Appendix J Demonstration Exercise EXE-VLD-07-002 (COP Sequencer for Hotspot Resolution) Report

This appendix is a report concerning the execution of the Demonstration Exercise EXE-VLD-07-002.

This exercise had been implemented with three different configurations and each configuration had executed one or more times as depicted in the figure below:

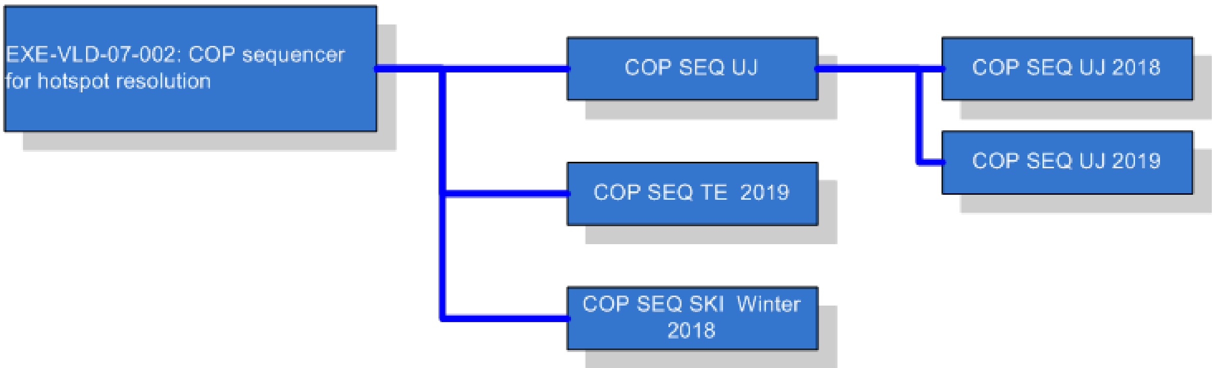


Fig. 1: Summary of all implementations of COP SEQ scenario

J.1 Summary of the Demonstration Exercise EXE-VLD-07-002 Plan

J.1.1 Exercise Description and Scope

The "COP Sequencer for hotspot resolution" trial uses Extended Arrival management techniques in order to smooth an arrival peak at the entry of the Extended TMA. It is part of a general concept for improving arrival management in Paris Area, as shown in the figure below:

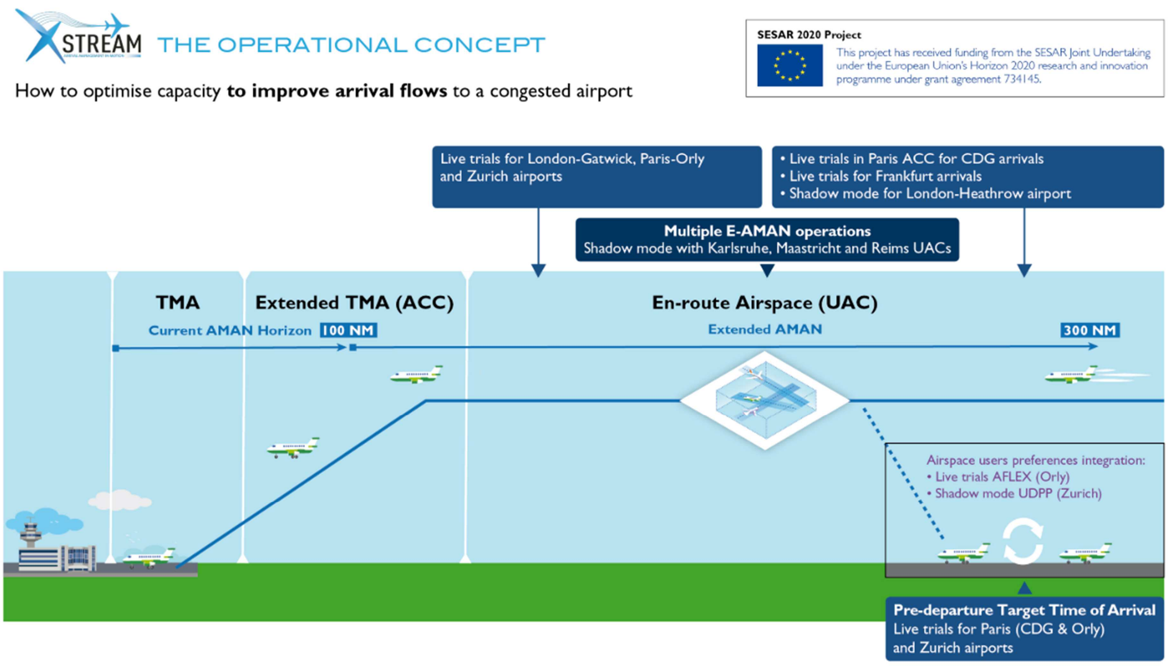


Fig. 2: Overview of Paris area arrival management concept and links between WP7 trials

Currently, in Paris ACC, arrival sequencing to Paris-CDG airport to streamline the arrival flows are being done by ATC at high altitude using radar vectors, speed control, and direct routings to comply with the different Letters of Agreement and Approach Control services in order to feed Paris TMA.

Due to the traffic structure and standard operating procedures in Paris TMA, Paris ACC has to provide all arrival flows to CDG 8 miles in trails at IAF to ensure an optimal feeding of the runway during traffic peaks.

These methods, when traffic load is heavy, may lead, with/without CASA regulations, to:

- Increased ATC complexity and workload,
- Inefficient ATFCM regulations generating unnecessary delays,
- Degraded flight efficiency.

For Paris ACC, the "COP Sequencer hotspot resolution" trials aimed at initiating arrival sequencing while the aircraft are still airborne in upstream en-route sectors. The concept is derived from Solution 5 – Extended Arrival Management horizon.

The trials were performed under the following conditions:

- When hotspots were detected by Paris FMP,
- Whether a CASA-regulation is activated or not,
- At a horizon of 20-30 mins before hotspot (depending on the amount of pop-up flights & data accuracy in the horizon).

An Extended AMAN Prototype tool (called iAMAN and derived from Paris operational AMAN) is used to compute an entry sequence into the extended-terminal sequencing area using ETFMS data from Eurocontrol's Network Manager B2B services.

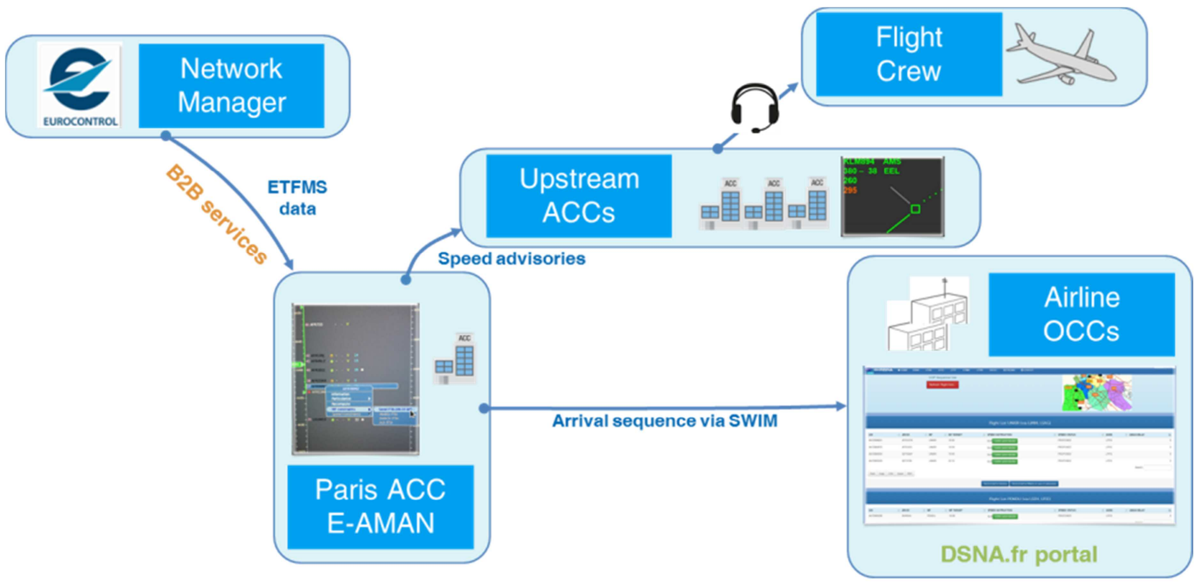


Fig. 3: Technical architecture for feeding of Extended AMAN tool and exchange of Arrival Sequence with partners during EXE-VLD-07-002

The COP Sequencer process is independent of the airspace configuration. Accordingly, the process described in the figure below is applicable to all implementations of the COP SEQ scenario.

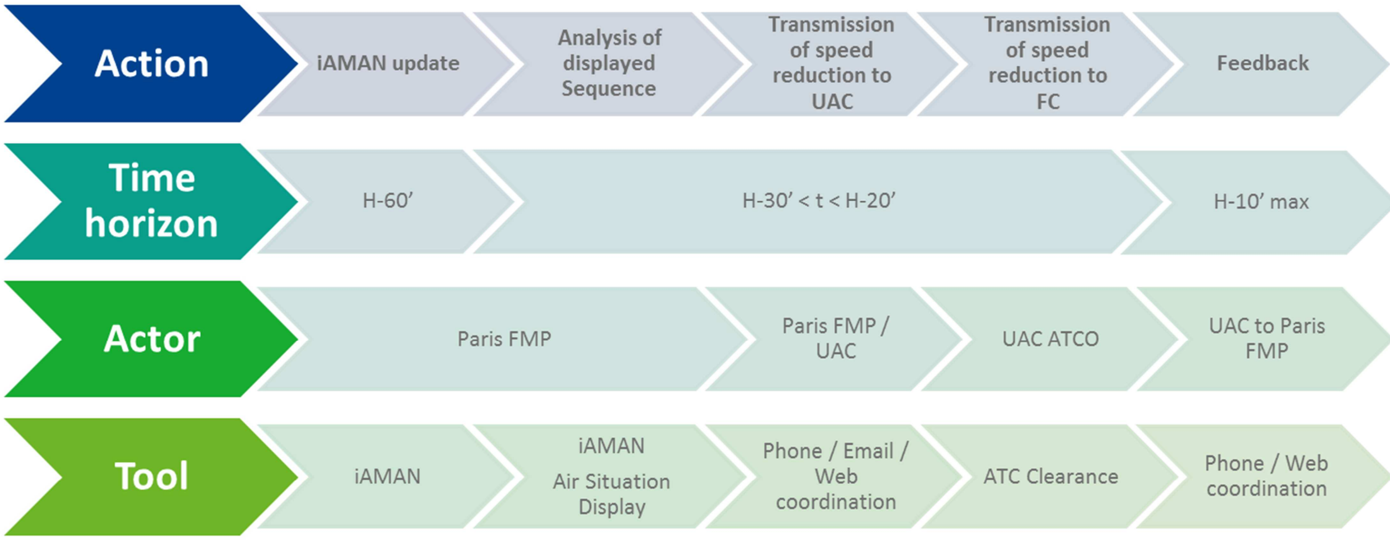


Fig. 4: Trial process for COP Sequencer for hotspot resolution

Note:

- H referring to the time of the detected arrival hotspot in the Extended TMA:

The process consists of the following steps:

- **H-60’**: Paris FMP operator analyses the incoming arrival hotspot using iAMAN, he also analyses the local conditions such as military activity, winds enroute, and TMA and E-TMA weather,
- **H-40’/H-20’**: Once the arrival sequence is built and stable, it is displayed on iAMAN in Paris ACC. Using the iAMAN HMI in Paris ACC and an available Air Situation Display on the FMP position, Paris FMP selects on iAMAN the flights that should receive speed reduction advisories in upstream ACC (Mach M0.04 reduction and speed 250 KIAS upon conversion),
- **H-30’/H-20’:** The selected flights are transmitted to the upstream ACCs by electronic transmission or phone, depending on the ACC and on the scenario plan,
- **H-30’/H-20’:** The upstream sectors’ ATCO then transmits the speed advisories to the concerned flight crews,
- **H-10’ max:** For situation awareness purposes, feedback to downstream ACCs may be transmitted depending on the scenario.

Once the speed advisories are given to the upstream ACC, no further revisions are transmitted.

