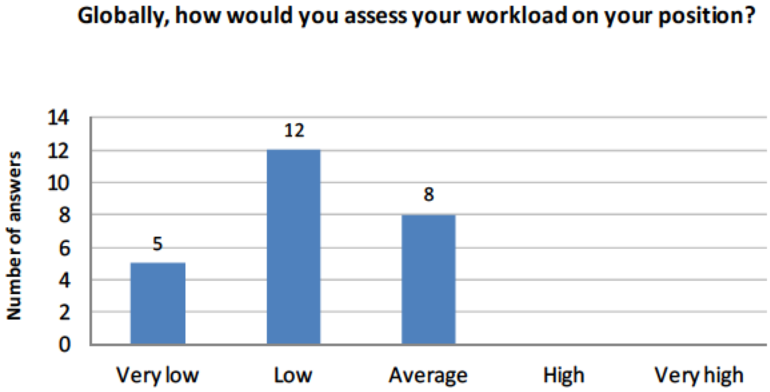


Figure 19: ACC controllers' rating regarding their perceived level of workload

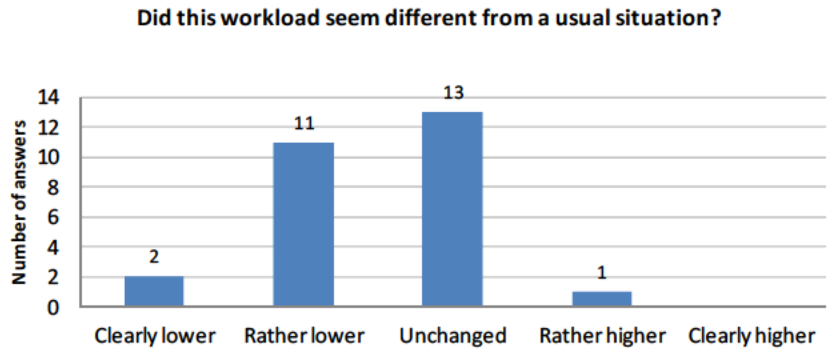


Figure 20: ACC controllers' rating regarding the level of workload compared to today's situation

6.1.3.2.2 Impact in APP/N

6.1.3.2.2.1 General Feedback

Note: The answers related to the delivery conditions of the arrival traffic to LFPG, although formulated in an absolute way, have to be taken relative to the current situation as it is in comparison to today's situation that the APP controllers gave their feedback.

The general feedback from the Approach controllers was positive (Figure 21).

Compared to today, some controllers reported benefits of the delay absorption strategy with the Point Merge. The aircraft did not have to enter the holding pattern at MOPAR. Some controllers think the Point Merge will be even more beneficial at LORNI where the situation is more complicated due to the more limited space to regulate the arrival traffic.

With the Point Merge, controllers reported a better quality of delivery of LFPG arrivals and of the other arrivals in terms of separation, vertical and speed constraints. Regarding the adherence to the AMAN advisories, a few controllers found that there was too much space between aircraft at the beginning of the peak of traffic. This "underfeeding" happened in strong wind situations, in which cases the regulation had to be refined for the delivery on the IAF. It might also be due to the fact that ACC controllers, wanting to relieve the Approach, reduced the total delay to zero by making a longer use of the leg. This reduced the pressure in Approach to zero, which created a chronic "underfeeding" of the runway doublets. In order to counterbalance this situation, the APP controllers tactically switched of arrival flights in the sequence. This happened during peak traffic. When the arrival sequence to MOPAR was « underfeeded », the APP controllers could switch MOPAR and LORNI arrival flights in the sequence, or else reroute arrival flights planned for the South runway to the North doublet. The runway pressure in the AMAN guarantees a continuous feed of the doublets when the traffic demand exists. When the existing pressure was absorbed on the legs in TP sector, APP controllers kept a pressure on the other IAF (2 minutes to be absorbed in APP for the nearest IAF, 3 minutes for the IAF with tail wind.

As illustrated on Figure 22, the majority of the participating APP controllers considered safety was higher than in the baseline notably due to the respect of the delivery conditions in terms of flight level and speed. In majority, the situational awareness was rated as unchanged to higher than in the baseline.

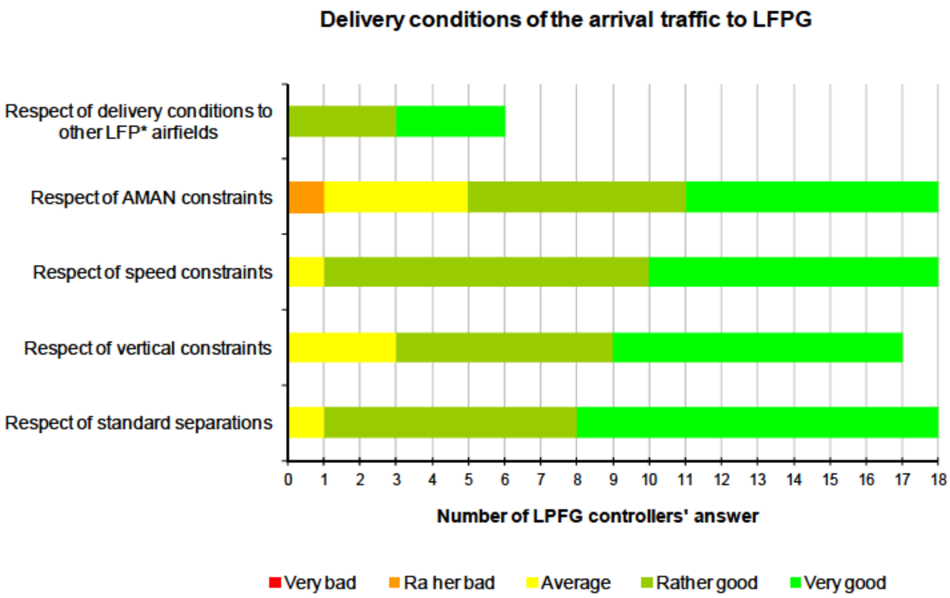


Figure 21: APP controllers' rating regarding the delivery conditions of the arrival traffic with the Point Merge + AMAN procedure

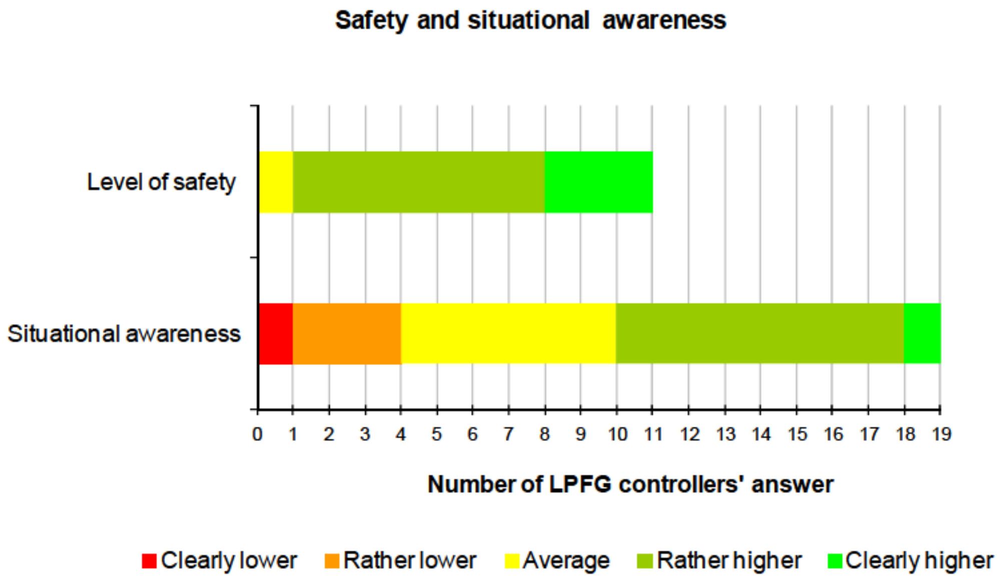


Figure 22: APP controllers' ratings regarding situational awareness and safety

Note: Among the four controllers who stated a lower level of situational awareness, two seemed to have misunderstood the question as they equated low situation awareness to low traffic / less challenging situation. One reported a lower level of situational awareness because he did not understand why some aircraft were delayed on the legs, and one because some AMAN constraints were not respected. Among these controllers (who reported lower situation awareness), two did not rate safety; one rated it as average, and one as very high.

6.1.3.2.2.2 Controller's Activity

To assess the Approach controllers' activity, the workload was analysed. As shown in Figure 23, the majority of the participating APP controllers rated their workload as average. However, some APP controllers, notably Sequence Managers, reported a high workload due to the fact that the traffic load was high (some controllers explained that the coordinator position had to be split during the session). It was also due to the fact that the arrival sequence order needs to be "frozen" earlier than in the baseline, which was a demanding task. However the time to loose seemed easier to absorb with the Point Merge.

Although having rated their workload as rather average to high during the simulation session, when asked during the debriefing to compare their workload with and without Point Merge, the participating APP controllers reported no significant impact of the Point Merge compared to today's situation.

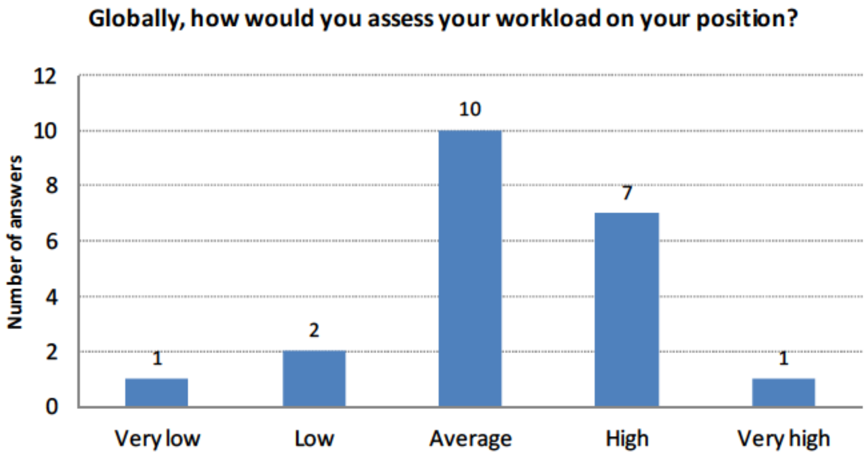


Figure 23: APP controllers' rating regarding their perceived level of workload

6.1.3.2.3 Performances in ACC + APP/N

6.1.3.2.3.1 Quality of Traffic Delivery

The Figure 24 below shows for each day of June 2012, the mean difference between sequenced time 15 minutes before MOPAR and time when aircraft fly over MOPAR. The beacon MOPAR is the IAF for North-West LFPG arrivals.

Note: for one LFPG runway configuration and for some kind of aircraft, the IAF for North-West LFPG arrivals can be MOBRO. But the IAF for most aircraft is MOPAR. That's why the analysis of the respect of the initial sequenced time has been focused on MOPAR.

Values for Point Merge days are closer of 00:00 than the other June days. Respect of the initial sequenced time is better for Point Merge days than other days.

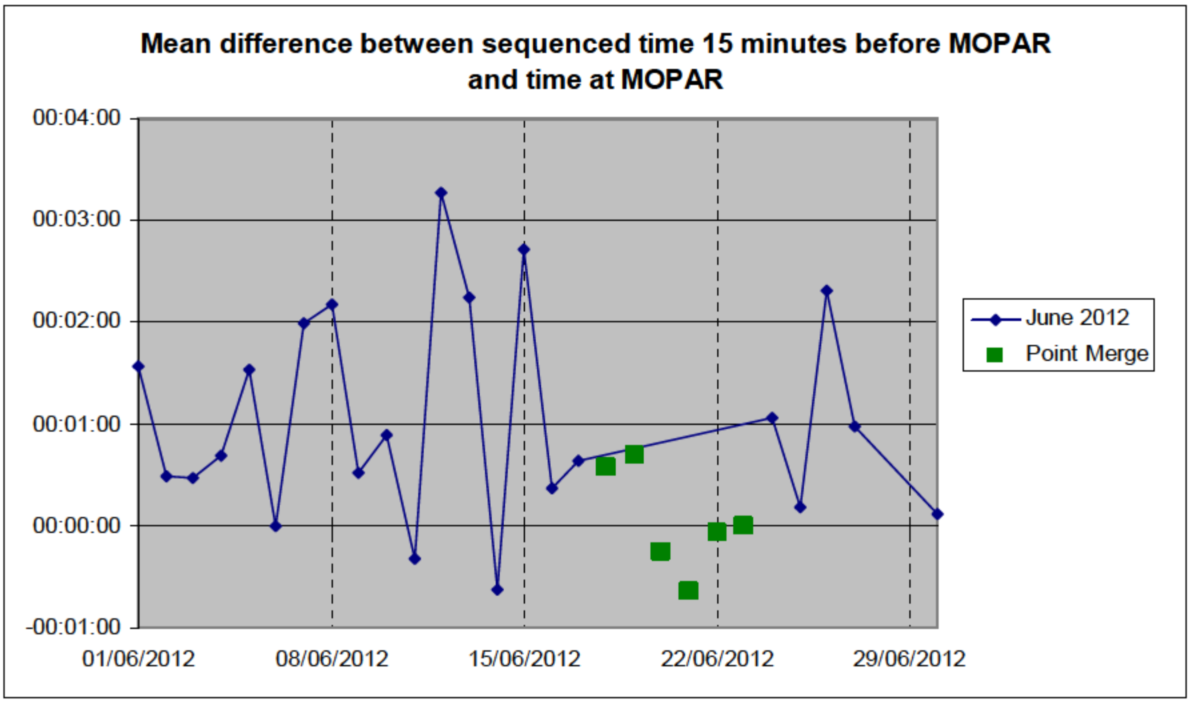


Figure 24: AMAN analysis: respect of the initial sequenced time at IAF MOPAR during peak traffic

Figure 25 shows the distribution of spacing over KOLIV during peak traffic. KOLIV is delivery point from ACC to APP for North-West arrivals. For Baseline days and for Point Merge days, all spacing between two aircraft over KOLIV during peak traffic have been calculated. Then, we counted how many times each value of spacing occurred. As there was 9 days for Baseline and 6 days for Point Merge, values for Baseline were multiplied by 2/3 to be comparable with values for Point Merge.

As usual, ACC controllers were tasked to deliver LFPG arrivals to APP/N with 8 NM spacing (minimum). As illustrated in Figure 25, the sequencing of arrival flows to KOLIV was similar in both conditions: most of LFPG arrivals were delivered to APP/N between 8 NM and 11 NM. Larger spacing values correspond to gaps in the traffic. With Point Merge, the first peak is around 8 NM whereas it is around 9 NM for Baseline. Aircraft spacing over KOLIV seems quite better for Point Merge. It is normal that the main peak is not at 8 NM because there was some delay in ACC due to high traffic in LFPG. Aircraft spacing were above the minimum spacing (8 NM).

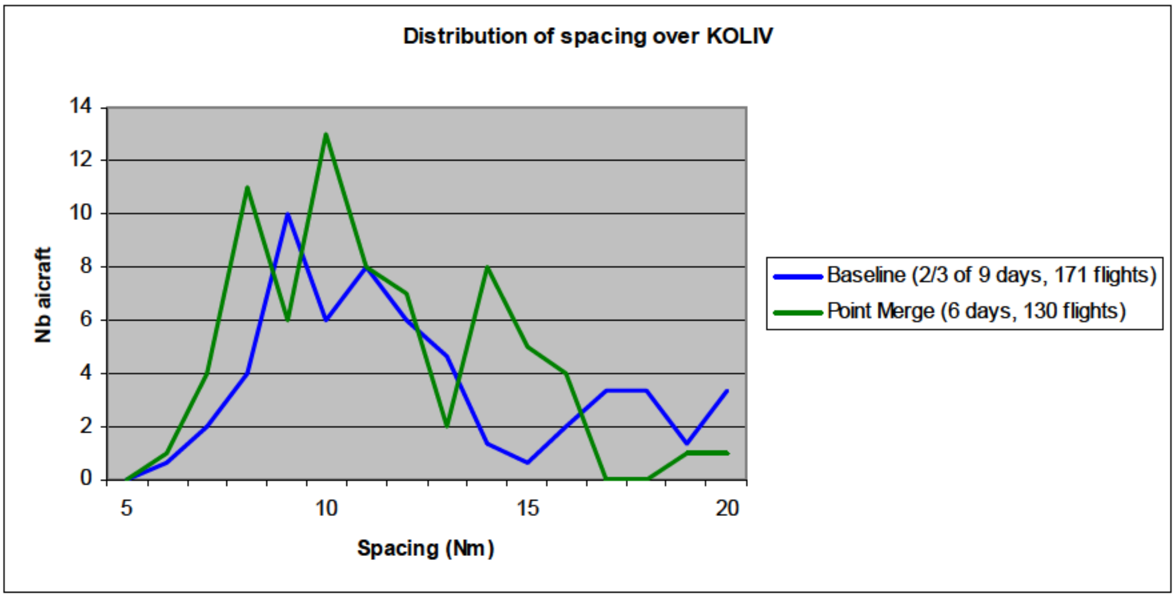


Figure 25: Distribution of spacing over KOLIV during peak traffic

6.1.3.2.3.2 Flight Efficiency

The different working methods in Baseline and Point Merge are clearly visible on North-West LFPG flown trajectories during peak traffic (Figure 26, Figure 27, Figure 28 and Figure 29). The use of radar vectoring and holdings is apparent in Baseline (Figure 26 and Figure 27) whereas the flow of traffic was more ordered with a contained and predefined dispersion of trajectories with Point Merge (Figure 28 and Figure 29). There is fewer dispersion in APP with Point Merge, which is due to that delay is more absorbed in E-TMA rather than in TMA.

In case an aircraft reached the end of the sequencing leg and still had some delay to be absorbed in ACC, the controller had the possibility to vector the traffic in the airspace available in between the sequencing leg and the IAF (see Figure 29). If the airspace available is not sufficient for the AMAN sequence to be adhered to, holding patterns shall be used.

The length of the legs was sufficient to absorb the AMAN delays. On two occasions, the entire leg was not enough to absorb all the delay for specific aircraft in the sequence that had a total of 8+ minutes of delays.

This tends to indicate that the dimensioning of the system is consistent with the needs in the TP sector.

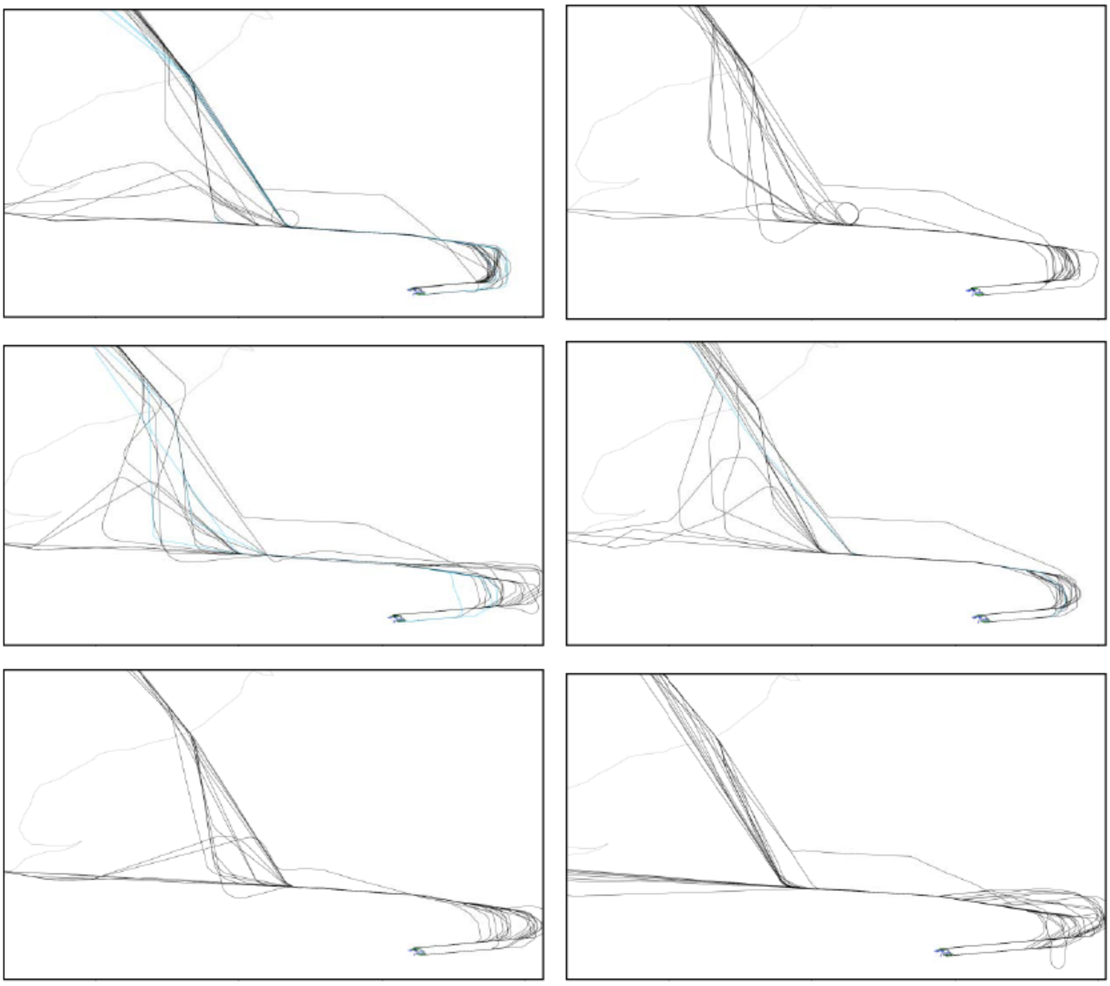


Figure 26: 6 days of Baseline (westerly)

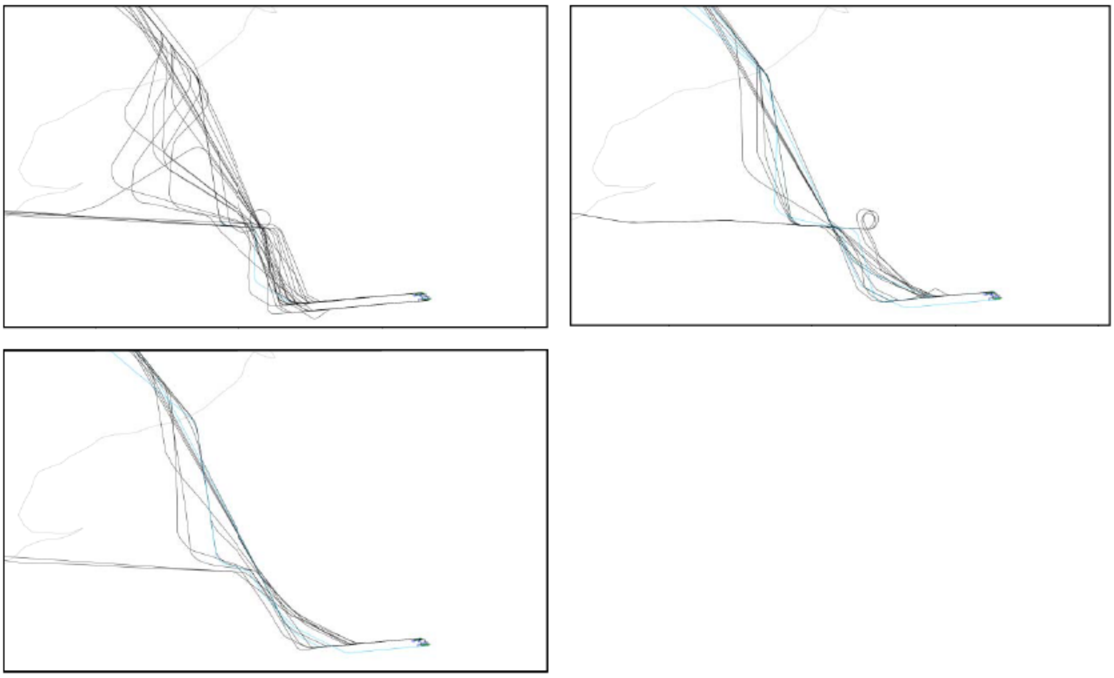


Figure 27: 3 days of Baseline (easterly)

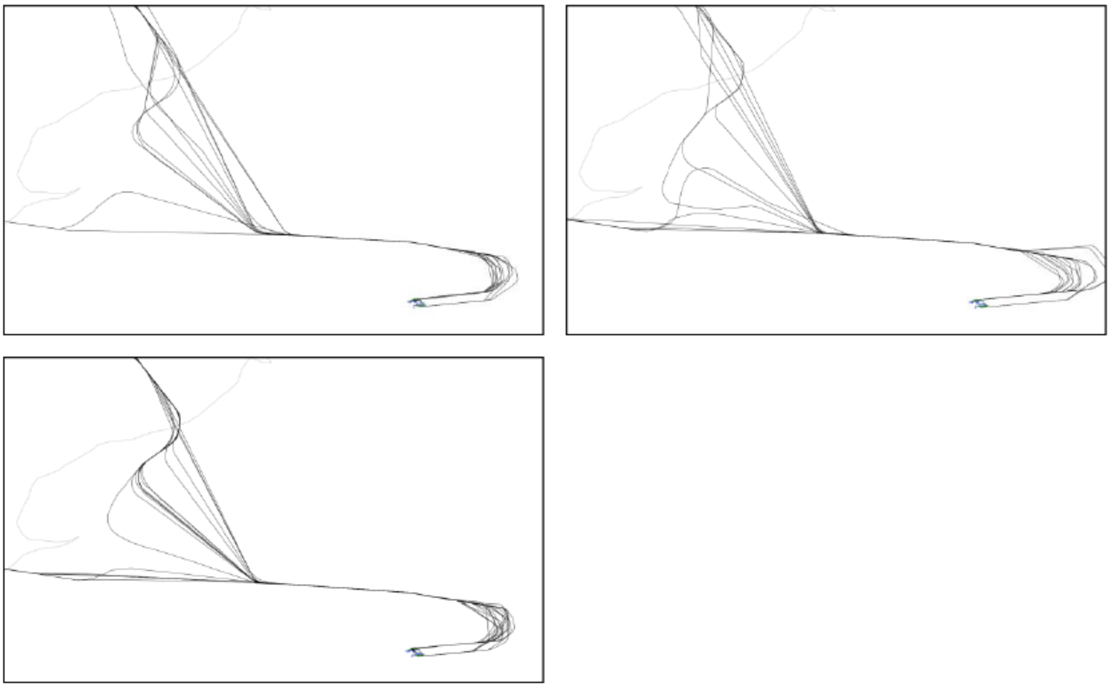


Figure 28: 3 days of Point Merge (westerly)

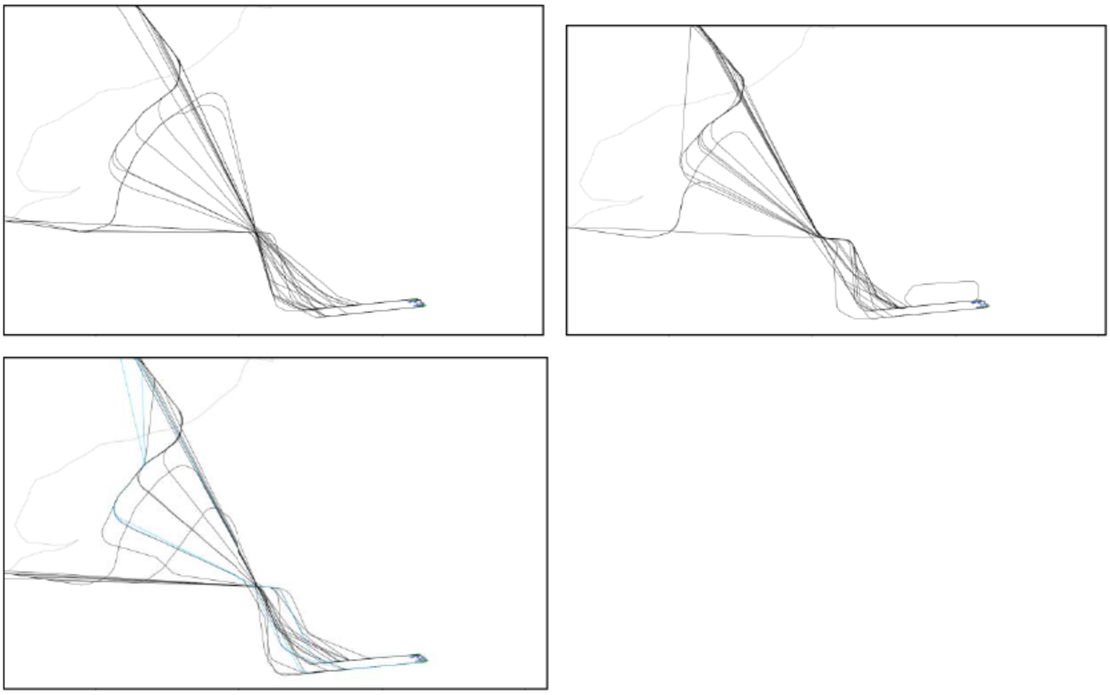


Figure 29: 3 days of Point Merge (easterly)

Here after are some figures such as number of flights which used the Point Merge procedure. The whole experimentation period of Point Merge is considered, i.e. the 6 Point Merge days (from 18/06/2012 to 23/06/2012), from 04:30 AM to 12:30 (UTC).

	number of flight	percentage of flight
flights during the whole experimentation period	469	100%
flights using PMS	90	19%
flights staying on PMS more than 4NM	78	17%
flights using radar vectoring and losing more than 4NM	20	4%

Table 17: Some number of flights about the use of the Point Merge System (PMS)

There are 19% of flights using PMS and 17% of flights losing more than 4NM on PMS. It means that most of flights using PMS stayed on the legs more than 4 NM.

The table below shows the time spent on Point Merge system for flights which stayed on PMS more than 4 NM. Those figures are calculated with arithmetic methods and based on radar trajectories. That's why some values might be approximated. For instance, the flight which stayed the longest time on the Point Merge is the flight AFR007, on 19/06/2012, between 06:45 AM and 07:00 AM (UTC). We estimated its lost time on the legs at 14 minutes. But in fact, this flight flew only 9-10 minutes on the leg and then had a direct to the merge point. This particularly flight flew almost the entire leg.

Mean	04:04
25th percentile	01:50
50th percentile	03:21
75th percentile	04:37
Max	14:26

Table 18: Time spent on Point Merge system (PMS) for flights which stayed more than 4NM on the PMS (mm:ss)

For information, the mean time lost by flights (considering all flights) during the whole experimentation period is 50 seconds.

The analysis of distance and time flown (from 100NM from LFPG to 5NM to LFPG) shows that aircraft flew slightly less distance in Point Merge, particularly during peak traffic (~1% to 1.5%). Aircraft flew less time in Point Merge with westerly LFPG runway configuration (~5.5% during peak traffic) but flew equivalent time in Point Merge with easterly LFPG runway configuration (~0.7% difference during peak traffic). This slightly increase of time flown is probably due to wind conditions. Indeed, in Figure 32, there is head wind and mean aircraft speed for days with easterly LFPG runway configuration. For the 3 Point Merge days, head wind was very low, whereas for 2 of 3 Baseline days, head wind was back wind with strength around 30 and 40 kts. This directly impacts the mean aircraft speed for those 2 Baseline days, which was 20 kts higher than days with little wind. That explains why aircraft flew slightly more time during peak traffic in Point Merge days with easterly LFPG runway configuration.

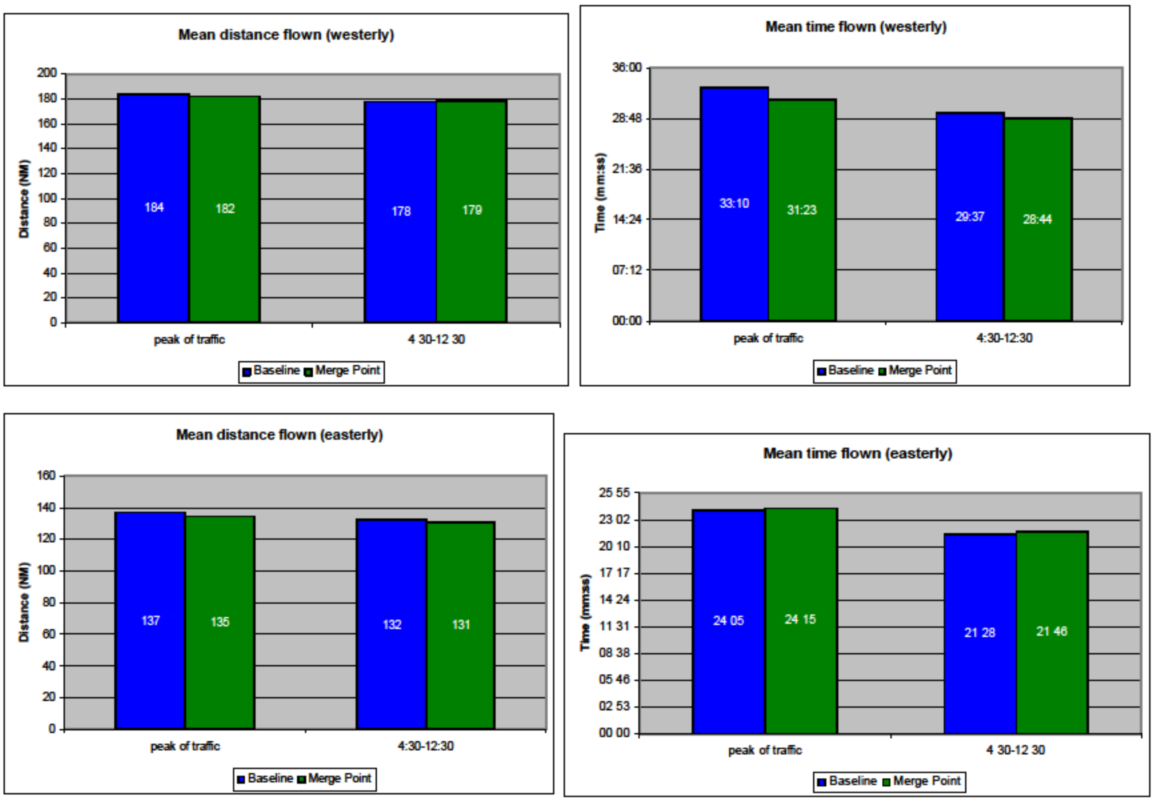


Figure 30: Distance and time flown in ACC+APP

The two figures below show head wind speed in sector TP for LFPG arrival flights during peak traffic, depending on the LFPG runway configuration. It show mean aircraft speed in TP too. It is very interesting to notice the relation between the strength of the head wind and the mean aircraft speed. The stronger head wind, the lower mean aircraft speed and vice versa.

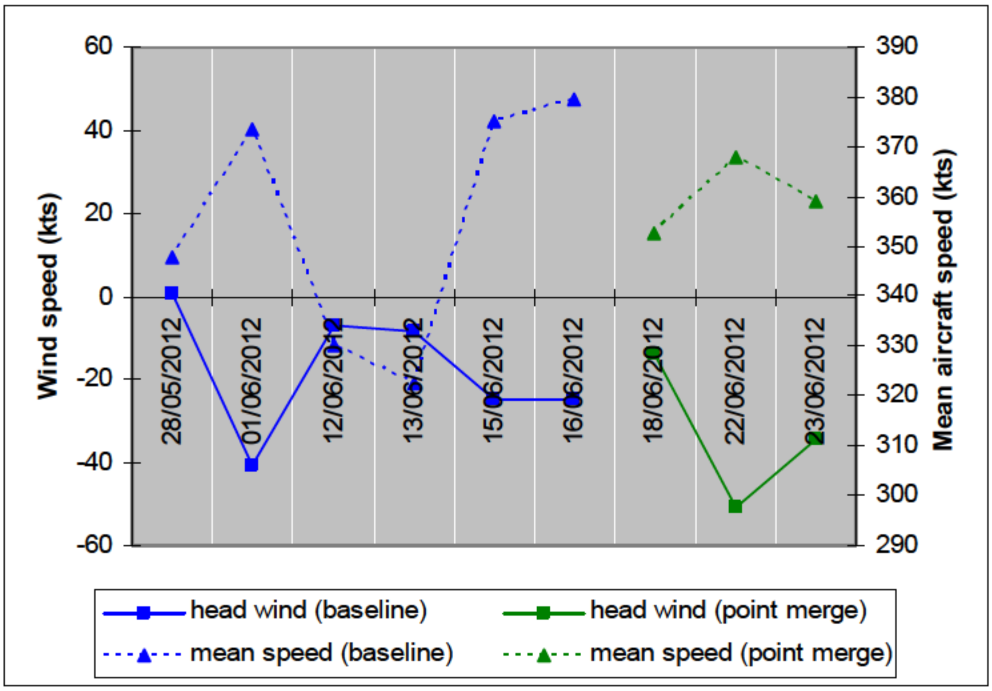


Figure 31: Head wind and mean aircraft speed when westerly LFPG runway configuration during peak traffic

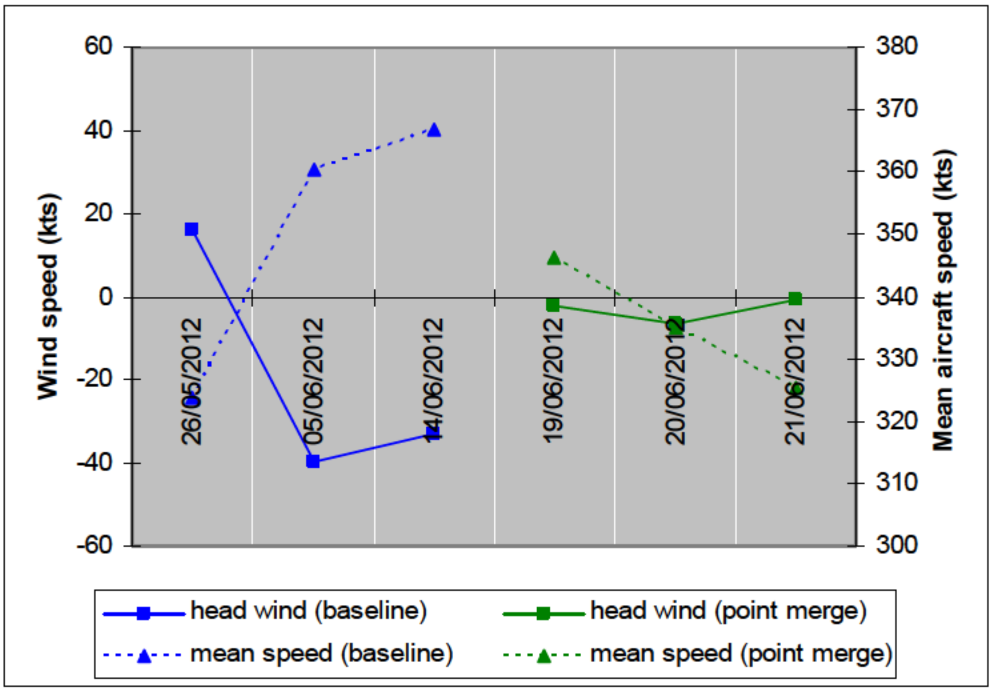


Figure 32: Head wind and mean aircraft speed when easterly LFPG runway configuration during peak traffic

It is worth analysing the distance and time flown in ACC and APP separately. Indeed, one objective of Point Merge was to absorb more delay in E-TMA (on the legs) rather than in TMA. The AMAN delay strategy during Point Merge experimentation was different from that in the baseline. The maximum delay absorption capability was configured in MAESTRO with 2 minutes in APP during the Point Merge experimentation instead of 5 minutes.