Based on computations on NM’s ETFMS data, iAMAN is presenting to Paris FMP the predicted arrival sequence in the appropriate Extended TMA sector and potential bunches of flights, as shown below:

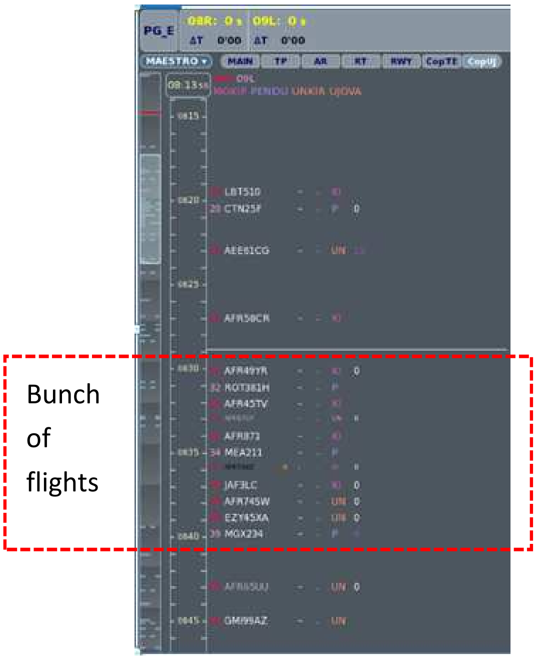


Fig. 5: Sequence of arrival computed by iAMAN

After his analysis, Paris FMP is able to pick a few flights in the sequence to be slowed down 20 to 30 minutes before the entry time in the E-TMA (usually the last ones in the sequence), allowing the arrival sequence to be "de-bunched" and optimized. Arrival sequence was also cross-checked using an Air Situation Display such as SALTO.

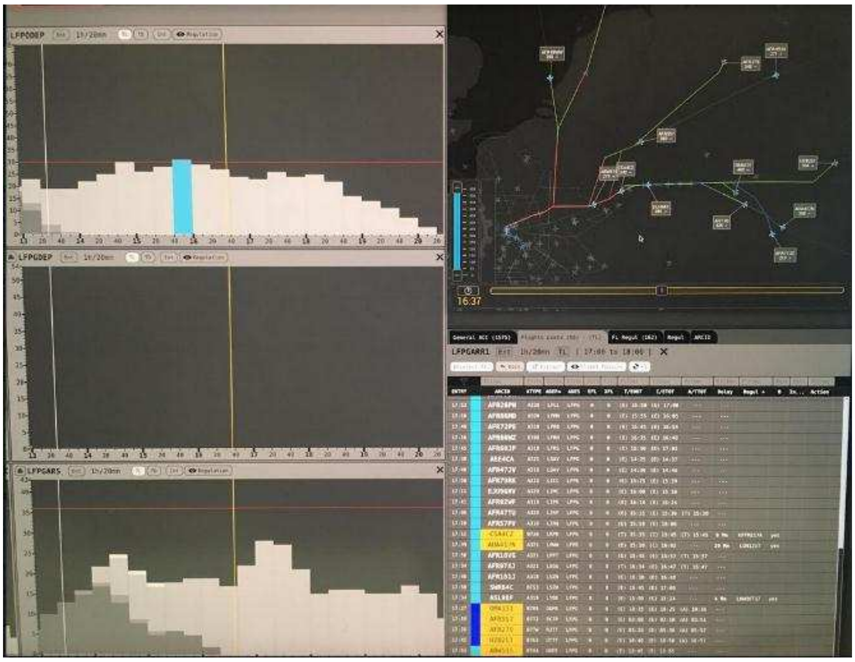


Fig. 6: Example of an Air Situation Display used during Cop Sequencer trials (SALTO)

Flights departing from airports inside the COP Sequencer horizon are excluded from the process (because still on the ground or in climbing phase and not speed manageable).

The flights to slow down may then be provided from Paris FMP to upstream ACC via different means:

- A web portal ("dsna.fr") or via email to the upstream FMP who will then notify the concerned CWP,
- A phone coordination to the upstream FMP who will then notify the concerned CWP,
- A direct electronic coordination directly to the concerned CWP in the upstream ACC.

When using the "DSNA.fr" web portal, Paris FMP could transmit speed advisories to upstream ACCs, as shown below:

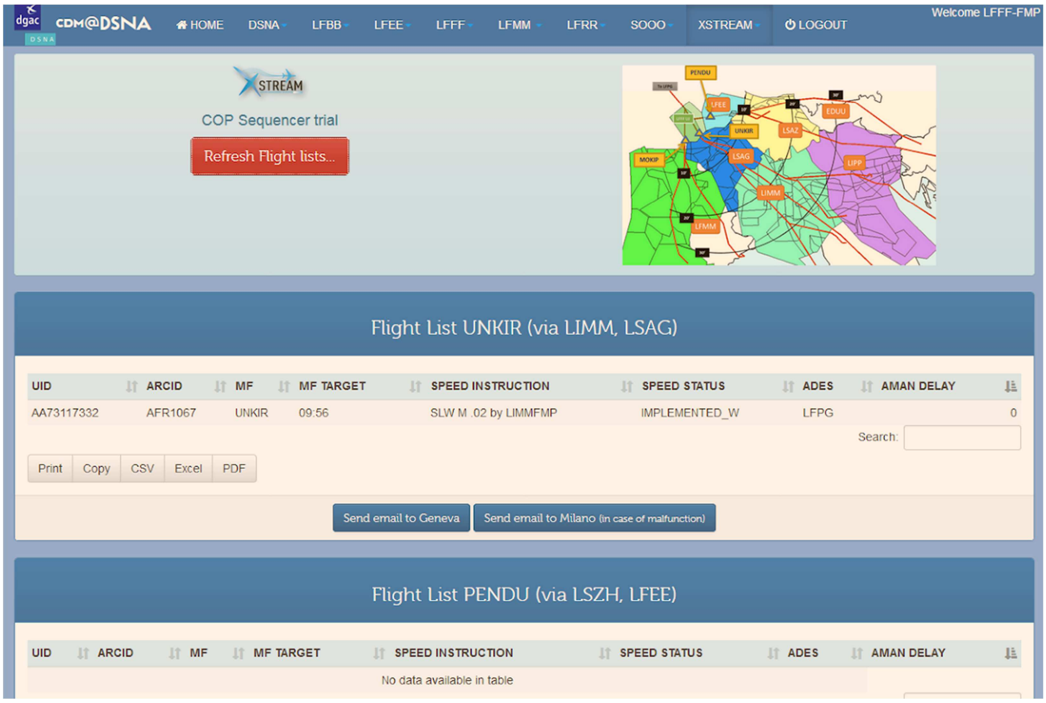


Fig. 7: Web portal for sharing flights to be slowed down

The corresponding process remains within the standard procedures for ATCO, in the upstream ACCs or in Paris ACC:

- Safety first,
- « Best effort » principle,
- LOA adherence remains mandatory.

The Paris ACC situation with the COP sequencer concept is summarized in the figure below:

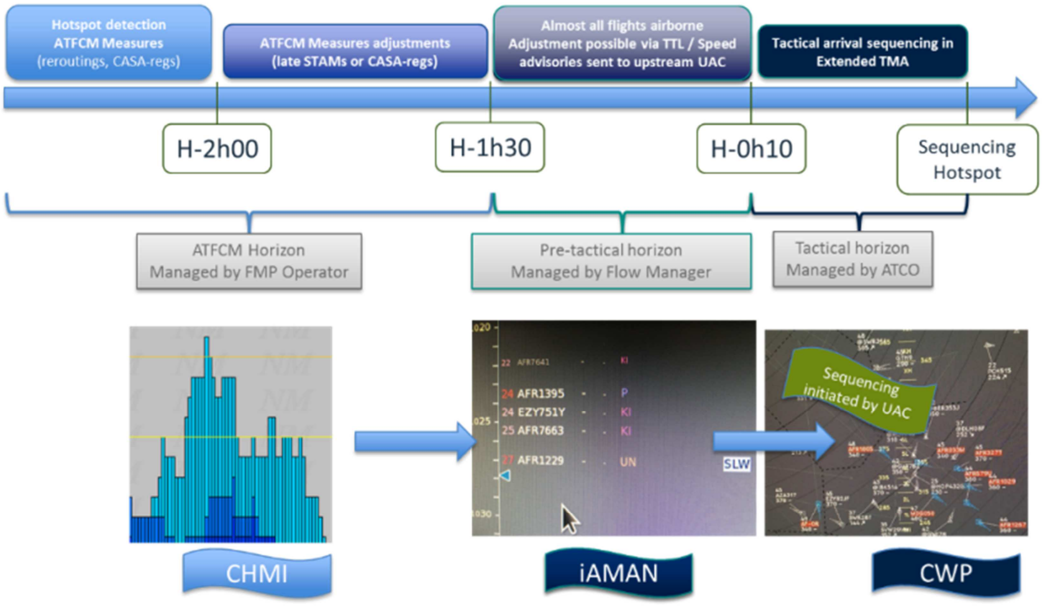


Fig. 8: Paris ACC situation with COP sequencer concept

As shown by the figure, using the COP Sequencer concept, Paris FMP now has a new tool to analyse the complexity of a hotspot 20 to 30 minutes in advance, and is provided with new means of action to mitigate it by transmitting speed advisories to upstream ACC.

This process is complementary to existing ATFCM procedures (horizon 1h30 to 2h before hotspot), and enables the smoothing of the arrival sequence ahead from ATCOs tactical horizon (10 minutes before entry in the sector).

This COP sequencer concept is a collaborative process involving many actors, who are sharing traffic information with tools. The combination of several sources of information (e.g. weather, military activity, and predicted sequence) is used by Paris FMP to build an optimal strategy for managing the arrival hotspot:

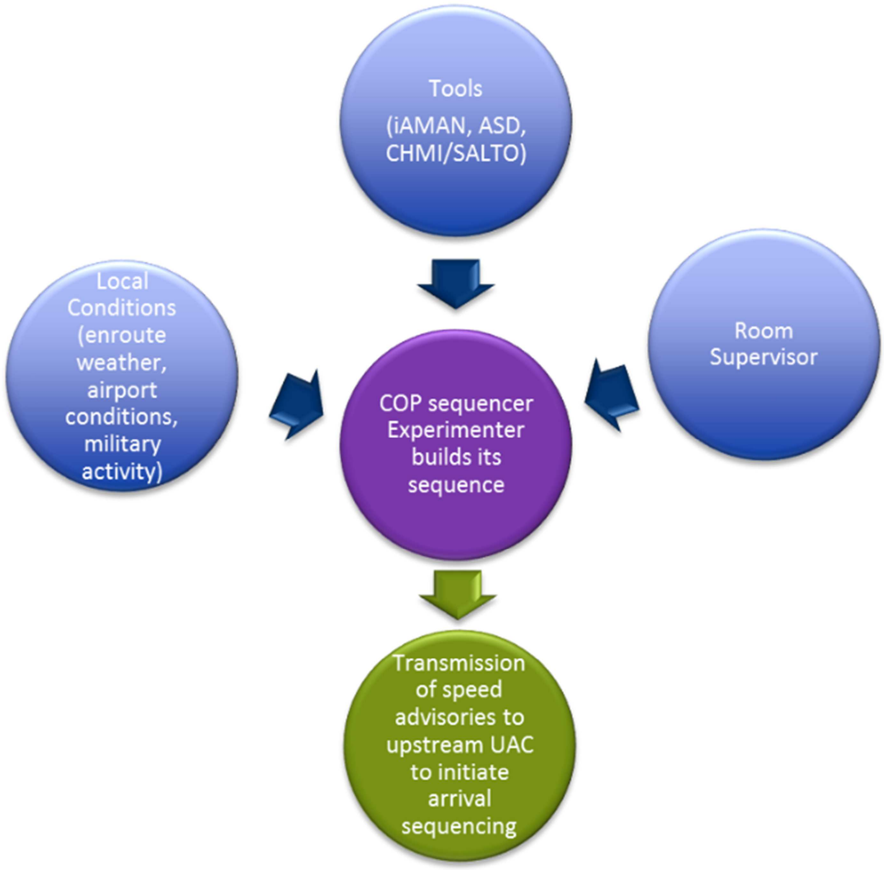


Fig. 9: Actors and tools involved in the COP sequencer concept

J.1.2 Summary of Demonstration Exercise EXE-VLD-07-002 Demonstration Objectives and Success Criteria

The Objectives and success criteria for EXE-VLD-07-001 are provided in the xStream DEMOR, in chapter 3.4 “Summary of xStream Demonstration Plan”.

J.1.3 Summary of Demonstration Exercise EXE-VLD-07-002 Scenarios

Two main scenarios have been executed on this trial: COP SEQ UJ (Paris-CDG arrivals via South-East sector UJ) and COP SEQ TE (Paris-CDG arrivals via North-East sector TE). An additional one, COP SEQ SKI (arrivals to Lyon St Exupery and Geneva airports via Paris ACC sector LMH) has been put in place during Ski charter weekends of the winter season 2018/2019. This exercise has been executed on the following dates and daytimes:

Scenario	Period	**Daytime**
COP SEQ UJ (South-East)	March 05, 2018 to March 29, 2018	• P3 (10h20-11h20 LOC), • Mondays, Thursdays, Fridays
COP SEQ UJ (South-East)	April 09, 2018 to April 13, 2018	• P3 (10h20-11h20 LOC), • Mondays, Thursdays, Fridays
COP SEQ UJ (South-East)	April 16, 2018 to April 27, 2018	• P2 (7h40-8h40 LT) & P3

Scenario	Period	Daytime
		(10h20-11h20 LT), • Everyday.
COP SEQ UJ (South-East)	June 02, 2018 to June 29, 2018	• P2 (7h40-8h40 LT), P3 (10h20-11h20 LT), P6 (18h30-19h30 LT) • Everyday.
COP SEQ UJ (South-East)	Sept 06, 2018 to Oct 26, 2018	• P2 (7h40-8h40 LT), P3 (10h20-11h20 LT), P6 (18h30-19h30 LT) • Everyday.
COP SEQ TE (North-East)	March 22, 2019 to April 16, 2019	• P2: 7h40 – 9h00 LT & P5: 16h00 – 17h40 LT. • All weekdays
COP SEQ UJ (South-East)	April 22, 2019 to June 28, 2019	• All days and following peaks: P2: 07h40 – 08h40 LT, P3: 10h20 – 11h20 LT, P5: 15h40 – 16h40 LT, P6: 18h30 – 19h30 LT.
COP SEQ SKI	Dec 15, 2018 to March 31, 2019	• Week-ends • All day

Table 1: Planned trial periods and peaks for EXE-VLD-07-002

The implementations of COP SEQ scenario for UJ and TE sectors are detailed in the following sub-chapters.