The analysis of distance and time flown in ACC (from 100NM from LFPG to 42NM to LFPG) and APP (from 42NM from LFPG to 5NM to LFPG) during peak traffic shows that aircraft flew:

- more distance and time in ACC in Point Merge
  - +3NM and +23'' with westerly LFPG runway configuration
  - +5NM and +1'14 with easterly LFPG runway configuration
- less distance and time in APP in Point Merge
  - -5NM and -2'10 with westerly LFPG runway configuration
  - -7NM and -1'04 with easterly LFPG runway configuration

This analysis shows that delay was moved from TMA to E-TMA.

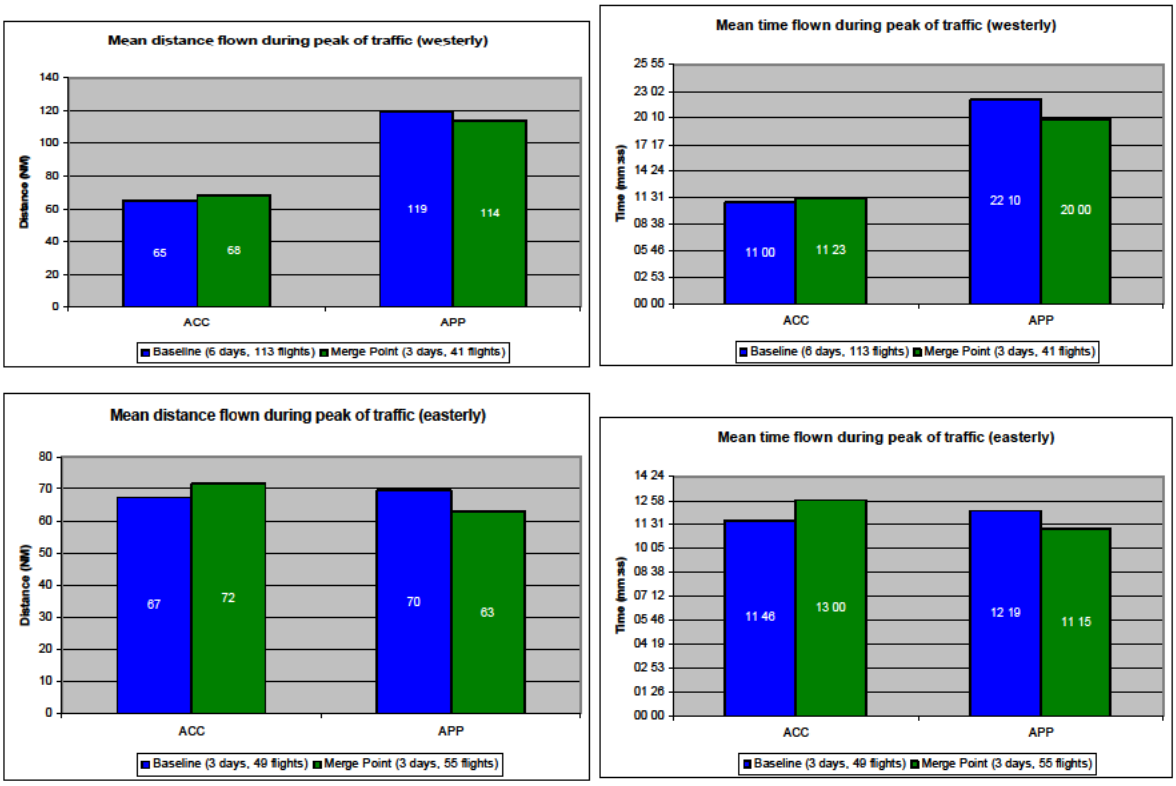
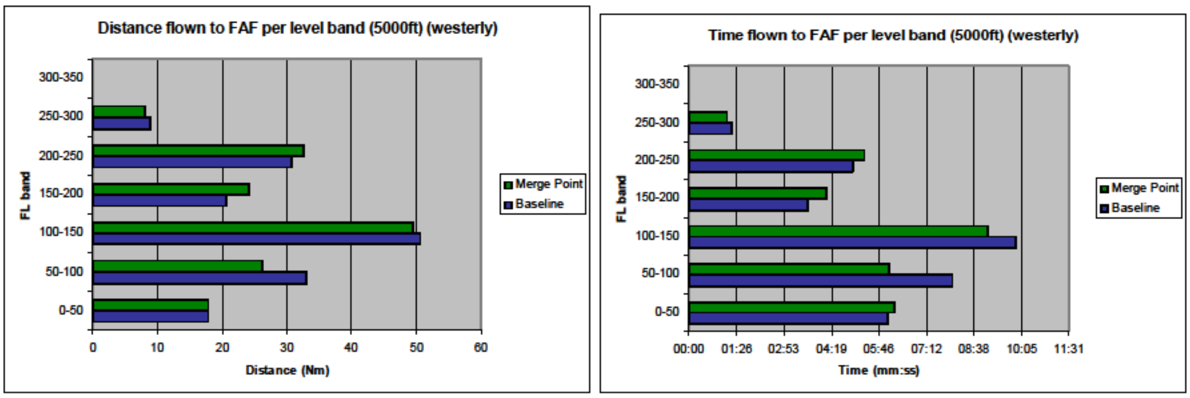


Figure 33: Distance and time flown in ACC and APP during peak traffic

The analysis of distance and time flown per level band during peak traffic shows that with Point Merge aircraft stayed longer higher (typically between FL150 and FL250 as shown in Figure 34). This illustrates the Point Merge method where the path stretching is done along the legs above FL200 whereas in Baseline the use of vectoring may require to further descent aircraft and levelling off at lower altitude.

Remark: when an aircraft is flying on a leg at FL200, distance and time spent on the leg is included in the 150-200 flight level band.



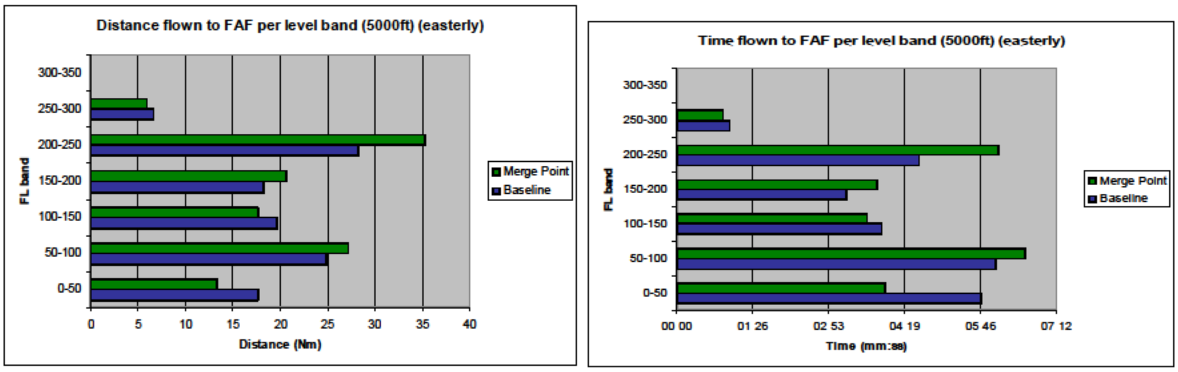


Figure 34: Distance and time flown per level band during peak traffic

The mean descent profiles of North-West LFPG arrivals shown in Figure 35 are consistent with previous results and show that with Point Merge aircraft were maintained longer at higher level.

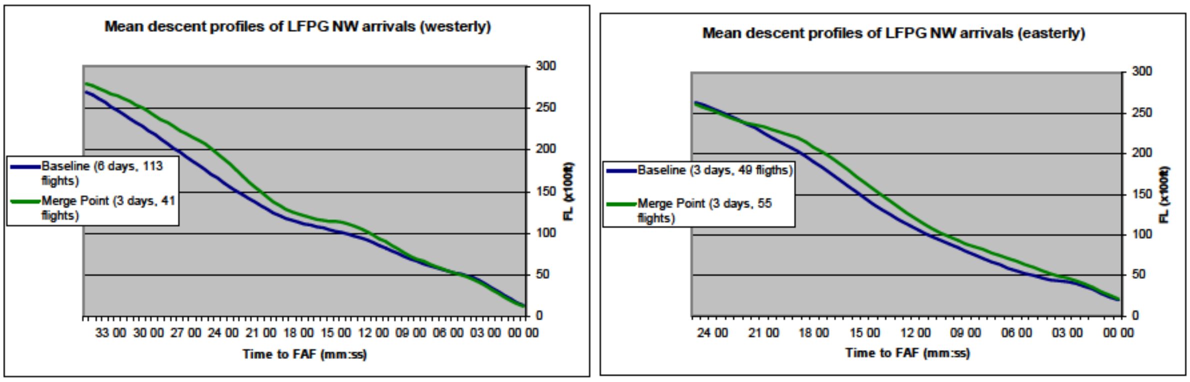


Figure 35: Mean descent profiles during peak traffic

6.1.3.2.4 Flight Crew's Opinion

Flight crews were invited to give their opinion on the Point Merge procedure through a questionnaire. Among about 40 airlines having received the Point Merge questionnaire, only three (i.e. Air Canada, Easy Jet, Air France) provided feedback with twenty pilots having answered the questionnaire. Regarding Air France feedbacks from June trials, they are considered to be representative as the responses correspond to a sufficient percentage of flights among those that have flown to CDG through Paris TP sector during the sessions, i.e. >15% for Boeing Long Haul flights and about 50% for Airbus Long Haul flights.

As illustrated in Figure 36, most of the pilots who answered the questionnaire stated that they received a direct clearance before the first point of the STAR, which means that they might not have fully experienced the new procedure.

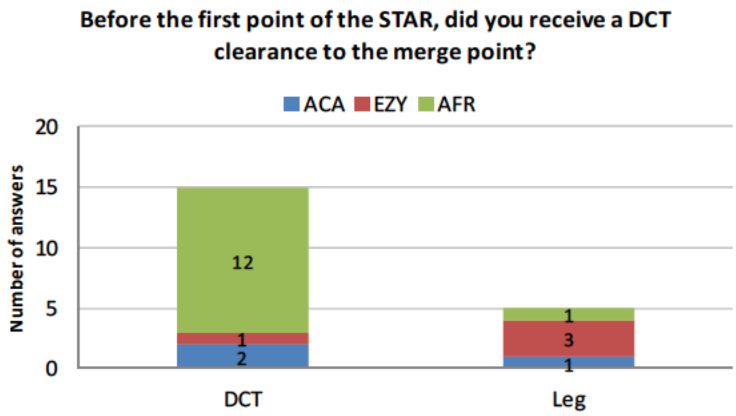


Figure 36: Number of pilots' answers on having received a direct clearance or flown on the leg

Among the pilots who replied, the speed was more often imposed by the ATC than chosen. It was also, in majority, adapted to their needs (Figure 37 & Figure 38).

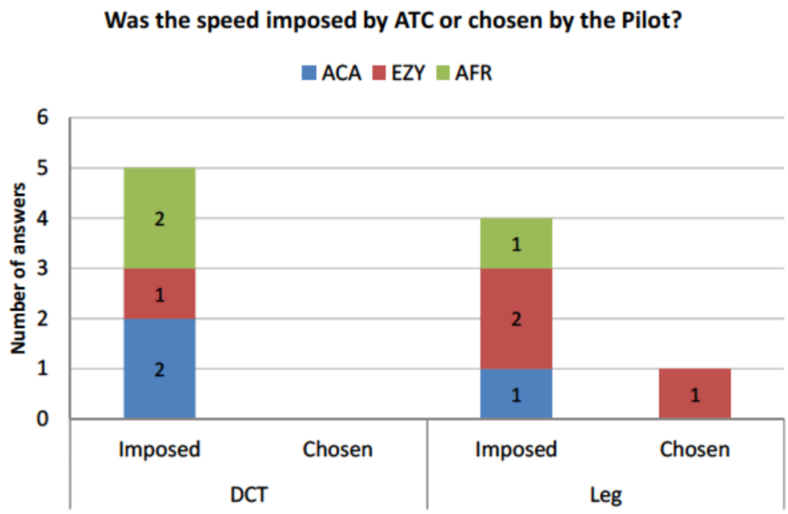


Figure 37: Number of pilots' answers on having had speed imposed or chosen

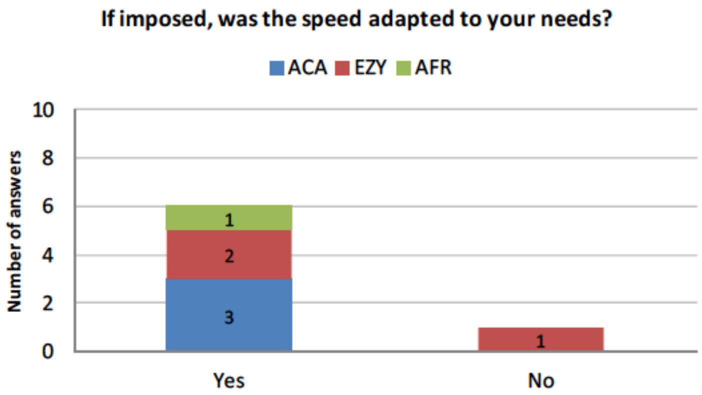


Figure 38: Number of pilots' answers on whether speed was considered as adapted

Seven pilots out of the twelve who replied reported that the ATC did not request a fixed rate of descent, especially those who flown the legs (Figure 39)

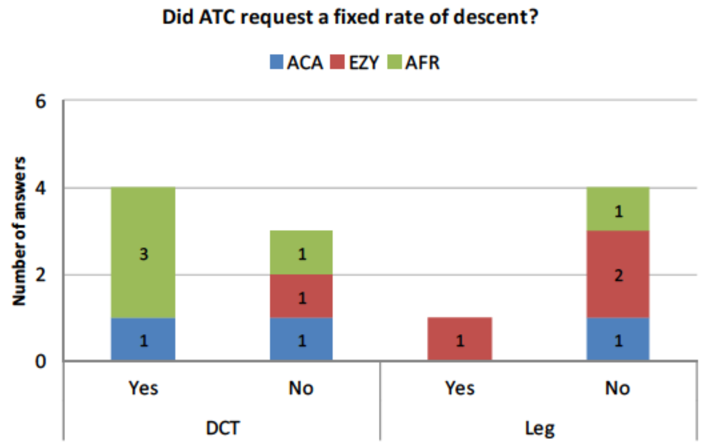


Figure 39: Number of pilots' answers on whether a fixed rate of descent was requested

As shown in Figure 40 below, half of the pilots who answered the question (i.e. 6) reported they had to extend the airbrakes during the descent, half that they did not.

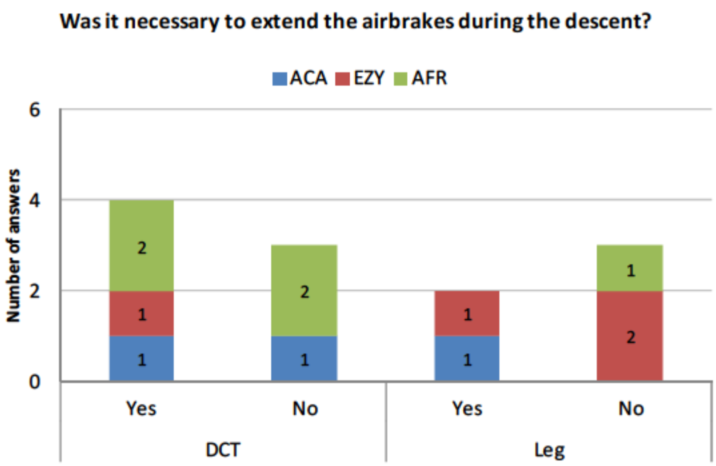


Figure 40: Number of pilots' answers on having had to extend the airbrakes during the descent

Figure 42 below shows that pilots' general impression was globally positive in terms of safety, radio communications, and handling of the procedure and clarity of phraseology.

The 4 negative feedbacks come from two pilots, one form Air Canada who answered to the three questions stating that the Point Merge procedure "bore no resemblance to the published procedure". The other negative answer was provided by a pilot from Air France regarding radio communication and referring to a late transfer to Paris arrival sector.

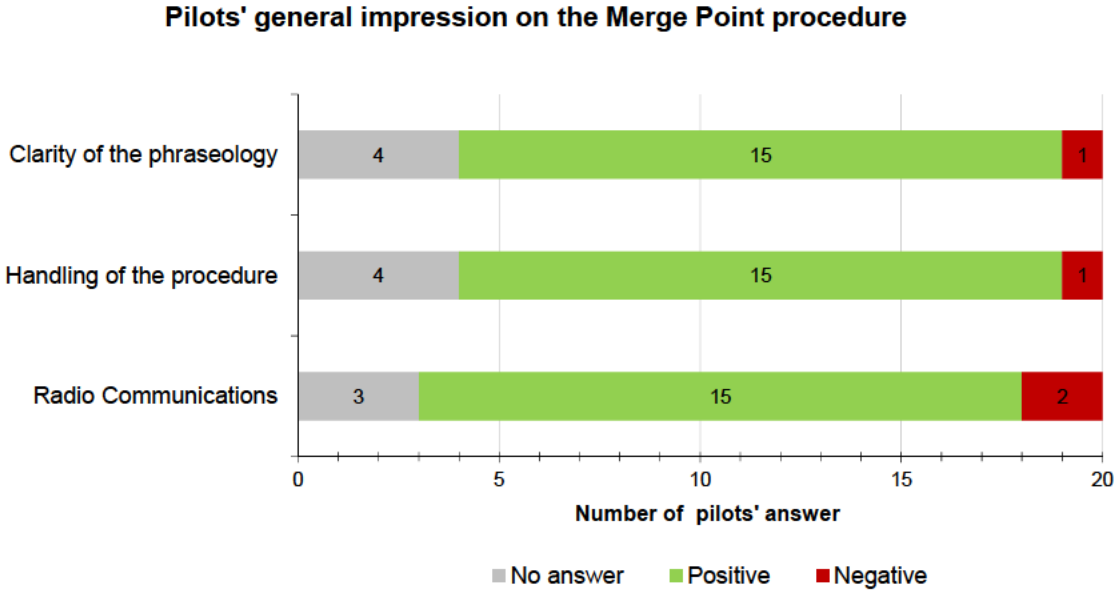


Figure 41: Pilots' answers on their general impression on the Point Merge procedure

Figure 42 below shows the number of flights which carried extra fuel compared to usual operations. Only ACA and EZY gave their feedback to this question as it was not explicitly asked in AFR pilot's questionnaire, all AFR pilots having decided to carry extra fuel for the leg.

Five out of seven pilots answered they did not carry extra fuel. Amongst the two pilots who reported having carried extra fuel, one explained it was because the flight planned route is longer, the other reported it was also because of the weather and not only because of the new procedure.

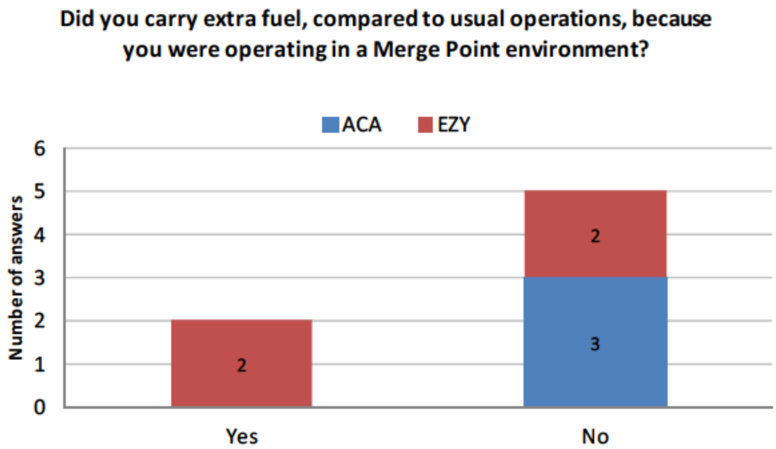


Figure 42: Number of pilots' answers on extra fuel carriage compared to usual operations

The issue of fuel carriage, in terms of regulation, has been raised by the pilots. The Point Merge with AMAN procedure is used as a substitute for the current linear holding and shows no negative impact on the flown distance compared to today's situation. The regulation texts should be updated taking into account this new method of control[4]. In addition, the ANSP could provide the information on the arriving flights' flown distance in order for the airline operators to plan the fuel load needed according to the regulation.

A second aspect is the issue of FMS computation while in flight using the long route. As long as the pilot has not inputted the direct route to the merge point, the Estimated Time of Arrival is wrong. Once updated, the ETA shows a gain in time, which leads the pilot to accelerate as s/he and believes the flight will be late.

6.1.3.3 Unexpected Behaviours/Results

Regarding the airlines, as the merge point procedure was coded in the FMS route, the fuel prediction and the calculated ETA were wrong during all the flight because in most cases the aircraft did not fly the leg and proceed direct to the Merge Point.

6.1.3.4 Confidence in Results of Validation Exercise

6.1.3.4.1 Quality of Validation Exercise Results

The validation exercise unfolded as planned without major problems.

Wind has an impact on the time flown by aircrafts. That's why time flown indicators should be considered with caution. Distance flown indicators are more comparable from a day to another.

For a same quantity of traffic, there is not same delay. The way that traffic comes into a sector is very important and make days difficult to compare.

The results from the controllers' questionnaire were reviewed by the ATC centres involved (i.e. Paris ACC and Paris CDG), which ensured confidence in these results.

6.1.3.4.2 Significance of Validation Exercise Results

There is no absolute Baseline because traffic, wind and weather conditions are always quite different and even more than expected in the VALP.

To analyse the respect of the initial AMAN sequenced time, some statistical tests have been performed as measurements on each day in June.

No statistical test was performed from the questionnaires.

As to the operational significance, there was full representativeness of the validation exercise performed as live trials.

6.1.4 Conclusions and recommendations

6.1.4.1 Conclusions

The first conclusion is that Point Merge Trials have gone well. Except in two special circumstances (i.e. aircraft flying beyond the end of the leg because the AMAN delay was above 8min), controllers made aircraft fly on the Point Merge Procedure, without using radar vectoring after the legs until the IAF.

In summary, the use of the Point Merge with the AMAN had a positive impact on the management of the arrival sequence.

The different data analyses have shown that:

[4] The French regulator (DSAC) actually allowed for fuel calculation upon the shortest route (OPS 1.255 - fuel policy), i.e. a direct route from the first point of the STAR to the merge point. It seems that it was not considered.

- The frequency occupancy with Point Merge was slightly more loaded during low traffic and equivalent during high traffic. This result is balanced by the fact that controllers gave more information to pilots (e.g. time to loose on the leg, descent at discretion towards the IAF flight level).
- Aircraft flew slightly less distance and time in Paris ACC + APP with Point Merge.
- It was shown that aircraft stayed at higher altitude with Point Merge, which could have a positive impact on fuel efficiency.
- Delay was more absorbed in E-TMA on the legs rather than in TMA. This allows better anticipating the arrival sequence. Planning Controller had more time to perform a more intensive coordination task with the TMA Sequence Manager to improve the management of the arrival sequence.
- The respect of the initial AMAN sequenced time was better than other days in June 2012.
- Aircraft spacing over delivery point during peak traffic were similar to Baseline.

From a Human Performance perspective, the Point Merge with AMAN procedure has been perceived positively:

- Paris ACC controllers reported improved safety and situational awareness. They considered that the use of the Point Merge and AMAN improved the quality of the delivery, the quality of the sequencing, and the quality of service provided to the flight crews.
- Paris APP controllers considered that their situational awareness was enhanced. They also reported improved delivery conditions of LFPG arrivals in terms of separation, vertical and speed constraints, and thus improved safety due to the respect of these delivery conditions. However, some controllers raised an issue regarding delay absorption in the ACC. In case of strong wind situations, there was too much space between aircraft on the IAF at the beginning of the peak of traffic, the wind having an effect on the inertia and turn radius of the flights. Too much delay was thus absorbed in the ACC and Paris APP controllers had to apply a strategy to maintain a pressure on the other IAFs. .
- Pilots' general impression was positive in terms of safety, radio communications, handling of the procedure and clarity of phraseology.

6.1.4.2Recommendations

- Listening frequency recordings of Point Merge to evaluate the quantity of further information given by controllers to pilots
- Pay attention to have days for Baseline with the same sector configuration than Point Merge. For example, for this session, the TP sector was opened as a standalone sector which is not usual. Controllers had to open the TP sector as a standalone sector some other days to make them useable as Baseline.
- Take into consideration wind conditions which impact time flown in ACC for the choice of baseline or at least for flight efficiency analysis.
- An action should be engaged with EASA / ICAO concerning fuel calculation and Point Merge. The Point Merge with AMAN procedure is used as a substitute for the current linear holding and shows no negative impact on the flown distance compared to today's situation. The regulation texts should be updated taking into account this new method of control. In addition, the ANSP could provide the information on the arriving flights' flown distance in order for the airline operators to plan the fuel load needed according to the regulation.
- In order to avoid that too much delay is absorbed in the ACC, there is a need for clear guidance to ACC controllers so as to make sure a sufficient level of runway pressure is kept even though Point Merge might offer capability to absorb more delays. If the ACC controllers only absorb the allotted ACC delay (by aiming at 0 minute), a pressure will be ensured in the APP. In order to adapt to the wind condition notably, the AMAN should allow for a dynamic configuration of the runway pressure so as to reduce the gaps on the arrival sequence.

6.2 Validation EXE-05.06.07-VP-427 – Nov.-Dec. 2012 trials

This section reports the main results derived from the EXE-05.06.07-VP-427 conducted by DSNA on 4 Saturdays from 17th November 2012 to 8th December 2012.

6.2.1 Exercise Scope

For a description of the Point Merge concept, see section 6.1.1

The exercise performed in November - December 2012 corresponds to the second live trial session aiming at assessing the implementation of the E-TMA Point Merge system coupled to the use of the MAESTRO AMAN for Northwest and Northeast traffic to Paris CDG. This second exercise complements the first one with the implementation of a second E-TMA Point Merge system for Northeast arrivals in addition to the one tested in June trials for the Northwest arrivals of the CDG airport. The Point Merge system for Northeast arrivals was being fed from EUROCONTROL Maastricht UAC and Belgocontrol Brussels ACC.

6.2.1.1 STAR procedure

The figures below are the Paris CDG North Western which have been published in AIP and used during Point Merge Trials.

The Paris CDG North Eastern STAR procedures are presented in section 6.1.1.1.

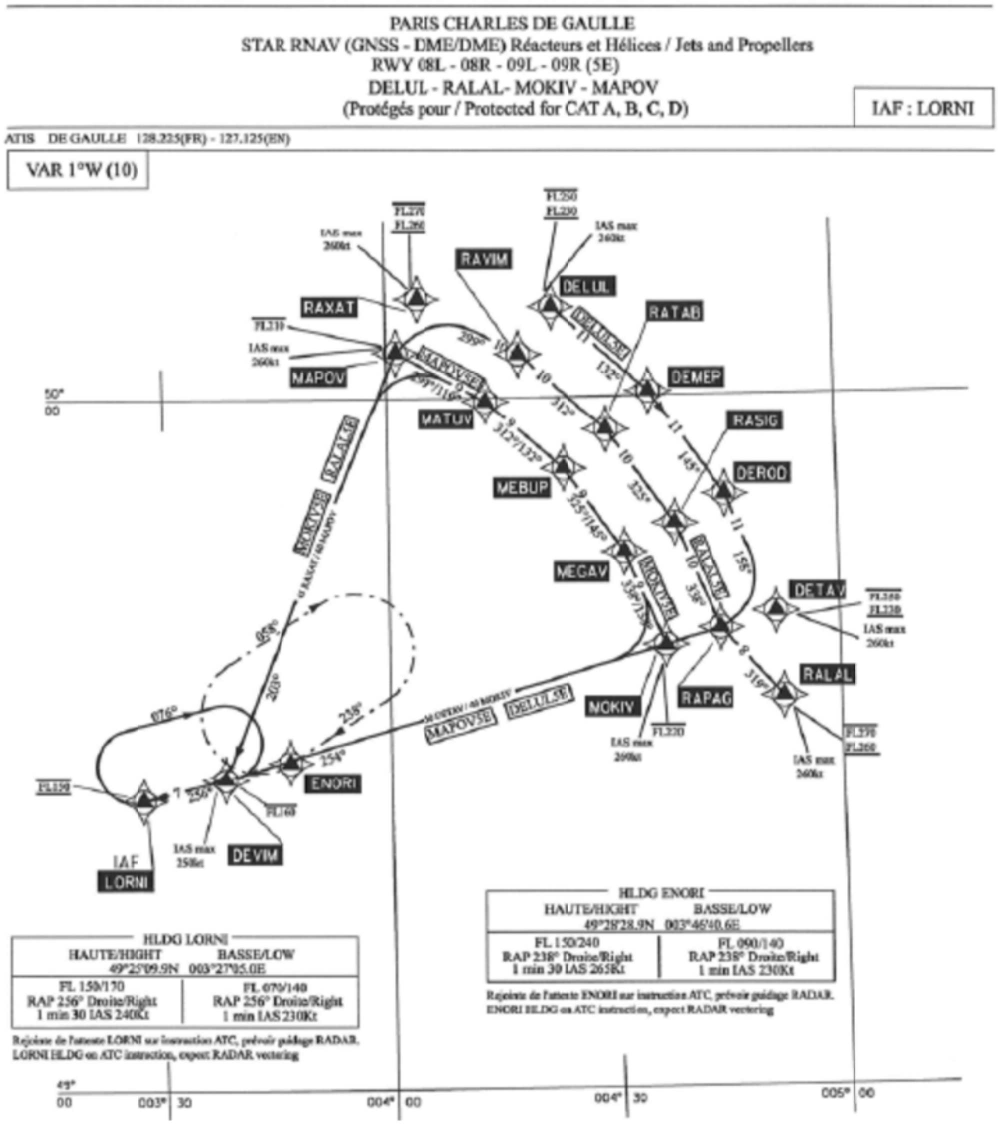


Figure 43: Paris CDG North Western STAR (incl. Point Merge) Procedure facing East

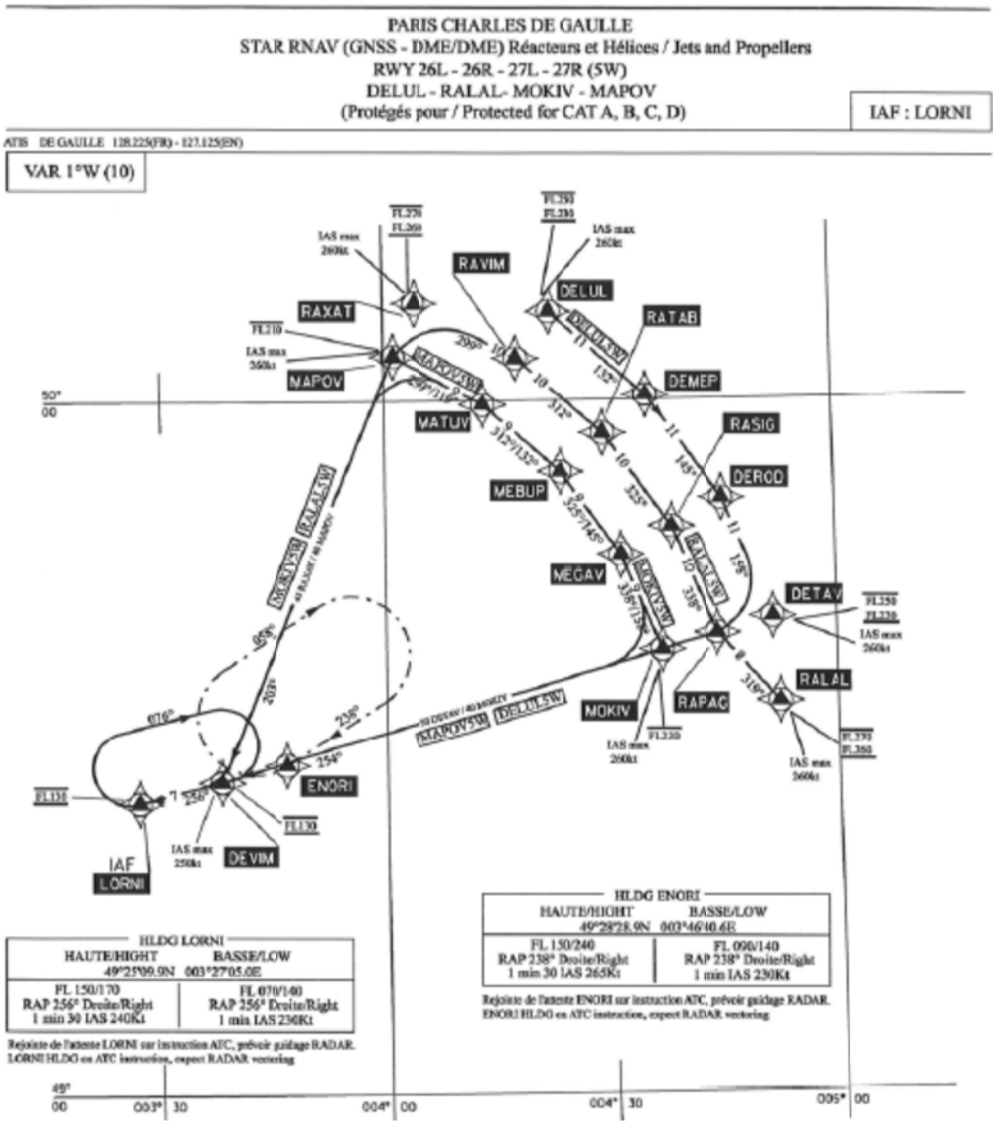


Figure 44: Paris CDG North Western STAR (incl. Point Merge) Procedure facing West

6.2.2 Conduct of Validation Exercise

6.2.2.1 Exercise Preparation

6.2.2.1.1 Preparatory activities

The main preparatory activities carried out by the DSNA and the airlines for the November – December live trials were the same as the one carried out for the June trials. They are described in section 6.1.2.1.1.

The main preparatory activities carried out by Belgocontrol and Maastricht UAC are as follows:

- **Maastricht UAC and Belgocontrol Safety Cases**.
- **Achieving technical & system implementation**
  - *Paris ACC*
  - AMAN configuration adjustment (i.e. maximum delay absorption capability configured in MAESTRO of 2 minutes instead of 5 minutes in APP). *MUAC and Belgocontrol*
    - o Prepare and deliver ATC data (RDPS + FDPS + Other systems)
    - o Control Quality before operational use
- **Questionnaires**
    - o EDYY and EBBU questionnaires.
    - o LFFF and LFPG questionnaires have been adapted to the exercise of the Northeast.

6.2.2.1.2 Operational environment

The platform used for the live trials is described in section 6.1.2.1.2.

The description of the operational environment that follows is extracted from EUROCONTROL report [19] as it corresponds to the one of the live trials.

In the E-TMA (i.e. Paris ACC):

- The Paris terminal sector TP, in the North West was manned by an executive controller assisted by a planning controller. The TP sector has two or three delivery points (Initial Approach Fixes) depending on the runway configuration: MOPAR, MATID in Easterly runway configuration, plus MOBRO in Westerly runway configuration. All arrival aircraft have to be delivered over those waypoints at 250kts (or 280kts at MOPAR), 8 NM spacing (+AMAN constraints) and at specific delivery FLs (see Table 19). TP also handles overflights.
- The Paris terminal sectors TE and overlying "AP" (adjacent to Maastricht airspace) in the North East, were each manned by an executive controller and a planning controller. The TE sector has two delivery points (Initial Approach Fixes): LORNI and VEBEK. All arrival aircraft have to be delivered over those waypoints at 250kts (or 280kts at LORNI), 8NM spacing (+AMAN constraints) and at specific delivery FLs (see Table 19). TE and AP also handle overflights and only AP is concerned by Paris departures.

TP (ACC NW)		TE (ACC NE)	
Easterly	**Westerly**	**Easterly**	**Westerly**
• MOPAR : - PG FL100 - PB/PC/PT FL70 • MATID - OB FL70	• MOPAR : - PG-Jets FL120 - PB/PC/PT FL70 • MOBRO : - PG-Prop./PB FL70 • MATID - OB FL70	• LORNI : - PG FL150 - OB/PC/PT FL80 • VEBEK : - PB/PN/PV/PT FL110	• LORNI : - PG FL130 - OB/PC/PT FL80 • VEBEK : - PB/PN/PV/PT FL110

Table 19: E-TMA NW & NE: delivery FLs over IAFs according to destination airport and runway configuration (from [19])

In the TMA (i.e. Paris CDG), CDG North arrival positions handle LFPG arrivals to the North runway and associated airports (LFPB, LFOB; LFPT and LFPC arrivals from East and South-East). The APP/N positions are:

- SEQ
  - o Sequencing and metering CDG and Le Bourget arrival flights; distributing the arrival traffic on CDG runways (i.e. handling the AMAN to optimise the sequence on the runways).
- COOR-INI
  - o Ensuring the coordination with TP and TE for the arrivals delivery, and between the INI and the ITM.
- INI/N
  - o Receiving traffic from ACC and initiating the arrival sequence to LFPG North runway prior transfer to ITM/N.
  - o Controlling North-Eastern and North-Western arrivals to LFPO/PV/PN prior transfer to Orly APP.
- ITM/N
  - o Finalising the sequence to LFPG North runway prior transfer to the tower.

The "Point Merge" design in the North-East, developed by DSNA and refined/validated through real-time prototyping sessions carried out with the support of EUROCONTROL, was composed of (see Figure 45):

- A "large" Point Merge for the main flow (LFPG arrivals) composed of two main sequencing legs and a secondary one (bidirectional), all centred on the delivery point DEVIM. For delay absorption and flight efficiency considerations, the legs were up to 45NM length (outer leg) and up to FL280 (middle leg). The secondary leg (inner) was for low altitude LFPG arrivals (around 10% of the traffic). The distance between legs was 5nm and located from 40nm (inner) to 50NM (outer) from the Point Merge (DEVIM). Main levels were FL260 via RALAL (spare: FL270/FL280). FL250 via DELUL (spare FL230/FL240). Even FL with FL220 max via MOKIV, odd FL with FL210 max via MAPOV.
- Two specific routes were designed on both sides of the legs for flights with destination Orly, Le Bourget (via VEBEK) and Beauvais (via DEVIM).

The secondary arrival routes were moved outside the main Point Merge in order to segregate the arrival flows. In addition, vertical constraints were added to these routes so that the secondary flow would pass below the main flow (as today).

The routes for overflights remain unchanged compared to the current operational environment (Baseline).

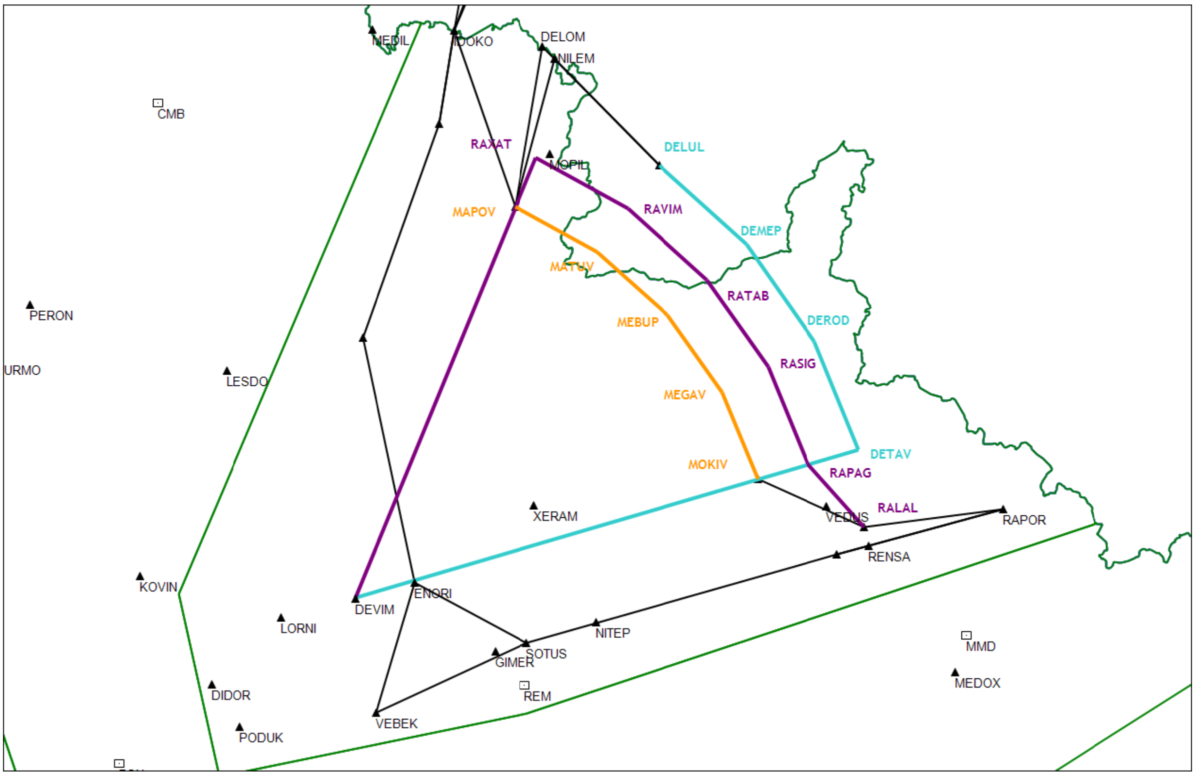


Figure 45: Point Merge in E-TMA APTE sectors (North-East)

For an efficient use of Point Merge, a "functional" split of AP / TE was needed with AP managing the legs and TE the descent to the merge point. More precisely, the proposed task allocation was as follows:

- AP:
    - Build LFPG arrivals sequence (speed reduction, initial descent to reach leg entry and direct to the merge point when spacing reached).
    - Handle other arrivals and overflights above FL195.
    - Handle LFPG departures.

- TE:
    - Maintain LFPG arrival sequence (descent to IAF and speed reduction).
    - Build and maintain secondary arrival sequence towards VEBEK and DEVIM.
    - Handle overflights below FL195.

For that purpose, the lower limit of the AP volume was lowered down to FL195 (compared to FL265 in the current operational environment) in order to keep the sequencing legs within its area of responsibility.

AP and TE were each manned by an executive controller and a planning controller.

The "Point Merge" design in the North-West is described in section 6.1.2.1.2.

Compared to today's situation, two changes have been done to enable the Point Merge introduction in the North East of Paris ACC:

- The transfer levels for the North arrival flow (DELOM/MOPIL) were more constraining ("stable FL250" compared to "descending to FL250") with an impact on Maastricht UAC and Brussels ACC (assessed through Maastricht UAC and Brussels ACC questionnaires. This change in delivery conditions with Brussels ACC and Maastricht UAC was described in Letters of Agreements (*note*: there was no modification of the delivery conditions from APTE to Paris Approach)[5].
- The boundaries of the NE sectors were extended in the AoR of Brussels ACC and MUAC. A temporary Cross Border Working Volume (CBWV) was assigned to Paris ACC. *Remark*: during weekdays, this portion of airspace will conflict with military activity in LF-CBA16B and EB-TRA South. A number of CDRs (also some not penetrating the CBWV) had to be closed in order to (1) ensure a routing for Paris arrivals that is compatible with the Point Merge System and (2) to ensure that other traffic did not infringe with the Point Merge system. As a consequence of this, the flying distance for certain traffic flows was increased (e.g. for traffic via France with destination in the Langen FIR).

One objective of Point Merge in that particular case of that exercise and airspace is to absorb more delay in E-TMA rather than in TMA. The AMAN delay sharing strategy during Point Merge experimentation was different from that in the baseline. The AMAN (MAESTRO) is usually set with an maximum delay absorption capability of 5 minutes in average in APP (i.e. 2-3 min. for base and up to 7 min. for downwind). During the Point Merge experimentation, the AMAN was set with a maximum delay of 2 minutes in APP.

6.2.2.2 Exercise execution

DSNA performed an implementation of the North West and North East Point Merges on four Saturdays in November and December from 05:30 AM to 18:30 PM (UTC) for NE and from 05:30 AM to 14:30 PM (UTC) for NW.

During this trial, Paris ACC applied a sector configuration based only on operational needs: sectors collapsed when traffic was low and split when the traffic was high. This was felt as needed in order to keep the controllers' awareness high. Thus Paris ACC TP sector (NW) was opened either as a standalone sector or grouped with another sector when the traffic load was low. Paris ACC AP and TE sectors (NE) were opened either as standalone sectors or grouped when the traffic load was low.

Except STAR and the fact that the TP sector was opened as a standalone sector, no other system change has been planned; operations remained the same as usual.

As in June live trials, a show room was made available to receive all the external observers or attendees (see section 6.1.2.2 for details on the observers who attended the trial).

Controllers on duty during the sessions and pilots having flown to CDG through Paris TP, or APTE sectors during the sessions were asked to fill in a questionnaire.

Globally, the Live Trial went well. Among the four Saturdays Live Trial, for three of them the runway configuration was facing West with a level rather low traffic due to meteorological conditions; for one of them (24th Nov), the runway configuration was facing East and there were no ATFCM restrictions.

A feedback per each Saturday is provided below.

[5] The modified transfer conditions between MUAC and Paris ACC are as follows: at FL250 over NILEM, or, after coordination, at FL260 over NILEM (instead of transfer further downstream, over MOPIL, descending from FL310 to FL250, FL260 or, after coordination, to FL270).
The modified transfer conditions between Brussels ACC and Paris ACC are as follows: TBD

Saturday 17th November 2012

General situation

The weather in Paris was foggy for most of the day, with poor visibility at Paris airports. As it is the case under such weather conditions, CFMU regulations were in place for inbounds Paris CDG. The airport was regulated at 44 flights per hour instead of 60 under normal conditions, in the morning the demand was at 77. As a result, the traffic load on TP and APTE sectors remained very low during most of the day. The wind was 210/40kts at FL200, meaning that flights on the RALAL STAR had tailwind. No technical problem was identified, and only a few aircraft were not able to follow the specific STARs.

The Point Merge STARs were seldom used until 16:15 UTC. Only a few flights were delayed on the sequencing legs, for example to group Heavy aircraft together on the runway. 7 flights destination CDG arrived in the North-East APTE sectors between 16:24 and 16:37 UTC. This was the very first opportunity to use the STARs to sequence the arrival traffic.

Very first feedback

BELGOCONTROL

Very few traffic but a lot of phone communication. In addition, Belgocontrol mentioned that the start of live trial has not been verbally coordinated. Belgocontrol would like traffic on standard procedure to test automatic system coordination (ACT message): no direct route to check and no right turn after IDOKO. Advise airliners to flight going to Beauvais to fly via CIV-CMB instead IDOKO.

MUAC

No difficulties but traffic loads were too low to assess the effects of the concept under busier (summer) conditions. There was not enough overall traffic to assess (1) the feasibility to achieve the more stringent transfer constraints and (2) the impact on other streams in the MUAC AoR (West and Eastbound flows).

PARIS ACC

No technical issues. There were some couple of non-correct FPL and some few aircraft with no updated STAR set in the FMS. Paris ACC sent email to remind the procedures to be used during live trials.

PARIS ACC ATCO

Only few ATCOs had the opportunity to make use of the STARs. They all were very positive about the new system. They felt that building the sequence was safer and more efficient. Without being a goal, spontaneously, some controllers grouped traffic by wake turbulence.

Saturday 24th November 2012

General situation

Wind was calm and the landings facing to the East all day long. A wind component W in altitude could explain that some arrivals were a little bit higher than expected over MOPAR, the northwest IAF.
The initial CFMU restriction on south landing runway was cancelled at 06h30 and there was no CFMU restriction at all during all day.
In addition, it was decided to group heavy aircraft together and thus two A380 were positioned in AMAN to land on the same runway, one behind the other.
Finally, no incidents were reported.
In conclusion, the work carried out during this live trial could be taken into account for comparison with a standard day.

Very first ever feedback

BELGOCONTROL

Some directs were refused to Paris ACC because Belgocontrol was willing to test their system, especially the sending of the ACT message.

MUAC

Okay to continue. Something needed to be clarified regarding LFOB arrivals. It was not clear how to handle the flights (transferred to Belgocontrol or not). Traffic in MUAC was not sufficient to judge but MUAC considered that the constraint over NILEM could be a problem with a higher workload.

Air France

No difficulty to manage the FPL. It was too early to be provided with pilots' feedback.

Saturday 1st December 2012

General situation

No problem came up.
Runway configuration was facing West.
Usual ATFCM restrictions (44A/H) were in place in the morning to respond to LVP situation. Late in the afternoon, there was a small peak of traffic localised only in the north-east, just enough for a local experiment on coordination between ACC and APP.
Besides, NOTAM have been sent to prevent the reoccurrence of some flight plan problems but it did not work.

Very first feedback

BELGOCONTROL

Traffic was light or too light to appreciate possible issue. Phone coordination to request direct routing from Belgium airspace seemed to be more numerous than usual. Some controllers did not fill the questionnaire provided as they felt that the traffic was not significant to judge the impact of the system.

MUAC

No problems in the conduct of the trial. Traffic was again considered too low to make conclusions that remain valid in more busy periods throughout the year.

Air France

No feedback from pilots at the time. Flight plan staff workload was correct and no major problems came up.

PARIS CDG

No difficulties.

PARIS ACC

No difficulty encountered on Paris ACC side. Because of the ATFCM limitations in place at CDG in the morning, only few aircraft were delayed on the sequencing legs. The afternoon peak of traffic was handled using the legs for some of the traffic to CDG.

Saturday 8th December 2012

General situation

Runway configuration was facing West.
Initially a situation with 74 arrivals aircraft an hour divided between North and South. A regulation was in place for traffic coming from the south, but no regulation was in place for flights with destination CDG impacted by the trial. Nevertheless, due to icing conditions on numerous airfields located in Northern Europe and reorganisation of traffic following the snow conditions the previous day, some flights have been cancelled. In 69 flights landed at the peak hour, with very few of them that had to be sequenced on the Point Merge systems.
The 11 o'clock hub was interesting for both north-west and north-east sectors.

From pilots who assisted to live trails and controllers, it seems that an adequate phraseology would clarify understandings of chain actors. A phraseology compatible with the current one should be defined to improve the service provided. All the actors participating to the arrival flights management should understand each other without any risk of lack of understanding or confusion.

6.2.2.2.1 Choice of Baseline

To analyse flight efficiency, Paris ACC controllers have established a baseline by choosing days with comparable traffic during peak traffic in terms of:

- Between 07:40 AM and 08:20 AM, the number of:
  - flights through TP (North-West part)
  - flights through TE (North-East part)
  - flights through TP+TE
  - arrivals in LFPG
- The maximum number during one hour of:
  - arrivals in LFPG
  - arrivals in North runway
- Runway configuration
- Regulation

The table below shows the Point Merge days and Baseline days chosen to analyse and compare flight efficiency.

Point Merge days	Baseline days
Saturday 17th November	Tuesday 20th November
Saturday 24th November	Wednesday 28th November
Saturday 1st December	Monday 12th November
Saturday 8th December	Monday 3rd December

Table 20: Baseline and Point Merge days for flight efficiency analysis

The table below shows the different values which permitted to choose Baseline days:

Day	RWY Configuration	Regulation	07:20 to 08:40				Arrivals maximum in one hour	
			TP	TE	TP+TE	LFPG	North RWY	All RWY
17/11/2012	Westerly	LFPGARR1=44	18	17	35	61	27	52
20/11/2012	Westerly	LFPGARR1 0730-0900=48	17	18	35	69	25	54
24/11/2012	Easterly		20	17	37	84	37	72
28/11/2012	Easterly		15	16	31	81	34	71
01/12/2012	Westerly		21	16	37	67	27	52
12/11/2012	Westerly		19	20	39	68	28	54
08/12/2012	Westerly	LFPGARS 0720-0840=56	19	21	40	81	33	69
03/12/2012	Westerly	LFPGARR1 0700-0820=60	20	21	41	83	32	69

Table 21: Actual traffic for Baseline and Point Merge days

Figure 46 and Figure 47 below shows the head wind strength for LFPG arrivals in sector TE and in sector TP. Each Point Merge day is compared with its chosen Baseline day. Even if the traffic is corresponding (more or less) between Point Merge days and there Baseline days, those figures show that wind condition was not exactly the same. Wind had an impact on flight efficiency. There are too many parameters to take into consideration to obtain a perfect Baseline day for each Point Merge days, i.e. same entering traffic in ACC, same weather, same wind, same transit traffic, etc… Wind condition has not been a parameter taken into consideration for the choice of the Baseline, but it will be used in the flight efficiency analysis.

Some differences between Point Merge day and its corresponding Baseline days can be observed. For instance:

- for sector TE, head wind of 17/11/2012 is 25 knots stronger than 20/11/2012
- for sector TE, head wind of 08/12/2012 was a strong back wind (30 knots) and head wind of 03/12/2012 was quite low (5 knots)
- for sector TP, back wind of 24/11/2012 was 20 knots stronger than back wind of 28/11/2012
- for sector TP, back wind of 01/12/2012 was 20 knots stronger than back wind of 12/11/2012.

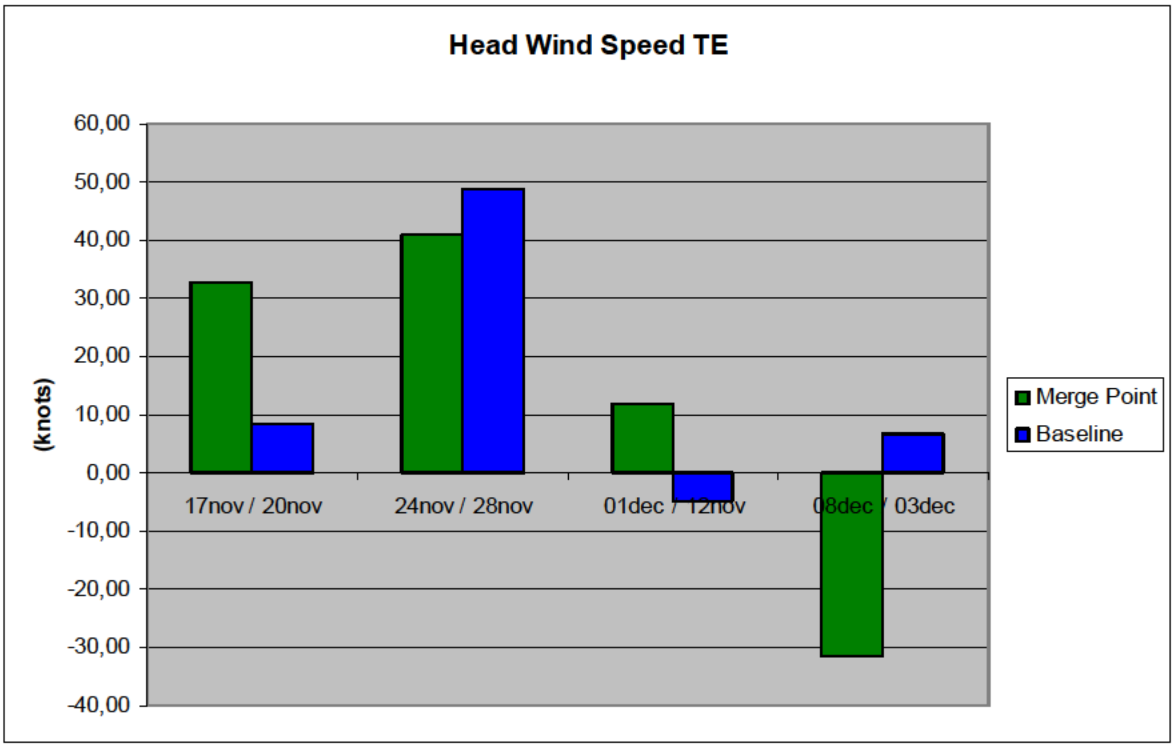


Figure 46: Head Wind for LFPG arrivals in sector TE during peak traffic

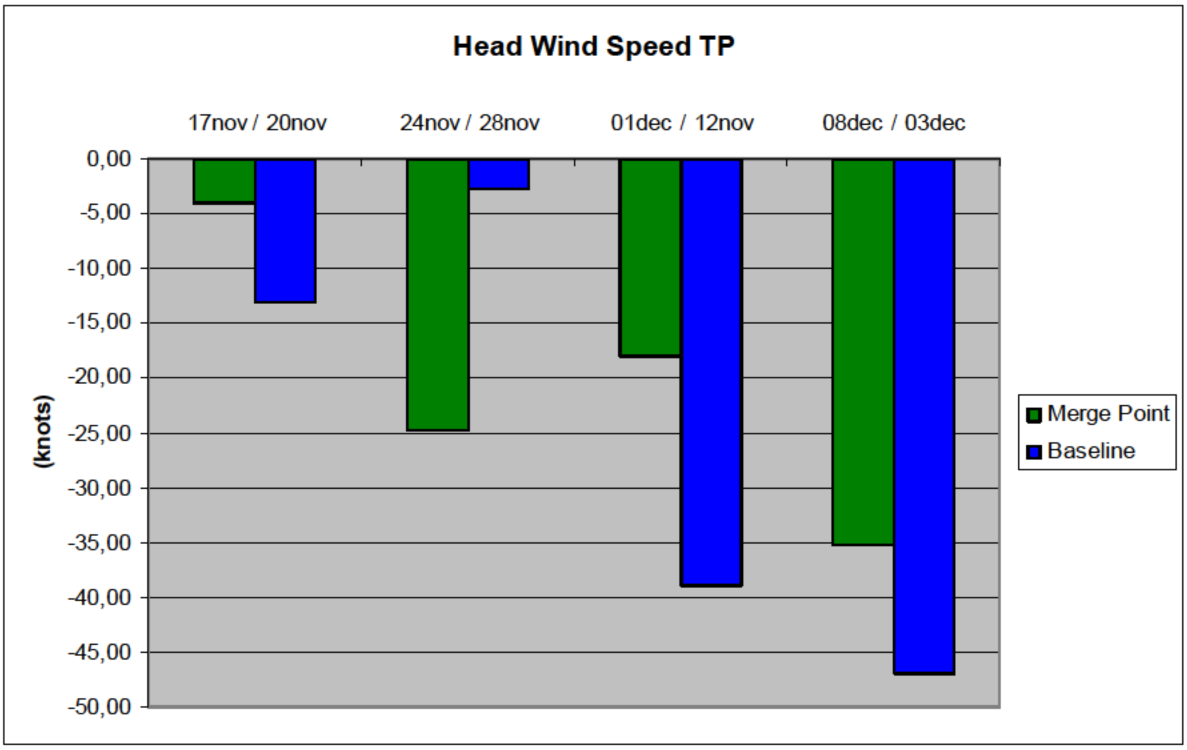


Figure 47: Head Wind for LFPG arrivals in sector TP during peak traffic

To analyse controllers' activity, Saturdays before and after the Point Merge experimentations were used. The LFPG runway configuration is considered as having no impact. We do not compare each day of Point Merge day with a Baseline day, whole Point Merge days are compared with whole Baseline days.

Baseline days	Point Merge days
Saturday 27th October	Saturday 17th November
Saturday 3rd November	Saturday 24th November
Saturday 10th November	Saturday 1st December
Saturday 15th December	Saturday 8th December

Table 22: Baseline and Point Merge days for controller's activity analysis

6.2.2.2.2 Data collection

Data were collected just after the Point Merge experimentation:

- questionnaires filled in by pilots and controllers,
- processing of radar data (RDPS) of Paris ACC for Baseline days and Point Merge days (trajectories are beginning before legs of Point Merge and ending on LFPG runways),
- recordings of the frequency of the TP, AP and TE sectors (Saturdays of Point Merge and some Saturdays before and after),
- logs of phone communications of Paris ACC,
- recordings from AMAN,
- wind conditions,
- recordings of sector configurations in ACC (from COURAGE system),
- Flight Data recording (time, localisation, altitude, wind direction/speed, Fuel Flow per engine, ground speed, calibrated airspeed, A/C weight…).

6.2.2.2.3 Hours for analysis

Point Merge Trials were performed from 05:30 AM to 18:30 AM (UTC) for NE and from 05:30 to 14:30 (UTC) for NW. But the most interesting for analysis happened during peak traffic which was from 06:45 AM to 08:45 AM (UTC).

6.2.2.3 Deviation from the planned activities

Deviation with respect to the Validation Plan

- Measures of aircraft speeds and FL over IAF were not performed because:
  - Speed contained in radar trajectories is ground speed (which depends on wind conditions). Aircraft speed over IAF would have been interesting in case of indicated air speed (IAS).
- Measures (number, duration and FL) of level off segment were not performed.
- Measures were not performed for those criteria:
  - CRT-05.06.07-VALP-0427.0230 Pilots most often obtained a direct to the Merge Point before entering the STAR.
  - CRT-05.06.07-VALP-0427.0240 Controllers most often proposed the pilots to "descend at discretion" at the exit of the leg toward the Merge Point
  - CRT-05.06.07-VALP-0427.0620 Fuel burn equal or better than in Baseline

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

6.2.3.1.1 Results on concept clarification

Results on concept clarification are presented in section 4.1.1.

6.2.3.1.2 Results per KPA

The main results per KPA that were addressed by EXE-05.06.07-VP-427 are summarized in the table below:

KPAs	Validation Objective ID	Validation Objective	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
Capacity	**OBJ-05.06.07-VALP-0427.0100**	Controller workload assessment	**CRT-05.06.07-VALP-0427.0100**	Average answer to perceived workload question is that PMS reduces workload	A majority of the participating E-TMA controllers stated that the workload was unchanged to lower. A majority of the participating TMA controllers stated that the workload was unchanged (i.e. no impact of the Point Merge on workload).	**OK**
	OBJ-05.06.07-VALP-0427.0100	Controller workload assessment	**CRT-05.06.07-VALP-0427.0110**	Frequency usage reduced.	Frequency occupancy in APTE sector is lower during the Point Merge days.	**OK**
Predictability	**OBJ-05.06.07-VALP-0427.0200**	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0200**	Better compliance with initial AMAN sequenced time than in baseline	The respect of the initial AMAN sequenced time is equivalent to other days in November and December 2012	**OK**
	OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0210**	Number of open loops / holdings lower than in baseline	Most of the E-TMA controllers stated that they did not have to issue heading clearances due to the Point Merge.	**OK**
	OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	**CRT-05.06.07-VALP-0427.0220**	Number of level segments lower than in baseline	Most of the E-TMA controllers stated that they did not have to issue and monitor intermediary levels due to the Point	**OK**

KPAs	Validation Objective ID	Validation Objective	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
					Merge.	
Efficiency	**OBJ-05.06.07-VALP-0427.0300**	Metering efficiency assessment	**CRT-05.06.07-VALP-0427.0300**	More delay absorbed on the legs rather than in TMA and rather than in vectoring in E-TMA.	Delay in ACC is mainly absorbed on the legs rather than in vectoring whereas in Baseline all delay in ACC is absorbed in vectoring	**OK**
	OBJ-05.06.07-VALP-0427.0400	IAF delivery conditions assessment	**CRT-05.06.07-VALP-0427.0400**	Aircraft separations and speeds over IAF equal or better than in baseline	Aircraft spacing over delivery points during peak traffic are similar to Baseline	**OK**
	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	**CRT-05.06.07-VALP-0427.0600**	Flight duration equal or better than in baseline	Flight duration in ACC+APP is equivalent to other days	**OK**
	OBJ-05.06.07-VALP-0427.0600	Flight efficiency assessment	**CRT-05.06.07-VALP-0427.0610**	Flight distance might be longer than in baseline because aircraft are holding at higher altitude	Flight distance in ACC+APP is equivalent to other days	**OK**
Safety	**OBJ-05.06.07-VALP-0427.0500**	Safety assessment	**CRT-05.06.07-VALP-0427.0500**	Level of safety felt by controllers equal or better than in baseline	All the participating E-TMA and TMA and TMA controllers stated that the level of safety was higher than in baseline or at least the same.	**OK**
	OBJ-05.06.07-VALP-0427.0500	Safety assessment	**CRT-05.06.07-VALP-0427.0510**	Controllers average answer to situation awareness question is that situation awareness is better than in baseline	E-TMA controllers considered that they had a better situational awareness with the Point Merge than without. All the participating TMA controllers reported a better situation awareness with Point Merge or at least equal.	**OK**
	OBJ-05.06.07-VALP-0427.0500	Safety assessment	**CRT-05.06.07-VALP-0427.0520**	Pilots' general impression on the PMS procedure about radio communications, simplicity of the procedure, and clarity of the	Pilots' general impression on the Point Merge procedure about radio communications, simplicity of the	**OK**

KPAs	Validation Objective ID	Validation Objective	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
				phraseology is globally positive.	procedure, and clarity of the phraseology was globally positive.	

Table 23: DSNA EXE-05.06.07-VP-427 - Results per KPA

6.2.3.1.3 Results impacting regulation and standardisation initiatives

Results impacting regulation are presented in section 4.1.3.

6.2.3.2 Analysis of Exercise Results

The performance indicators measured during EXE-05.06.07-VP-427 in November – December Live Trials are the same as the ones in June Live Trials (see section 6.1.3.2).

Regarding the number of answers per question in the controllers' questionnaires:

In Paris ACC: each controller filled a questionnaire after each day of trial s/he was participating at.

- In the North-East: 38 controllers out of 40 filled the questionnaire on APTE sector.
- In the North-West: 15 controllers out of 16 filled the questionnaire on TP sector.

In Paris CDG: One questionnaire was filled by a Point Merge expert who was in charge of debriefing 3 controllers (SEQ, COOR and INI) after each peak of traffic. Out of the 80 controllers who participated to the trial, 40 answered the questions of the questionnaire (15 questionnaires x 3 controllers = 45 controllers having answered the questions, except that on some hours the SEQ position was manned by the COOR, which makes 40).

Regarding the number of answers per question in the pilots' questionnaires:

- 29 Air France pilots' answered the questionnaire.
- 8 Regional pilots provided a feedback.

Note: In the figures presented in the following sections, the number of answers to the questions is sometimes different. This is due to the fact that the controllers and the pilots did not always answer all the questions.

The following sections provide with a general analysis of EXE-05.06.07-VP-427 results.

6.2.3.2.1 Operability in ACC

6.2.3.2.1.1 General Feedback

As illustrated in Figure 48 to Figure 51, the feedback from Paris ACC controllers was very positive and consistent with June live trials. Regarding the level of difficulty of the Point Merge + AMAN procedure to manage the overall traffic (to LFPG, overflights and peripheral flights), and to perform the coordination was rated in majority as unchanged to clearly easier in the North West as well as in the North East (see Figure 48 and Figure 49).

The controllers reported more flexibility to change the sequence order, typically to accommodate requests from the Approach. The coordination with LFPG regarding the sequence order and the spacing (to leave room to insert flights from other entry points) was facilitated as the Point Merge system allows to easily create any order. If the flights had to lose time (for example because of LVP conditions in CDG), it was easy for the E-TMA controllers to let the flights on the legs and to make them turn (i.e. leave) when there was no more time to absorb. TE PLN controller had more time than today to coordinate each aircraft speed in order to optimise the sequence. The reduction in frequency load (notably in case of high traffic load) allowed focusing on the coordination with the Approach and to try and build a sequence perfectly suited to CDG.

The Point Merge combined with the AMAN allowed a better respect of the arrival time and a better respect of the delivery conditions notably in terms of level constraints. The AMAN was used to decide of the moment to make the aircraft leave the legs.

The Point Merge combined with the AMAN improved flight profiles as the number of level offs were reduced to one (the one on the leg). It also improved the quality of the sequence (precision, spacing) thanks to a better adherence to AMAN delay.

Regarding the management of the RAPOR-GIMER take-offs (i.e. mainly climbing traffic departing from Germany and Luxemburg), today it represents a difficulty as these flights are in potential conflict with the arrivals. Today, the E-TMA controllers have to ask Maastricht ACC controllers to give a heading to the arrivals in their sector in order to prevent the conflict. With the Point Merge, the E-TMA controllers can themselves act on the arrivals by giving them a direct to one of the legs' waypoint, thus avoiding the take-off routes. In case speed reduction or use of multiple levels on leg are not sufficient to cope with simultaneous arrival of excessive number of aircraft to leg entry, the E-TMA controllers might instruct one or several inbound aircraft direct to a waypoint of the leg other than the entry point or decide to temporarily use the level dedicated to the adjacent leg, provided that level is not occupied (cf. [3]).

The management of the peripheral flights, which are transits that are slow to climb and thus can be in potential conflict with the arrivals, is considered as unchanged compared to today. No comment was provided that could explain the orange ratings visible in Figure 48 (2 'Rather more difficult" answers).

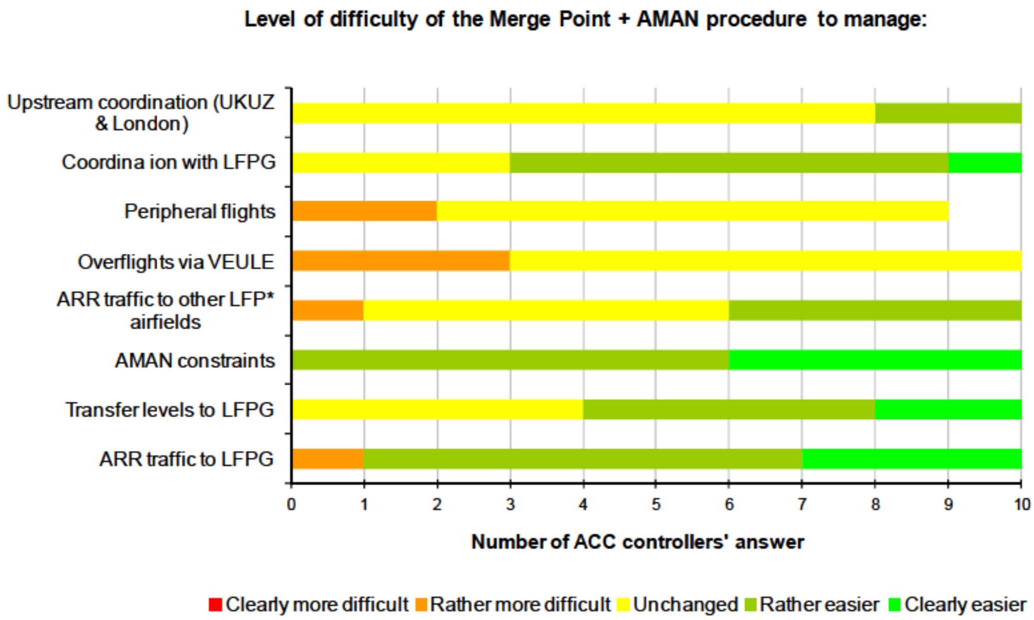


Figure 48: ACC controllers' rating regarding the level of difficulty of the Point Merge + AMAN procedure in the North West

Note: The orange rating related to the sequencing of ARR traffic to LFPG visible in Figure 48 (1 “Rather more difficult” answer) was explained by the difficulty to perform a precise sequencing of 8NM during the trial. The sharp turns from the legs to the Merge Point needs some time to get used to. However, the controllers believe that after sufficient practice, the system can provide higher precision than current vectoring method. Concerning the orange rating related to the ARR traffic to other LFP* airfields (“1 Rather more difficult” answer), the controller explained having had more difficulties to deal with LFOB arrivals when focused on continuous descent inside the cone of the Point Merge system. No comment was provided that could explain the orange ratings about the management of the overflights (3 “Rather more difficult” answers).

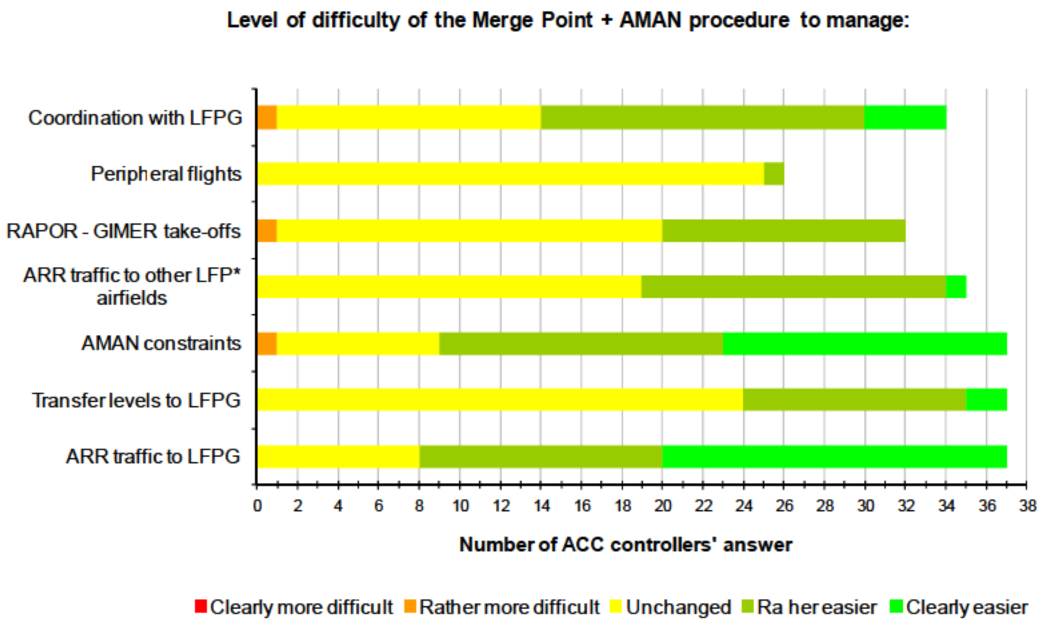


Figure 49: ACC controllers' rating regarding the level of difficulty of the Point Merge + AMAN procedure in the North East

Note: The orange rating regarding the RAPOR-GIMER take-offs (1 “Rather more difficult” answer) was related to a case of a take-off having caught up a LFPG arrival. The controller had to give a heading to solve the problem.

The orange rating in Figure 49 regarding the AMAN constraints (1 “Rather more difficult” answer) was due to the fact that during the session, the AMAN was not updated soon enough (before the aircraft left the legs), which caused the opening of a holding at LOR II. The orange rating regarding coordination with LFPG (1 “Rather more difficult” answer) was explained by the fact that on the AP sector, there was no direct communication with CDG sequence manager; when a change in the AMAN was requested the AP controller had to communicate the information to TE controller who would transmit it to CDG, which took too long.

According to the majority of the participating ACC controllers, the safety was either improved or at least as safe as today. The aircraft were strategically separated on the legs, which made the traffic less conflicting. The controllers reported that the Point Merge STARs, naturally separating the traffic, provided margin to manage the traffic and potential unusual situations. Once stabilized on the legs, the aircraft in sequencing are no longer conflicting whereas with the headings, the controller has to constantly monitor them.

The controllers found that the Point Merge system provided more flexibility and saved mental resources (e.g. fewer messages to give) which could be redeployed to optimise the sequencing and the conflict resolutions. Once the levels given the aircraft, which are stable on the legs, the controller has time for other tasks and does not only focus on the sequencing. S/He has more time to monitor the whole traffic.

In TP sector, the controllers found that the Point Merge STARs on TP were adapted to the current traffic in TP sector and facilitated the work.