J.1.3.1 UJ Scenario (South East sector)

UJ sector is Paris ACC pre-sequencing Extended-TMA sector for CDG arrivals coming from the South-East (e.g. mainly flows from Italy, southeast Europe, Northern Africa and Middle-East). Flows crossing the UJ Sector are depicted as shown in the figure below:

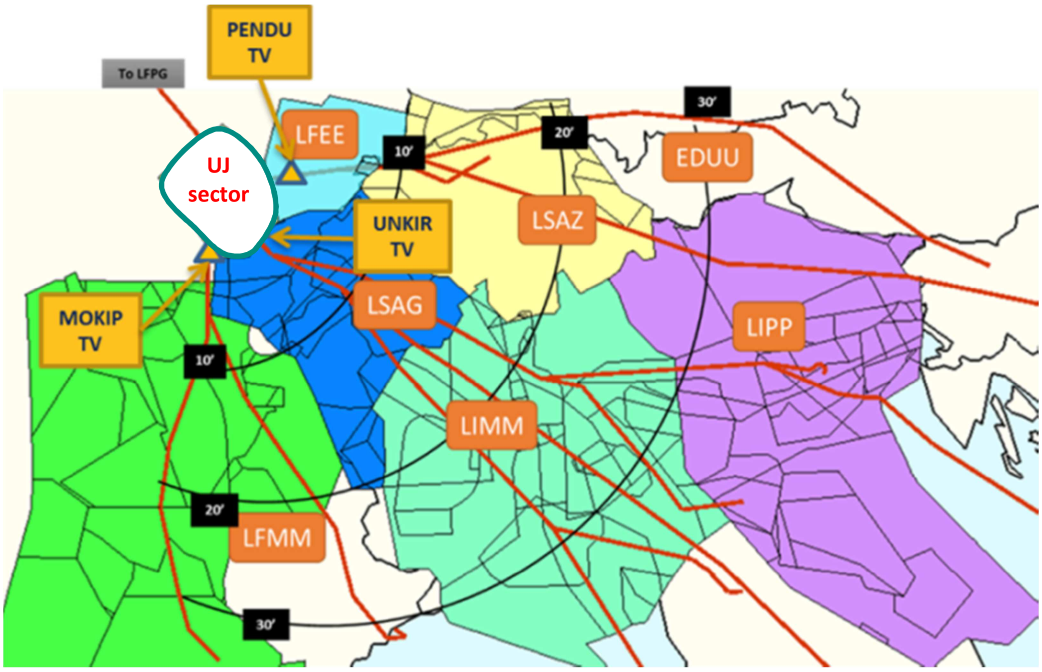


Fig. 10: Scope of the COP SEQ UJ scenario

The scenario is designed with an active horizon between 20 and 30 minutes before entering in the LFFF UJ sector with arrivals to Paris CDG airport.

For this scenario, a new and dedicated airspace called "LFFFUJX" was created on purpose in Eurocontrol Network Manager Environment Database (ENV) equidistant to the feeder fix to CDG APP (URELO) to build the sequence for CDG South East arrivals via TINIL at RFL>195, which account for 95% of arrivals into Paris-CDM TMA from the south east.

Three Traffic Volumes (TV), matching the sector's Metering Fixes just for COP SEQ UJ use, have been created, based on airspace:

- PENDU (CDG arrival flows coming from Zurich ACC and Reims ACC),
- UNKIR (CDG arrival flows coming from Milan ACC and Geneva ACC)
- MOKIP (CDG arrival flows coming from Marseille ACC).

These TV are used to build the arrival sequence and allow iAMAN to be fed by the proper NM B2B data, as detailed in the picture below:

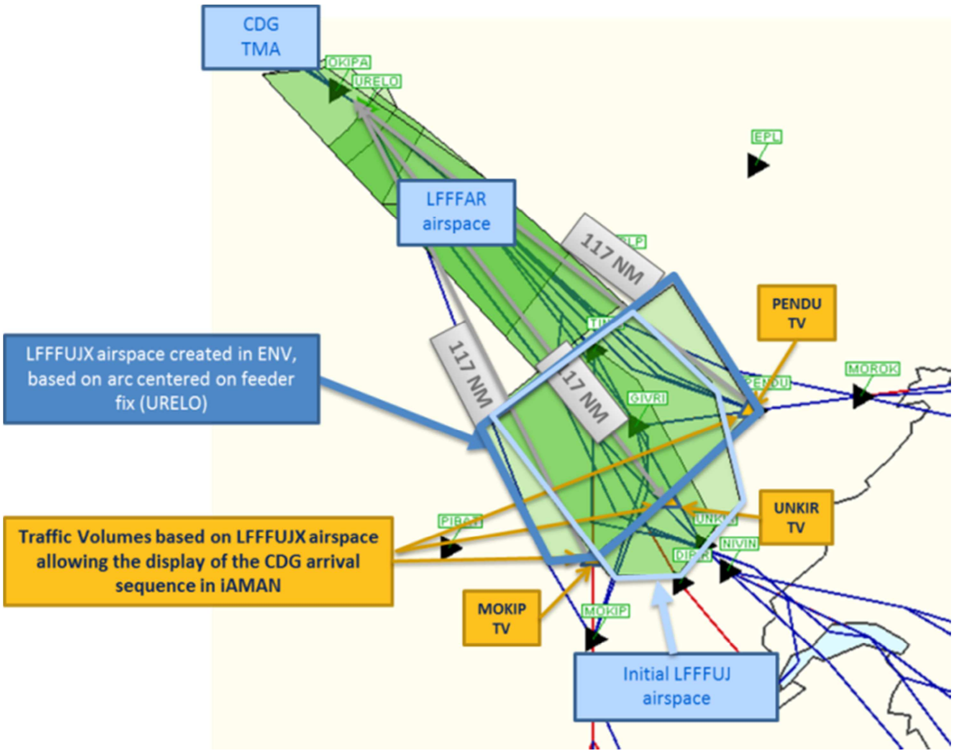


Fig. 11: Airspace configuration used by iAMAN for the COP SEQ UJ scenario

The actors of this scenario are summarized below:

ACC	Role	Way of transmitting speed advisories	Targeted horizon (mins before entry in E-TMA)	Targeted horizon (waypoint)	Metering Fix feeding UJ sector	% of the total CDG arrivals via UJ sector
Reims (LFEE)	Supporting	None	10	HOC	PENDU	30%
Zurich (LSAZ)	Acting	Phone coordination + email	20	ROMIR ARGAX		
Milano (LIMM)	Acting	Phone coordination + web portal	25	SRN IXORA	UNKIR	50%
Geneva (LSAG)	Acting	Phone coordination	15	ORSUD		
Marseille (LFMM)	None	None	-	-	MOKIP	20%

Table 2: Summary of participants to COP SEQ UJ scenario and horizon of action

80% of the CDG arrival flows via UJ sector were eligible to being reduced upstream during the trials. No action was performed on in-horizon departures from LIMC, LIML, LSGG, LFSB, LSZH, LFLL because they were too unstable in the arrival sequence.

Trial periods were planned when the traffic demand in UJ sector is high in terms of CDG arrival bunches, according to the analysis of 2017 traffic figures, i.e.:

- P2 peak from 07h40 to 08h40 LT,
- P3 peak from 10h20 to 11h20 LT,
- P6 peak from 18h30 to 19h30 LT.

Based on an analysis of 2018 traffic figures, an additional peak was identified for 2019 trials:

- P5 peak from 15h40 to 16h40 LT.

The iAMAN HMI for COP Sequencer UJ scenario is shown below:

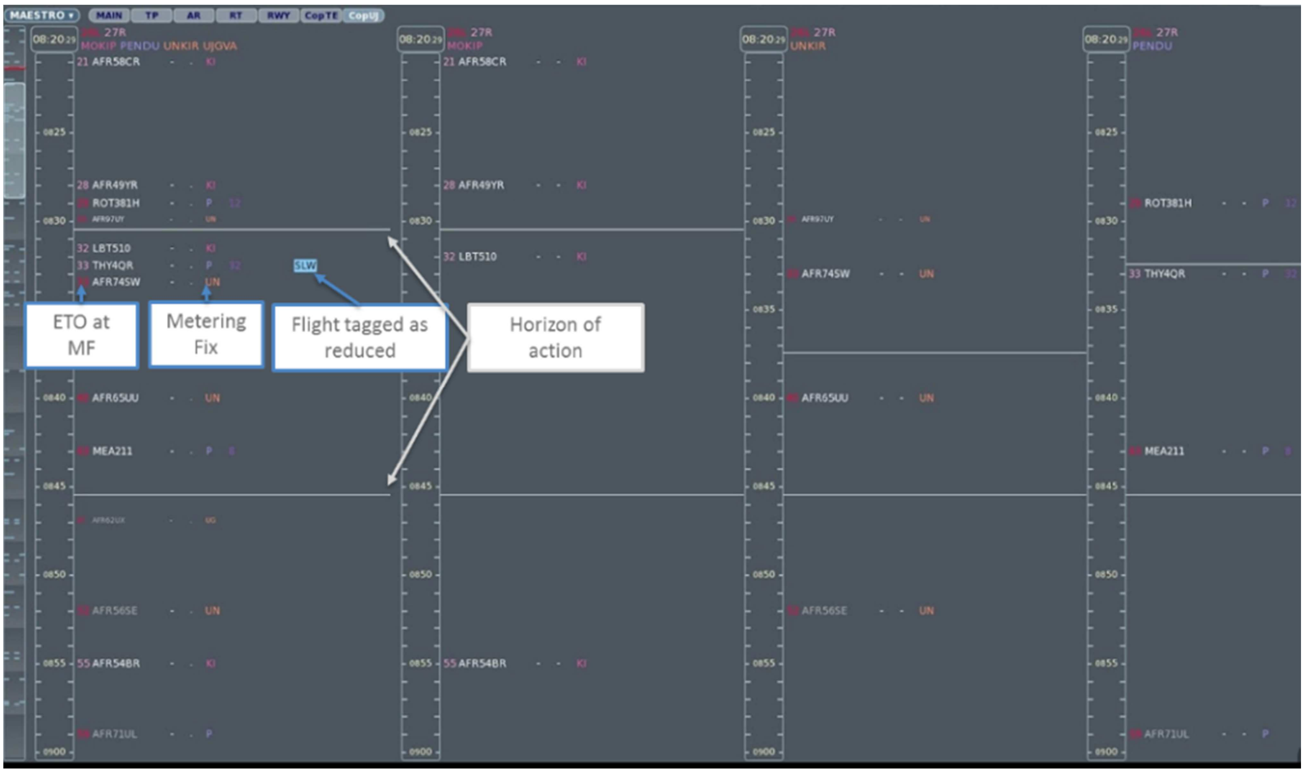


Fig. 12: iAMAN HMI installed for Paris FMP during COP Sequencer UJ

When the arrival hotspot is detected inside the bars of horizon of action depicted on iAMAN above, Paris FMP tags the flight as “XMAN Request to slow down” which triggers a “**SLW’** tag on iAMAN.

The XML arrival sequence is updated with a “SPEED STATUS” as “PROPOSED”.

Then DSNA.fr web portal is able to retrieve the XML and updates his COP Sequencer page with the flights proposed to be slowed down.

Fig. 13: COP Sequencer UJ page on DSNA.fr web portal

From the DSNA.fr web portal:

- Milano FMP is able to see the XMAN request,
- Milano FMP is able to enter a feedback on the requested action,
- Paris FMP can send an automatic email to Zurich ACC informing Zurich FMP of a XMAN request.

J.1.3.2 TE Scenario (North East sector)

TE sector is Paris ACC pre-sequencing Extended TMA sector for CDG arrivals coming from the North-East (i.e. mainly flows from Benelux, Germany, Northern and Easter Europe).