In APT E sectors, some controllers found that the system made it easier to adjust the sequence depending on the delivery conditions from the preceding sectors..

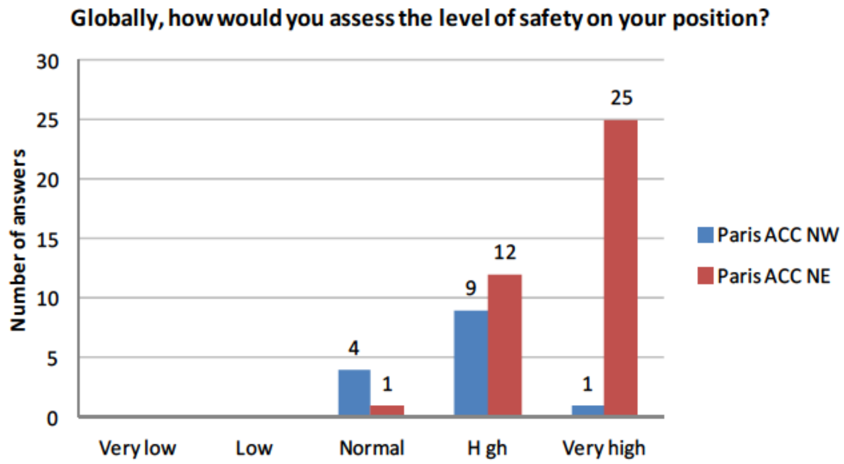


Figure 50: ACC controllers' ratings regarding safety on their control position

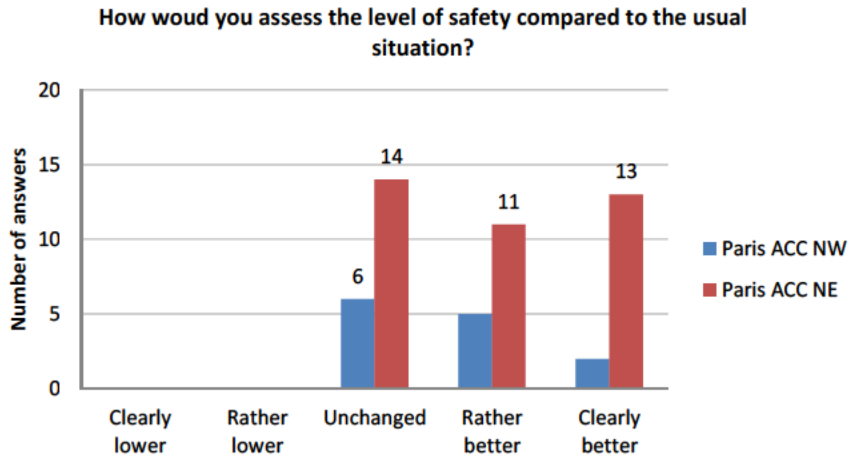


Figure 51: ACC controllers' ratings regarding safety compared to today's situation

On APT E sectors (i.e. in the North East), regarding the DELUL leg which is the leg close to the sector's entry, and the associated space which protects the leg, all the controllers answered they seemed adapted (leg not too far and space sufficient).

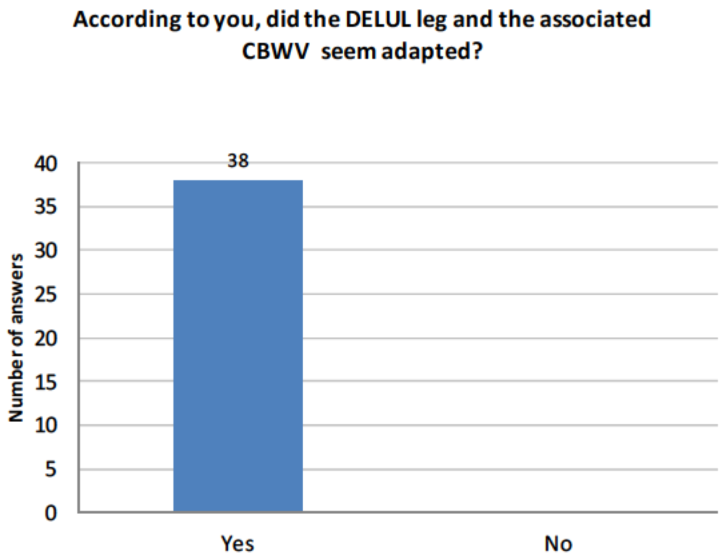


Figure 52: ACC controllers' ratings regarding the adaptation of DELUL leg and the associated CBWV

All the controllers, except one, reported that the handover procedure at FL250 of the arrivals via NILEM seemed relevant to manage the flights on DELUL legs. Controllers felt that the procedure FL250 at NILEM as defined in the LoA was adequate to provide early vertical separation with traffic FL260+ flying the opposite leg. However, they noticed that several times the traffic was delivered at a higher level than planned, resulting in extra workload for the controllers (need to adapt the sequence accordingly in some cases). Today, the arrivals are delivered via MOPIL below FL310 in the descent to FL250 or FL260 (and even FL270 can be used after coordination). With the Point Merge procedure, the arrivals had to be delivered stable at FL250 over NILEM (which is situated 9 NM to the North of MOPIL). This results in a transfer from MUAC to Paris ACC which had to be done much earlier and which was more constraining for Maastricht ACC controllers than today. The location of the N-E Point Merge system protection area, together with the lower profile constraint required by the Point Merge System procedure for traffic from the North, had an impact on major en-route European flows to/from UK and from further west (traffic on ATS routes UL607 and UL608/UL610). This network impact of the N-E PMS would inevitably be aggravated if the system would be applied during summer and/or weekday traffic loads.

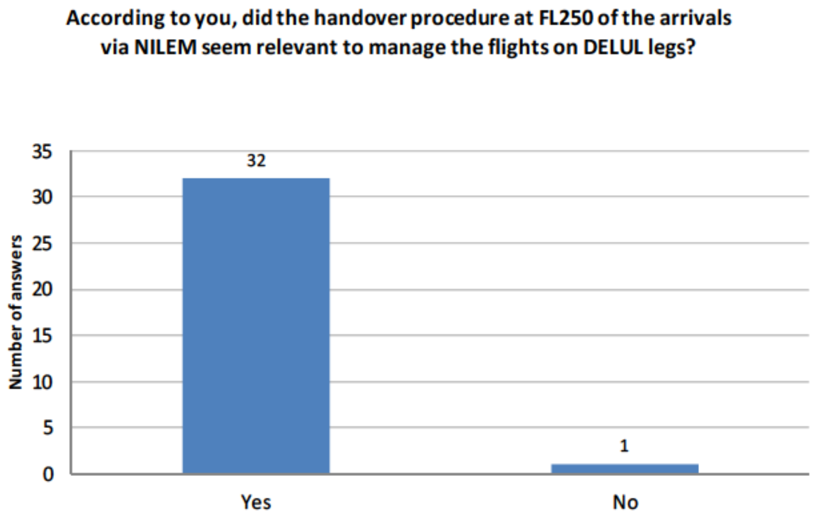


Figure 53: ACC controllers' ratings regarding the relevance of the handover procedure via NILEM

Note: The negative answer in Figure 53 is explained by the controller by the fact that if delivered too late, the aircraft take the leg before the Paris ACC controller can give any instructions.

The controllers reported a better and efficient balance of tasks allocation between AP and TE compared to the current situation (baseline). Today, under standard conditions, flights via REPOR are transferred from MUAC to AP sector, while MOPIL inbounds are transferred directly to TE sector. Because the sequence is built by TE by giving radar headings, an initial descent and possibly a speed reduction and an initial heading is issued by AP to the arrival flights before transferring them to TE so that all the arrivals are handled by one sector (for safety reasons, in order to issue descent and heading clearances according to the rest of the traffic). With the Point Merge organisation, all the flights above FL195 (95% of the traffic) are transferred from MUAC / Belgocontrol to AP (even the MOPIL flow). The workload thus is split between AP and TE, with AP building the sequence (descent towards leg's FL, giving speed reductions and then directs to DEVIM) before transferring the flights to TE. TE then descends the traffic according to the other flows to the level required at the IAF.

This tasks allocation between AP and TE enables continuous descents for LFPG arrival (no level off from leaving the legs down to the merge point) as it is easier (yet not systematic) for TE to directly give the descent towards the flight level to the IAF without intermediary constraint.

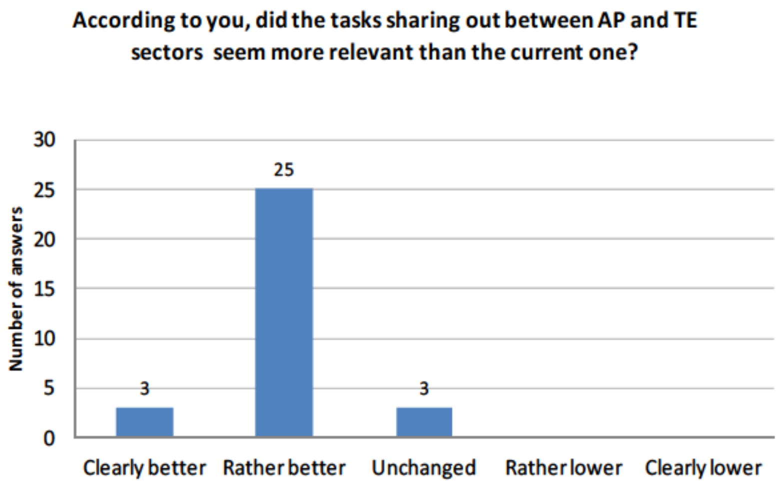


Figure 54: ACC controllers' ratings regarding the relevance of the task sharing between AP and TE

Note: Among the three "Unchanged" answers, two were not explained; one stated that the workload was increased on AP with the management of the departures and of the ELLY arrivals.

6.2.3.2.1.2 Controller's Activity

6.2.3.2.1.2.1 North-East Point Merge

The frequency occupancy is calculated over 5 minute ranges every 5 minutes when the AP and TE sectors are grouped together as APTE.

As the traffic is not exactly the same in Baseline and during Point Merge, we analysed the frequency occupancy with the number of flights in. This number of flights is an instantaneous number of flights in APTE, calculated in the middle of the 5 minute ranges during which the frequency occupancy is calculated. To know if a flight is in APTE or not, we analysed the trajectory in the radar recordings and calculated when the flight entered and exited APTE (geographically).

The analysis of the frequency occupancy shows that:

- During low traffic, the frequency load was equivalent in Point Merge and in Baseline;
- During medium and high traffic, the frequency was less loaded with Point Merge than in Baseline.

In conclusion, the frequency load is equal or lower with Point Merge than in Baseline.

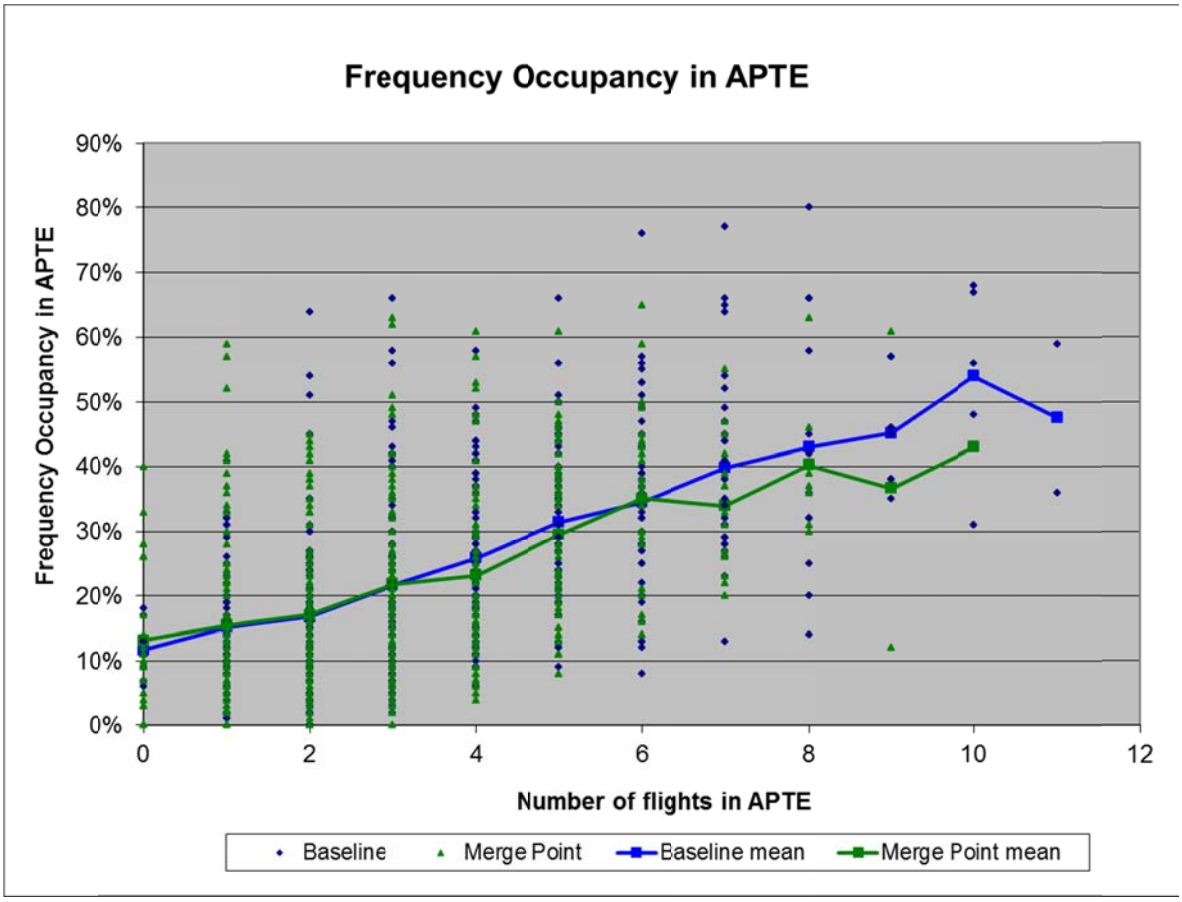


Figure 55: Frequency occupancy in APTE

For further analysis, we focused on flights with delays to see if with Point Merge the frequency load was clearly lower than in Baseline.

To detect delays, we calculated the distance flown in ACC (from 100NM of LFPG to 50NM of LFPG) of flights arriving in LFPG. We defined an indicator called “trajectory extension” as the percentage of extension of the distance flown in ACC. For example, if the distance flown in ACC is 55NM, the trajectory extension is (55-50)/50 %.

Every 5 minutes, we considered flights in APTE and selected the frequency occupancy when the mean of trajectory extension of flights in APTE at this time was above 10%.

The analysis of the frequency occupancy when trajectory extension was above 10% shows the same thing as previously when we considered all the values. The frequency load was equivalent or lower in Point Merge than in Baseline.

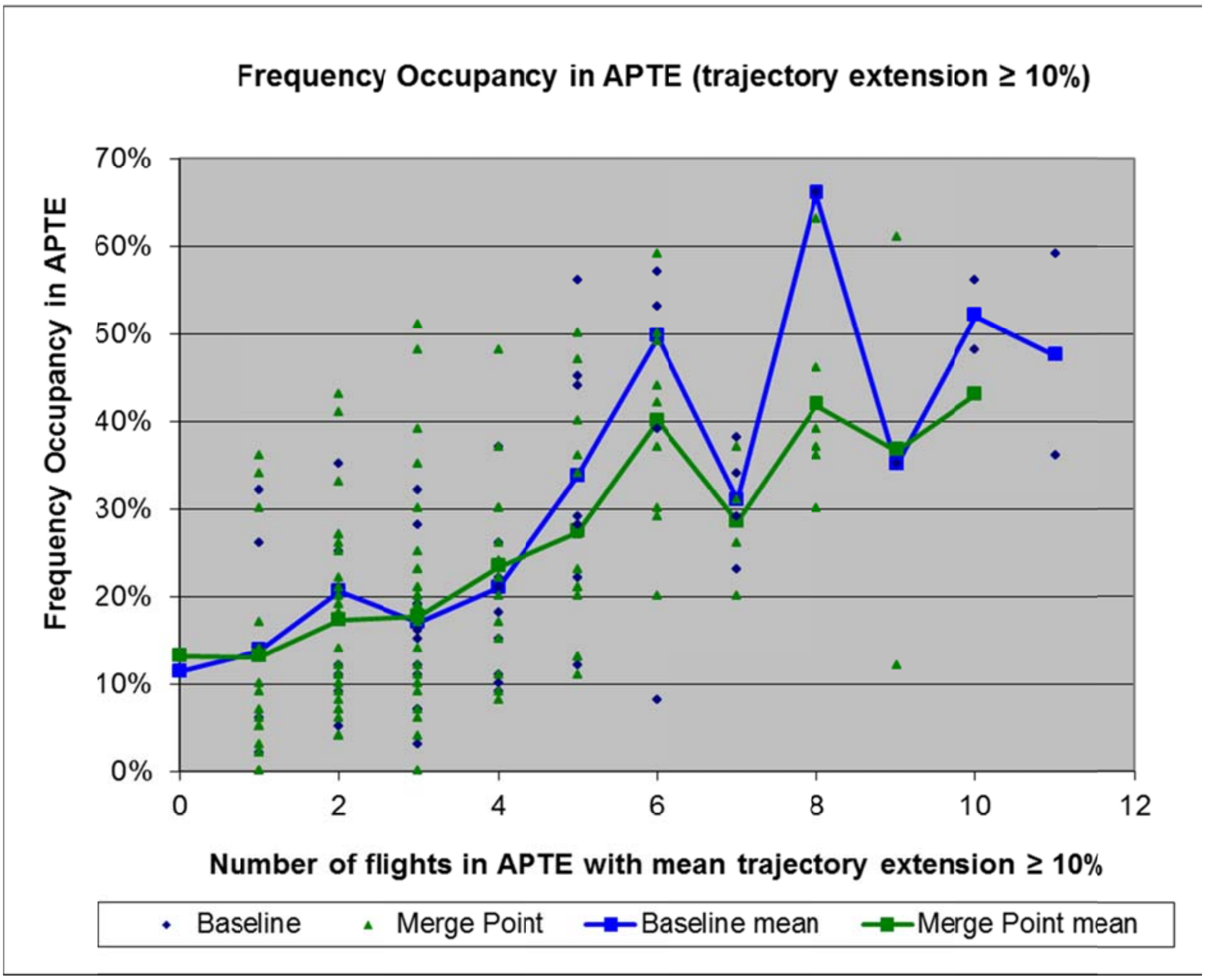


Figure 56: Frequency occupancy in APTE with trajectory extension above 10%

We analysed the frequency occupancy depending on the mean trajectory extension of flights in APTE every 5 minutes. We grouped trajectory extension as follow: 0%-5%, 5%-10%, 10%-15% …

As previously, the figure shows that the frequency load is equivalent or lower in Point Merge as in Baseline.

In the figure below, vertical black lines represent confidence intervals.

It is very interesting to notice that most of the time and especially when frequency load is lower for Point Merge, the mean frequency occupancy is outside of the confidence interval of the other data (Baseline or Point Merge). This shows that we have enough data to conclude that frequency load is lower with Point Merge.

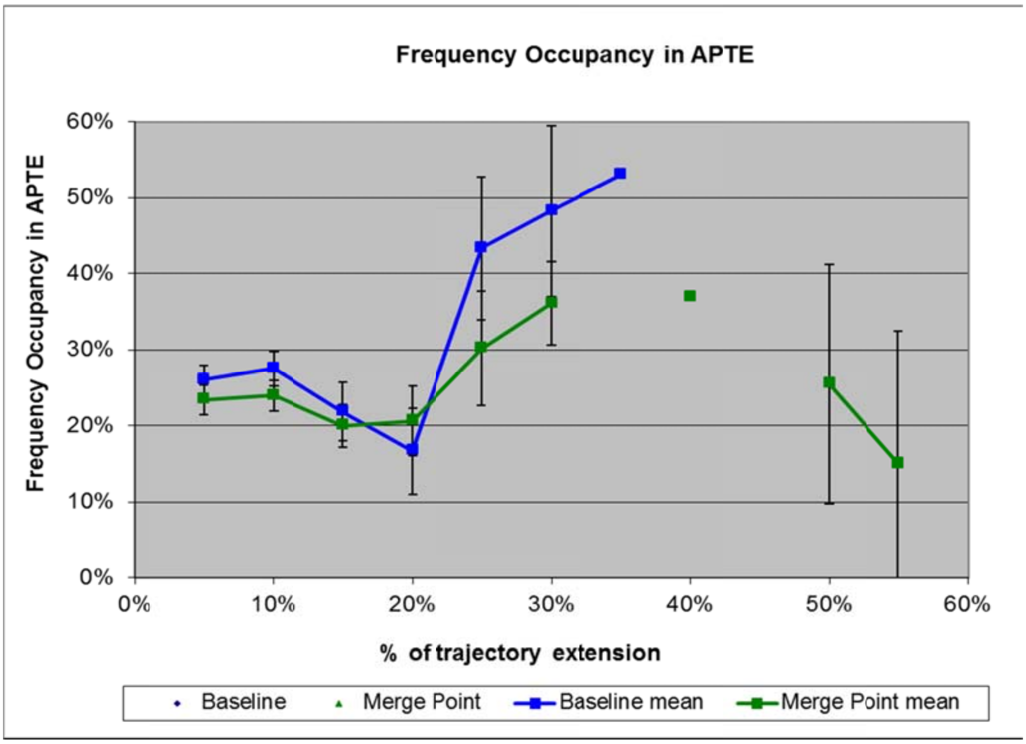


Figure 57: Frequency occupancy in APTE depending on trajectory extension

The scatter plot below confirms this analysis. The difference with the previous scatter plot is that the number of flights is not an instantaneous number. This is the number of flights in APTE weighted with the time spent in APTE during the 5 minute range during which the frequency occupancy is calculated.

The linear regression shows that frequency occupancy is equivalent with little traffic in Baseline and in Point Merge, but with higher traffic, the frequency occupancy is lower in case of Point Merge.

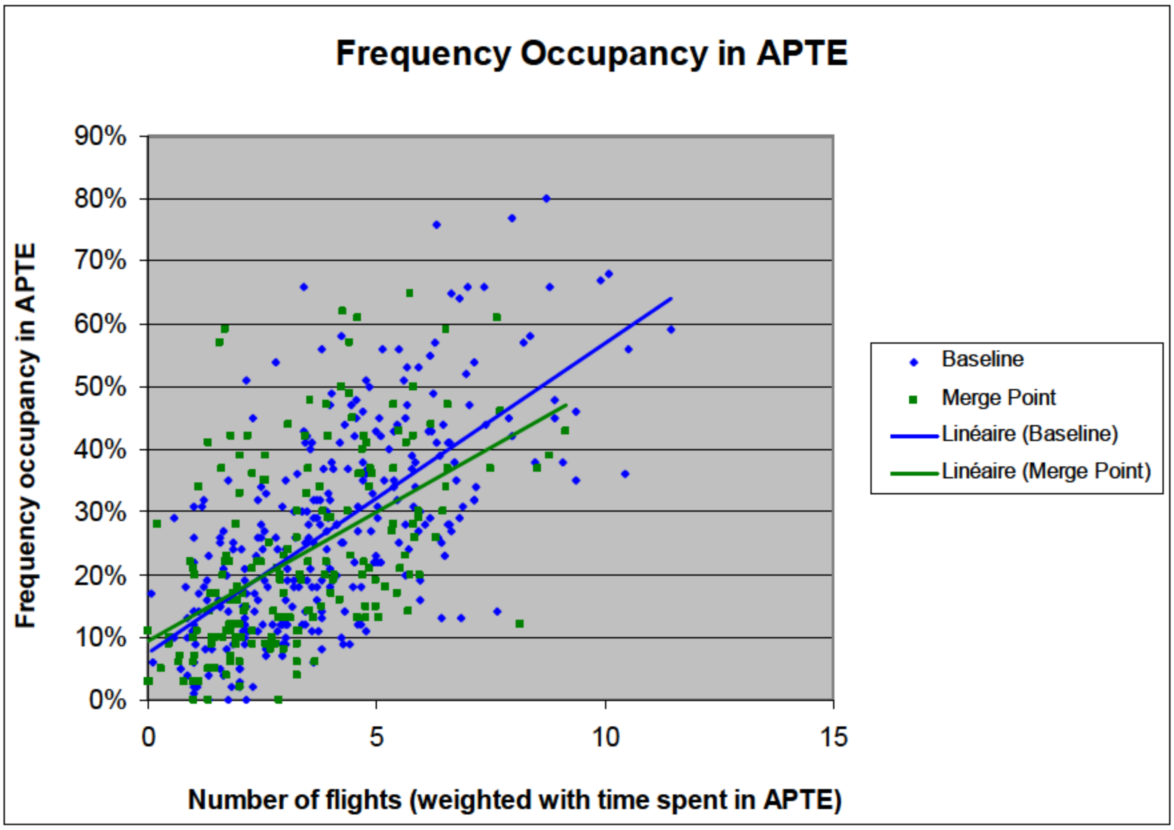


Figure 58: Frequency occupancy in APTE (number of flights weighted with time spent in APTE)

The analysis of phone communications between the APTE sector and APP shows that controllers of the APTE sector called slightly more the Approach with Point Merge (+0.3%pt) but were slightly less called by the Approach with Point Merge (-0.4%pt). In conclusion, phone communications between APTE and APP with Point Merge were similar to Baseline.

Those numbers were calculated during two hours during peak traffic (from 06:45 AM to 08:45 AM (UTC)) for each day of Point Merge and its corresponding Baseline day (same days used for the analysis of flight efficiency). The figure below is the mean of the phone call occupancy and the total number of phone call between APTE and APP for Baseline days and for Point Merge days.

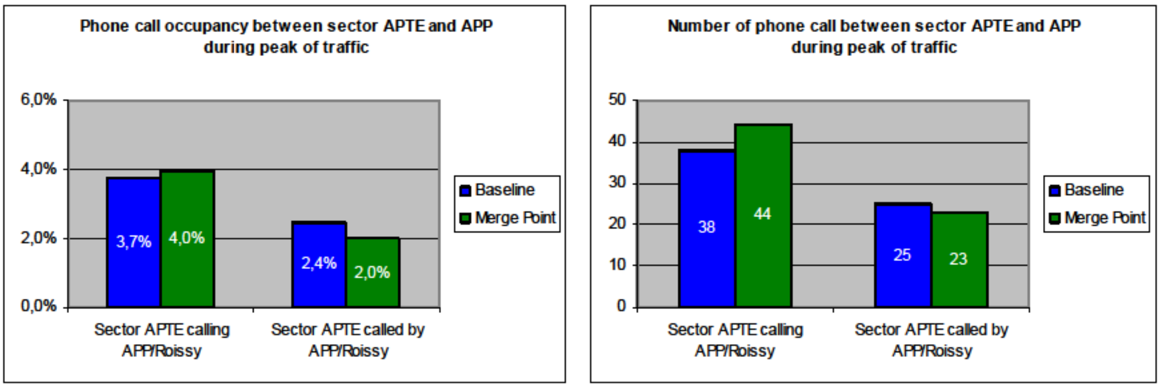


Figure 59: Phone communication between sector APTE and APP

6.2.3.2.1.2.2 North-West Point Merge

TP sector was seldom opened as a standalone sector (only 20 minutes during 3 days of Point Merge, and never during Baseline days). TP is usually grouped with TH and LN (=TPHN), or with TH, LN, UK and UZ (=HPKZ). We don't have enough data to measure the impact of Point Merge on the frequency occupancy in sector TP.

The analysis of phone communications between the TP sector and APP shows that controllers of the TP sector called less the Approach with Point Merge (-0.9%pt) and were less called by the Approach with Point Merge (-0.4%pt). Those results should be considered with caution because there is an important variation from a day to another. For example, for 20/11/2012 which is a Baseline day, phone communication occupancy from sector TP to APP was 5.2% whereas for other days it was 3% or less. This high value increases the mean phone communication occupancy from sector TP to APP.

Those numbers were calculated during two hours during peak traffic (from 06:45 AM to 08:45 AM (UTC)) for each day of Point Merge and its corresponding Baseline day (same days used for the analysis of flight efficiency). The figure below is the mean of the phone call occupancy and the total number of phone call between TP and APP for Baseline days and for Point Merge days. When TP was not opened as a standalone sector, the measure was done on the grouped sector including TP.

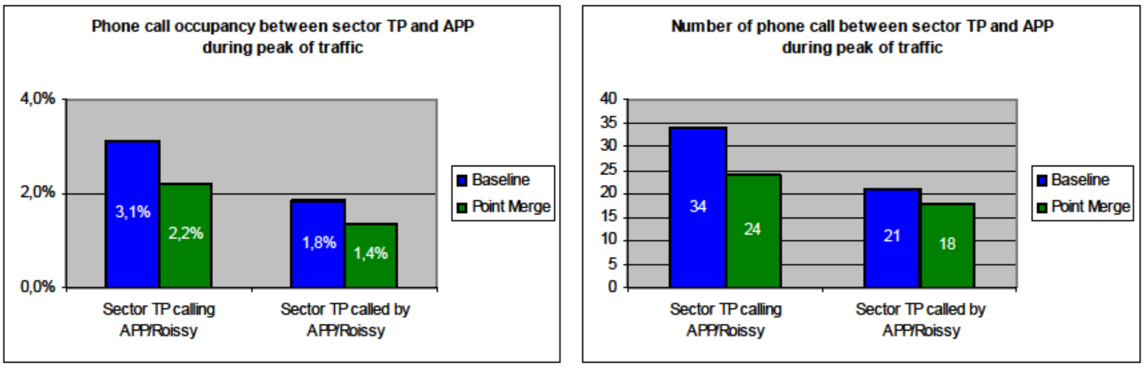


Figure 60: Phone Communication between sector TP and APP

6.2.3.2.1.3 Controller's Workload

Overall, ACC controllers' feedback about their perceived workload was that they were not overloaded.

The workload was considered as average to very low with the Point Merge and AMAN. In majority, it was considered as rather unchanged to clearly lower with the Point Merge. Compared to today, the reduction in workload was due to the fact that the arrivals are separated on the legs and the Point Merge and AMAN procedure is easy to apply.

The grouping of aircraft is facilitated with the Point Merge system, which is less demanding than the radar vectoring. This should enable capacity improvement. With the Point Merge, the controllers can more easily group aircraft according to their wake turbulence category. They have more time and it is easier to choose which aircraft and when make them leave the legs.

The Point Merge system enabled the E-TMA EXE controllers to be less loaded by the frequency, thus more available to improve the service provided to the flight crews and the Approach.

In AP sector, the aircraft did not stay long on the frequency except when they were on the legs. The workload was felt as lower than today.

In TE, the workload was also felt as lower than today due to the fact that there were few messages to give (descend at discretion, speed), the AP sector having prepared the sequence, and that that there were no conflicts. However, the workload might be increased by the will to improve the delivery conditions.

In TP, the workload was felt as lower than today but, for some, it increased the vigilance (e.g. on the levels - with turns at 90°, the separation is reduced; and on the delays to absorb).

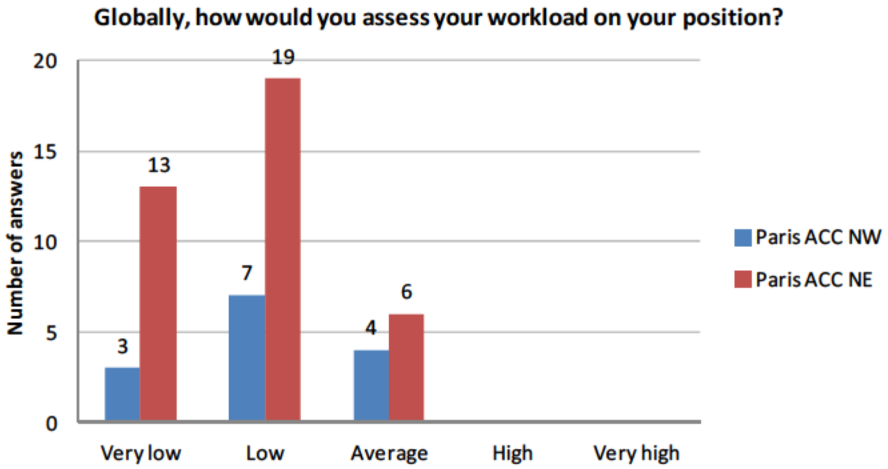


Figure 61: ACC controllers' rating regarding their perceived level of workload

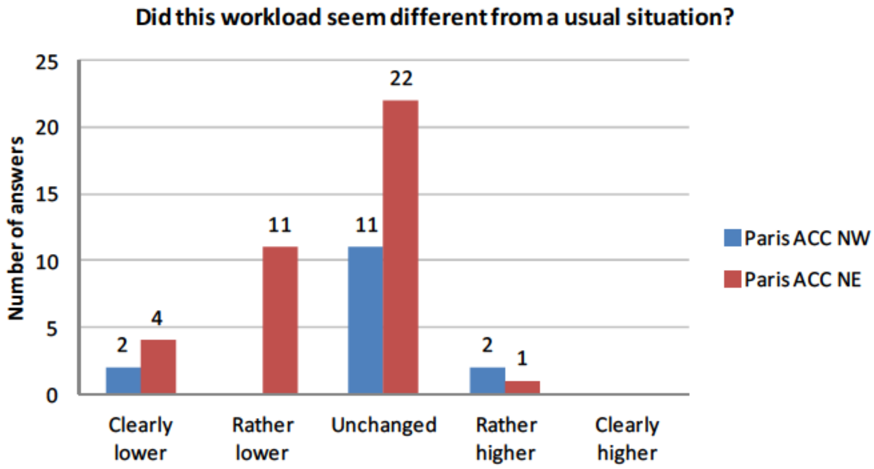


Figure 62: ACC controllers' rating regarding the level of workload compared to today's situation

Note: Ratings presented in Figure 62 regarding a rather higher workload compared to without the Point Merge (2 "Rather higher" answers in the NW, 1 "Rather higher" answer in the NE) were explained as follows:

- In the NW: one controller referred to a lack of habit; the other controller explained that the sequence requested by LFPG was more complex than usual.
- In the NE: the controller explained that as Planning Controller, there was more coordination (with AP and MAESTRO), but that the workload was also better balanced between the EXE and PLN controllers (EXE ATCO being more available, the communication is easier between EXE and PLN controllers).

6.2.3.2.2 Impact in APP/N

6.2.3.2.2.1 General Feedback

Note: The answers related to the delivery conditions of the arrival traffic to LFPG, although formulated in an absolute way, have to be taken relative to the current situation as it is in comparison to today's situation that the APP controllers gave their feedback.

As in June exercise, the general feedback from the Approach controllers was globally positive (Figure 63). Except in some cases described below referring to the orange ratings, compared to today, APP controllers reported benefits of the Point Merge + AMAN in the delivery conditions of the arrival traffic to LFPG and to the other LFP* airfields.

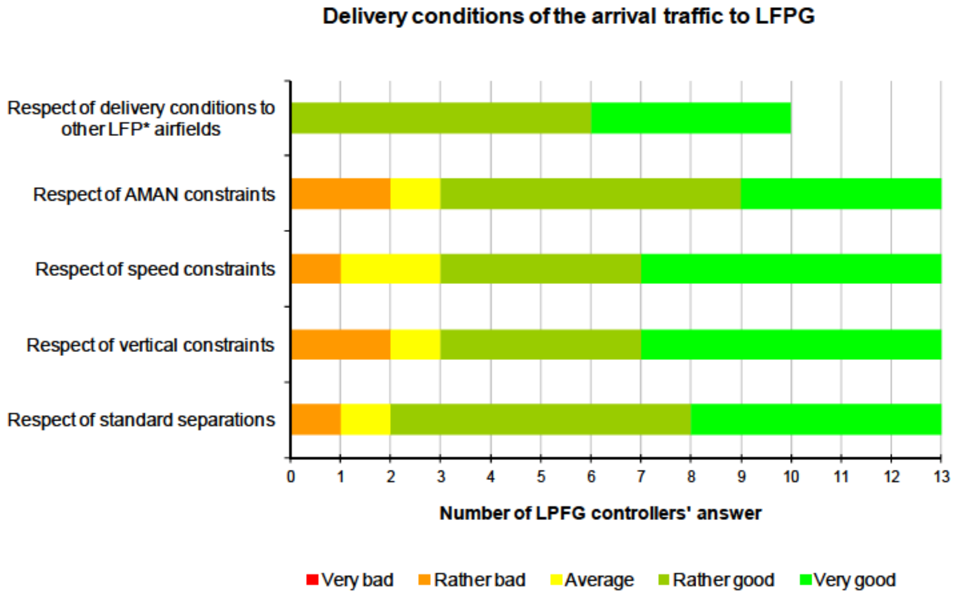


Figure 63: APP controllers' rating regarding the delivery conditions of the arrival traffic with the Point Merge + AMAN procedure

Note: The orange rating in Figure 63 regarding the standard separations (1 "Rather bad" answer) and the vertical constraints (2 "Rather bad" answers) were explained by the fact that during a session, several aircraft took the legs whereas there was no AMAN delay, which led to a spacing of 12NM between aircraft in this sequence. In some cases, controllers were struggling to give the direct to Merge Point instruction at the right time, depending on the position of the previous aircraft. The direct needed to be given when the preceding aircraft was at 5NM, whereas they were used to wait until the separation was of 7NM (like during the simulations) to give this instruction. This led to increased separation between the flights inbound CDG. In another case, it led to the opening of a holding at LORNI as explained in section 6.2.3.2.1.1. The orange ratings regarding the vertical constraints (2 "Rather bad" answers) were related to the fact that aircraft were often delivered at VEBEK too high). The orange rating regarding the speed constraints (1 "Rather bad" answer) refers to the fact that during a session, an aircraft was rerouted via VEBEK for the 26L runway with a speed to high.

As illustrated in Figure 64, the participating APP controllers considered safety and situational awareness were higher than in the baseline, which is consistent with June live trials results.

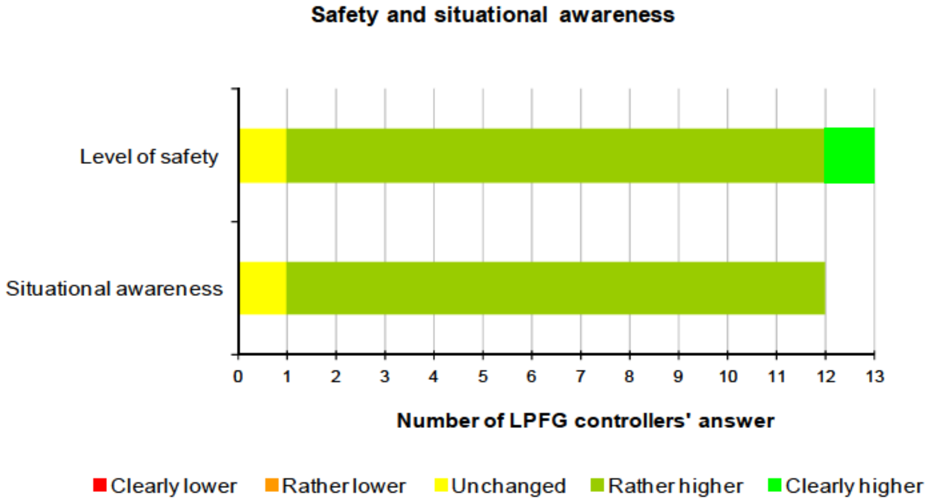


Figure 64: APP controllers' ratings regarding situational awareness and safety

6.2.3.2.2.2 Controller's Activity

To assess the Approach controllers' activity, the workload was analysed. As shown in Figure 65, the majority of the participating APP controllers rated their workload as average. Regarding the "High" answer, the controller gave the following explanation: the Sequence Manager was increased due to a confusion regarding the strategy to put in place because of a late briefing between Approach supervisors, between Approach supervisor and SEQ, and between Approach supervisor and TE. The workload of the INI N as also increased because aircraft were delivered too high at VEBEK.

When asked during the debriefing to compare their workload with and without Point Merge, the participating APP controllers reported no significant impact of the Point Merge compared to today's situation.

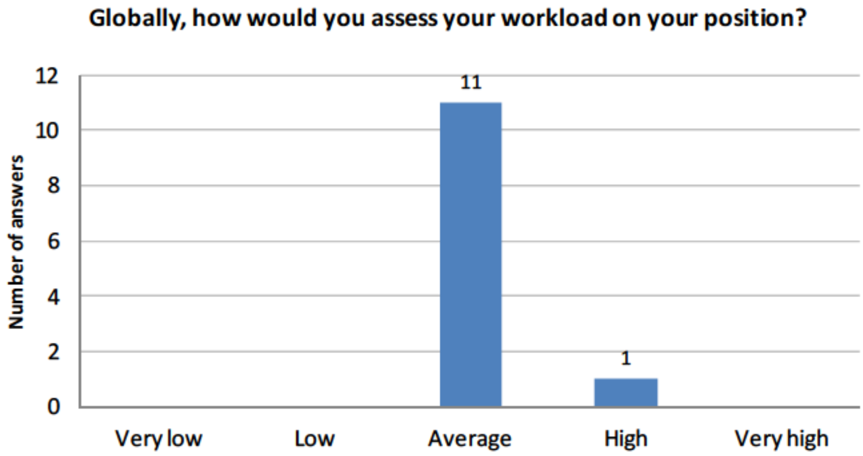


Figure 65: APP controllers' rating regarding their perceived level of workload

6.2.3.2.3 Performances in ACC + APP/N

6.2.3.2.3.1 Quality of Traffic Delivery

Figure 66 and Figure 67 below show for each day of November and December 2012, the mean difference between sequenced time 15 minutes before LORNI or MOPAR and time when aircraft fly over the IAF. The beacon MOPAR is the IAF for North-West LFPG arrivals and the beacon LORNI is the IAF for North-East LFPG arrivals.

Note: for one LFPG runway configuration and for some kind of aircraft, the IAF for North-West LFPG arrivals can be MOBRO. But the IAF for most aircraft is MOPAR. That's why the analysis of the respect of the initial sequenced time for North-West LFPG arrivals has been focused on MOPAR.

There is no obvious conclusion with those figures. Values for Point Merge days seem to be in the usual variation. The respect of the initial sequenced time is equivalent to other days.

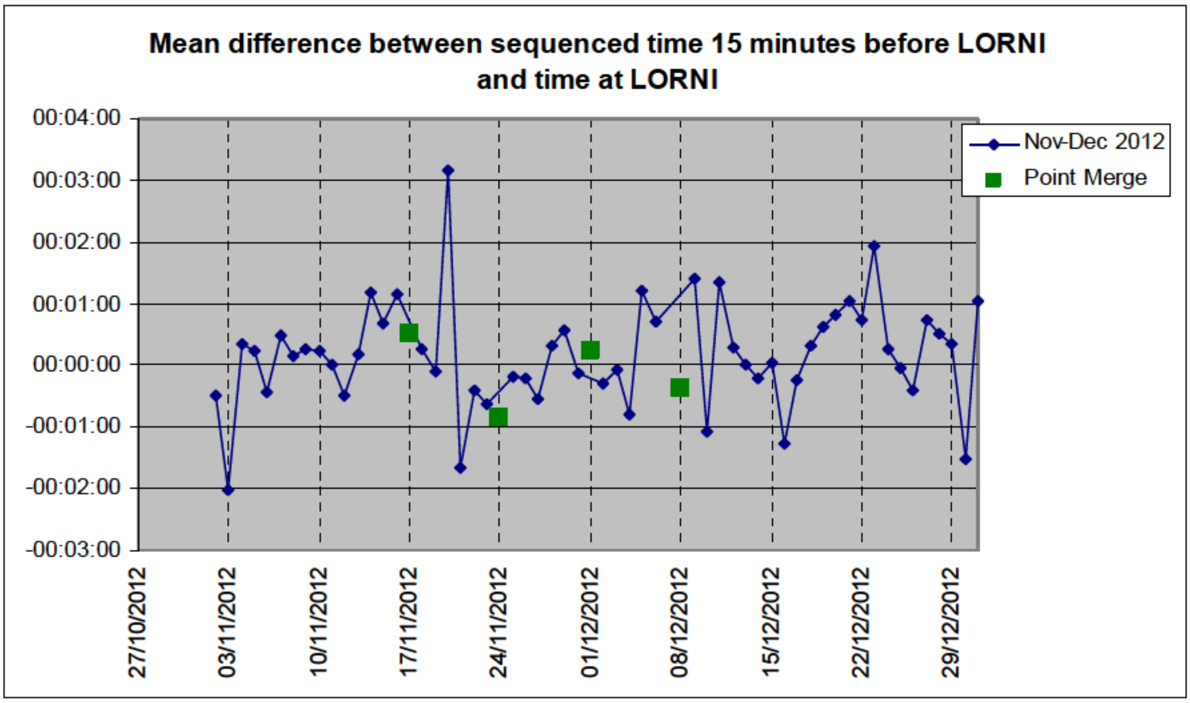


Figure 66: AMAN analysis: Respect of the initial sequenced time at IAF LORNI

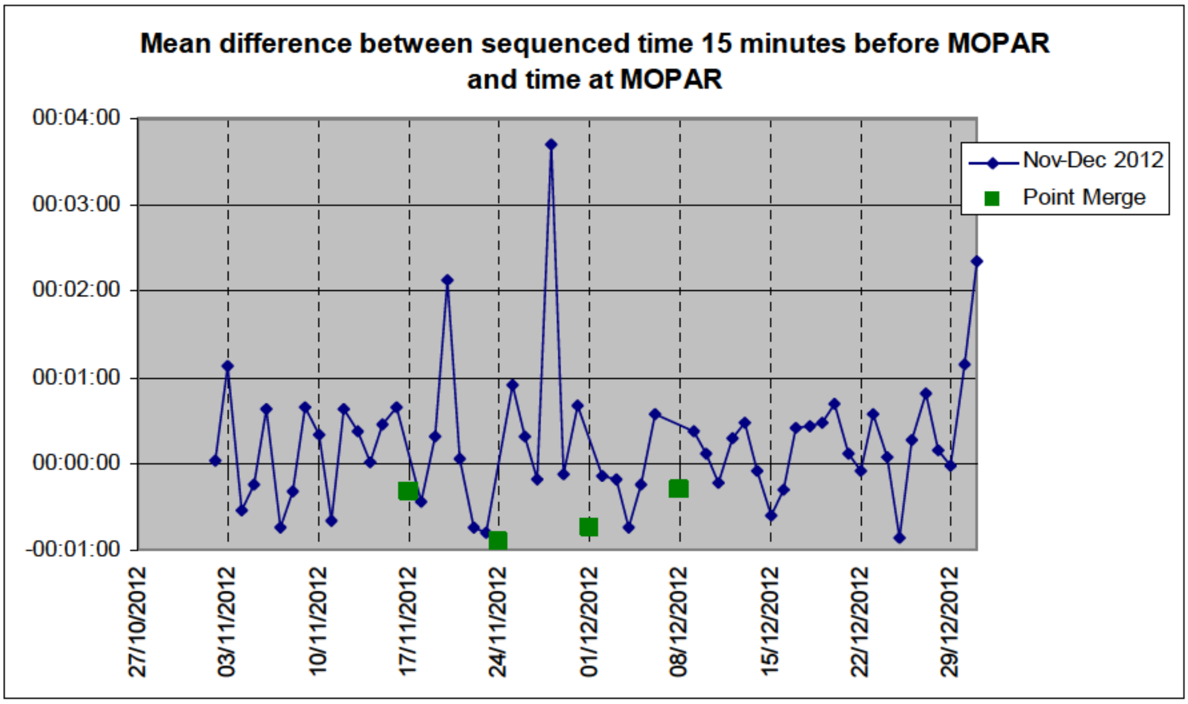


Figure 67: AMAN analysis: Respect of the initial sequenced time at IAF MOPAR

Figure 68 and Figure 69 show the distribution of spacing over DEVIM and KOLIV during peak traffic. Those beacons are delivery points from ACC to APP, DEVIM for North-East arrivals and KOLIV for North-West arrivals. For Baseline days and for Point Merge days, all spacing between two aircraft over DEVIM and KOLIV during peak traffic have been calculated. Then, we counted how many times each value of spacing occurred.

As usual, ACC controllers were tasked to deliver LFPG arrivals to APP/N with 8 NM spacing (minimum). As illustrated in Figure 68 and Figure 69, the sequencing of arrival flows to DEVIM and KOLIV was similar in both conditions:

- Most of LFPG NE arrivals were delivered to APP/N over DEVIM between 8 NM and 11 NM.
- Most of LFPG NW arrivals were delivered to APP/N over KOLIV between 8 NM and 11 NM for Baseline and between 8 NM and 12 NM for Point Merge.

Larger spacing values correspond to gaps in the traffic. It is normal that the main peak is not at 8 NM because there was some delay in ACC due to high traffic in LFPG. Aircraft spacing were above the minimum spacing (8 NM).

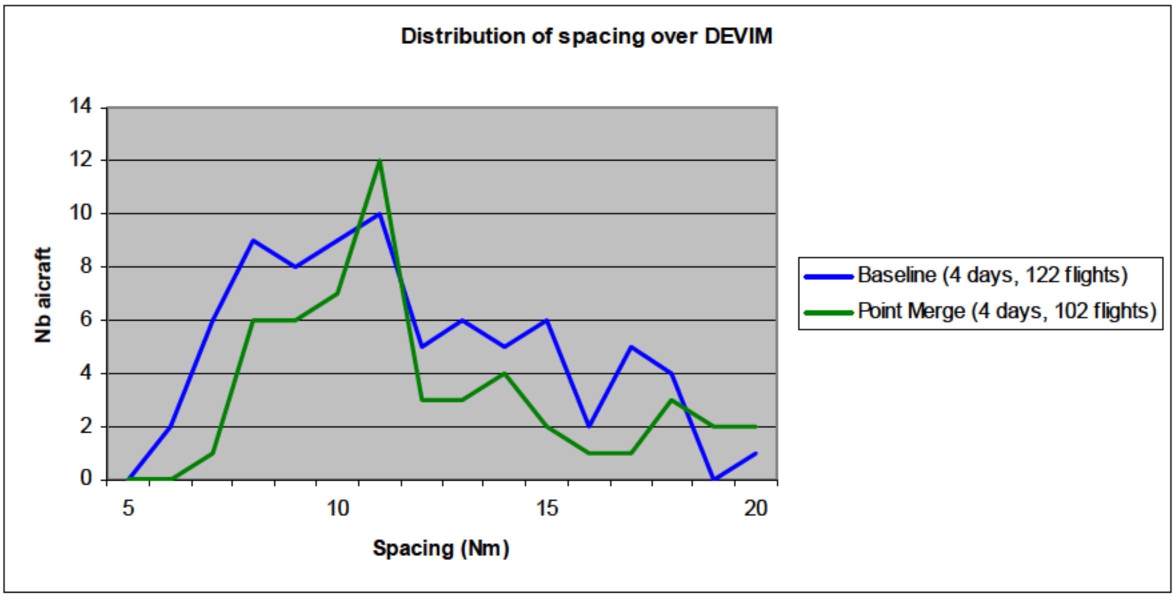


Figure 68: Distribution of spacing over DEVIM during peak traffic

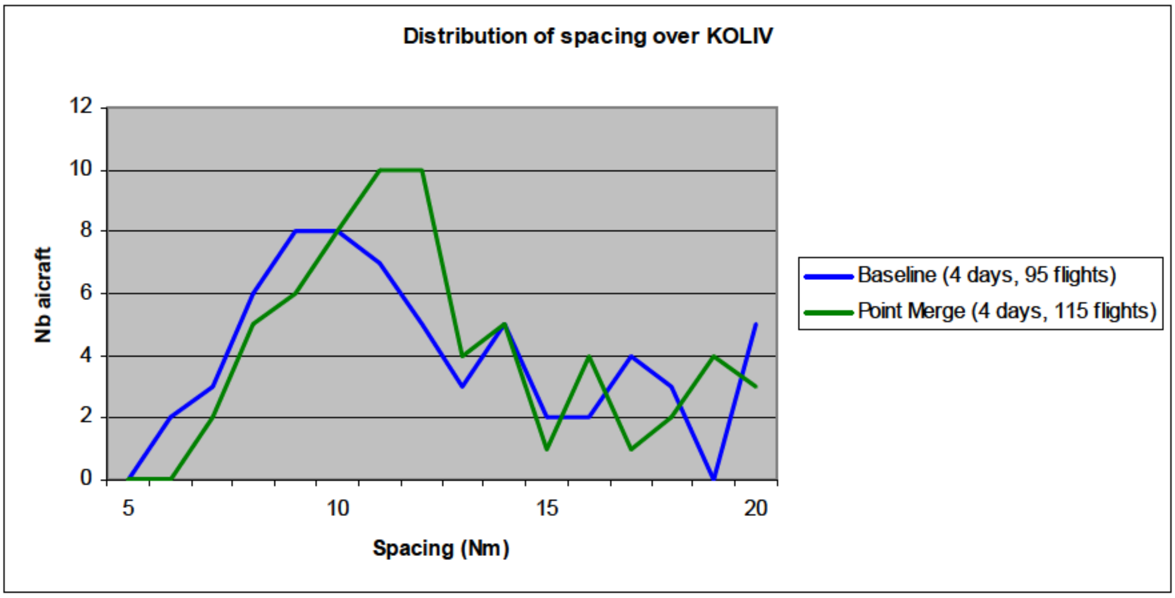


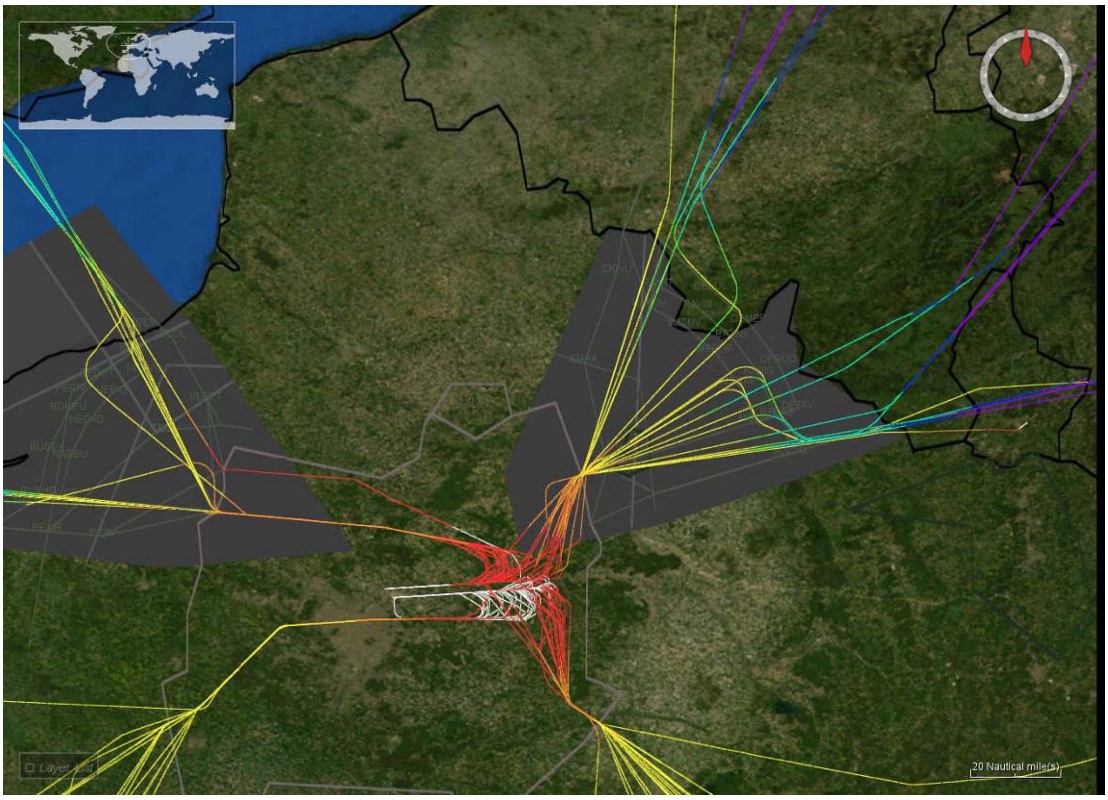
Figure 69: Distribution of spacing over KOLIV during peak traffic

6.2.3.2.3.2 Flight Efficiency

The different working methods in Baseline and Point Merge are clearly visible on North-West and North-East LFPG flown trajectories during peak traffic (Figure 70, Figure 71, Figure 72, Figure 73). The use of radar vectoring and holdings is apparent in Baseline whereas the flow of traffic was more order with a contained and predefined dispersion of trajectories with Point Merge.

The last day of Point Merge experimentation, controllers performed flow management and some North-East arrivals have been sent on the VEBEK IAF to land on South LFPG runway (see 08/12/2012 on Figure 73)

In case an aircraft reached the end of the sequencing leg and still had some delay to be absorbed in ACC, the controller had the possibility to vector the traffic in the airspace available in between the sequencing leg and the IAF. If the airspace available is not sufficient for the AMAN sequence to be adhered to, holding patterns shall be used.



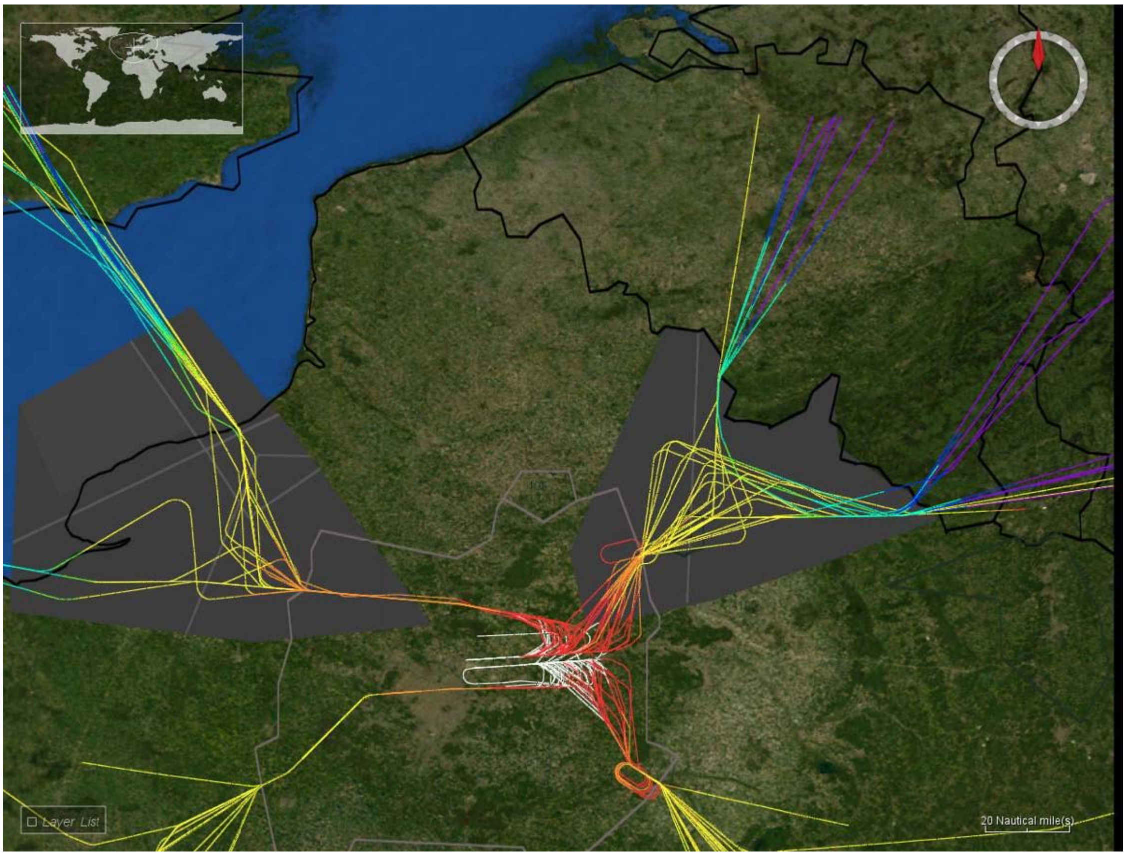
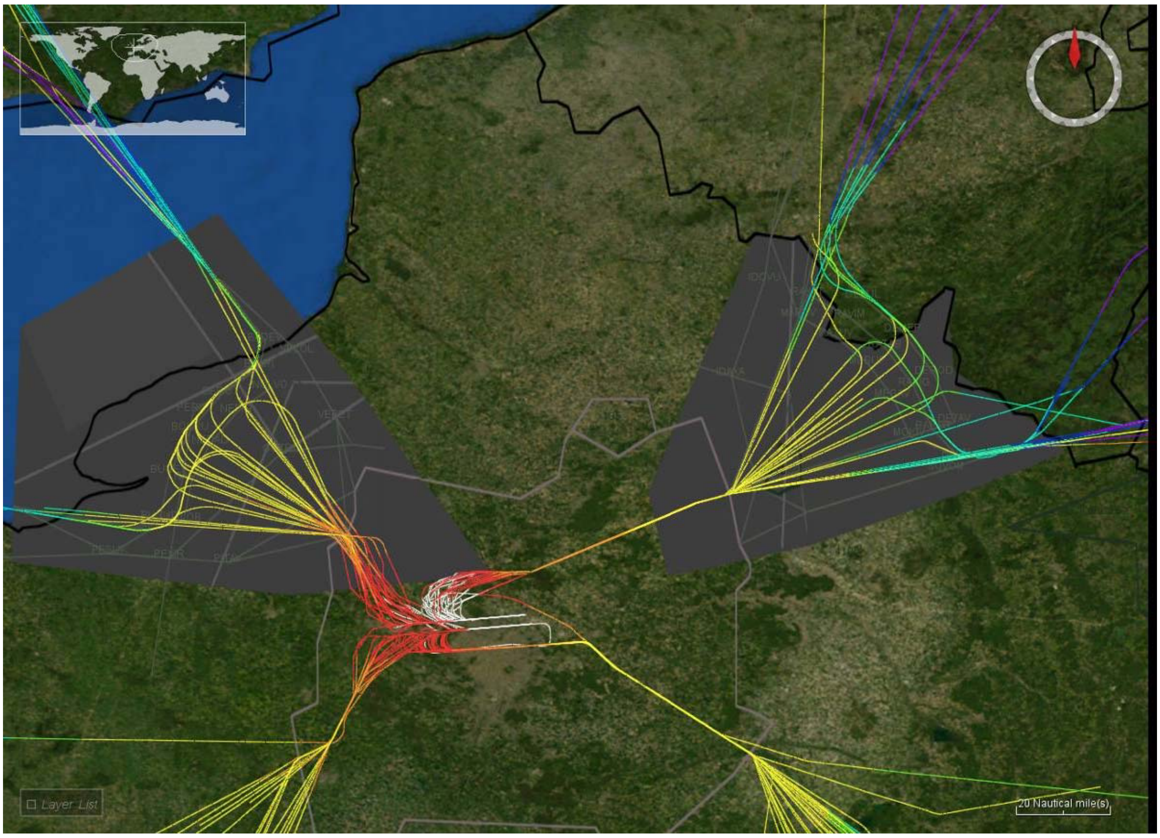


Figure 70: 07:00-09:00 AM - 17/11/2012 (Point Merge) and 20/11/2012 (Baseline)



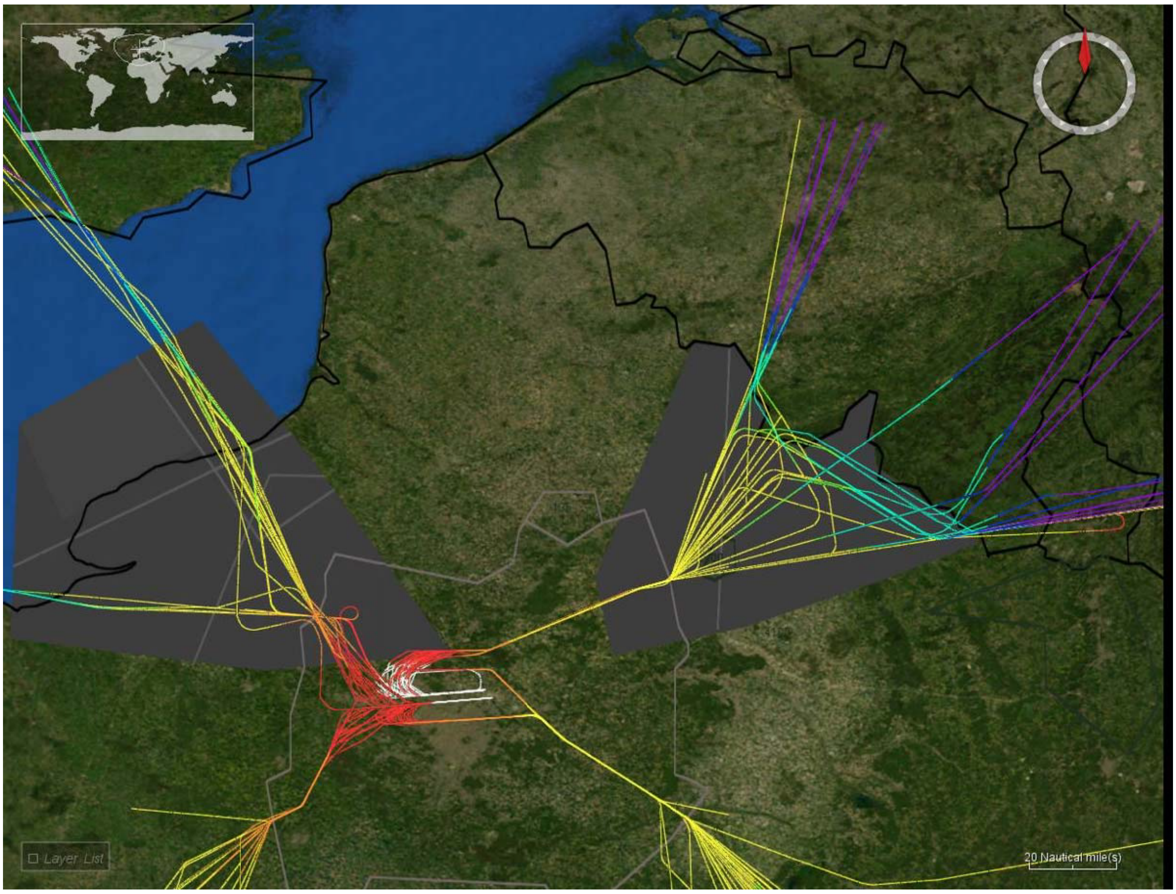
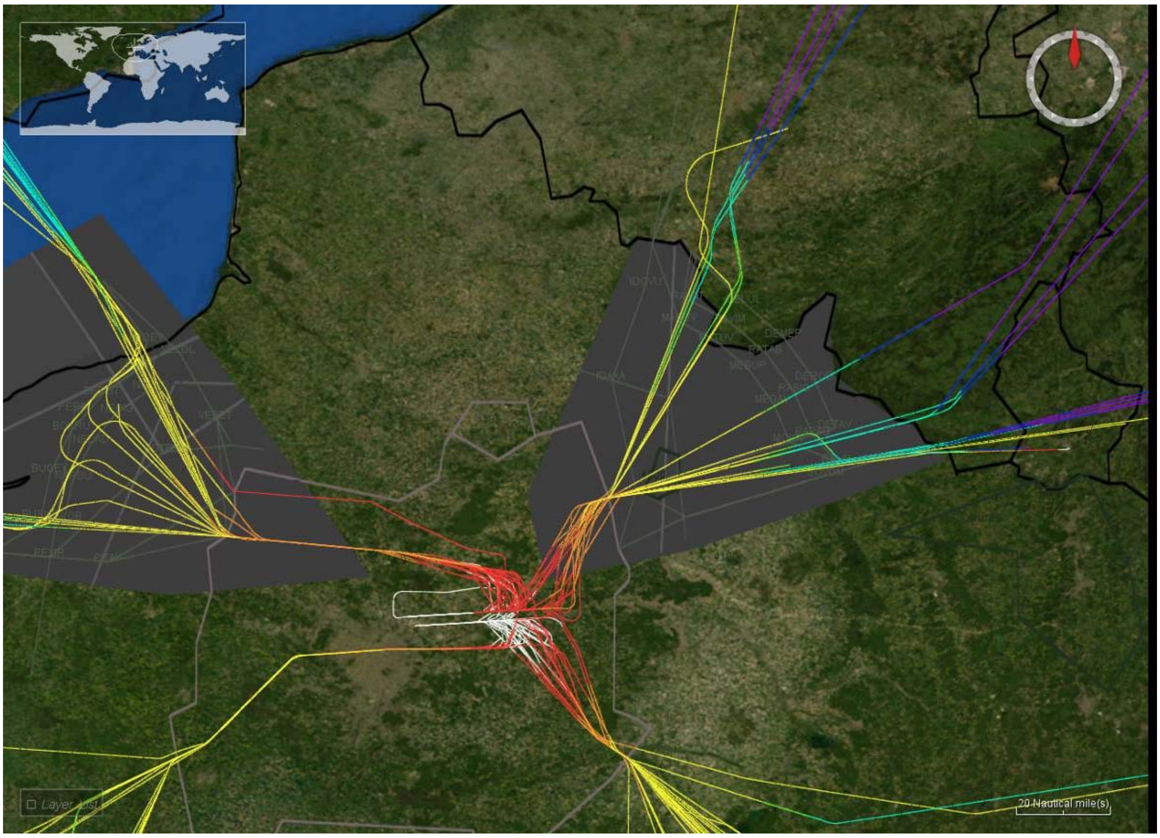


Figure 71: 07:00-09:00 AM - 24/11/2012 (Point Merge) and 28/11/2012 (Baseline)



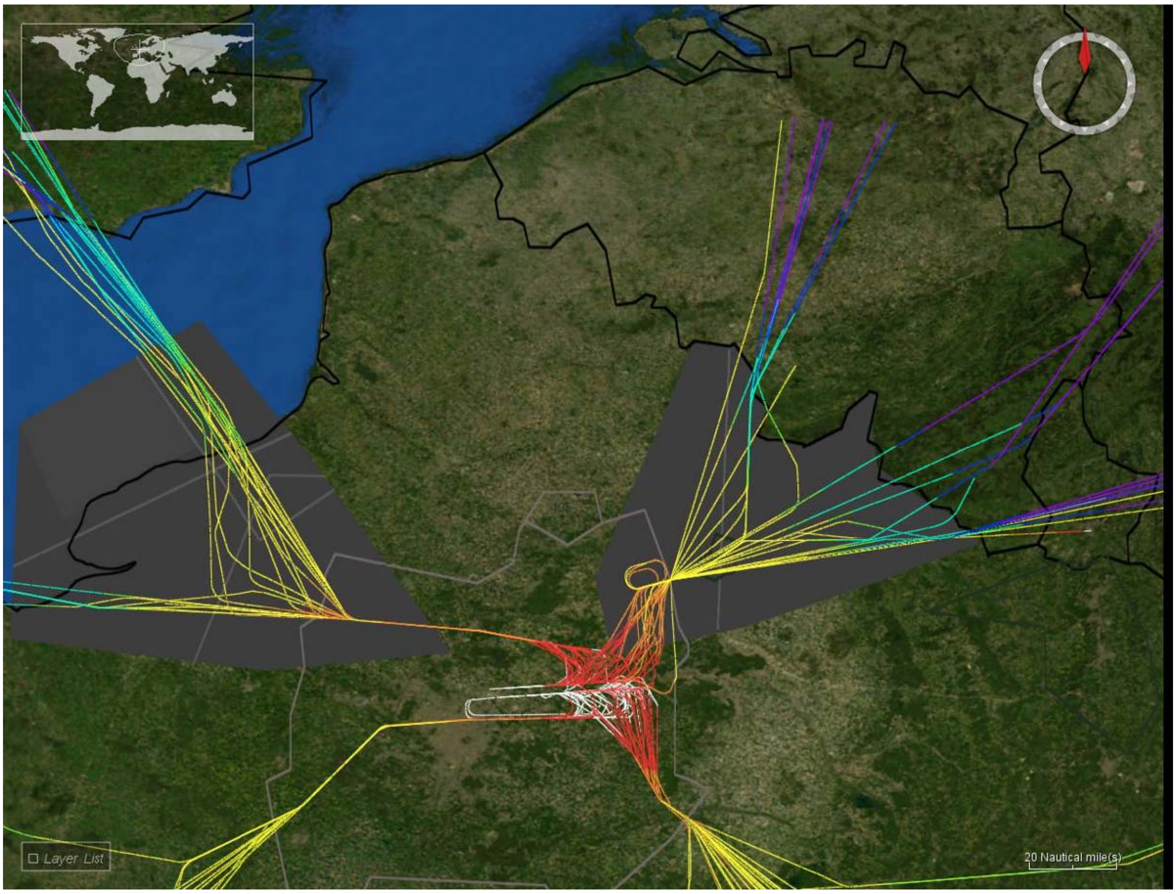


Figure 72: 07:00-09:00 AM – 01/12/2012 (Point Merge) and 12/11/2012 (Baseline)

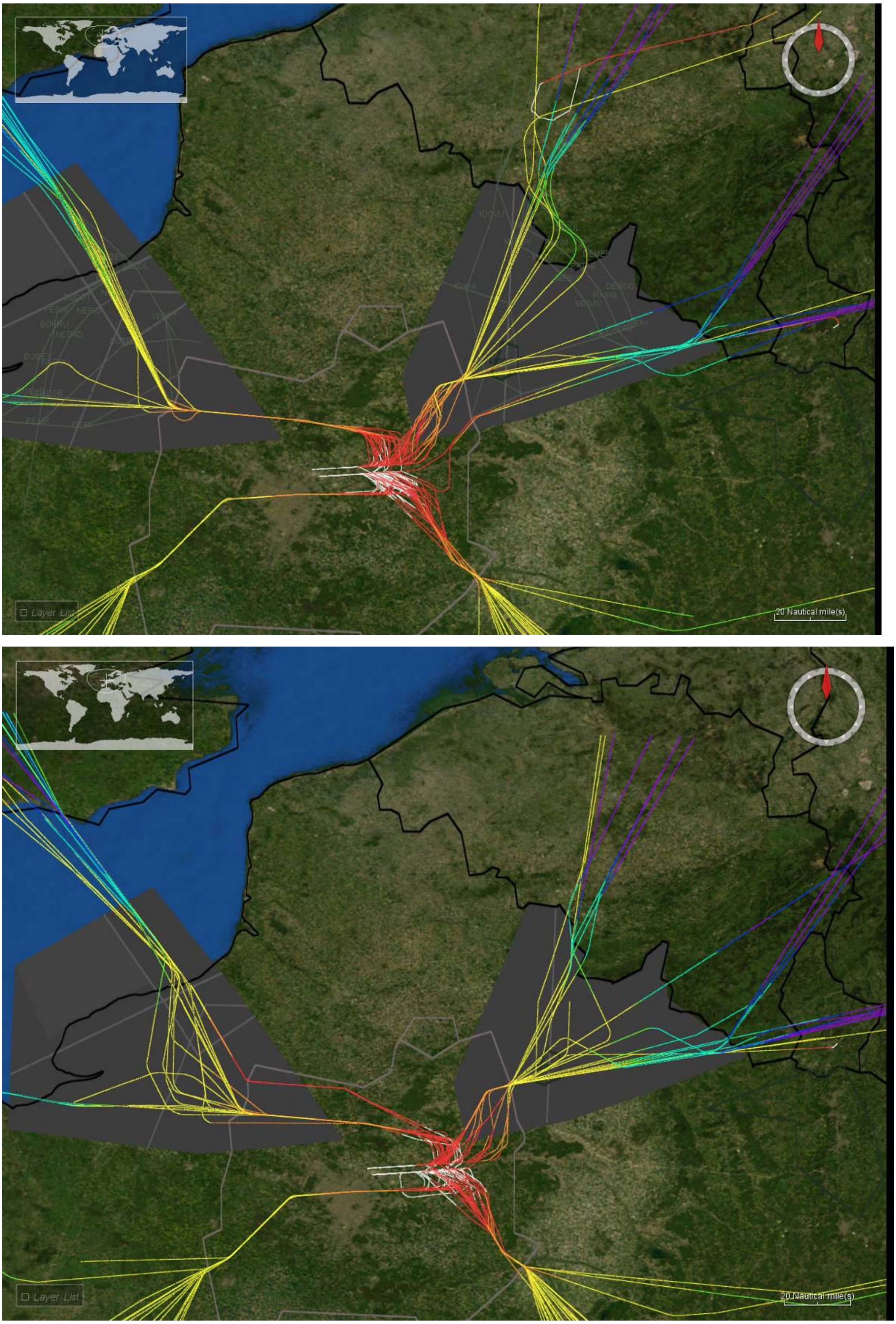


Figure 73: 07:00-09:00 AM – 03/12/2012 (Point Merge) and 03/12/2012 (Baseline)

Here after are some figures about the use of both Point Merge procedures. The whole experimentation period of Point Merge is considered, i.e. the 4 Point Merge days from 05:30 AM to 14:30 (UTC) for North-East LFPG arrivals and from 05:30 AM to 18:30 (UTC) for North-West LFPG arrivals.