Flows crossing the TE Sector (North East) are depicted as shown in the figure below:

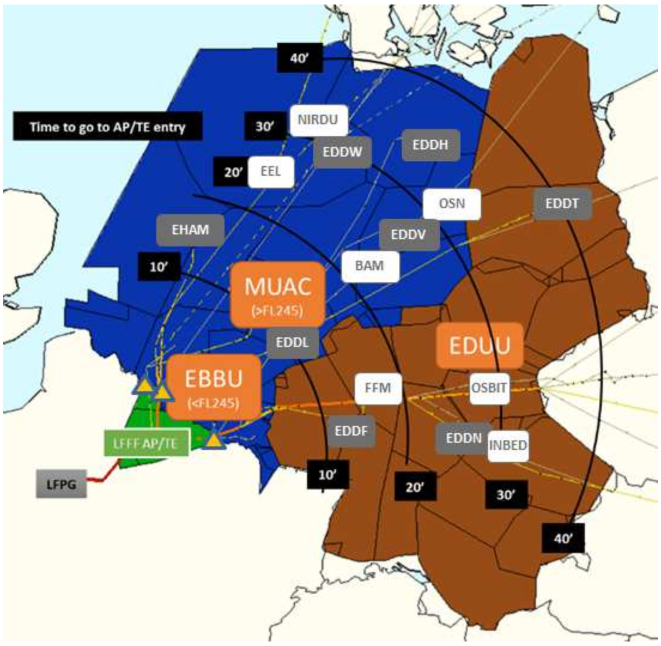


Fig. 14: Scope of the 2019 COP SEQ TE scenario

For this COP SEQ TE scenario, the iAMAN tool uses a dedicated airspace named "LFFFTEX" created in ENV to build the sequence for CDG North East arrivals via MATIX, MOPIL and VEDUS Metering Fixes as described in the figure below:

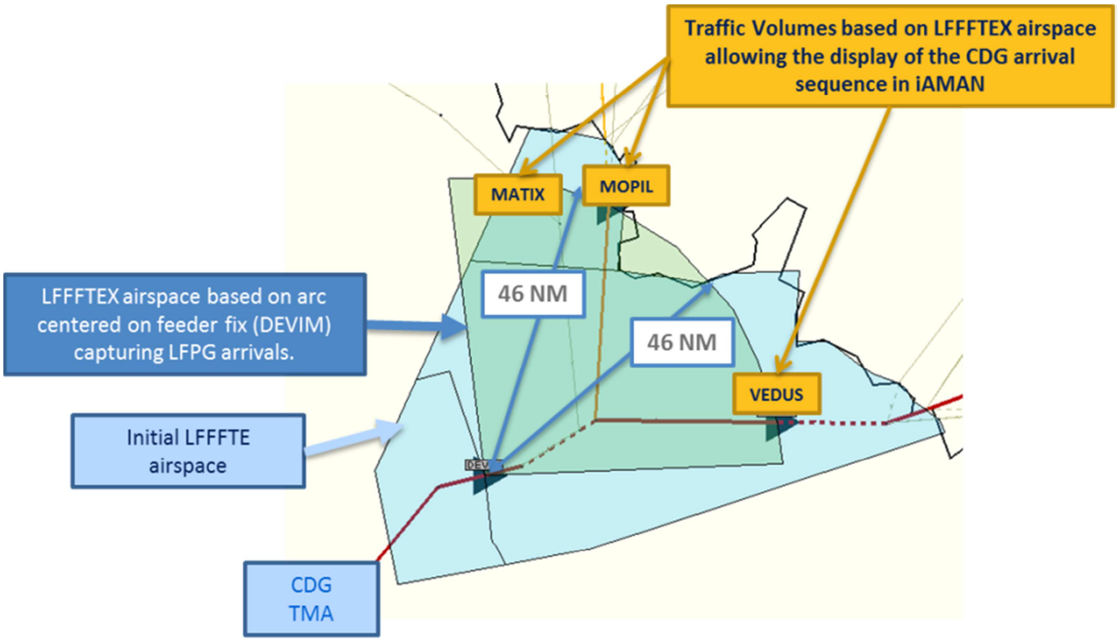


Fig. 15: Airspace used by iAMAN for the COP SEQ TE scenario

As for the COP SEQ UJ scenario, the COP SEQ TE scenario is designed with an active horizon before entering in the LFFF TE sector for arrivals to Paris CDG airport with the following limits:

- Maximum target horizon of action = 30' for KUAC / 30' for MUAC, i.e. approximatively 300 NM from CDG

- Minimum target of action for Paris ACC is 20’ from AP/TE entry, i.e. approximatively 240 NM from CDG.

Flights flying via Brussels ACC (EBBU) being a clear minority (only <FL245), the actors of this scenario are Maastricht ACC (MUAC) and Karlsruhe ACC (KUAC) as detailed below:

Upstream ACC	ADEP	CDG MF	First sector	Time from TE entry	Coordination method for speed advisories
MUAC (transmission of speed advisories)	EDDH / EDDW	VEDUS	RUHR	30’	Electronic coordination from Paris FMP to MUAC CWP
		MOPIL	DELTA / (MUNSTER)	30’	
	EDDT	VEDUS	MUNSTER	30’	
	EDDV	VEDUS	RUHR	30’	
	EKCH	MOPIL	HOLSTEIN (JEVER)	+45’ (40’)	
	EKBI / EN**	MOPIL	JEVER	+45’, if not possible ASAP and +35’	
	ES** / EE** / EF** / EV** R*** / U*** / V*** / Z***	MOPIL	HOLSTEIN (JEVER / MUNSTER-CELLE)	+45’ (40’)	

Fig. 16: MUAC horizon of action for the COP SEQ TE scenario

Upstream ACC	CDG MF	Sector	Point of action (30’ from AP/TE)	Coordination method for speed advisories
KUAC (transmission of speed advisories) Then MUAC (notification)	VEDUS	NTM	OSBIT	KUAC: phone coordination MUAC: electronic from Paris FMP to MUAC CWP
			INBED	

Fig. 17: KUAC horizon of action for the COP SEQ TE scenario

Trials periods were planned when the traffic demand is high in terms of flight bunches.

According to the analysis of 2017 traffic figures, the most loaded peaks had been identified:

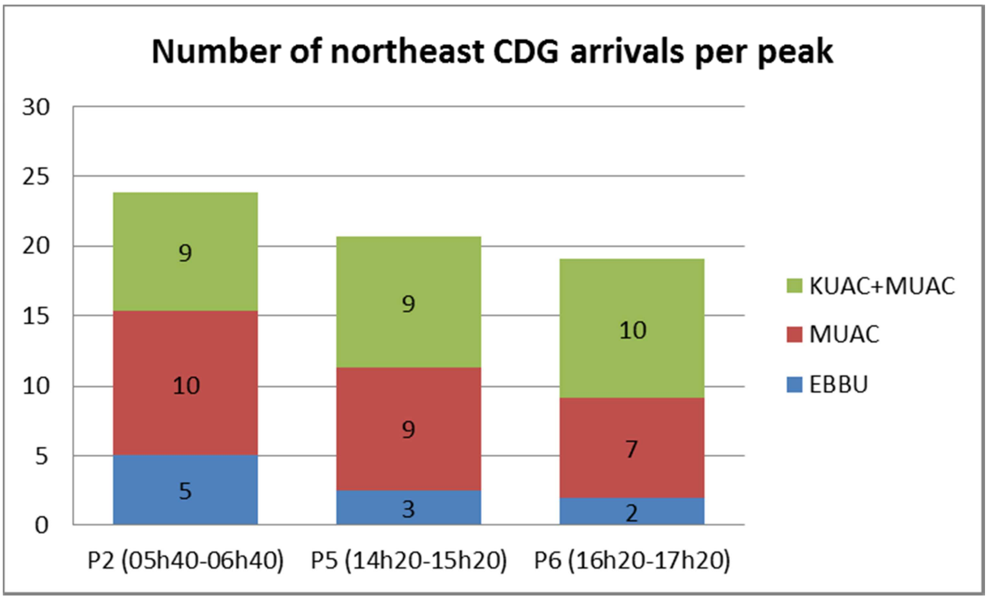


Fig. 18: 2017 average entry count for CDG arrivals in the TE sector (by ACC of origin) – UTC time in summer

According to the figure above, 75% to 80% of the CDG arrivals via TE sector (all the arrivals except via EBBU ACC) were eligible to speed reductions upstream.

The targeted peaks have been confirmed in 2018 by measuring the number of predecessors passing VEDUS/MOPIL 5 minutes before each flight.

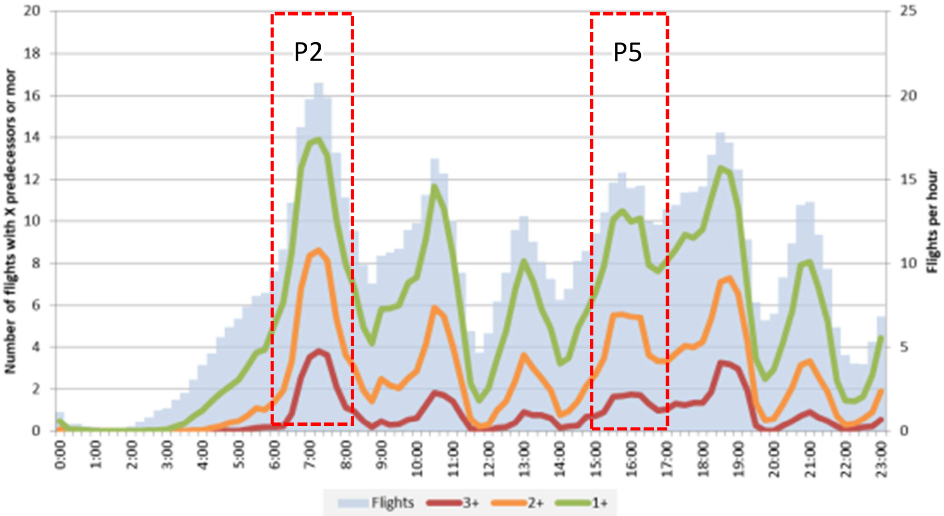


Fig. 19: Number of predecessors passing VEDUS/MOPIL 5 minutes before each flight, at 30 minutes' notice, in 2018

Accordingly, the COP SEQ TE scenario has executed all weekdays addressing the following peaks:

- P2: 7h40 – 9h00 LT, with an action from 07h00 to 08h40 LT,
- P5: 16h00 – 17h40 LT, with an action from 15h20 to 17h20 LT.

At Paris ACC, the iAMAN was installed on Paris FMP West position.

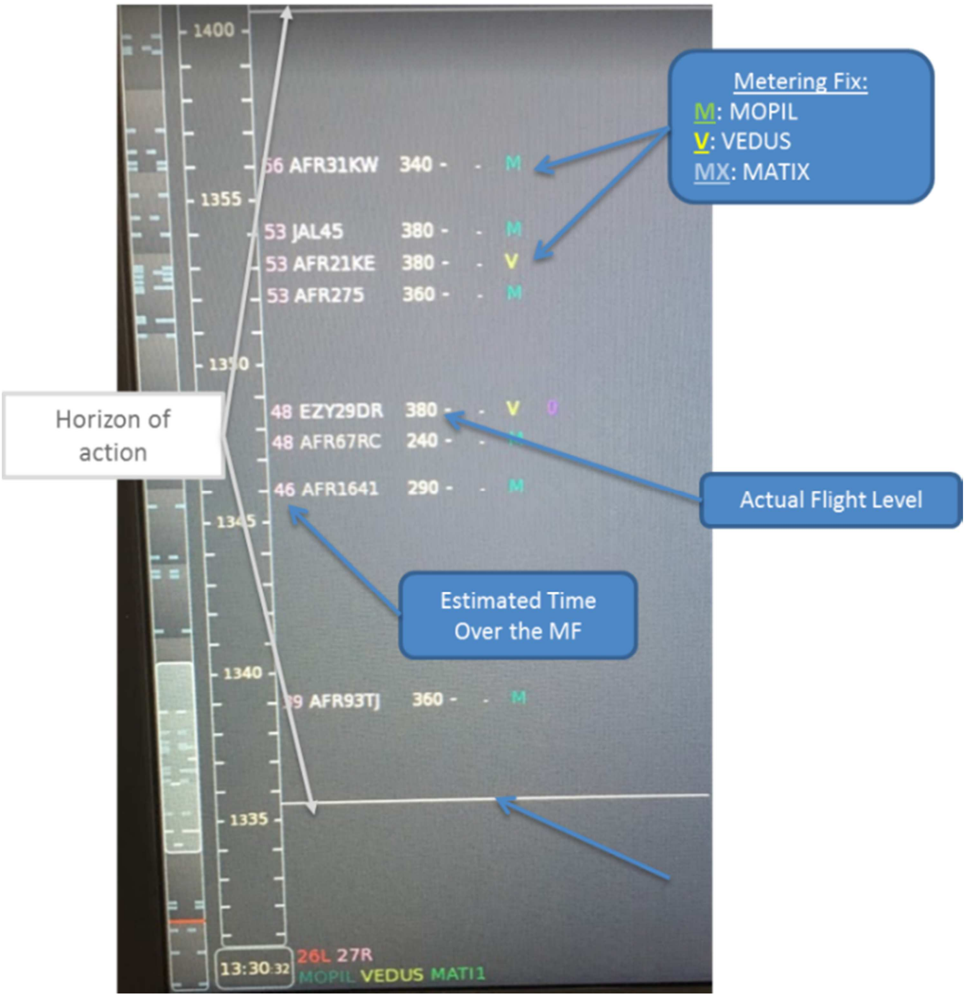


Fig. 20: iAMAN HMI installed for Paris FMP during COP Sequencer TE

In addition, with the phone coordination used with KUAC (as used for COP SEQ UJ), an electronic coordination of speed requests has been deployed with MUAC.