In this table, flights using PMS are flights with a trajectory extension in ACC greater than 8 NM.

	NE LFPG arrivals	NW LFPG arrivals
Number of flights during the whole experimentation period	501	265
Number of flights using PMS	71	35
Percentage of flights using PMS	14%	13%
Mean distance flown on the legs (NM)	17	21

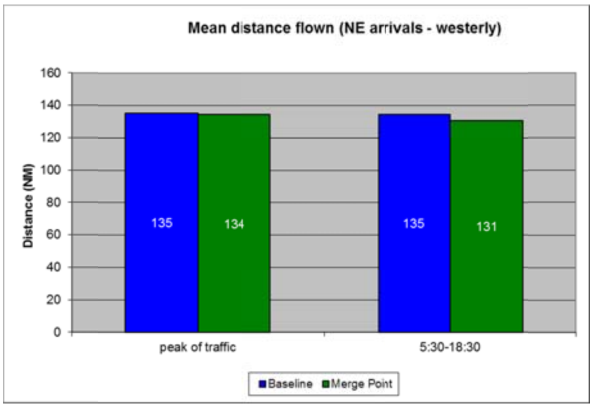
Table 24: Some number of flights about the use of both Point Merge Systems (PMS)

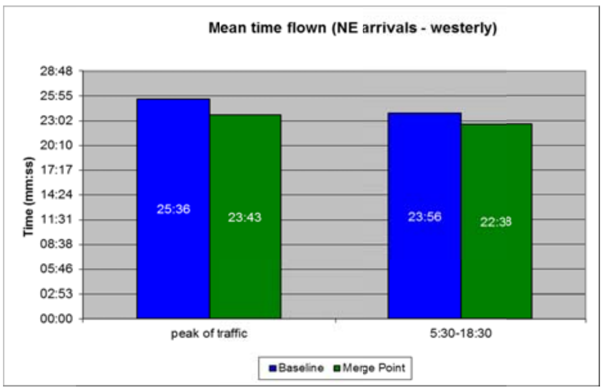
6.2.3.2.3.2.1 North-East Point Merge

The analysis of distance and time flown (from 100NM from LFPG to 5NM to LFPG) of LFPG North-East arrivals shows that aircraft flew equivalent distance and time in Point Merge.

Particularly, during peak traffic, aircraft flew:

- with westerly LFPG runway configuration
  - -1NM in Point Merge (-0.7%)
  - -1'53 in Point Merge (-7%)
- with easterly LFPG runway configuration
  - +1NM in Point Merge (+0.6%)
  - +52'' more in Point Merge (+3%)





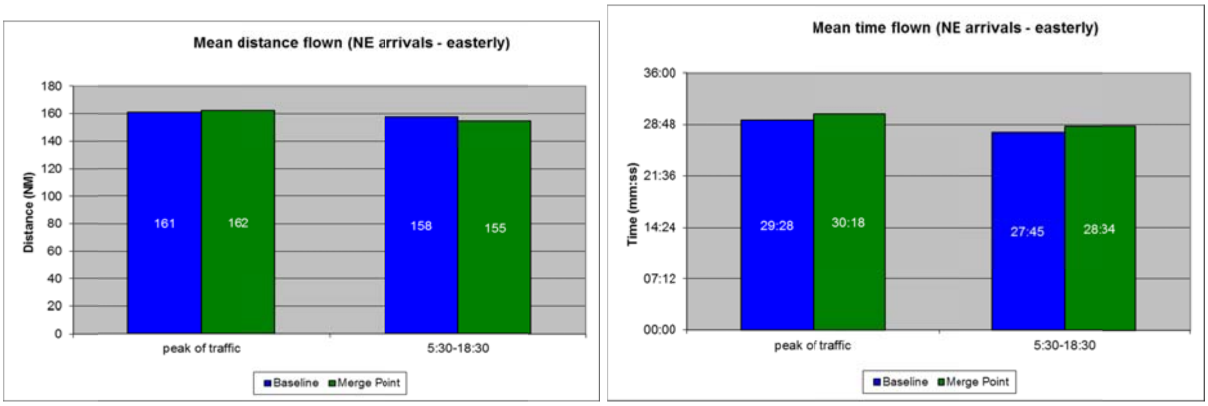


Figure 74: Distance and time flown in ACC+APP (NE arrivals)

It is interesting to note that during the whole day (from 05:30 to 18:30) with easterly LFPG runway configuration, aircraft flew less distance (-3NM) and more time (+49'') in Point Merge. 24/11/2012 is the only Point Merge day with easterly LFPG runway configuration, its corresponding Baseline day is 28/11/2012. The analysis of the wind those days between 05:30 and 18:30 shows that in Baseline, head wind decreased in TE, whereas it stayed strong during Point Merge day. It explain that aircraft could fly less distance and more time. The table below shows head wind in TE for LFPG arrivals at different time for 24/11/2012 and 28/11/2012.

	06:00	09:00	12:00	15:00	18:00
24/11/2012 (Point Merge)	47 kts	41 kts	41 kts	42 kts	52 kts
28/11/2012 (Baseline)	49 kts	43 kts	40 kts	28 kts	15 kts

Table 25: Head wind in TE for LFPG arrivals for 24/11/2012 and 28/11/2012

It is worth analysing the distance and time flown in ACC and APP separately. Indeed, one objective of Point Merge was to absorb more delay in E-TMA (on the legs) rather than in TMA (and rather than in vectoring in E-TMA).

The analysis of distance and time flown in ACC (from 100NM from LFPG to 49NM to LFPG) and APP (from 49NM from LFPG to 5NM to LFPG) during peak traffic shows that aircraft flew:

- Equivalent distance and time in ACC in Point Merge
  - o -1NM and -1'03 with westerly LFPG runway configuration
  - o +1NM and +14'' with easterly LFPG runway configuration
- same distance and equivalent time in APP in Point Merge
  - o -50'' with westerly LFPG runway configuration
  - o +36'' with easterly LFPG runway configuration

This analysis shows that aircraft flew same distance in ACC and in APP and equivalent time in ACC and in APP. Those equivalent distance and time flown are confirmed with the analysis of the months of November and December 2012 presented in this part: 6.2.3.2.3.2.36.2.3.2.3.2.3.

This analysis doesn't show that delay was moved from TMA to E-TMA like North-West Point Merge in June.

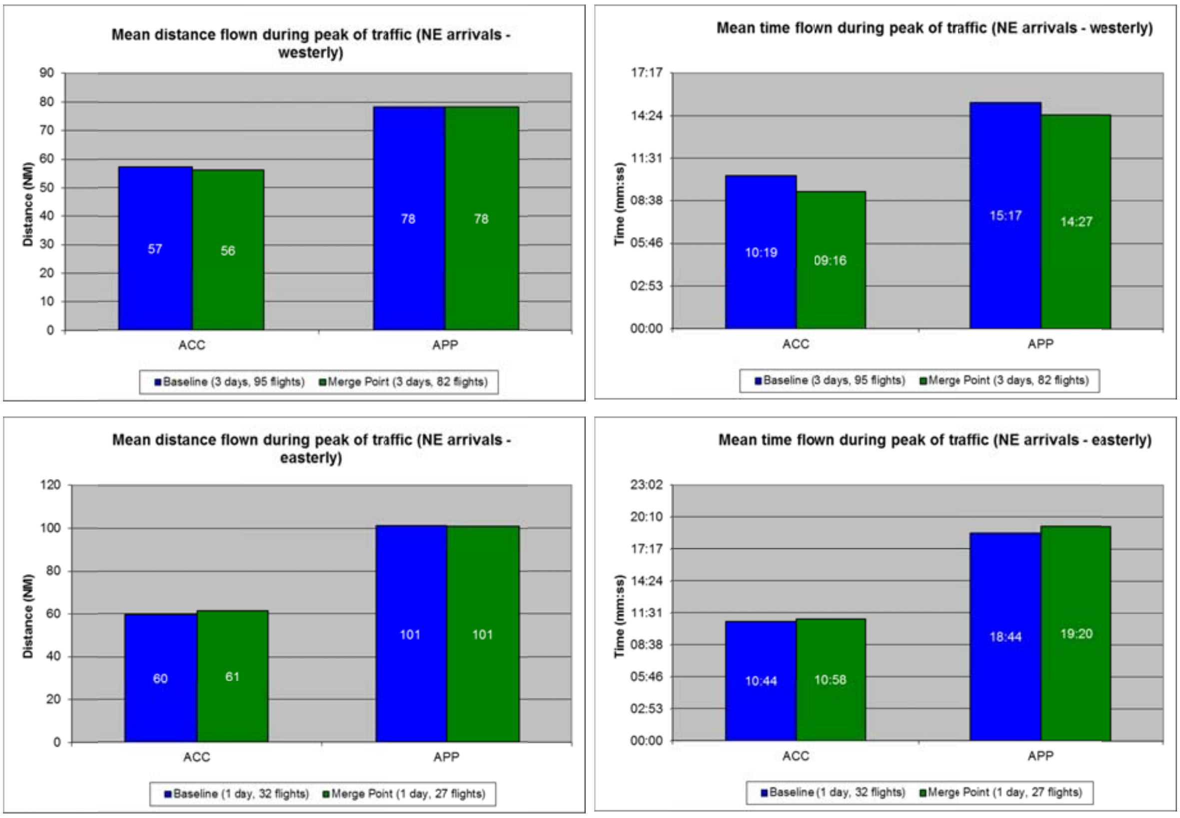
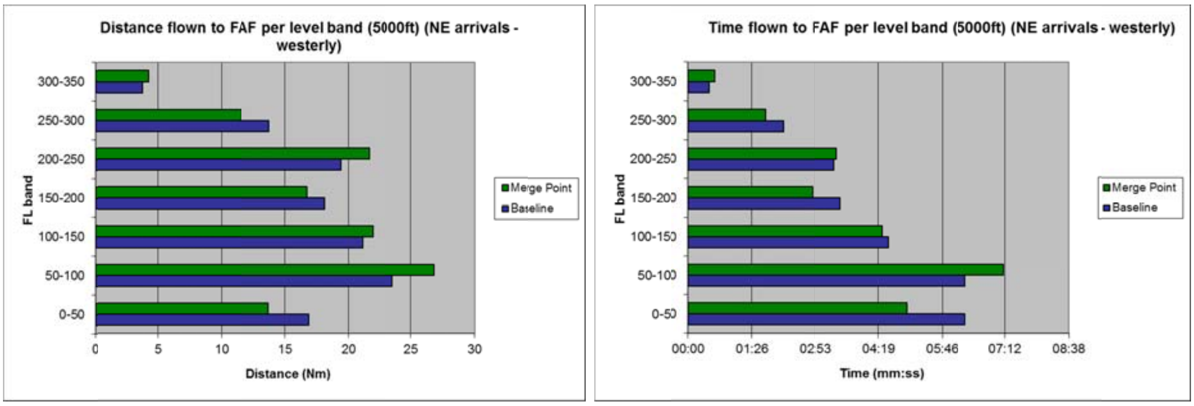


Figure 75: Distance and time flown in ACC and APP during peak traffic (NE arrivals)

The analysis of distance and time flown per level band during peak traffic shows that with Point Merge aircraft stayed longer higher, typically between FL200 and FL350 with easterly configuration. With westerly configuration, distance and time flown per level band above FL200 are slightly higher with Point Merge: between FL200 and FL350 and between FL200 and FL250 aircraft stayed longer with Point Merge but between FL250 and FL300 aircraft stayed longer in Baseline.



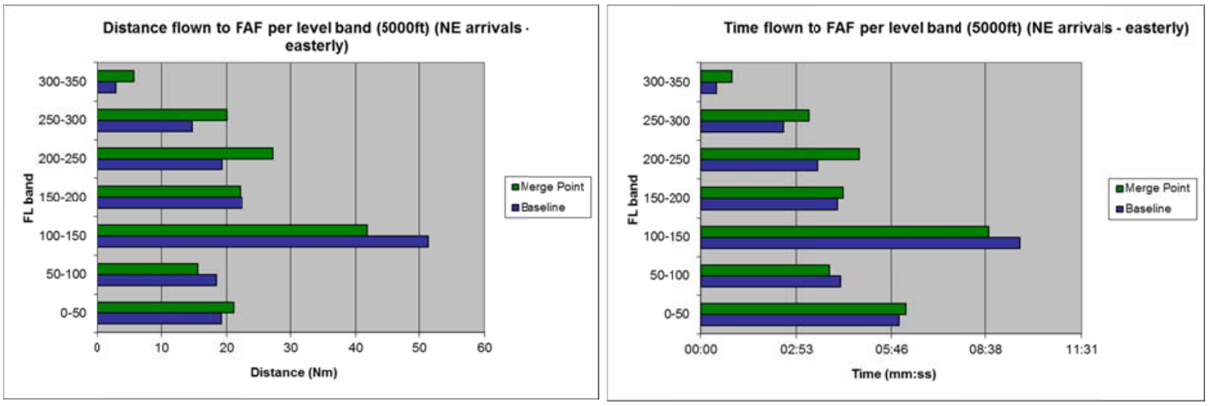


Figure 76: Distance and time flown per level band during peak traffic (NE arrivals)

The mean descent profiles of North-East LFPG arrivals shown in Figure 77 are consistent with previous results and show that with Point Merge aircraft were maintained longer at higher level, especially in westerly LFPG runway configuration.

In easterly LFPG runway configuration, aircraft were lower in Point Merge until FL270 and then, aircraft stayed longer at higher level.

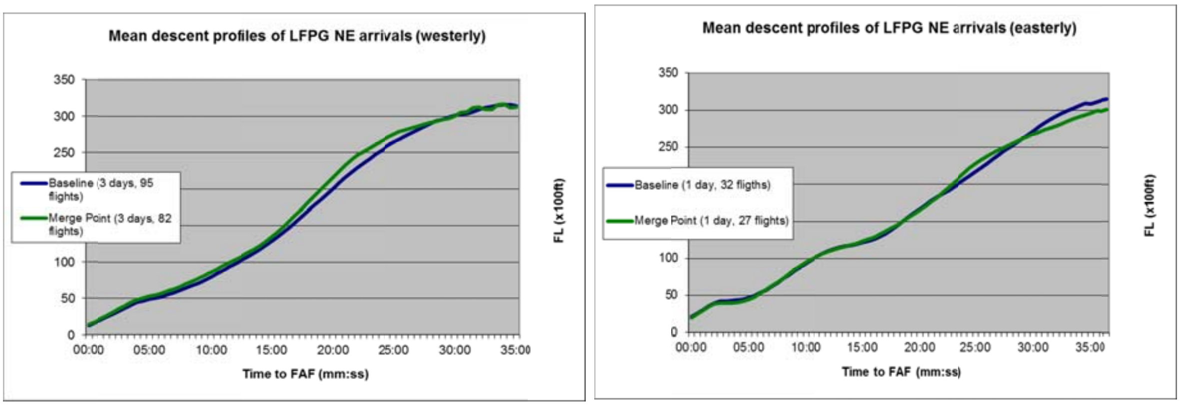


Figure 77: Mean descent profiles during peak traffic (NE arrivals)

6.2.3.2.3.2.2 North-West Point Merge

The analysis of distance and time flown (from 100NM from LFPG to 5NM to LFPG) of LFPG North-East arrivals shows that aircraft flew equivalent distance and time in Point Merge.

Particularly, during peak traffic, aircraft flew:

- with westerly LFPG runway configuration
  - -1NM in Point Merge (-0.5%)
  - -1'39 in Point Merge (-5%)
- with easterly LFPG runway configuration
  - +11NM in Point Merge (+8.5%)
  - +35'' more in Point Merge (+2.6%)

The main difference between Point Merge and Baseline is during peak traffic in easterly LFPG runway configuration. 24/11/2012 is the only Point Merge day with easterly LFPG runway configuration, its corresponding Baseline day is 28/11/2012. The analysis of the wind those days during peak traffic shows that:

- in Baseline day the wind was very low,
- in Point Merge day there was a strong back wind for flights in TP.

Therefor aircraft had to flight more distance for loosing same time. That's why there is +8.6% of distance in Point Merge and only +2.6% of time.

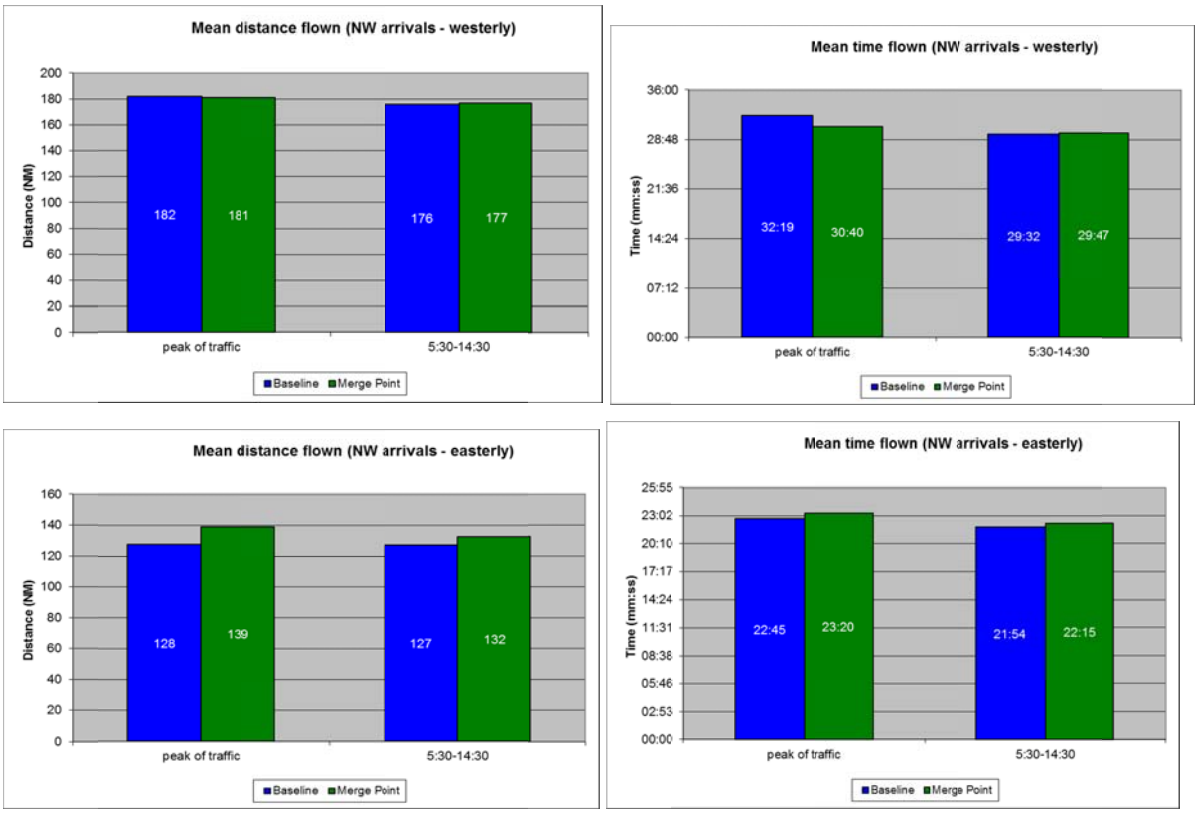


Figure 78: Distance and time flown in ACC+APP (NW arrivals)

As for North-East Merge Point, it is worth analysing the distance and time flown in ACC and APP separately. Indeed, one objective of Point Merge was to absorb more delay in E-TMA (on the legs) rather than in TMA (and rather than in vectoring in E-TMA).

The analysis of distance and time flown in ACC (from 100NM from LFPG to 42NM to LFPG) and APP (from 42NM from LFPG to 5NM to LFPG) during peak traffic shows that aircraft flew:

- Equivalent distance and time in ACC in Point Merge
  - o -1NM and -49'' with westerly LFPG runway configuration
  - o +8NM and +46'' with easterly LFPG runway configuration
- equivalent distance and time in APP in Point Merge
  - o -50'' with westerly LFPG runway configuration
  - o +3NM and -11'' with easterly LFPG runway configuration

Except for distance flown in ACC with easterly LFPG runway configuration (i.e. 24/11/2012), this analysis shows that aircraft flew equivalent distance and time in ACC and in APP. Those equivalent distance and time flown are confirmed with the analysis of the months of November and December 2012 presented in this part: 6.2.3.2.3.2.36.2.3.2.3.2.3.

As explained previously, 24/11/2012 was a special day for two reasons: a strong back wind for LFPG flights in TP and apparently, controller made aircraft flown on legs more than necessary.

This analysis doesn't show that delay was moved from TMA to E-TMA like North-West Point Merge in June.

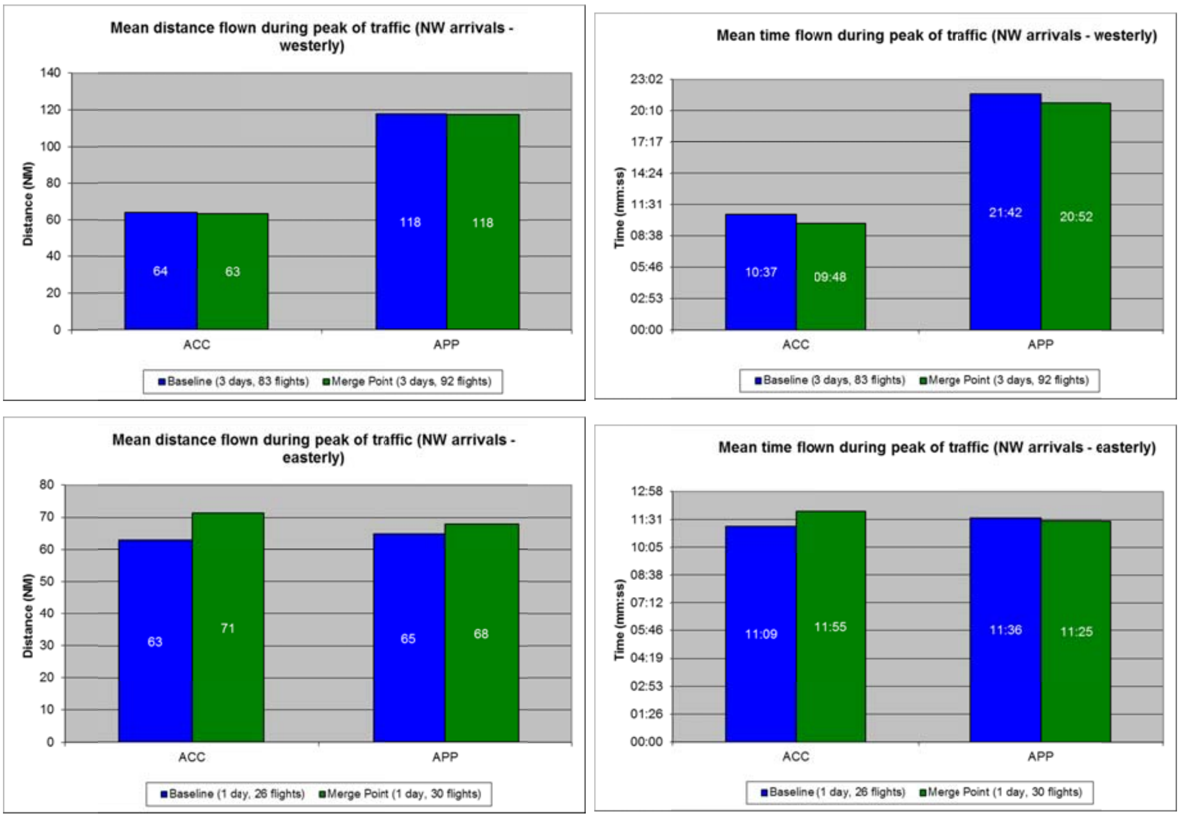
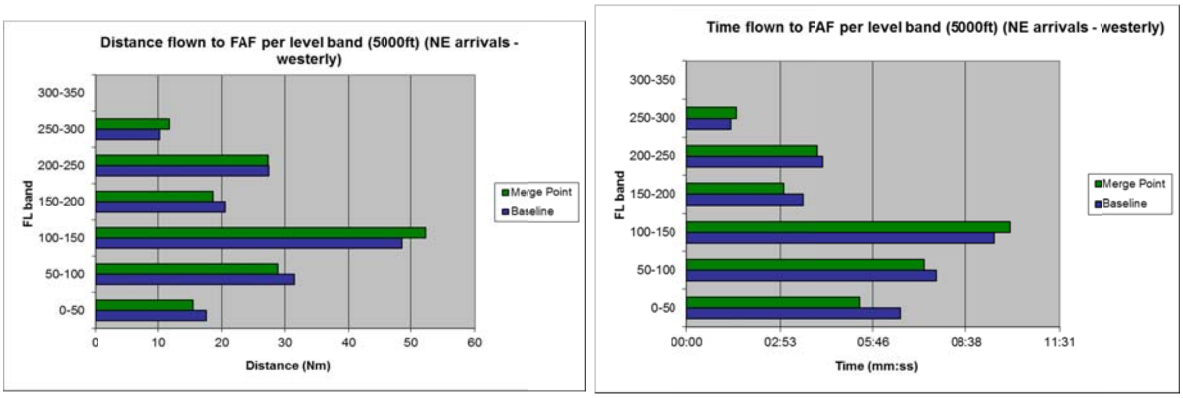


Figure 79: Distance and time flown in ACC and APP during peak traffic (NW arrivals)

The analysis of distance and time flown per level band during peak traffic shows that with Point Merge aircraft stayed longer higher, typically between FL150 and FL250 with easterly configuration.

With westerly configuration:

- above FL200 distance and time flown per level band are equivalent in Point Merge and in Baseline,
- below FL100 distance and time flown per level band are lower in Point Merge,
- between FL100 and FL150 aircraft stayed longer with Point Merge.



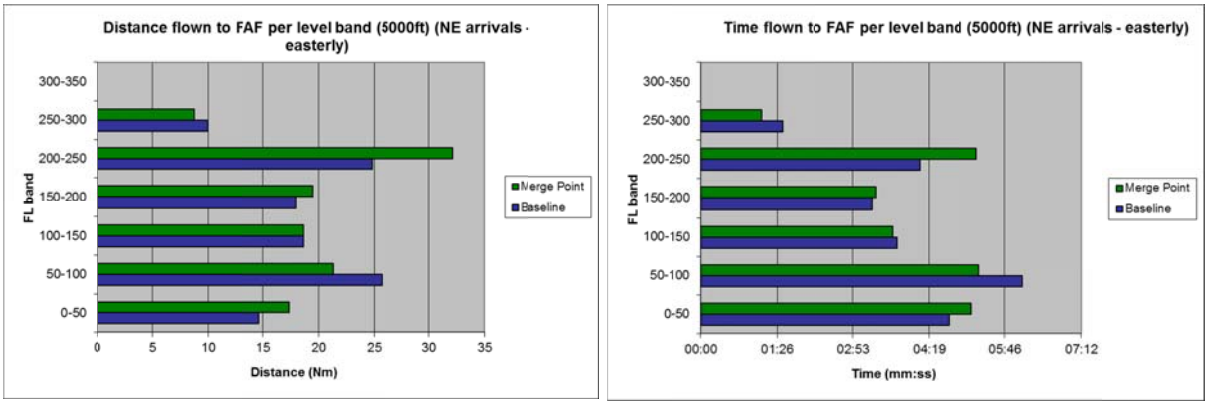


Figure 80: Distance and time flown per level band during peak of traffic (NE arrivals)

The mean descent profiles of North-West LFPG arrivals shown in Figure 81 are consistent with previous results and show that with Point Merge aircraft were maintained longer at higher level, in both LFPG runway configurations.

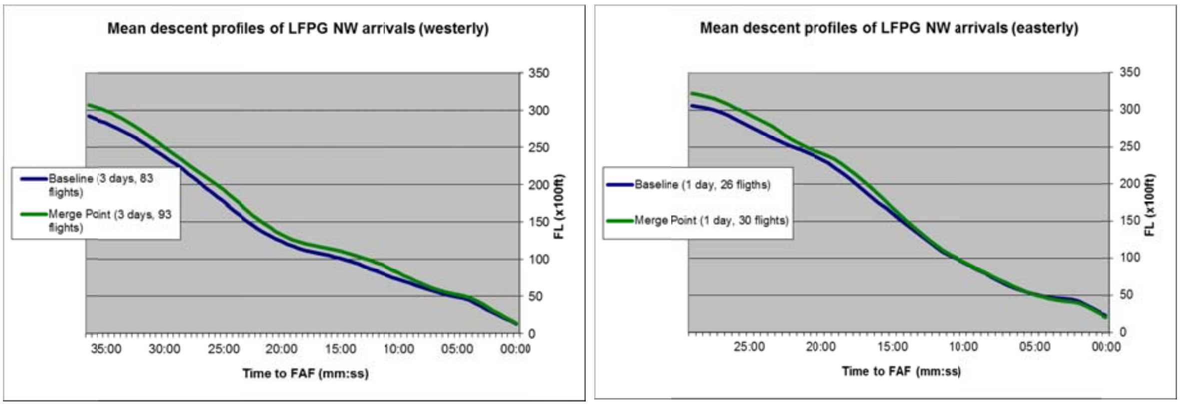


Figure 81: Mean descent profiles during peak traffic (NW arrivals)

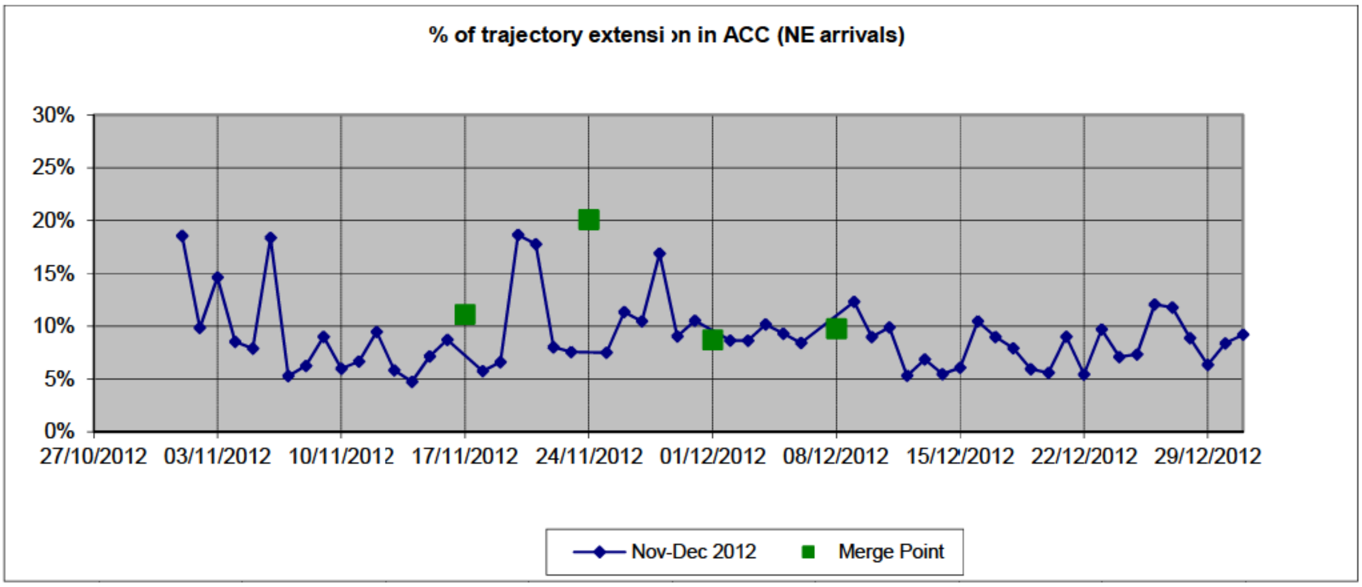
6.2.3.2.3.2.3 Statistics in November2012

As it is complicated to have a comparable Baseline, we performed some measures on every day of November and December 2012 during peak traffic. Two kinds of figure have been produced:

- Percentage of trajectory extension in ACC
- Mean distance and time flown in ACC+APP.

Mean distance and time flown in ACC+APP has been only calculated for westerly LFPG runway configuration because most of days in November 2012 had westerly LFPG runway configuration.

Figure 82 below shows that the percentage of trajectory extension in ACC is very different depending on days. This mean that mean delay is very different. It depends a lot of how the traffic enters in ACC, and not only how much traffic there is. There is an important variation from a day to another.



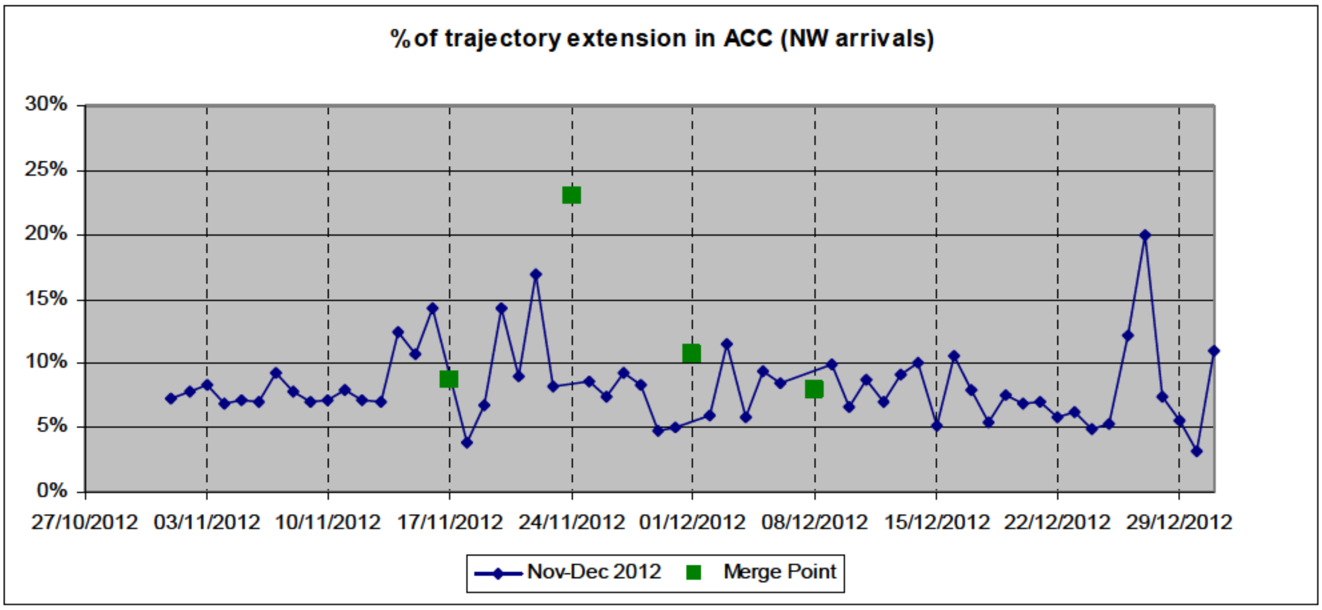
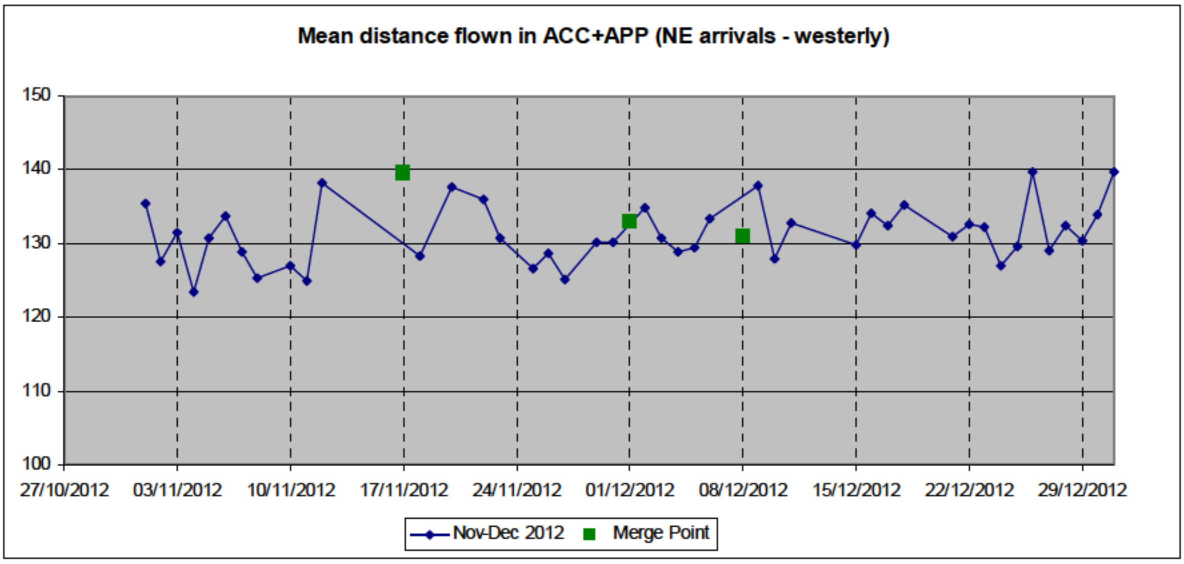


Figure 82: Percentage of trajectory extension in ACC for November and December 2012 during peak traffic

Figure 83 and Figure 84 shows the mean distance and the mean time flown in ACC+APP during peak traffic. It only concerns days with westerly LFPG runway configuration. In both North-East arrivals and North-West arrivals the variation of distance and time flown in ACC+APP is quite noticing. And values for Point Merge days are totally included in this variation.

The conclusion is that distance and time flown in ACC+APP is equivalent to other days.