For the flights via VEDUS slowed down by KUAC, they transit in MUAC airspace for around 6 minutes and then are transferred to Paris TE sector (see Fig. 21:).

MUAC is notified of a XMAN flight flying in LUX sector thanks to the retrieval of iAMAN XML data which shows the imposed iAMAN delay. In this case, MUAC will instruct 250 KIAS at the conversion altitude.

For flights transiting KUAC airspace before MUAC airspace, any speed change applied by KUAC less than a certain distance from the boundary was coordinated verbally (as per CONOPS).

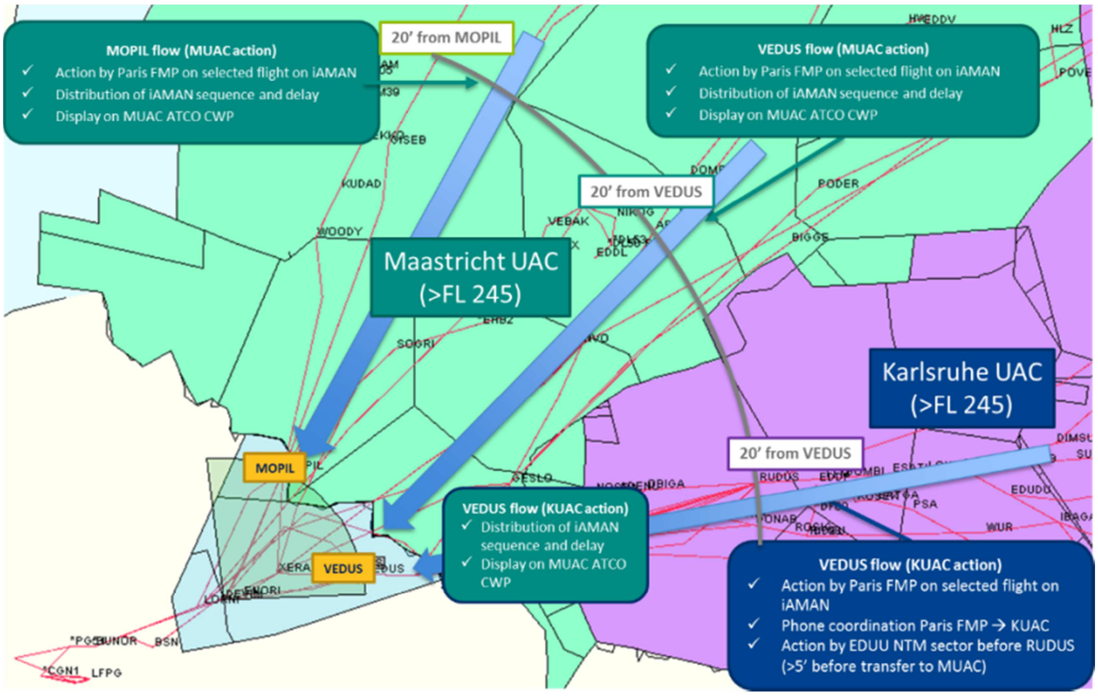


Fig. 21: Summary of coordination process for COP SEQ TE with MUAC and KUAC

With this electronic coordination, MUAC is able to retrieve the iAMAN sequence (via XML data feed) and the selected flights that are asked for a speed reduction by Paris ACC FMP operator.

The speed advisory is triggered in MUAC when iAMAN delay (in yellow in Fig. 22: , forced by Paris FMP), is equal or greater than 2 minutes. Then, this request is then provided to MUAC ATCO on the radar label as shown below:

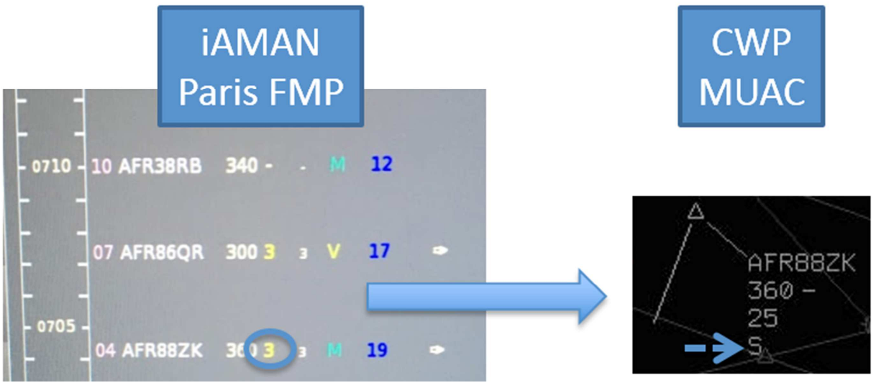


Fig. 22: Request for speed reduction displayed on MUAC CWP

J.1.3.3 SKI Scenario

For this COP SEQ scenario, the targeted flows are linked to the arrival to Lyon and Geneva airports crossing Paris ACC sector LMH during SKI weekends.

The objective is to improve the traffic management of PARIS ACC for the airport arrivals, in the configuration depicted in the figure below:

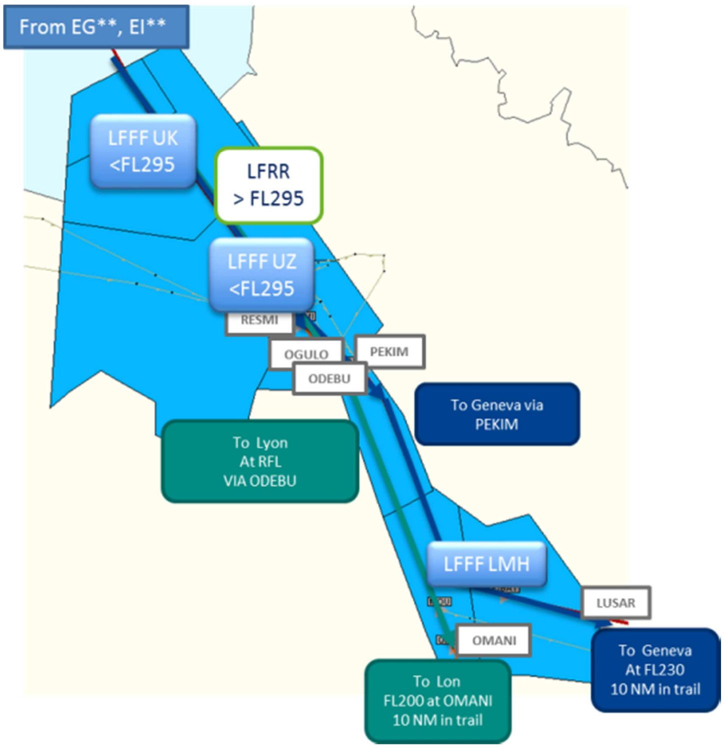


Fig. 23: SKI arrival flows to Lyon and Geneva airports

The actor of this scenario is limited to internal Paris ACC coordination (flights to Lyon & Geneva airports flying at FL<295), as Brest ACC wasn't in position to contribute to this scenario.

ACC	Role	Way of transmitting speed advisories	Targeted horizon (mins before entry in E-TMA)	Targeted horizon (waypoint)	Metering Fix feeding LMH sector	% of the total SKI arrivals via LMH sector
Paris (LFFF)	Acting	Phone/oral coordination	20	VEULE	PEKIM ODEBU	40%
Brest (LFRR)	None	None	-	-		60%

Fig. 24: Summary of participants to COP SEQ SKI scenario and horizon of action

For this scenario, the iAMAN tool was configured for LFLL / LSGG arrivals.

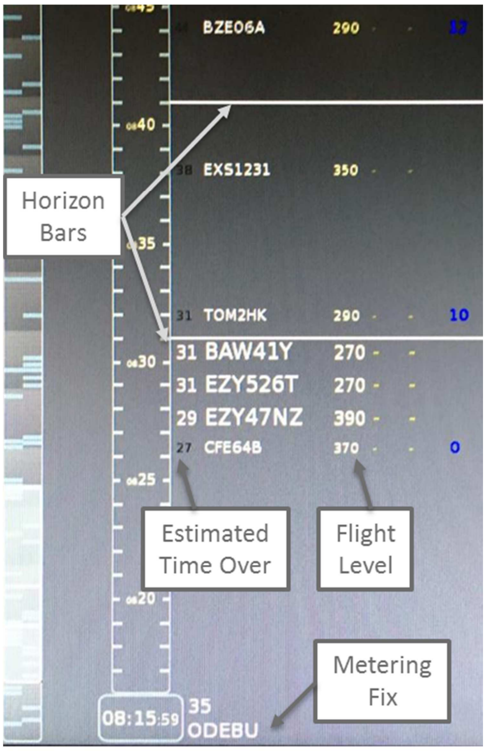


Fig. 25: iAMAN tool configured for SKI arrivals (here ODEBU Metering fix feeding LFLL, LFLS, LFLY, LFLB arrivals)

The Paris ACC provides demands to certain flights under FL295 with a direct phone coordination with the sector to reduce their speed.

This scenario has been planned to be executed from December 15, 2018 and March 31, 2019.

J.1.4 Summary of Demonstration Exercise EXE-VLD-07-002 Assumptions

The assumptions concerning EXE-VLD-07-002 are provided in the xStream DEMOR, in chapter 3.4 “Summary of xStream Demonstration Plan”.

J.2 Deviation from the planned activities

The EXE-VLD-07-002 scenario had been executed as expected.

However, due to a few number of dates for COP SKI scenario, only qualitative assessment could be provided for this scenario.

J.3 Demonstration Exercise EXE-VLD-07-002 Results

J.3.1 UJ Scenario

Several trial periods in 2018 and 2019 were conducted on different traffic peaks.

They are assumed not to be fully comparable to each other, which is why they have been analysed separately.

The following table gives an overview on performed trial periods. “Internal ID” field is mentioned later on in the report to identify which periods have been used for quantitative assessment.

Internal ID(s)	Start Date	Stop date	Target peak (LT)	Days
EXE7#2-UJ-P2-1-2018	April 16, 2018	July 06, 2018	P2: 7h40-8h40	Everyday excl. June 30, July 01 to July 05
EXE7#2-UJ-P3-1-2018	March 05, 2018	July 06, 2018	P3: 10h20-11h20	March 05 - April 13: Mondays, Thursdays, Fridays April 16-July 05: Everyday excl. June 30, July 01 to July 05
EXE7#2-UJ-P6-1-2018	June 02, 2018	July 06, 2018	P6: 18h30-19h30	Everyday excl. June 30, July 01 to July 05
EXE7#2-UJ-P2-2-2018, EXE7#2-UJ-P3-2-2018, EXE7#2-UJ-P6-2-2018.	Sept 06, 2018	Oct 26, 2018	P2: 7h40-8h40 P3: 10h20-11h20 P6: 18h30-19h30	Everyday
EXE7#2-UJ-P2-1-2019, EXE7#2-UJ-P3-1-2019, EXE7#2-UJ-P5-1-2019, EXE7#2-UJ-P6-1-2019.	March 22, 2019	June 14, 2019	P2: 07h40-08h40 P3: 10h40-11h40 P5: 15h40-16h40 P6: 18h30-19h30	Everyday

Table 3: Trial periods for EXE-VLD-07-002: COP sequencer for the UJ sector

In the above-mentioned periods, the scenario execution has been suspended several times for the following reasons:

- Technical issues,
- Bad weather conditions (strong winds or CBs in vicinity of UJ sector in May/June 2018),
- Low traffic demand,
- Suspension of trials requested by upstream ACCs during the summer peak (July and August 2018),
- ATC industrial action.

In order to keep the complexity and clarity of this document at a reasonable level the results presented below are the results collected during trial period 5th March 2018 to 6th July 2018 for Peak 3 (EXE7#2-UJ-P3-1-2018), based on the comparability and the number of speed advisories given.

The justifications are provided in the following table.