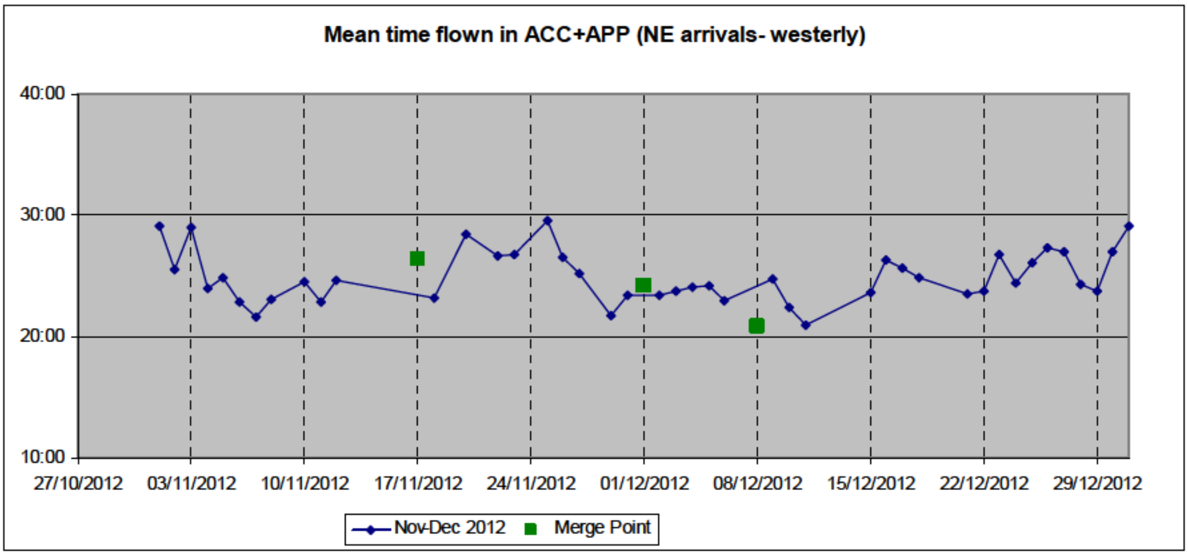
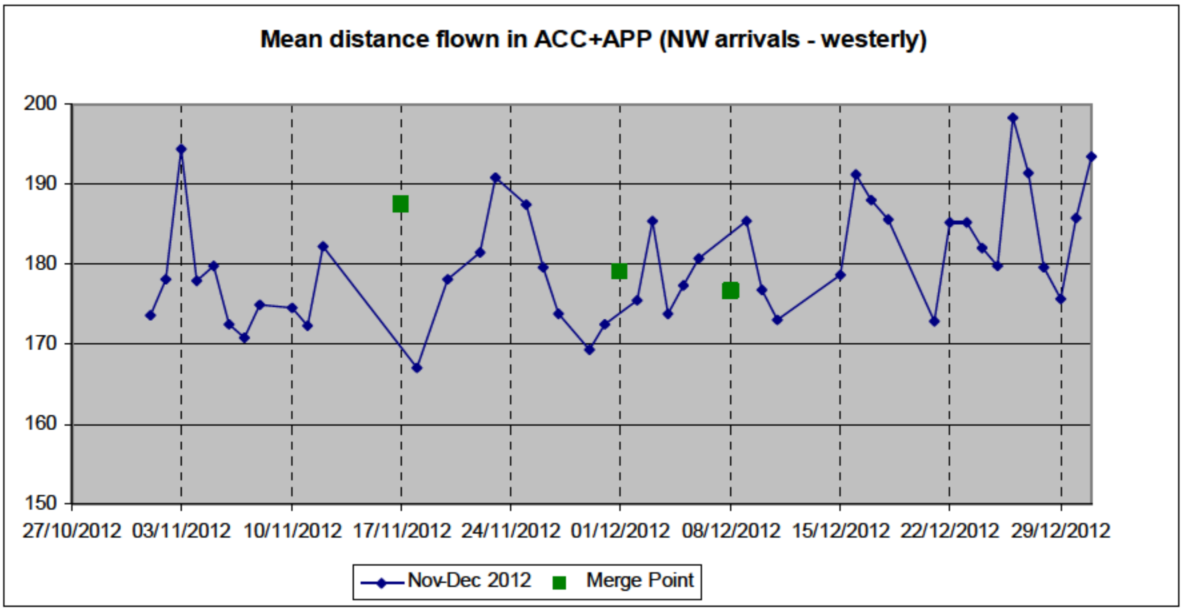


Figure 83: Mean distance and time flown in ACC+APP for November and December 2012 during peak traffic (NE arrivals, westerly)



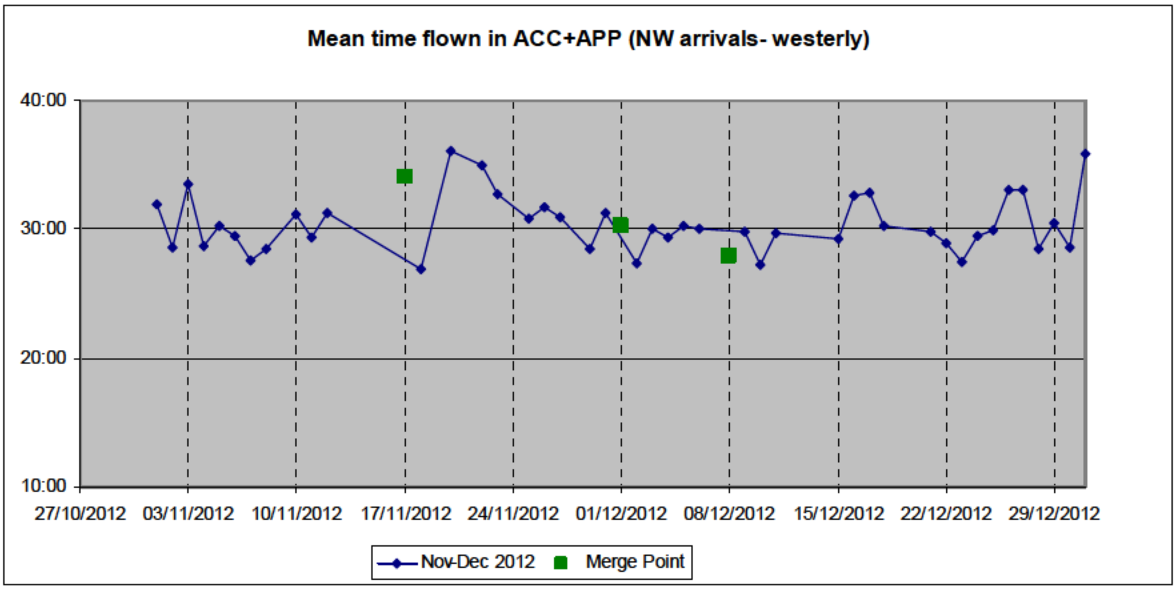


Figure 84: Mean distance and time flown in ACC+APP for November and December 2012 during peak traffic (NW arrivals, westerly)

6.2.3.2.4 Flight Crew's Opinion

Flight crews were invited to give their opinion on the Point Merge procedure through a questionnaire. The questionnaire was sent to about 40 airlines. Only Air France and Regional airlines provided some feedback.

As shown in Figure 85:

- 29 Air France pilots filled in the questionnaire. Among them, one took the leg; the 28 others received a direct clearance to the Merge Point (i.e. IAF).
- 8 Regional pilots filled in the questionnaire (among the 44 concerned flights). 6 received a direct clearance to the Merge Point.

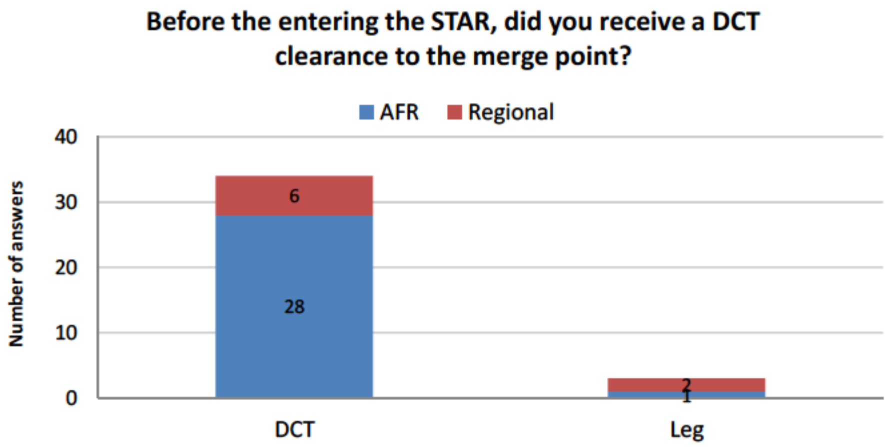


Figure 85: Number of pilots' answers on having received a direct clearance or flown on the leg

Note: Only Air France provided a complete feedback to the Point Merge questionnaire. However, few pilots answered all the questions.

As shown in Figure 86, two pilots (the one having flown the leg and one having had a direct clearance) stated that the speed was imposed by the ATC.

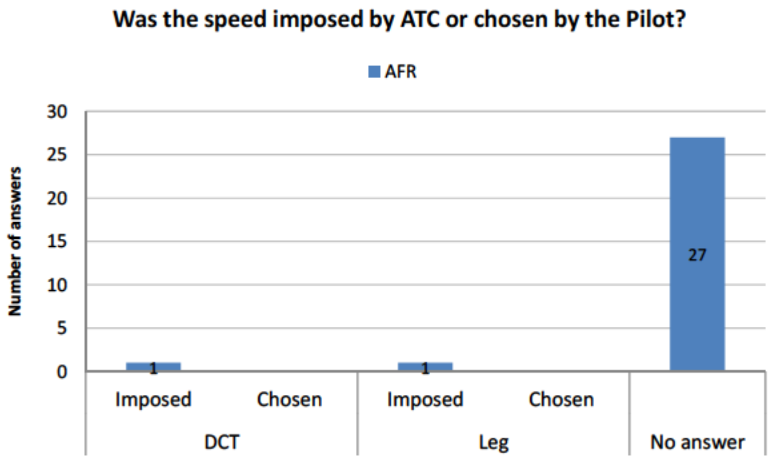


Figure 86: Number of pilots' answers on having had speed imposed or chosen

Figure 87 shows that the pilot who flown the leg was not proposed to descend at discretion. Among the pilots who received a direct to the Merge Point, 3 answered they were not proposed to descend at discretion, 3 that they were.

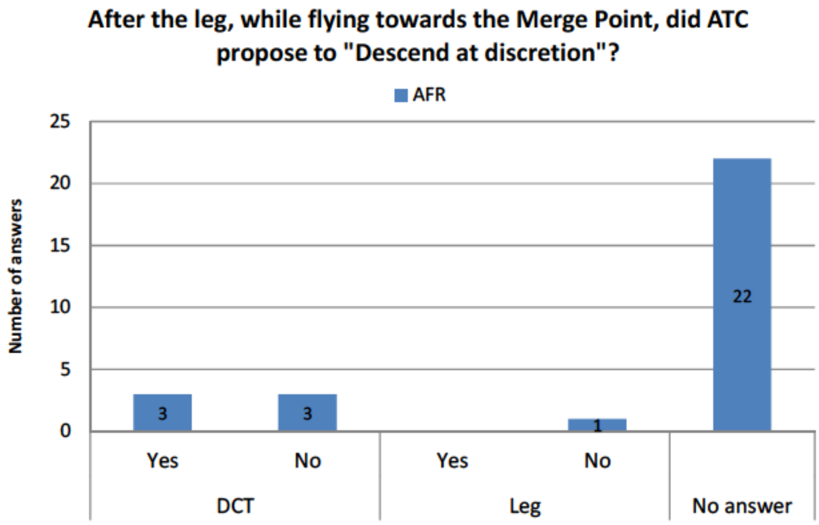


Figure 87: Number of pilots' answers on having been proposed to “descend at discretion”

Figure 88 and Figure 89 show that the pilot who flown the leg reported that the ATC requested a fixed rate of descent and that it necessitated to extend the airbrakes. Among the pilots who received a direct to the Merge Point, 1 answered that the ATC requested a fixed rate of descent, 5 that they did not.

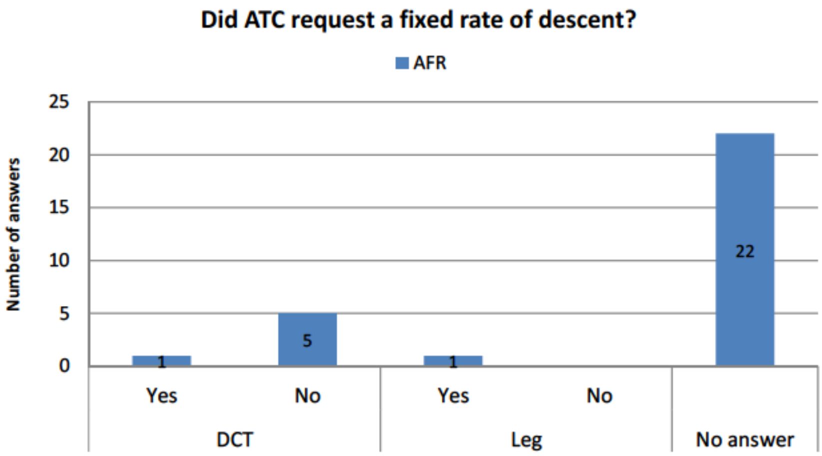


Figure 88: Number of pilots' answers on having had to extend the airbrakes during the descent

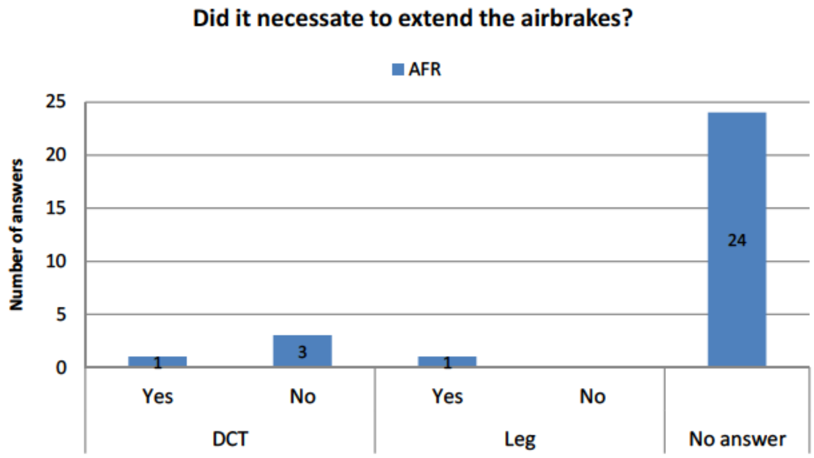


Figure 89: Number of pilots' answers on having had to extend the airbrakes

As shown in Figure 90, the pilot who flown the leg answered the ATC did not provide the information of the estimated time to loose on the leg. One pilot out of 15 pilots who received a direct and answered the question stated that s/he was provided with the information of the estimated time to get to the Merge Point.

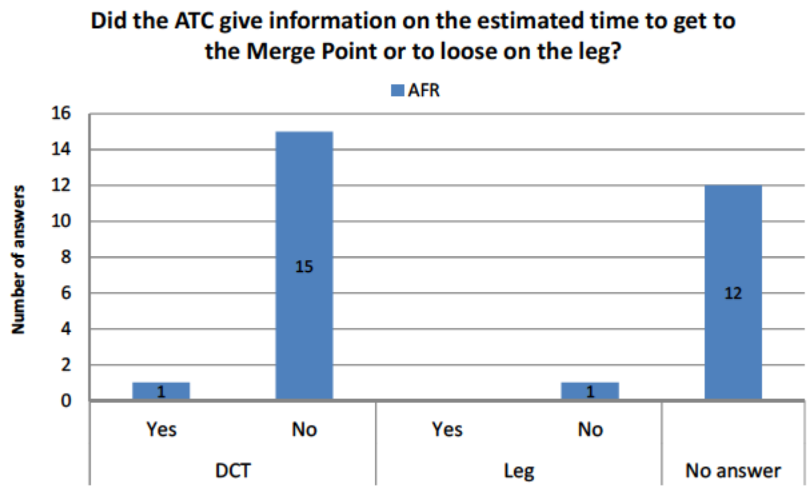


Figure 90: Number of pilots' answers on having received information on the estimated time to get to the Merge Point or to loose on the leg

As shown in Figure 91 below, the few pilots who gave their impression about the Point Merge procedure in terms of safety, radio communications, handling of the procedure and clarity of phraseology was positive or neutral (RAS, i.e. nothing to signal).

The negative answer was given by a pilot who did not take the legs. No explanation was provided but the general negative comments along the questionnaire revolve around the issue of fuel calculation.

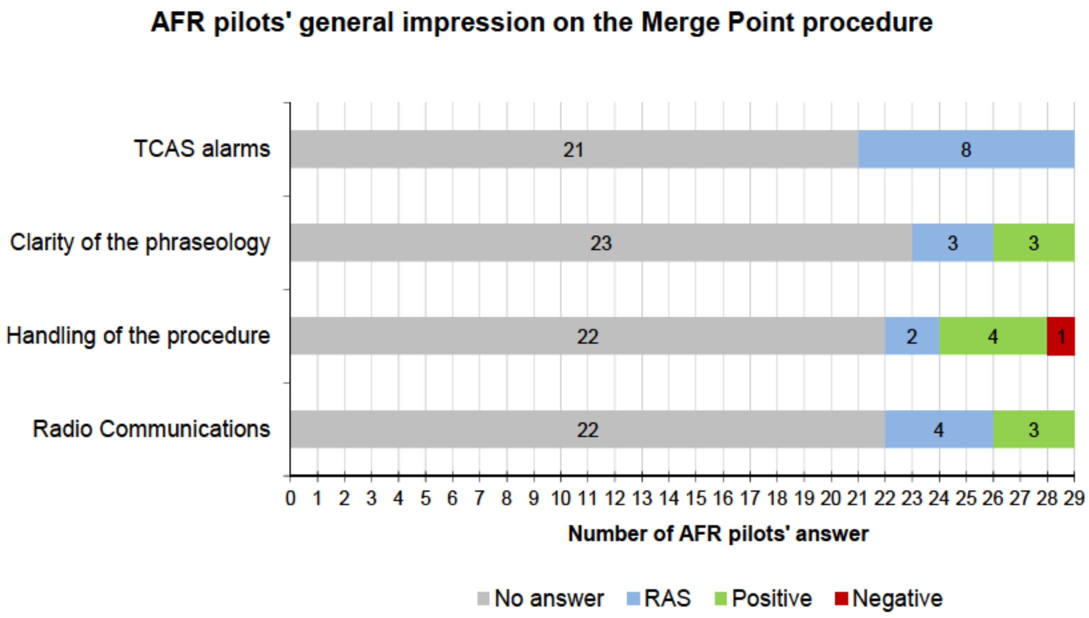


Figure 91: AFR pilots' answers on their general impression on the Point Merge procedure

Consistent with the feedback in June Live Trials, the issue of fuel calculation was reported. The coding of the entire route in the FMS leads to an overestimate of fuel carriage and thus to extra fuel consumption, which results in a wrong Estimated Time of Arrival (which happened in 85% of the time in November – December Live Trial, that is in case of direct routing). This point necessitates clarification possibly in terms of regulation: the Point Merge should be considered as a holding pattern and therefore not be part of fuel calculation for the trip.

6.2.3.2.5 Unexpected Behaviours/Results

Globally, the Live Trials went well. The few following unexpected events occurred:

- As in June Live Trials, flight fuel management during the end part of the flight required changes to the pilots. As the Point Merge procedure was coded in the FMS route, the fuel prediction and the calculated ETA were wrong during all the flight because there was a high probability that the aircraft would not fly the leg and would proceed direct to the Merge Point. This behaviour, unexpected at the beginning of the project, was confirmed during the second session of live trials.
- Some few aircraft did not have the updated STAR set in the FMS (mostly arrivals to LFPB).
- Some aircraft had odd trajectories when entering the leg (turn anticipation) especially at DELOM in APTE.
- There were LVP conditions three Saturdays out of four, which led to a reduction in traffic load.
- Delivery conditions from MUAC at DELOM at FL250 were not always respected (aircraft were sometimes too high) with no major consequence on the sector.
- There were some mistakes from Belgocontrol on the frequencies: aircraft that should have been sent to AP because of the change on lower limit were sent to TE.
- One specific event on TP occurred with a flight sent by NATS. The flight did not have the STAR and was no more RNAV due to FMS problem. A lack of coordination from NATS made the E-TMA controller change his strategy and the sequence. The flight has been guided with radar vectoring in order to be integrated in the sequence.

6.2.3.3 Confidence in Results of Validation Exercise

6.2.3.3.1 Quality of Validation Exercise Results

The validation exercise unfolded as planned without major problems.

The analysis of the frequency occupancy has a good quality. Indeed, deterioration could have occurred as it was a new procedure which could have required more talk between controllers and pilots. This is even more conclusive that the frequency occupancy was lower than in Baseline.

Wind has an impact on the time flown by aircrafts. That's why time flown indicators should be considered with caution. Distance flown indicators are more comparable from a day to another.

For a same quantity of traffic, there is not same delay. The way that traffic comes into a sector is very important and make days difficult to compare.

6.2.3.3.2 Significance of Validation Exercise Results

The frequency occupancy has been analysed depending to different values:

- depending to the number of flights in the sector,
- depending to the trajectory extension,
- depending to the number of flights with an important trajectory extension.

Those different comparisons make the result significant. Furthermore, confidence intervals have been calculated and confirm the result.

There is no absolute Baseline because traffic, wind and weather conditions are always quite different and even more than expected in the VALP.

To analyse the respect of the initial AMAN sequenced time and the distance and time flown in ACC+APP, some statistical tests have been performed as measurements on each day in November and December.

No statistical test was performed from the questionnaires.

As to the operational significance, there was full representativeness of the validation exercise performed as live trials.

6.2.4 Conclusions and recommendations

6.2.4.1 Conclusions

Point Merge November – December Live Trials went well. However, the traffic load was globally rather low.

The results are consistent with those obtained in June Live Trials and show that the use of the Point Merge with the AMAN had a global positive impact on the management of the arrival sequence.

The different data analyses have shown that:

- Frequency occupancy in APTE sector was lower during Point Merge days.
- Distance and duration flown was equivalent to other days in November and December 2012.
- The respect of the initial AMAN sequenced time was equivalent to other days in November and December 2012.
- Aircraft spacing over delivery points during peak traffic were similar to Baseline.
- It was shown that aircraft stayed at higher altitude with Point Merge, which could have a positive impact on fuel efficiency.
- Fuel consumption was equivalent with the Point Merge than in baseline for an equivalent time to loose (to be confirmed for Nov/Dec trial).

From a Human Performance perspective, the Point Merge with AMAN procedure has been perceived positively:

- Paris ACC controllers reported that the Point Merge system provided more flexibility and saved mental resources which could be redeployed to optimise the sequencing and the conflict resolutions. They considered that the use of the Point Merge and AMAN improved the quality of the delivery, of the sequencing, and of the service provided to the flight crews and to the Approach. Controllers also reported improved safety and situational awareness as the fights were strategically separated on the legs, which made the traffic less conflicting. On the North-East sector, the task allocation between controllers was considered as improved compared as today (better balanced in terms of workload and more efficient).
- Paris APP controllers reported improved delivery conditions of LFPG arrivals, and thus improved safety due to the respect of these delivery conditions. They considered that their situational awareness was enhanced compared as today. No impact on workload was reported.
- Pilots' general impression was positive. As in June Live Trials, the issue of fuel calculation taking into account the entire route (including the legs) was raised: it leads to extra fuel carriage, which prevents flight optimisation, and sends a wrong Estimated Time of Arrival (ETA) to the arrival station.

6.2.4.2Recommendations

Please refer to 5.2.

7 References

Reference to Main Documentation, delete If not required.

This section identifies the documents (name, reference, source project) the Validation Report has to comply to or to be used as additional inputs.

7.1 Applicable Documents

[1] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

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

[5] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

7.2 Reference Documents

The following documents provide input/guidance/further information/other:

[6] WP C.03, C.03-D03-Regulatory Roadmap Development and Maintenance Process
https://extranet.sesarju.eu/Programme%20Library/Forms/General.aspx

[7] WP C.03, C.03-D02-Standardisation Roadmap Development and Maintenance Process
https://extranet.sesarju.eu/Programme%20Library/Forms/General.aspx

[8] SESAR Business Case Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[9] SESAR Safety Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[10] SESAR Security Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[11] SESAR Environment Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[12] SESAR Human Performance Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[13] D07 Guidance on list of KPIs for Step 1 Performance Assessment Ed1
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

Remark: *if help is needed, the* ***WP16 Front-Office*** *can be contacted by e-mail. Do not hesitate to send an e-mail to extranet@sesarju.eu. Please start the subject line with Front-Office and use relevant keywords e.g. Safety, ATM Security, etc., or 16.06.01, 16.06.02 ..."*

[14] ATM Master Plan
https://www.atmmasterplan.eu

[15]05.06.07-D09-Step 1 AMAN + Point Merge - Validation Plan, Edition 00.01.00 https://extranet.sesarju.eu/WP_05/Project_05.06.07/Project%20Plan/DEL-05.06.07_D09_VALP_AMAN_Point_Merge.doc

[16]05.06.07-D04-Step 1 AMAN + Point Merge - OSED, Edition 00.02.00 https://extranet.sesarju.eu/WP_05/Project_05.06.07/Project%20Plan/DEL-05.06.07_D04_OSED_Point_Merge_00.02.00.doc

[17]05.06.07-Exercise 427 - Live trials “Point Merge and AMAN” at Paris ACC in 2012

[18]PMS live trials FABEC review meeting #2 – 6th of August 2012, Meeting minutes, 20/08/2012

[19] 05.06.07 Real-time simulations in support of the Point Merge live trials in Paris ACC, Edition 00.00.01, 19/09/2012

[20]Belgocontrol, SESAR 5.6.7 ex 427: Operational Impact Analysis of PMS NE Live Trials, Edition 1.0, dated 19/01/2013 https://extranet.sesarju.eu/WP_05/Project_05.06.07/Other%20Documentation/DSNA%20EXE%20427%20Point%20Merge%20in%20complex%20E-TMA/REP05.06.07-Exercise427%20Step%201%20AMAN%20+%20Point%20Merge%20-%20Operational%20Impact%20Analysis%20of%20PMS%20by%20Belgocontrol%20v1.pdf

[21] 5.06.07-D04-Step 1 AMAN + Point Merge – SPR, Edition 00.00.04

Appendix A Safety Assessment Plan

The Safety Assessment Plan consists in showing how to make use of the OFA Validation exercises (through the identification of adequate Validation Objectives and Success Criteria) in order to demonstrate that the Safety Criteria are achievable by the PMS+AMAN in E-TMA design.

In preparation of the validation of the concept for Point Merge + AMAN in E-TMA, Safety Acceptance Criteria (SAC) corresponding to success criteria for the validation objectives have been defined in the Appendix A.1.1 of the SPR [21], namely the PMS+AMAN Safety Assessment Report.

The demonstration of the SAC achievability by the PMS+AMAN in E-TMA design will be provided by making use of the Validation Results reported in the PMS+AMAN Validation Report.

The following tables extracted from the Appendix A.1.1 of the SPR [21], presents the link of the two Safety Assessment Criteria (SAC#1 and SAC#2) to EXE-427 Validation objectives and success criteria as per AMAN+Point Merge in E-TMA Validation Plan **Erreur ! Source du renvoi introuvable.**.

In these tables are identified the Validation Objectives and associated Success criteria which would deliver validation results that are pertinent for demonstrating that the AMAN+PMS in E-TMA design achieves the SACs. Each choice is justified through an argument of the type: “would the success criteria be fulfilled in the Validation exercise, how does it contribute to demonstrate qualitatively that the SAC is met by the design.”

Table 26. Link of SAC#1 to EXE-427 Validation objectives and success criteria

Validation Objective ID	Validation Objective title	Success crit. ID	Success criterion title	Applied to (ACC, E-TMA or APP)	Justification for adequacy to SAC#1
OBJ-05.06.07-VALP-0427.0100	Controller workload assessment	CRT-05.06.07-VALP-0427.0100	Average answer to perceived workload question is that PMS reduces workload.	APP	Reduction in APP workload (compared to Baseline) indicates that less numerous and/or less complex plan-induced conflicts remain to be solved in TMA, hence confirms the increased efficiency of the Traffic Planning&Synchronisation barrier (B10) in relation to the arrival traffic pre-sequencing performed in E-TMA
OBJ-05.06.07-VALP-0427.0200	Trajectory predictability assessment	CRT-05.06.07-VALP-0427.0200	Better compliance with initial AMAN sequenced time than in baseline	E-TMA + APP	The fact that AMAN delay to be absorbed is more accurately respected shows a potential to increase RWY throughput, whilst maintaing the current level of safety, which can be interpreted as an increased efficiency of the Traffic Planning&Synchronisation barrier (B10)
VALP-0427.0400	IAF delivery conditions assessment	CRT-05.06.07-VALP-0427.0400	Aircraft separations and speeds over IAF equal or better than in baseline	APP	The improved IAF delivery conditions indicates the increased efficiency of the Traffic Planning&Synchronisation barrier (B10) in relation to how arrival traffic is managed in E-TMA in view of being handed over to TMA
OBJ-05.06.07-VALP-0427.0500	Safety assessment	CRT-05.06.07-VALP-0427.0500	Level of safety felt by controllers equal or better than in baseline	APP	The better “safety perception” of APP controllers indicates that less numerous and/or less complex plan-induced conflicts remain to be solved in TMA, hence confirms the increased efficiency of the Traffic Planning&Synchronisation barrier (B10) in relation to the arrival traffic pre-sequencing performed in E-TMA
OBJ-05.06.07-VALP-0427.0500	Safety assessment	CRT-05.06.07-VALP-0427.0510	Controllers average answer to situation awareness question is that situation awareness is better than in baseline	APP	The better situation awareness of APP controllers indicates that less numerous and/or less complex plan-induced conflicts remain to be solved in TMA, hence confirms the increased efficiency of the Traffic Planning&Synchronisation barrier (B10) in relation to the arrival traffic pre-sequencing performed in E-TMA

Table 27. Link of SAC#2 to EXE-427 Validation objectives and success criteria

Validation Objective ID	Validation Objective title	Success crit. ID	Success criterion title	Applied to (ACC, E-TMA or APP)	Justification for adequacy to SAC#2
OBJ-05.06.07-VALP-0427.0100	Controller workload assessment	**CRT-05.06.07-VALP-0427.0100**	Average answer to perceived workload question is that PMS reduces workload.	E-TMA	Reduction in E-TMA EXE controller workload (compared to Baseline) indicates that less effort is required for the tactical control, that might be interpreted as an increase in Tactical Conflict Resolution barrier efficiency (B5, B6, B7) and a reduction for the ATC potential to induce conflicts (frequency of MF7.1)
OBJ-05.06.07-VALP-0427.0100	Controller workload assessment	**CRT-05.06.07-VALP-0427.0100**	Average answer to perceived workload question is that PMS reduces workload.	ACC	The absence of negative impact on workload in upstream ACC adjacent sectors, in relation to ensuring the correct traffic delivery conditions to E-TMA, shows that the Tactical Conflict Resolution barrier efficiency (B5, B6, B7) within those ACC sectors is not affected
OBJ-05.06.07-VALP-0427.0500	Safety assessment	**CRT-05.06.07-VALP-0427.0500**	Level of safety felt by controllers equal or better than in baseline	E-TMA	The better “safety perception” of E-TMA controllers can be interpreted as an increase in Tactical Conflict Resolution barrier efficiency (B5, B6, B7) and a reduction for the ATC potential to induce conflicts (frequency of MF7.1) NOTE (regarding analysis of validation results): It is particularly important to get the “safety perception” of the E-TMA PLN controller involved in the sequence coordination with the SEQ and traffic planning &coordination with TMA, as his workload is expected to increase in AMAN+Point Merge.
OBJ-05.06.07-VALP-0427.0500	Safety assessment	**CRT-05.06.07-VALP-0427.0510**	Controllers average answer to situation awareness question is that situation awareness is better than in baseline	E-TMA	The better situation awareness of E-TMA controllers can be interpreted as an increase in Tactical Conflict Resolution barrier efficiency (B5, B6, B7) and a reduction for the ATC potential to induce conflicts (frequency of MF7.1)

Appendix B Human Performance Assessment Plan

This appendix describes the result of the activities conducted to date according to the Human Performance Assessment Process to derive the Human Performance Plan for the project 05.06.07 Point Merge + AMAN concept. It corresponds to the completion of the first steps of the Human Performance Assessment Process.

The outputs of the steps are described and used to scope and identify the Human Performance activities that should be performed given the level of maturity of the concept at this stage of the project (V3 after live trials).

The recommended human performance activities identified form the basis for the Human Performance Plan presented in this appendix. Two activities have been recommended in the plan to address the potential issues and impacts identified in several HP work areas, namely:

1. Live trials in June 2012
2. Live trials in November - December 2012.

B.1 Introduction

B.3.1 Purpose of the appendix

The purpose of this appendix is to describe the result of the activities conducted according to the Human Performance (HP) assessment process [2] in order to derive the HP assessment report for Point Merge + AMAN including requirements and recommendations.

Note: The objective of the HP Assessment Plan is to ensure that HP aspects are taken into account. As the HP aspects were already addressed in the project before the production of this appendix became mandatory, its content is somewhat redundant with the work done in the framework of the VALP and VALR. While some new information is provided regarding the nature of the change, the results themselves mostly replicate the ones already given in the previous sections of this validation plan.

B.3.2 Intended readership

The intended audience for this appendix are the other team members of the project 05.06.07 under investigation, and those in the corresponding technical project 10.09.02 Multiple airport arrival/departure management.

At the level of the transversal areas and federating projects, WP16.06.05 and X.2 are also expected to have an interest in this appendix.

Other stakeholders that may be interested in this appendix are to be found among:

- Affected employee unions
- ANS providers
- Airport owners / providers
- Airspace users

B.3.3 Scope of the appendix

The aim of the SESAR project P05.06.07 Point Merge + AMAN is to assess an operational concept that enables efficient and early management of arrival constraints, which relies on E-TMA / TMA close coordination. Point Merge operating method relies on a systematic sequence of actions, attached to predefined geographic locations including merging to a single point (instead of merging to an axis), and path stretching along sequencing legs (at the same distance from the merge point). The Point Merge is a systemised method for sequencing arrival flows designed to replace radar vectoring (see section 6.1.1 of project 05.06.07 Validation Plan).

This appendix describes the HP Assessment Plan for the Point Merge + AMAN concept applied in Paris ACC for sequencing Northern arrival flows to Paris CDG.

A Point Merge + AMAN Safety Assessment Report [3] is also available, which describes safety requirements and mitigation effects in case abnormal conditions and hazards would prevent the normal use of the Point Merge procedure.

Note: The Human Performance Assessment Plan does not take into consideration the effects on upstream sectors (such as MUAC). It is assumed that the Merge Pont System is acceptable with regard to its effects on upstream sectors/centres, from a network point of view.

B.3.4 Human performance work schedule within the project

The Human Performance Assessment for the Point Merge + AMAN started in June 2011 and is expected to finish in February 2013.

B.3.5 Structure of the appendix

This appendix is structured as follows:

- Section 1 (this section) introduces the appendix.
- Section 2 provides a short overview of the Human Performance assessment process.
- Section 3 presents the activities performed and the findings obtained from the Human Performance assessment steps conducted and completed to date. The HP validation objectives for the given level of maturity of the concept are identified and the HP activities required to meet these objectives are described.
- Section 4 lists the documents referenced in this appendix.

B.3.6 Acronyms and Terminology

Term	***Description***
Human Factors (HF)	HF is used to denote aspects that influence a human's capability to accomplish tasks and meet job requirements. These can be external to the human (e.g. light & noise conditions at the work place) or internal (e.g. fatigue). In this way, "Human Factors" can be considered as *focussing on the variables that determine Human Performance*.
Human Performance (HP)	HP is used to denote the human capability to successfully accomplish tasks and meet job requirements. In this way, "Human Performance" can be considered *as focussing on the observable result of human activity in a work context*. Human Performance is a function of Human Factors (see above). It also depends on aspects related to Recruitment, Training, Competence, and Staffing (RTCS) as well as Social Factors and Change Management.
HP activity	An HP activity is an evidence-gathering activity carried out as part of Step 3 of the HP assessment process. An HP activity can relate to, among others, task analyses, cognitive walkthroughs, and experimental studies.
HP assessment	An HP assessment is the documented result of applying the HP assessment process to the SESAR project-level (i.e. WP4-15 projects). HP assessment provide the input for the HP case.
HP assessment process	The HP assessment process is the process by which HP aspects related to the proposed changes in SESAR are identified and addressed. The development of this process constitutes the scope

	of Project 16.04.01. It covers the conduct of HP assessments on the project-level as well as the HP case building over larger clusters of projects.
HP benefit	An HP benefit relates to those aspects of the proposed ATM concept that are likely to have a positive impact on human performance.
HP case	An HP case is the documented result of combining HP assessments from projects into larger clusters (e.g. Operational Focus Areas, deployment packages) in SESAR.
HP issue	An HP issue relates to those aspects in the ATM concept that need to be resolved before the proposed change can deliver the intended positive effects on Human Performance.
HP impact	An HP impact relates to the effect of the proposed solution on the human operator. Impacts can be positive (i.e. leading to an increase in Human Performance) or negative (leading to a decrease in Human Performance).
HP recommendations	HP recommendations propose means for mitigating HP issues related to a specific operational or technical change. HF recommendations are proposals that require additional analysis (i.e. refinement and validation). Once this additional analysis is performed, HF recommendations may be transformed into HF requirements.
HP requirements	HP requirements are statements that specify required characteristics of a solution from an HF point of view. HP requirements should be integrated into the DOD, OSED, SPR, or specifications. HF requirements can be seen as the stable result of the HF contribution to the project, leading to a redefinition of the operational concept or the specification of the technical solution.

B.2 The Human Performance Assessment Process: Objective and Approach

The purpose of the HP assessment process described in detail in [2] is to ensure that HP aspects related to SESAR technical and operational developments are systematically identified and managed.

It is a four-step process. Figure 92 provides an overview of these four steps with the tasks to be carried out and the two main outputs (i.e. HP plan and HP assessment report).