Internal ID(s)	Number of trial dates	Number of flights with requested XMAN actions	Remarks
EXE7#2-UJ-P2-1-2018	4	7	Successful trial, but benefit is less visible due to lower number of speed advisories given; some issues with traffic comparability
EXE7#2-UJ-P3-1-2018	35	21	Results are described in the following sections

Internal ID(s)	Number of trial dates	Number of flights with requested XMAN actions	Remarks
EXE7#2-UJ-P6-1-2018	1	1	Serious comparability problems due to weather (thunderstorms) as well as traffic constellation, not enough XMAN actions to create a measurable effect
EXE7#2-UJ-P2-2-2018	2	7	Benefit was not measurable due to traffic comparability
EXE7#2-UJ-P3-2-2018	6	8	Benefit was not measurable due to traffic comparability
EXE7#2-UJ-P6-2-2018	3	7	Benefit was not measurable due to traffic comparability
EXE7#2-UJ-P2-1-2019	1	1	Benefit was not measureable due to comparability problems (e.g. strong winds in the baseline data) and low number of speed advisories
EXE7#2-UJ-P3-1-2019	4	5	Slight benefit is measureable, some comparability problems (strong winds)
EXE7#2-UJ-P5-1-2019	2	2	No difference between trial and reference measureable; multiple comparability issues due to thunderstorm and strong wind occurrences
EXE7#2-UJ-P6-1-2019	2	8	Benefit was not measureable due to comparability problems (multiple comparability issues due to thunderstorm and strong wind occurrences)

Table 4: Main Outcomes for EXE-VLD-07-002: COP sequencer for the UJ sector

The overall recorded data for EXE-VLD-07-002 UJ scenario is listed below:

- 95 flights total were requested to be reduced by Paris FMP to upstream ACCs during 54 peaks:
- Average number of requested XMAN action per peak: 1,8
- Maximum number of requested XMAN action per peak: 6
- Acceptation rate: 89% implemented; 6% not implemented; 5% unknown.

The acceptation rate was calculated according to FlightRadar24 data (when flight was observed in the upstream sector) or Mode S data observed by Paris FMP when entering UJ sector.

- Metering Fixes for arrivals concerned by XMAN action: 65% via UNKIR / 35% via PENDU
- Upstream ACCs where XMAN actions were implemented: 38% in LIMM / 27% in LSAG / 35% in LSAZ
- Reaccelerated flights in E-TMA: 1% of the flights were re-accelerated in TE sector when in contact with Paris ACC ATCO because they finally were #1 in the arrival sequence or the ATCO changed the sequencing strategy
- Reaccelerated flights in buffer ACC: when XMAN actions were implemented in Milano ACC (LIMM) or Zurich ACC (LSAZ), 11% of flights were reaccelerated in the buffer ACC as shown below before reaching UJ sector.

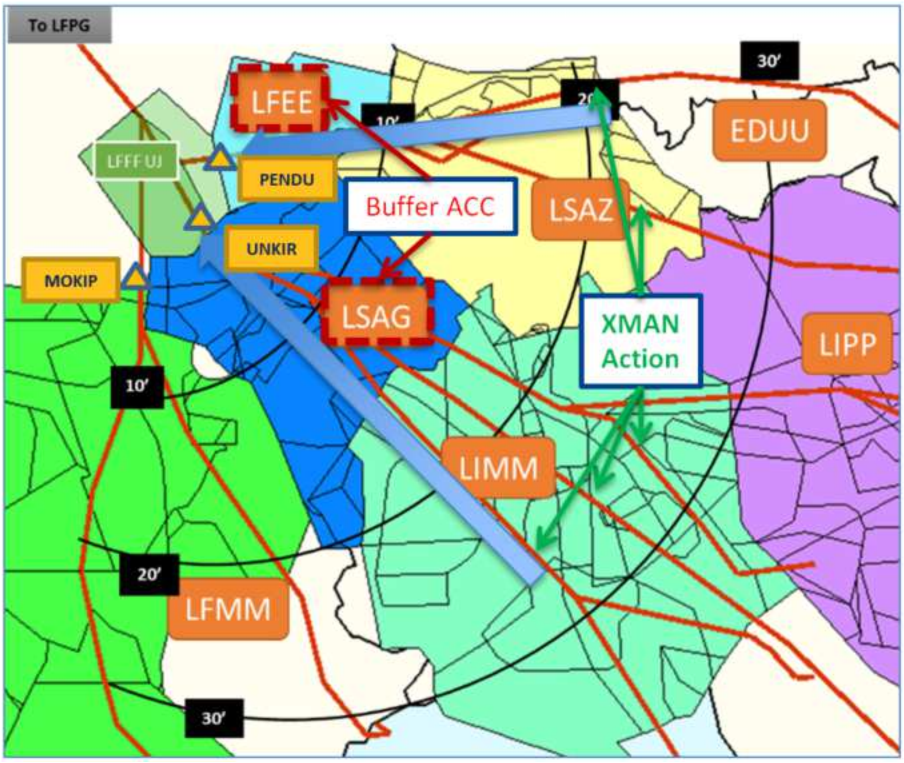


Fig. 26: Average position of XMAN requests in LIMM & LSAZ and buffer ACCs

- Average notice of XMAN request before Metering Fix: 24 minutes,
- Average distance of XMAN request from Metering Fix: 180 NM,
- Average distance of XMAN request from CDG runway: 350 NM,
- Average flight parameters before XMAN reduction request: Mach 0.79 / Ground speed 440 kts / FL370,
- Average flight parameters after XMAN reduction request: Mach 0.75.

The execution of the COP SEQ UJ scenario is detailed below on one example, considered as significant improvement for Paris ACC operations.

The example is addressing a flight situation on the UJ sector on June 13, 2018, around 06:00 UTC.

The iAMAN displayed to the Paris FMP a status of incoming flights at 05:20 UTC identifying a bunch of 4 flights in a time frame of 2 minutes:

- Scheduled at 05:54: AFR100K et AFR33HZ,
- Scheduled at 05:55: AFR49RP and AFR53FL.

The corresponding air situation is provided in the figure below:

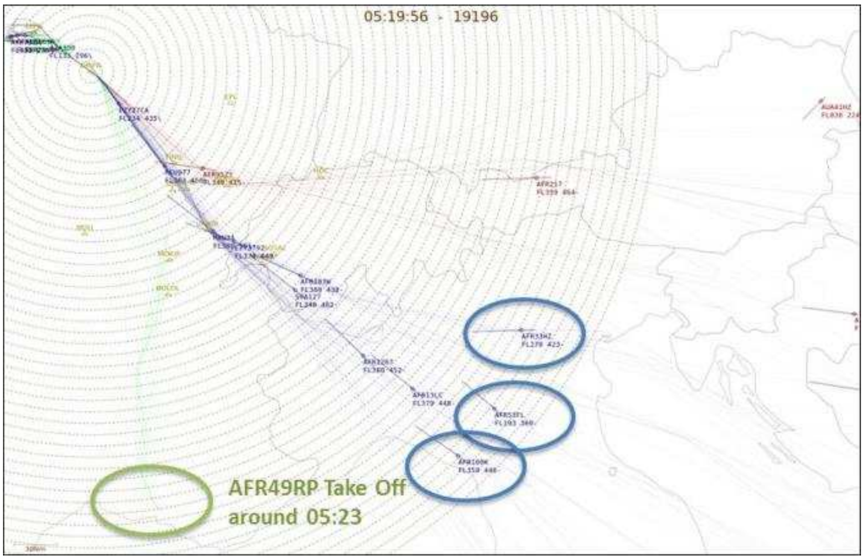


Fig. 27: xStream example of COP SEQ UJ improvement for a bunch on June 13,2018

The FMP ACC managed the situation with a bunch by:

- Requesting at 05:28 a speed reduction to AFR53FL,
- No action on AFR33HZ and AFR49RP on the same range but AFR49RP on climb,
- No action on AFR53FL and AFR100K on the same range.

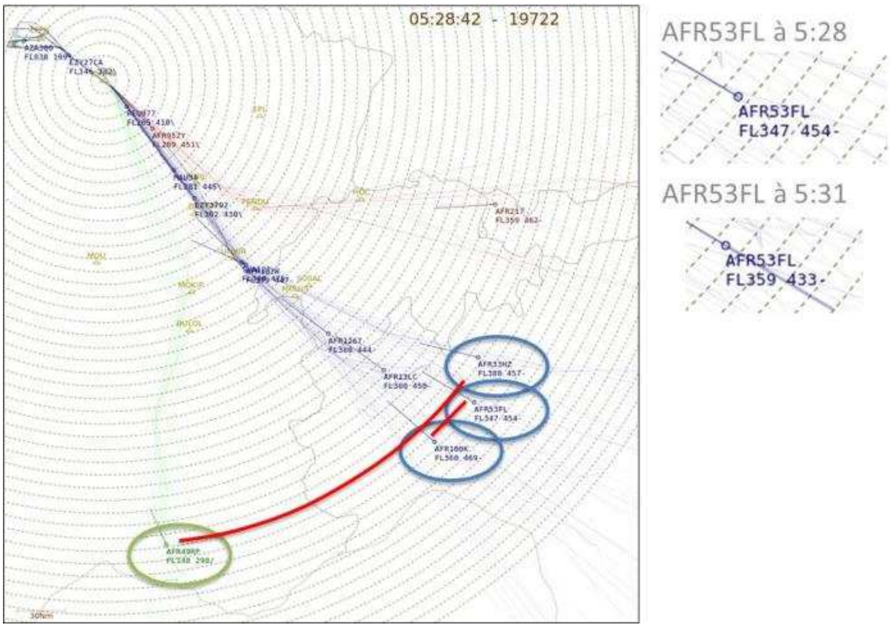


Fig. 28: xStream example of flight COP SEQ debunching performed on June 13,2018

After requesting a speed reduction to AFR53FL, the situation had been improved with:

- At 5:42, all flights are on cruise,
- AFR33HZ and AFR49RP are both ahead, respectively 116 Nm and 133 Nm from TINIL,
- AFR100K is one range behind the two first in the sequence at 123 Nm from TINIL,
- AFR53FL is now two ranges behind the previous flights due to the speed reduction.

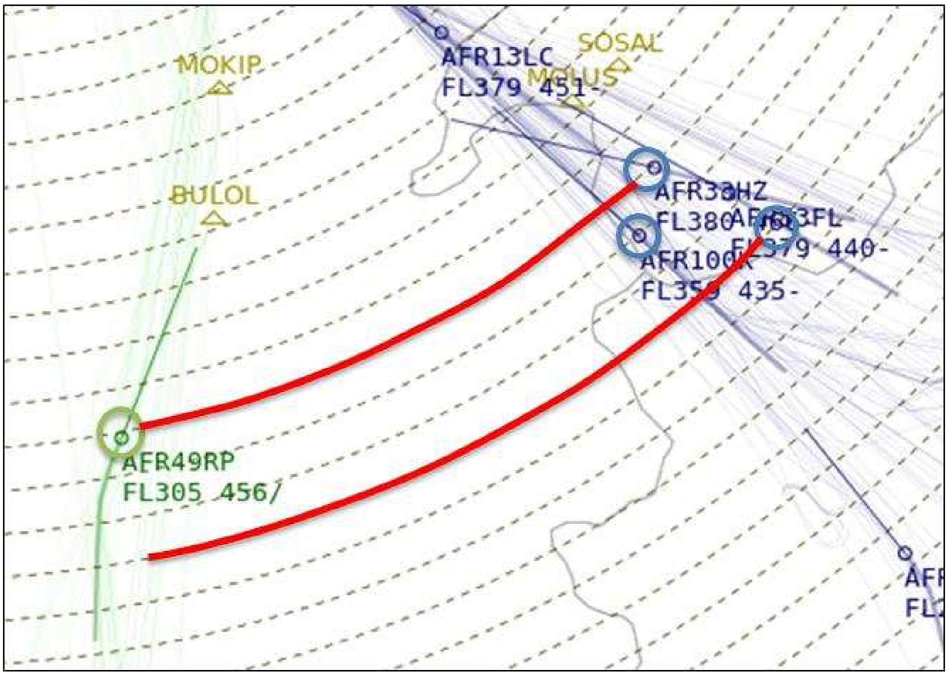


Fig. 29: xStream example of improvements after COP SEQ debunching performed on June 13,2018

Note:

- AFR53FL is instructed a small radar vector to add 6,9 NN from the previous arrival. But the 24 minutes with a reduced speed (-20 kts) permitted to increase the separation of 9 NM and then not to be instructed a greater vectoring.

In conclusion, the sequence at TINIL is optimized with spreading the four flights on a time slot of four minutes, with a saving of 9 NM of radar vectors in the UJ sector:

- 5:57 for AFR33HZ,
- 5:58 for AFR100K,
- 5:59 for AFR49RP,
- 6:01 for AFR53FL.

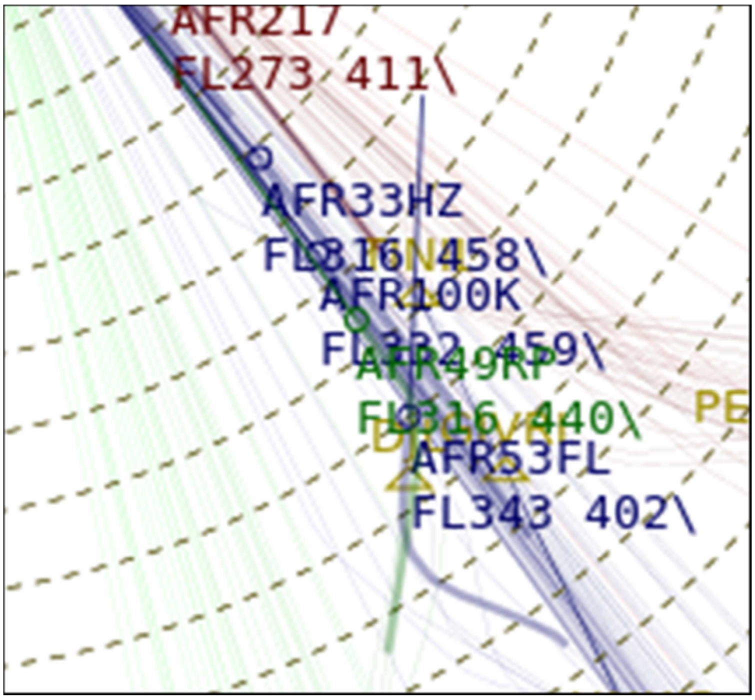


Fig. 30: xStream example of optimized sequence on TINIL with COP SEQ performed on June 13,2018

J.3.1.1 Summary of Scenario Results

See main document chapter 4.1.2.2.1.