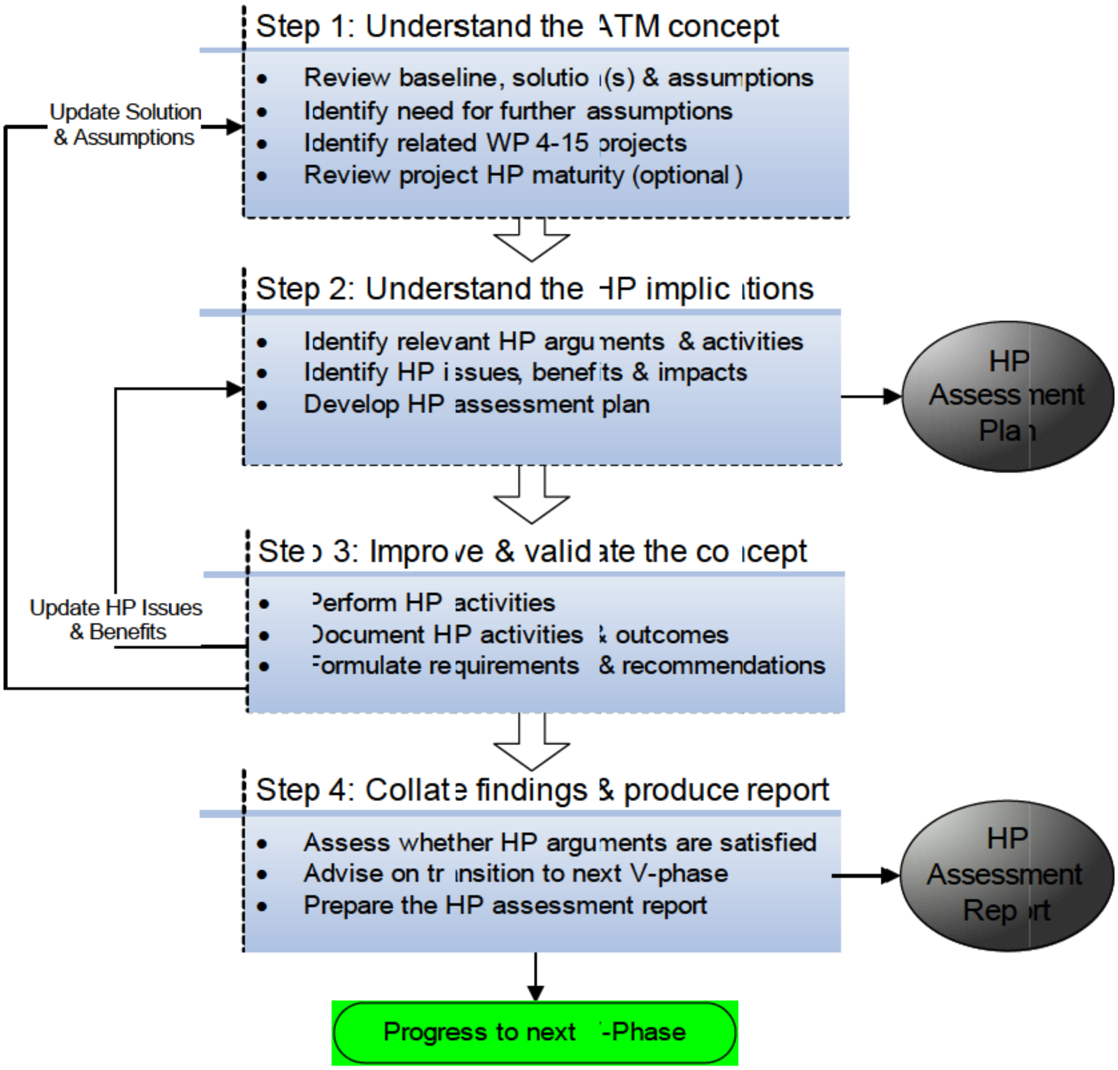


Figure 92: Steps of the HP assessment process

B.3 Human Performance Assessment

B.3.1 Step 1 Understand the ATM concept

B.3.1.1 Description of reference/solution scenarios

Table 22 summarises the main changes currently foreseen due to the introduction of the Point Merge + AMAN. It defines the system 'element' that will change and describes at a high level the current system and the system proposed in future operations. The information provided in the table is extracted from the Point Merge + AMAN OSED [4], from EUROCONTROL Point Merge OSED [5] and from the Point Merge + AMAN Safety Assessment Report [3].

Table 28: Comparison of reference system with proposed system under Point Merge + AMAN operations

REFERENCE AND PROPOSED SYSTEM COMPARISON		
ELEMENT	**REFERENCE ATM SYSTEM**	**PROPOSED ATM SYSTEM**
Airspace structure and routes	Current P-RNAV procedures defined for high density operations in terminal airspace often replicate pre-existing or typical vectoring patterns, merging to an axis.	The baseline airspace structure and routes (e.g. STARs) are modified in order to host a merging pattern composed of sequencing legs shaped as an arc of a circle centred towards a point defined strategically, called "Merge Point". The merging of the air traffic is performed on this point of convergence instead of to an axis. The sequencing of the air traffic flows is defined tactically. The sequencing legs are to be included in the STAR description.
Operating methods	Today's procedures to manage the arrival sequence (merging of arrival flows into a runway sequence) involve open-loop radar vectoring. Currently, the delays provided by the AMAN are applied first in APP (via Time To Lose/Time To Gain instructions i.e. speed, level, heading) and then, when above a limit, to the ACC. In current day operations, the sequencing, metering and separation aspects of arrival flows integration are often overlapping.	The Point Merge procedure involves closed loop instructions (closed STARs), i.e. flights follow FMS predefined lateral trajectories. Open-loop radar vectors are only used to recover from unexpected situations. The Point Merge supports another method for splitting delay absorption, allowing to transfer delay from APP to ACC. Point Merge introduces a clear split of arrival flows integration between sequencing (related to the order in which the controller issues the 'direct-to' instruction) and inter-aircraft spacing (related to the time when the 'direct-to' instruction is issued, and to subsequent speed control). The delay to be absorbed in E-TMA is provided by the AMAN.
Workload	In case of high traffic, air traffic controllers issue a large number of heading, speed and FL/altitude tactical instructions, which results in high workload both for flight crews and controllers, and in an intensive use of the R/T.	The Point Merge method requires fewer tactical interventions, which has a positive impact on E-TMA EXE controllers' and pilots' workload and R/T occupancy. As closed STARs are used, flights will follow FMS predefined lateral trajectories. The ATCO work is standardized. The Point Merge + AMAN concept allows optimising the arrival sequence by extending the anticipatory horizon. This involves a more

REFERENCE AND PROPOSED SYSTEM COMPARISON		
ELEMENT	**REFERENCE ATM SYSTEM**	**PROPOSED ATM SYSTEM**
		intensive coordination task for the E-TMA Planning Controller and the TMA Sequence Manager, which may increase their workload.
Organisation system	Today, there is one TMA sequence (SEQ) manager whose role is to establish the arrival sequence and one TMA Planning controller (or coordinator) to coordinate if needed with the E-TMA planning controller (provided with AMAN display) for time to lose / time to gain instructions.	There might be one or two SEQ managers (one in TMA and one in E-TMA), depending on whether TMA and E-TMA controllers are on the same location and/or on TMA traffic level and complexity, and/or specific Point Merge design considered.

B.3.1.2 Consolidated list of assumptions

The assumptions related to the Point Merge + AMAN concept are listed in chapter 2.2.5

B.3.1.3 List of related WP 4-15 projects to be considered in the HP assessment

The following projects could be influenced by the HP assessment of project 05.06.07 Point Merge + AMAN:

- SESAR WP 03 Validation Infrastructure Adaptation and Integration: The HP assessment findings may be of use in future integrated validation that would include advanced AMAN and Point Merge System.
- SESAR WP 05.02 Consolidation of Operational Concept Definition and Validation: The outcome of the HP validation objectives of this project may be of use for the validation of the SESAR TMA Operations concept for Step1.
- SESAR WP 05.03 Integrated and Pre-Operational Validation & Cross Validation: Since the HP validation objectives provide validation information to the SESAR TMA Operations concept for Step1, WP 05.03 should be aware of the outcomes of this HP assessment.

B.3.2 Step 2 Understand the HP implications

B.3.2.1 Identification of the nature of the change

This section describes the main HP-related impacts of the changes resulting from the introduction of the proposed concept in terms of who will be impacted and how, and identifies the impacted HF work areas on which to focus the HP assessments.

Some of the information included in the following table comes from EUROCONTROL Point Merge OSED [5].

Table 29: Description of the change

ARGUMENT BRANCH / HF AREA	CHANGE & AFFECTED ACTORS
ROLES & RESPONSIBILITIES	
ROLES & RESPONSIBILITIES	Depending on local conditions, two possible implementations of the Point Merge can be envisaged involving two to four controllers: • Implementation 1: the sector is managed by one Executive Controller + one Planning Controller as today in the E-TMA. • Implementation 2: the sector (corresponding to two sectors in today operations, each managed by an EXE and a PLN) is managed by two Executive Controllers (one responsible for the legs, one for the descent to the MP) + two Planning Controllers (one responsible for the upstream and downstream coordination with the feeding sectors for arrival and departure flows, one for the coordination with SEQ);. In case there are two SEQ managers (cf. table 1), the Planning Controller works in coordination with the E-TMA SEQ in charge of flow management, who works him/herself in coordination with the TMA SEQ Manager.
OPERATING METHODS	The use of a Point Merge combined with an AMAN to merge arrival flows in a runway sequence requires fewer tactical interventions as the flights follow closed STARs. The Point Merge + AMAN constitute an important change towards a simplification: the procedure is easy to apply (no headings, one level to give, speed is set). Because of this, there may be a risk of skill loss with regards to open-loop vectoring if radar vectoring is no more used by the controllers in normal operations on any of the sectors or on any of the configurations (westerly or easterly). In that case, the following mitigation strategies could be applied: • Recurrent training to open-loop vectoring to cope with unexpected / non-nominal situations. • ATFCM restrictions (reduce arrivals, stop departures etc.) when reverting to radar vectoring. The MP + AMAN system is more predictable than the current operations allowing an anticipated synchronization work between the E-TMA and the TMA to prepare the sequence: with the current system, the sequencing point is located at the transfer point; with the MP + AMAN, it is located on the sequencing legs 35 NM to 45 NM before the transfer point, which leaves time to refine the sequence. The anticipatory horizon is extended because the

	sequence is visible earlier. A better knowledge of trajectory and speed will allow flight crews to increase the use of the FMS (the aircraft FMS will have the description of Point Merge legs). As the Point Merge will reduce the need for controllers to interfere in the flight profile after the aircraft leave the legs, this will allow FMS optimised descent. As the Point Merge procedure is coded in the FMS route, the fuel prediction and the calculated ETA might be wrong during all the flight because there is a high probability that the aircraft will not fly the leg and proceed direct to the Merge Point. Pilots will therefore probably keep this “full” trajectory in the secondary flight plan but modify their primary FMS flight plan into a “direct” one in order to retrieve accurate time and fuel estimates.
TASKS	The use of the MP with the AMAN facilitates the building of the arrival sequence It allows optimising the arrival sequence by extending the anticipatory horizon. In the E-TMA, a new task consists in assessing all the arrival traffic flows in coordination with the TMA Sequence Manager in order to improve the runway sequence. The use of the Point Merge + AMAN implies a wider awareness of the TMA needs and pilots’ requests (e.g. meet arrival delay, provide time to loose on the legs, grouping / ordering aircraft according to the wake turbulence and performance). The iso/equidistance property of the sequencing legs from the merge point helps the controller, during the path stretching phase, to more easily assess the spacing with the preceding aircraft in the sequence (already on course to the merge point), and therefore to determine with sufficient accuracy the appropriate moment to issue the ‘direct-to’ instruction. The procedure saves the E-TMA controllers’ mental resources which are redeployed to improve the service provided to the pilots. It improves the quality of the delivery (more accuracy) and the quality of the sequencing (e.g. respect of AMAN sequence).
HUMAN & SYSTEM	
ALLOCATION OF TASKS	The AMAN is a support tool, not a control tool. The Planning Controller still monitors the AMAN sequence and checks if it is consistent with what the Executive Controller is going to do. If not, the PC coordinates with the TMA Sequence Manager to change de sequence.
PERFORMANCE OF TECHNICAL SYSTEM	The Point Merge + AMAN configuration has to be done and the setting validated before being put in operations.
HUMAN – MACHINE INTERFACE	In the E-TMA working environment, an AMAN should be available displaying a local E-TMA view as well as a TMA view for the Sequence Management activity. The information of time to loose should be available in E-TMA on the AMAN display of the E-TMA positions. Recommendation: that information should be complemented by providing the E-TMA EXE Controllers with the moment when the aircraft have to turn towards the Merge Point. With the use of the Point Merge, the arrival sequence in the AMAN

	is stabilised before entering the leg, thus improving the predictability (without the MP, the arrival sequence information provided by the AMAN can change until late). The radar HMI has a default setting displaying all the waypoints to the Merge Point. The lateral distance between legs is determined, amongst others, by the ATCO capability for adequate radar monitoring of aircraft flying on adjacent legs (cf. Safety Assessment report [3]). With the Point Merge procedure, the flight crew is provided with information of the longest possible track before the IAF.
TEAMS & COMMUNICATION	
TEAM COMPOSITION	In case there are two SEQ managers (cf. Table 1), the E-TMA SEQ Manager would coordinate the global arrival sequence in coordination with the TMA SEQ Manager. He/She could balance the workload within the E-TMA sectors and help balancing the traffic on the runways.
ALLOCATION OF TASKS	Today, in the E-TMA with the radar vectoring, the sequence is decided by the Executive controller; the Planning controller coordinates with the TMA SEQ manager to give the aircraft order in the sequence. With the MP + AMAN, the sequence being frozen earlier than in the baseline, the PLN controller's task is enhanced. S/He informs the EXE controller of the best sequence order and spacing for the TMA. However, the EXE controller still remains in control of his/her choice, which can be different depending on the traffic in his/her sector. The PLN controller provides the information; s/he does not give an order.
COMMUNICATION	With the MP + AMAN, the frequency usage is reduced, with the same level of service as the one provided in the current operations. This is due to the fact that the MP procedure replaces radar vectoring, i.e. the route is the planned route available in the FMS. This has a positive impact on the Executive Controller's workload, which is reduced. The use of the MP combined with the AMAN allows a more efficient coordination between the E-TMA Planning Controller and the TMA Sequence Manager thanks to improved sequence predictability (due to the use of P-RNAV routes), which has a positive impact on the arrival sequence management. Whereas with the radar vectoring the coordination is more effort and time consuming for the trajectories are less predictable. The controllers' team dynamics is less complex because more standardized: the headings are "closed". The Planning Controller can anticipate what will happen by watching the Executive Controller's radar display. Thanks to the improved predictability, the PC knows earlier than today the order of the sequence. The handover is facilitated as it is much easier for the giving E-TMAExecutive Controller to explain the situation to the receiving E-TMAExecutive Controller as it is a standard one. A new phraseology has been defined (cf. SUP AIP AIRAC 1441/12: "Continuous descent to a flight level at waypoint"). A new phraseology is still to be defined for the controller to provide the flight crews with the information aimed to improve their flight profile. This is planned to be done for the end of 2013. *(Note: this part of the phraseology was not defined before the trials as the provision*

	of such information to the flight crews was not requested from the controllers).
HP RELATED TRANSITION FACTORS	
ACCEPTANCE & JOB SATISFACTION	The Point Merge + AMAN offer an intuitive way of sequencing the arrival traffic flows, which facilitates the controllers' confidence in the system. The Point Merge + AMAN improve the controllers' job satisfaction by allowing them to provide a better service to the flight crews.
COMPETENCE REQUIREMENTS	No negative transfer of training is identified. The knowledge of the use of the AMAN and radar vectoring is a prerequisite. An AMAN should be installed on the training platform. The trainer must be a global expert of the use of the Point Merge with the AMAN, and be qualified in flow management. The E-TMA Executive and Planning Controllers need to acquire additional competence to work with the MP combined with the AMAN. The E-TMA controllers shall also be trained to acquire an awareness of the global airport environment in order to be able to provide new services. Depending on the implementation, with the use the MP + AMAN, there is risk of skill degradation when reverting to radar vectoring if radar vectoring is no more used by the controllers on any of the sectors or on any of the configurations. In that case, the training should include contingency training regarding reverting to vectoring. In any cases, the training shall include recovery and contingency training regarding the following situations: • Arrival delay not absorbed • AMAN problem • Radio failure • Meteorological situations. Pilots' training should include: • Explanation of the logic of the Point Merge procedure; • Explanation in flight fuel management for the end part of the flight. If the FMS route incorporates the complete DME leg a pilot who is not trained will load fuel for the complete leg and send a wrong Estimated Time of Arrival (ETA) to the station. • Recovery and contingency training for lost communication procedures. No new regulatory requirements are defined with the use of the MP + AMAN as the Point Merge procedure is a STAR. The current regulation applies. However, there is a requirement regarding regulatory texts to be updated so that the direct route is planned for fuel calculation purpose in the objective of performance (see section 6.1.3.1.3 of the Validation Plan).
STAFFING REQUIREMENTS & STAFFING LEVELS	Depending on the Point Merge implementation and/or specific Point Merge design considered, and especially in case it is necessary to balance the traffic between many airports, one new role might be needed in big and complex E-TMAs: a Sequence

	Manager in the E-TMA in order to manage the AMAN in coordination with the TMA Sequence Manager (to manually adjust the sequences when required).

B.3.2.2 Relevant arguments, issues & benefits and HP activities

To identify HP arguments relevant for the project and their related potential HP issues and benefits due to the introduction of the Point Merge + AMAN concept, two activities were performed:

- A literature review was performed. It includes the Point Merge + AMAN OSED [4] and documents produced EUROCONTROL which has completed a series of small scale real-time simulations on this concept (OSED [5], Validation Report [6]).
- A half-day workshop was conducted with Paris ACC controllers in order to identify the HF issues related to the use of the Point Merge + AMAN and their potential impacts on the project.

These activities helped identify potential issues relating to the introduction of the Point Merge + AMAN system.

The identified issues and benefits, categorised into HP argument, are presented in the table below.

It should be noted that the identified issues may not be exhaustive or complete. Additional HP issues could be identified as the assessment processes / validation activities progress.

The table below includes some of the arguments identified in Table 29, except the following ones:

- The controllers' team dynamics is less complex because more standardized (teams and communication).
- The MP+AMAN offer an intuitive way of sequencing the arrival traffic flows, which facilitates the controllers' confidence in the system (acceptance & job satisfaction).
- The MP+AMAN improve the controllers' job satisfaction by allowing them to provide a better service to the flight crews (acceptance & job satisfaction).

Table 30: HP Arguments, related HP issues and benefits, and conducted HP activity

HP ARGUMENT	RELATED HP ISSUES & BENEFITS	HP ACTIVITY/IES
Arg. 1. The role of the human is consistent with the human capabilities and limitations **Arg. 1.3**. Human actors can achieve their tasks (in normal & abnormal conditions[6] of the operational environment and degrade modes of operation) **Arg. 1.3.3**. The level of workload (induced by cognitive and/or physical task demands) is acceptable.	**Reduced controller's workload.** Point Merge standardised procedures should reduce the usage of heading and level clearances for the controller, which should reduce the number of radio messages, and thus controller's workload. The reduction of frequency usage could be balanced by an improved service provision to flight crews. However, Point Merge + AMAN allow anticipating the sequencing of the arrival flows. This should involve a more intensive coordination task from the E-TMA PLN controller and the TMA Sequence Manager, therefore an increase of communication and workload.	Assess workload in Live trials (activities 1 & 2) through a subjective method (questionnaire). Measure frequency usage (to prove frequency usage reduction). Measure sequencing grouping, total delay absorbed, etc. (to prove improved service provision).

[6] Abnormal conditions (i.e.weather conditions like presence of CBs, AMAN failure and recovery, etc.) will be assessed whenever they occur during the live trials. In the case of operational live trials, only some limited parameters are within the control of the validation team for the experimental design (e.g. the time of the day when the observation session will take place...). Many factors, such as for instance the weather, cannot be controlled. Observation of these situations can only occur in an opportunist way.

Arg. 4. Human Performance related transition factors are considered **Arg. 4.2**. Changes in competence requirements are analysed. **Arg. 4.2.1**. Knowledge, skill and experience requirements for human actors have been identified.	**Risk of controllers' loss of skill** with regards to open-loop vectoring.	N/A *ATCOs' vectoring skills shall be maintained through recurrent training to cope with unexpected / non-nominal situations.*
Arg. 1. The role of the human is consistent with the human capabilities and limitations **Arg. 1.3**. Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degrade modes of operation) **Arg. 1.3.5**: Human actors can maintain a sufficient level of situation awareness.	**Improved ATCO & Pilots' situational awareness**. Point Merge standardised procedures provide a more structured airspace, which should contribute to increase controllers and pilots' situational awareness, which in turn should have a positive impact on safety.	Assess individual situational awareness in Live Trials (activities 1 & 2) with subjective methods (questionnaire, debriefings).
Arg. 1. The role of the human is consistent with the human capabilities and limitations **Arg. 1.3**. Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degrade modes of operation) **Arg. 1.3.5**: Human actors can maintain a sufficient level of situation awareness.	**Improved trajectory predictability.** Trajectory prediction should be improved through extensive RNAV application and use of FMS lateral guidance even in high traffic. The Point Merge allows applying metering measures before reaching the TMA using the legs, which should allow informing the pilot about the estimated approach time.	Assess individual situational awareness and trajectory predictability in Live Trials (activities 1 & 2) with objective methods (data recordings) and subjective methods (questionnaire, debriefings).

B.3.3 Step 3 Improve and validate the concept

B.3.3.1 Description of HP activities with results

Table 31 and Table 32 contain a detailed description of the proposed HP activities.

Note: the objectives identifiers used in the table below are those used in section 3.6 2 of the Validation Plan.

Table 31: Description of Activity 1- Live Trials: E-TMA Merge Point + AMAN use for Northwest traffic to Paris CDG

ACTIVITY 1.	LIVE TRIALS – JUNE 2012
DESCRIPTION	This activity consists in live operational validation of the Point Merge + AMAN concept. These live trials were performed at Paris ACC during 6 days from Monday 18th June to Saturday 23rd June 2012. This first live trials session aimed at assessing, real traffic conditions, one E-TMA Point Merge system for Northwest traffic to Paris CDG, coupled to the use of the MAESTRO AMAN in DSNA Paris-ACC and at the approach of the Paris CDG Airport, being fed from London ACC and Brest ACC.
RELATED ARGUMENTS	**Arguments 1.3.3 and 1.3.5 listed in** Table 30 can be satisfied by carrying out this Live Trials.
HP OBJECTIVES	The live trials addresses the following HP objectives described in the 05.06.07 Validation Plan: • OBJ-05.06.07-VALP-0427.0100 - Controller workload assessment • OBJ-05.06.07-VALP-0427.0200 - Trajectory predictability assessment • OBJ-05.06.07-VALP-0427.0500 - Safety assessment
ISSUES TO BE ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	The issues & benefits from Table 3 to be addressed by the Live Trials are as follows: • Reduced Controllers' workload • Improved trajectory predictability • Improved Controllers' & Pilots' situational awareness
TOOL SELECTED OUT OF THE HP RESPOSITORY	Questionnaires have been developed for both controllers and pilots. • The questionnaires for controllers are specific to each ATC environment (i.e. Paris ACC and Paris CDG). They were designed in accordance with the specificities of the needs/missions of the various controlling entities. Paris ACC and Paris CDG questionnaires have been designed from the questionnaires used by EUROCONTROL in their RTS in order to ensure continuity. • The questionnaire for pilots was designed with help of Air France. Objective measures compared to baseline (frequency usage, number of phone coordination between ATCOs).
DETAILS OF THE HP ACTIVITIES	The evaluation of the North West Point Merge system was performed during six days in June from 03:30 AM to 12:30 AM (UTC). In order to obtain a baseline for the analysis of controllers' activity, the E-TMA TP sector was opened as a standalone sector during peak traffic the week before the Point Merge experimentation. Except the new STAR and the fact

	that the TP sector was opened as a standalone sector (instead of being grouped with another sector), no other system change has been planned; operations remained the same as usual. All of the Paris ACC and Paris CDG controllers participating to the Live Trials were fully qualified and trained the new procedure. They had a questionnaire to fill in at the end of their working session. Flight crews having flown to CDG through Paris TP sector during the sessions were invited to give their opinion on the Point Merge procedure through a questionnaire. Twenty nine pilots from three airlines answered the questionnaire.
RESULTS / EVIDENCE	The main results of the HP activity are as follows: • **Workload**: o In majority, the participating E-TMA controllers considered the workload was rather unchanged to clearly lower than in Baseline with the Point Merge. o In majority, the participating TMA controllers reported no significant impact of the Point Merge compared to today's situation. o The frequency occupancy in E-TMA with Point Merge was slightly more loaded than in Baseline during low traffic and equivalent during high traffic. This result is balanced by the fact that E-TMA controllers gave more information to pilots. o While the E-TMA EXE Controller's workload seems to be reduced with the use of the Point Merge and AMAN, the E-TMA PLN Controller's workload seems to be increased due to the coordination task performed with the TMA Sequence Manager to improve the management of the arrival sequence. • **Trajectory predictability**: o Most of the E-TMA controllers stated that they did not have to issue heading clearances or to issue and monitor intermediary levels due to the Point Merge. o Some of E-TMA controllers stated that they proposed the pilots to "descend at discretion" at the exit of the leg toward the Merge Point. • **Safety / Situational awareness**: o E-TMA controllers reported improved safety and situational awareness. They considered that the use of the Point Merge and AMAN improved the quality of the delivery, the quality of the sequencing, and the quality of service provided to the flight crews. o TMA controllers reported improved delivery conditions of LFPG arrivals in terms of separation, vertical and speed constraints, and thus improved safety due to the respect of these delivery conditions. They considered that their situational awareness was enhanced. o Pilots' general impression on the Point Merge procedure about radio communications, simplicity of the procedure, and clarity of the phraseology was globally positive.
NEWLY IDENTIFIED ISSUES	No new issues have been identified throughout the HP activity.

RECOMMENDATIONS & REQUIREMENTS	Cf. Section 5.2.

Table 32: Description of Activity 2 - Live Trials: E-TMA Point Merge + AMAN use for Northwest and Northeast traffic to Paris CDG

ACTIVITY 2.	LIVE TRIALS – NOVEMBER / DECEMBER 2012
DESCRIPTION	This activity consists in live operational validation of the Point Merge + AMAN concept. These live trials were performed at Paris ACC on 4 Saturdays from 17th November to 8th December 2012. This second live trials session aimed at assessing, real traffic conditions, two E-TMA Point Merge systems <u>for Northwest and Northeast arrivals</u> of the CDG airport, coupled to the use of the MAESTRO AMAN in DSNA Paris-ACC and at the approach of the Paris CDG Airport, being fed from EUROCONTROL Maastricht UAC, Belgocontrol Brussels ACC, London ACC and Brest ACC.
RELATED ARGUMENTS	**Arguments 1.3.3 and 1.3.5 listed in** Table 30 can be satisfied by carrying out this Live Trials.
HP OBJECTIVES	The live trials addresses the following HP objectives described in the 05.06.07 Validation Plan: • OBJ-05.06.07-VALP-0427.0100 - Controller workload assessment • OBJ-05.06.07-VALP-0427.0200 - Trajectory predictability assessment • OBJ-05.06.07-VALP-0427.0500 - Safety assessment
ISSUES TO BE ADDRESSED / INVESTIGATED FROM ISSUES ANALYSIS	The issues & benefits from Table 3 to be addressed by the Live Trials are as follows: • Reduced Controllers' workload • Improved trajectory predictability • Improved Controllers' & Pilots' situational awareness
TOOL SELECTED OUT OF THE HP RESPOSITORY	Questionnaires have been developed for both controllers and pilots. • The questionnaires for controllers are specific to each ATC environment (i.e. Paris ACC, Paris CDG, Belgocontrol, and MUAC). They were designed in accordance with the specificities of the needs/missions of the various controlling entities. Paris ACC and Paris CDG questionnaires have been designed from the questionnaires used by EUROCONTROL in their RTS in order to ensure continuity. • The questionnaire for pilots was designed with help of Air France. Objective measures compared to baseline (frequency usage, number of phone coordination between ATCOs).
DETAILS OF THE HP ACTIVITIES	The evaluation of the North West and North East Point Merge systems was performed on 4 Saturdays from 17th November to 8th December 2012. This exercise involved: • Paris ACC controllers (20): 14 controllers on APTE sector, and 6 on TP sector. • CDG controllers (about 120 controllers, i.e. about 30 arrival controllers per day). • Maastricht UAC controllers. • Belgocontrol Brussels ACC controllers. All the participating controllers were fully qualified and trained to the new procedure. They had a questionnaire to fill in at the end of their working session.

	Flight crews having flown to CDG through Paris TP, or APTE sectors during the sessions were invited to give their opinion on the Merge Point procedure through a questionnaire. Thirty Air France pilots answered the questionnaire.

RESULTS/EVIDENCE	The main results of the HP activity are as follows:
	• **Workload**:
	  o In majority, the participating E-TMA controllers considered the workload was rather unchanged to clearly lower than in Baseline with the Point Merge.
	  o In majority, the participating TMA controllers stated that the workload was unchanged (i.e. no impact of the Point Merge on workload).
	  o In the North East sector, the controllers reported a better and efficient balance of tasks allocation between AP and TE sectors compared to the current situation (baseline). The workload is split between AP and TE sectors, with AP building the sequence (descending on the legs, giving speed reductions and then directs to DEVIM) before transferring the flights to TE. TE then descends the traffic according to the other flows to the level required at the IAF.
	  o The frequency occupancy in E-TMA with Point Merge was equal or lower than in Baseline.
	• **Trajectory predictability**:
	  o Most of the E-TMA controllers stated that they did not have to issue heading clearances or to issue and monitor intermediary levels due to the Point Merge.
	• **Safety / Situational awareness**:
	  o All the participating E-TMA and TMA and TMA controllers stated that the level of safety was higher than in baseline or at least the same.
	  o E-TMA controllers considered that they had a better situational awareness with the Point Merge than without.
	  o All the participating TMA controllers reported a better situation awareness with Point Merge or at least equal.
	  o Pilots' general impression on the Point Merge procedure about radio communications, simplicity of the procedure, and clarity of the phraseology was globally positive.

NEWLY IDENTIFIED ISSUES	No new issues have been identified throughout the HP activity.
RECOMMENDATIONS & REQUIREMENTS	Cf. Section 5.2.

B.3.4 Step 4 Collate findings

B.3.4.1 Summary of HP activities

Table 33 lists the relevant HP arguments with the conducted HP activity(ies) and their outcomes.

Table 33: Summary of HP activities

HP ARGUMENT	HP ACTIVITY(IES)	MAIN OUTCOMES/EVIDENCE
Arg. 1. The role of the human is consistent with the human capabilities and limitations **Arg. 1.3**. Human actors can achieve their tasks (in normal & abnormal conditions[7] of the operational environment and degrade modes of operation) **Arg. 1.3.3**. The level of workload (induced by cognitive and/or physical task demands) is acceptable.	Assess workload in Live trials (activities 1 & 2) through a subjective method (questionnaire). Measure frequency usage (to prove frequency usage reduction). Measure sequencing grouping, total delay absorbed, etc. (to prove improved service provision).	The results show that while the E-TMA EXE Controller's workload seems to be reduced with the use of the Point Merge and AMAN, the E-TMA PLN Controller's workload seems to be increased due to the coordination task performed with the TMA Sequence Manager to improve the management of the arrival sequence (see section 6.1.3.2.1.3 of the Validation Report). The majority of the participating CDG controllers reported no significant impact on workload. The frequency occupancy in E-TMA with Point Merge was slightly more loaded than in Baseline during low traffic and equivalent during high traffic. This result is balanced by the fact that E-TMA controllers gave more information to pilots. Delay was more absorbed in E-TMA on the legs than in TMA. This allowed better anticipating the arrival sequence. The E-TMA PLN Controller had to perform a more intensive coordination task with the TMA Sequence Manager to improve the management of the arrival sequence. These results conform to the required evidence.
Arg. 1. The role of the human is consistent with the human capabilities and limitations **Arg. 1.3**. Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degrade modes of operation) **Arg. 1.3.5**. Human actors can maintain a sufficient level of situation awareness.	Assess individual situational awareness in Live Trials (activities 1 & 2) with subjective methods (questionnaire, debriefings).	The E-TMA controllers considered their situation awareness was enhanced. They found that they could better anticipate the traffic and that they were more available for the coordination between the E-TMA EXE and PLN Controllers. The majority of the participating TMA controllers considered safety was high or very high notably due to the respect of the delivery conditions in terms of flight level and speed. In majority, the situational awareness was rated as average to very high. Pilots' general impression was positive in terms of safety, radio communications, handling of the procedure and clarity of phraseology. These results conform to the required evidence.

[7] Merge Point system under LVP conditions were assessed as they occurred during the live trials.

Arg. 1. The role of the human is consistent with the human capabilities and limitations **Arg. 1.3**. Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degrade modes of operation) **Arg. 1.3.5**. Human actors can maintain a sufficient level of situation awareness.	Assess individual situational awareness and trajectory predictability in Live Trials (activities 1 & 2) with objective methods (data recordings) and subjective methods (questionnaire, debriefings).	The procedure saved mental resources, which was used by the E-TMA controllers to improve the service provided to the pilots (e.g. time to loose on the leg provided to the flight crews, descent at discretion towards the IAF flight level proposed to the flight crews). These results conform to the required evidence.

B.3.4.2 HP maturity of the project

This V3 validation exercise showed feasibility from the operational and technical integration perspectives.

Point Merge System in E-TMA coupled with AMAN is a solution ready to deploy that brings substantial capacity and safety benefits, but requiring particular attention to local implementation.

B.3.4.3 Synthesis of HP Objectives, Results, Recommendations & Requirements

B.3.4.3.1 OBJ-05.06.07-VALP-0427.0100 - Controller workload assessment

Controller's workload was assessed through questionnaires and objective measures (i.e. frequency load).

Overall, E-TMA controllers stated that their workload was average to very low with the Point Merge and AMAN. The frequency usage was lower than in the baseline. The Point Merge procedure was less demanding than radar vectoring; it saved mental resources, which was used to improve the service provided to the pilots (e.g. time to loose on the leg provided to the flight crews, descent at discretion towards the IAF flight level proposed to the flight crews) and to the Approach (e.g. grouping of aircraft according to their wake turbulence category), and to solve potential conflicts.

The frequency occupancy in E-TMA with Point Merge was lower in the North-East sectors (APTE) during Point Merge days. It was very close to Baseline in the North-West sector (TP) but more information was given by controllers to pilots.

Regarding the number of phone coordination between ATCOs:

- Phone communications between TP sector and the APP with the Point Merge in June trial were slightly increased, which could be explained by a more intensive coordination of Planning Controllers with the TMA Sequence Manager to improve the management of the arrival sequence. However, this result was not confirmed in November – December trial (important variations from a day to another).
- Phone communications between APTE sectors and the APP with the Point Merge were similar to Baseline.

In TMA, the controllers stated that the Point Merge had no significant impact on the workload.

For recommendation and requirements, refer to section 5.2.

B.3.4.3.2 OBJ-05.06.07-VALP-0427.0200 - Trajectory predictability assessment

Trajectory predictability was assessed through questionnaires and objective measures.

All the participating controllers in E-TMA and in TMA, as well as all pilots" feedbacks reported that trajectory predictability was improved.

- E-TMA controllers found that it was easier to respect the AMAN delays of the arrival traffic to LFPG. They reported that the use of the Point Merge with AMAN improved the quality of the sequencing and of the delivery. The number of open loops / holdings was lower with the Point Merge than in baseline..
- TMA controllers reported benefits of the delay absorption strategy with the Point Merge. The aircraft did not have to enter the holding pattern. Regarding the adherence to the AMAN advisories, a few controllers found that there was sometimes too much space between aircraft may be due to strong wind situations and also to the fact that ACC controllers, wanting to relieve the Approach, reduced the total delay to zero by making a longer use of the legs.
- The service provided to pilots in terms of predictability was improved with the Point Merge: when the E-TMA controllers had time, they informed the pilots on the time to loose on the legs. The flight management was facilitated as, once on the leg, the pilot knew the distance from the leg to the IAF transfer point and the expected flight level at the IAF. There were less level-offs with the Point Merge system compared to radar vectoring. The descent was more continuous. However, flight fuel management during the end part of the flight required changes from the pilots. As the Point Merge procedure was coded in the FMS route, the fuel prediction and the calculated ETA were wrong during all the flight because the aircraft generally did not fly the leg and proceeded direct to the Merge Point

For recommendation and requirements, refer to section 5.2.

B.3.4.3.3 OBJ-05.06.07-VALP-0427.0500 - Safety assessment

The safety feeling and situation awareness were assessed through questionnaires.

A majority of the participating controllers, in E-TMA and TMA, stated a high level of safety using the Point Merge procedure combined with the AMAN.

- E-TMA controllers found that it was either improved or at least as safe as today. The Point Merge was considered as easy to use. The aircraft are strategically separated on the legs, which made the traffic less conflicting. The Point Merge with AMAN was considered as more efficient to handle arrivals than radar vectoring, with less workload and more comfort compared to today.
- TMA controllers considered that safety and situational awareness were higher than in the baseline notably due to the respect of the delivery conditions in terms of flight level and speed.

All pilots' feedbacks were positive regarding safety. There was no safety issue (no Air Safety Reports).

For recommendation and requirements, refer to section 5.2.

B.4 References

[1] **16.06 Strawman Paper on Case Building in SESAR SWP 16.6** v0.8., 2010

[2] **16.04.01 Evolution from the ATM HF case to a HP Case Methodology for SESAR**, HP assessment process for projects in V2 (Feasibility) D04-001, 00.01.0 I, October 2011

[3] **05.06.07 (OFA) Safety Assessment Report (SAR)**, November 2012

[4] **05.06.07 D04 Step 1 AMAN+ Point Merge OSED**, V00.02.00, November 2011

[5] **Point Merge Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous Descent – OSED**, EUROCONTROL, 2.0, July 2012

[6] **05.06.07 Real-time simulations in support of the Point Merge live trials in Paris ACC**, 00.00.01, September 2012

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