J.3.1.1.1 Results per KPA

During EXE-VLD-07-002 UJ scenario, 34 questionnaires were filled by Paris FMP that asked for actual speed reductions upstream and 34 questionnaires were filled by Paris ATCOs that were working the UJ sector during the targeted peaks.

These questionnaires are used in this section for qualitative assessment.

J.3.1.1.1.1 KPA Safety

J.3.1.1.1.1.1 Quantitative Assessment

Number of Incident Reports:

- No incidents were reported in connection with the trials in Paris ACC, Zurich ACC, Geneva ACC Reims ACC or Milano ACC.

J.3.1.1.1.1.2 Qualitative Assessment

Questionnaire Results related to Safety:

- Paris ACC ATCO feedback:

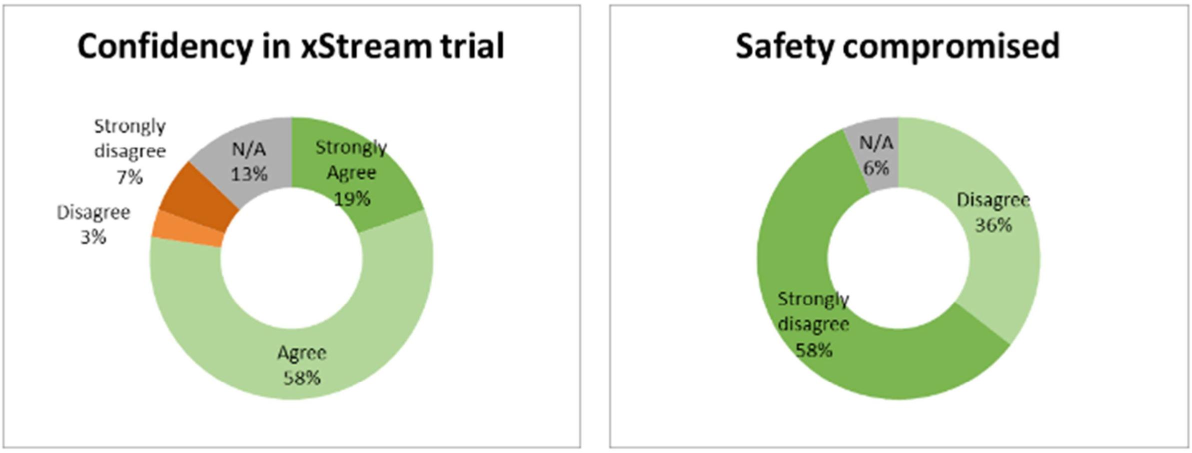


Fig. 31: Confidence & safety questionnaires results from Paris FMP

Paris ACC ATCOs that were running the trials had a good confidence in the trials (77%) and assessed that safety was never compromised.

- Paris FMP feedback:

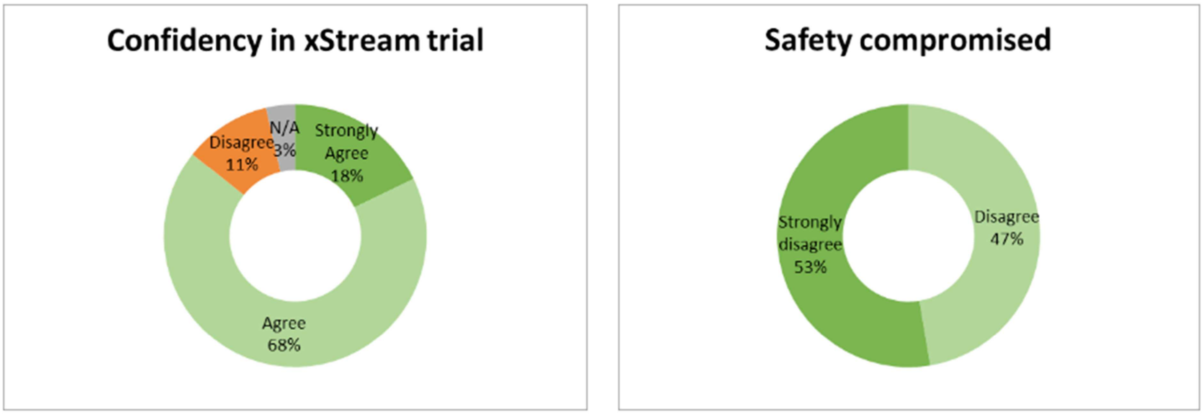


Fig. 32: Confidence & safety questionnaires results from Paris FMP

- Paris FMPs who were running the trials had a good confidence in the trials (86%) and assessed safety was never compromised.
- No other reports indicating safety issues were received from the upstream ACCs implementing speed reductions.

J.3.1.1.1.2 KPA Predictability and Punctuality

J.3.1.1.1.2.1 Quantitative Assessment

Time difference actual - planned

- iAMAN data was assessed compared to the predicted times over the Metering Fixes and the actual times over or maximum 10 NM abeam the Metering Fixes PENDU, MOKIP or UNKIR.

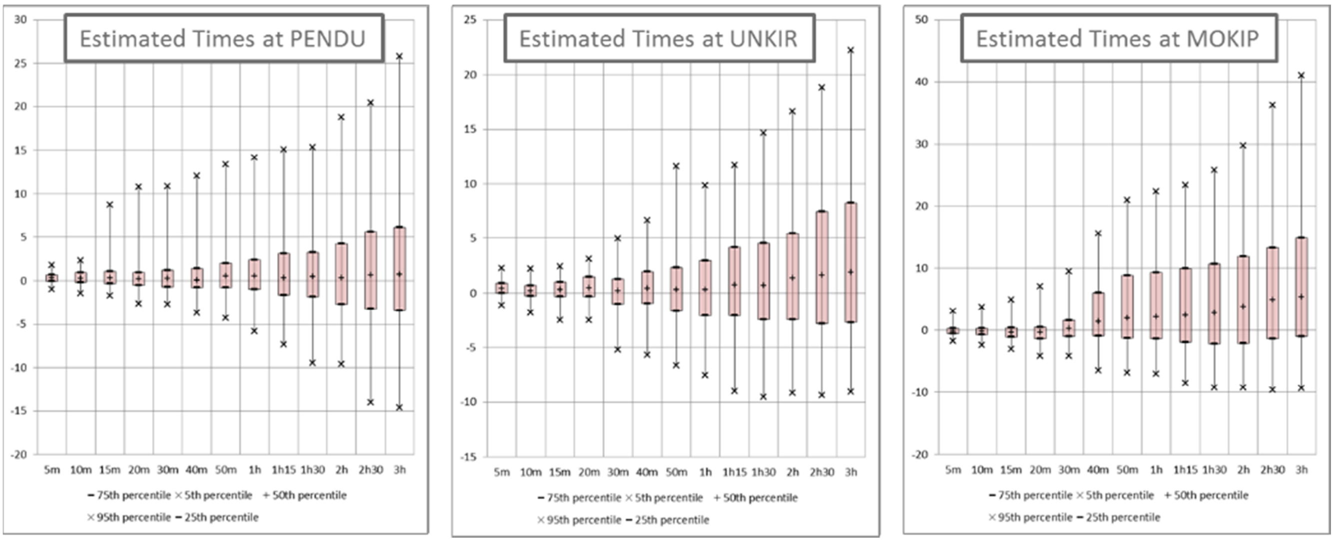


Fig. 33: Precision of Estimated Times Over the Metering Fixes feeding UJ sector, in minutes, during trials

According to the figure above, 30 minutes before the different Metering Fixes, ETOs predictability is:

- ±1.5 minute for 50% of the flights,
- ± 5 minutes for 90% of the flights.

The most reliable horizon for the arrival sequence compatible with the COP Sequencer concept remains the horizon 20 to 30 mins before the metering fix.

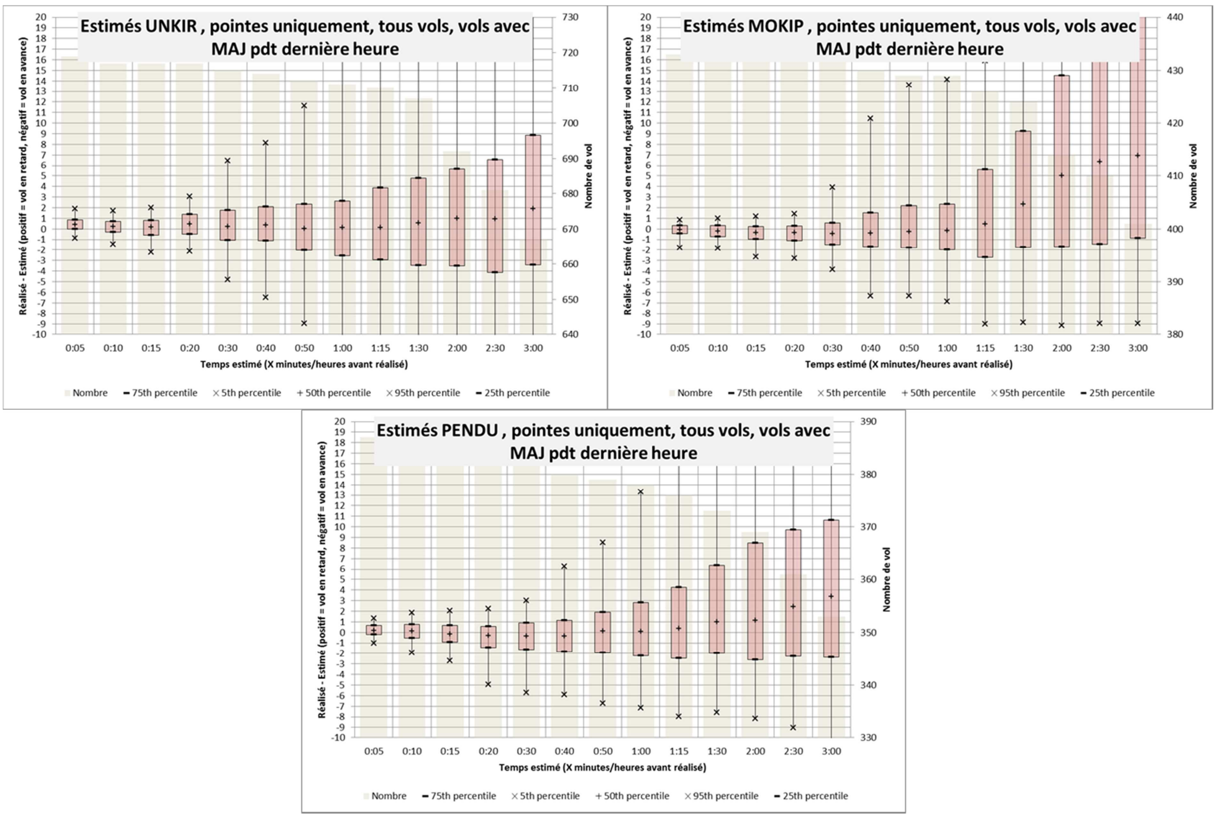


Fig. 34: Precision of Estimated Times Over the Metering Fixes feeding UJ sector, in minutes, during baseline

The predictability is unchanged between the baseline & the solution according to the recorded data.

Landing sequence predictability:

CPR and iAMAN scheduler data were used for this analysis. The results listed here were calculated with an in-house DLR software application which was developed especially for xStream performance assessment and calculates the number of sequence jumps in the predicted arrival sequence, compared to the actual arrival sequence, from the mentioned data.

All days between 01st March and 30th June 2018 that were no originally planned trial days were used as reference (66 days). Due to data quality (mainly data gaps in the scheduler data), 43 of 66 reference datasets and 22 of 50 trial datasets are useable for analysis.

Within these trial datasets, speed advisories were given on 6 of 22 usable trial datasets.

Comparability checks indicated that the used 43 reference datasets are usable to serve as baseline against the remaining 22 trial datasets.

The following table shows the measured average number of sequence jumps per flight for CDG arriving traffic between actual landing sequence and planned arrival sequence at 100NM distance from CDG (hypothesis: COP sequencer used in UJ sector leads to a smoother and more predictable arrival flow).

	Average sequence jumps per flight (standard deviation in brackets)	
	All usable datasets	Trial days with given speed advisories only
Reference	2,94 (SD: 1,55)	-
Trial	2,92 (SD: 1,04)	2,79 (SD: 0,85)
Difference	-0,02	-0,15

Table 5: Landing sequence predictability results

A very slight decrease of the average number of sequence jumps per flight can be seen, indicating a slightly improved predictability of the whole arrival sequence for all LFPG arrivals.

J.3.1.1.1.2.2 Qualitative Assessment

Paris FMP felt the arrival sequence was more much predictable during the EXE-VLD-07-002 UJ scenario trials with the use of iAMAN tool showing the forecast peaks with NM data on the new LFFFUJX airspace.

This is shown by the questionnaire related to confidence during the trials as shown in Fig. 32: .

J.3.1.1.1.3 KPA Environment

J.3.1.1.1.3.1 Quantitative Assessment

Fuel consumption:

CPR data was used for this analysis.

The results listed below were calculated with an in-house DLR software application which estimates the fuel consumption of aircraft flight trajectories based on BADA version 3.13. The results are therefore specific to the aircraft type.

To get reliable results, a certain number of flights of the same aircraft type must be contained in the datasets to average outliers.

For this reason, the 5 most frequent aircraft types were considered for the analysis, i.e. A318, A319, A320, A321, A332. In total, 77.4% of all flights were performed with one of these aircraft types. The shares of these aircraft types are visible in Fig. 35: .

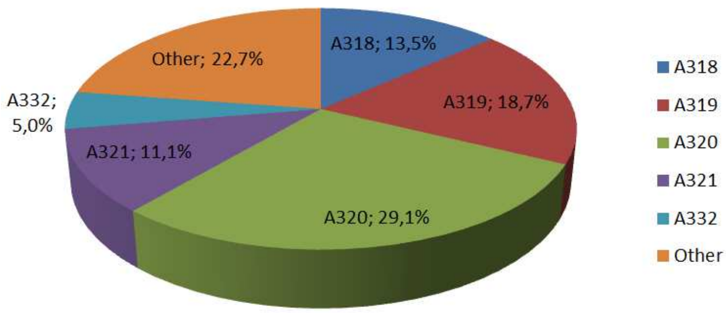


Fig. 35: Average aircraft type shares of the traffic during trial and reference datasets

As the results are an estimation based on BADA 3.13 data, which is not or just marginally considering most influencing factors for fuel consumption (actual aircraft weight, weather, engine types, etc.), the actual fuel consumption values (kg) are not meaningful.

Therefore, only the relative difference compared to the baseline datasets is written down below (average relative fuel savings within UJ sector).

The hypothesis is that the COP sequencer used in UJ sector leads to a reduction of fuel burn, which is directly connected to a reduction of gas emissions.

As result of the fuel calculation for these aircraft types, considering all traffic within all planned trial datasets (50 days) and comparing them to all reference datasets (66 days), the average fuel saved per flight for the leg within the UJ sector according to the performed analysis equals **-0,35% (fuel consumption in trial datasets was determined very slightly higher than in reference datasets).**

When only considering all trial and reference datasets which passed comparability checks as described in appendix E, the average fuel saved per flight for the leg within the UJ sector according to the performed analysis equals **-1,98%**.

When only comparing all days where speed advisories were given (21 datasets) and comparing them to datasets without speed advisories within the whole period with a comparable traffic throughput (69 datasets), the average fuel saved per flight for the leg within the UJ sector according to the performed analysis equals **5,07%**.

When additionally considering the results of the comparability checks as described in appendix E, the average fuel saved per flight for the leg within the UJ sector according to the performed analysis equals **12,19%**.

Summarized, when averaging over the whole trial period, the effect seems to be too small to be measurable with this method. However, a decrease of fuel consumption was clearly determined for those aircraft types when focussing on the runs where speed advisories were actually given.

CDG arrivals in UJ sector fly through the E-TMA airspace during around 6.5 minutes. According to Standard Inputs for EUROCONTROL Cost Benefit Analyses - Edition 8, this represents a fuel consumption of 285 kg for the most common aircraft type (A320 family).

A 12% saving represents a saving of fuel consumption of around 30 kg per arrival, and a reduction of 93 kg of CO2 gas emissions.

J.3.1.1.1.3.2 Qualitative Assessment

None

J.3.1.1.1.4 KPA Cost Efficiency (not required by DEMO objectives but covered)

J.3.1.1.1.4.1 Quantitative Assessment

Additional ASMA Time:

Additional ASMA (Arrival Sequencing and Metering Area) time in UJ sector ACC per flight was calculated during EXE7#2-UJ-P3-1-2018 and during the reference solution (EXE7#2-UJ-P3-1-2018 when no speed reductions were requested), with a comparable traffic throughput, and considering the results of the comparability checks passed as described in appendix E.

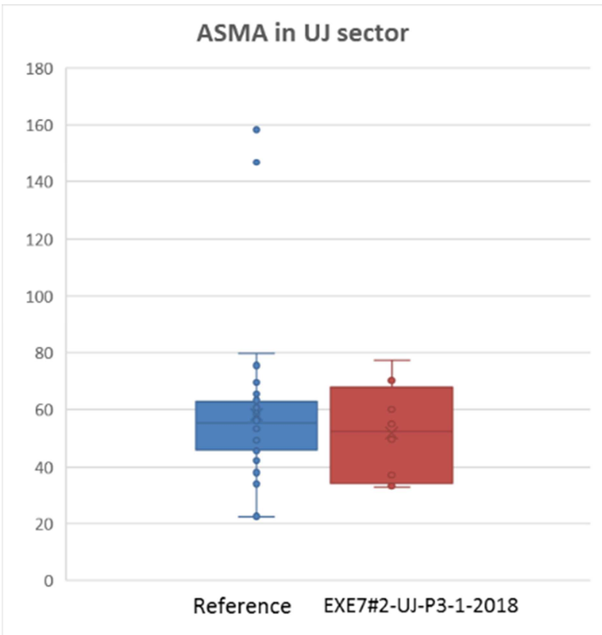


Fig. 36: Additional ASMA time (in seconds) during EXE#7-UJ-P3-1-2018 and reference solution

According to calculated additional ASMA time in LFFF UJ sector, a slight improvement could be measured between the reference solution and EXE#7-UJ-P3-1-2018 (average ASMA decreased from 58 seconds to 51 seconds).

Number of holding patterns flown in TMA:

- No holding patterns were measured during reference and EXE#7-UJ-P3-1-2018.

Flown distance between TOD and IAF:

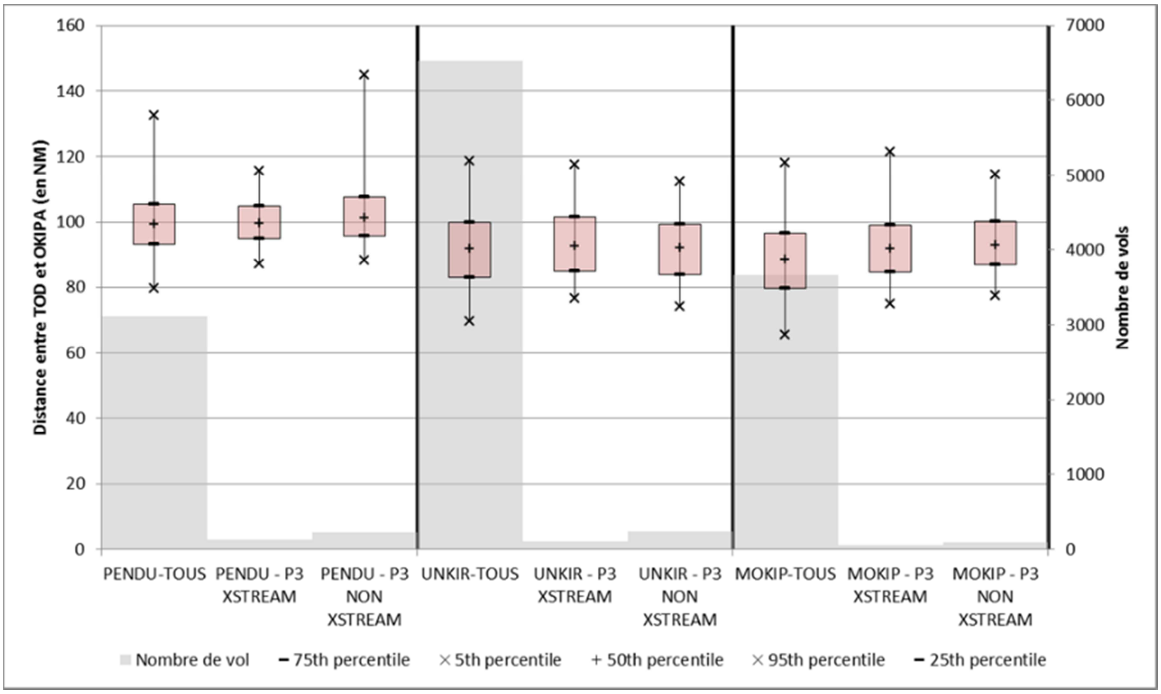


Fig. 37: Distance between TOD and OKIPA for flows from PENDU; UNKIR; MOKIP during EXE#7-UJ-P3-1-2018 and reference solution

The flown distance between the TOD and IAF remains very similar during reference solution and EXE#7-UJ-P3-1-2018. This was calculated when the flight was descending through FL345 to lower levels towards the IAF.

J.3.1.1.1.4.2 Qualitative Assessment

Other subjective feedback related to Cost Efficiency:

AU cost:

Air France had the intention to confirm the estimates of fuel reduction, brought by shorter flown distance and time, through the detailed analysis of actual fuel consumption on some of the flights concerned by the trials. This analysis has proved unsuccessful, because the grain of available fuel data is too coarse to isolate the effect.

Air France supports the estimated figures, since they have been obtained with a careful analysis and using the unit figures from the customary models.

In terms of incurred cost for the airline, the procedures of Exercise 2 do not introduce additional effort neither to pilots nor to ground personnel.

ANSP cost:

- According to the questionnaires filled by Paris ATCOs and post trials interviews, some Paris ACC ATCOs declared the speed reductions implemented upstream allowed them to avoid giving radar vectors, or just to give minimal radar vector to build the arrival sequence to CDG and therefore optimize the flights trajectories during the sequencing in the Extended TMA.

- Paris FMPs received training during their planned FMP course & multiple refresher courses in Paris ACC. They also received training on iAMAN during their planned FMP shift and performed the trial days during planned FMP shifts. Therefore EXE-VLD-07-002 implied no extra cost for the ANSP. No extra staff needs to be recruited to conduct the trials.
-

J.3.1.1.1.5 KPA Capacity

J.3.1.1.1.5.1 Quantitative Assessment

<u>TMA Throughput:</u>

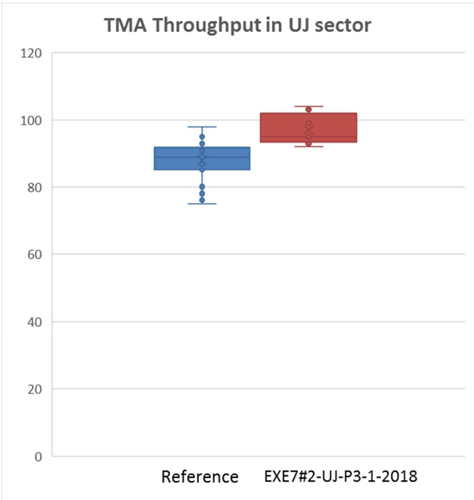


Fig. 38: TMA throughput between EXE#7-UJ-P3-1-2018 (blue) and reference solution (red)

TMA throughput in UJ sector is increased during EXE#7-UJ-P3-1-2018 compared to reference solution. This was calculated by counting the number of CDG arrivals flying via UJ sector from 09:00 LOC to 12:00 LOC. This is observed probably because the trial dates were chosen because the arrival peak was detected to be high and suitable for the trials.

<u>Traffic Density:</u>

CPR data was used for this analysis.

The results listed here were calculated with an in-house DLR software application (EWMS) which is capable of calculating various performance indicators and that was used here to analyse the flights per airspace volume (=UJ sector) as a function of time. Here, the following indicators where calculated:

- Average traffic density and standard deviation,
- Average traffic density maximum of the peak.

The following table shows the results for the measured indicators for CDG arriving traffic transiting the UJ sector (hypothesis: COP sequencer used in UJ sector leads to less bunching and a slight decrease in the above-mentioned indicators).

In total, four different dataset compositions were analysed again:

1) All planned trial days (50 days) are compared against all non-trial days between 01st March and 30th June 2018 (66 days).

2) Is a subset of composition 1) containing most comparable datasets following the comparability checks described in appendix E (22 trial days, 35 reference days).
3) Only those trial days where XMAN actions were actually performed are compared to all other days between 01st March and 30th June 2018 with a comparable traffic throughput (21 trial days, 69 reference days).
4) Is a subset of composition 3) containing most comparable datasets following the comparability checks described in appendix E (6 trial days, 39 reference days).

		Average traffic density (flights per volume) / Standard deviation (SD)	**Average traffic density maximum of the peak (flights per volume)**
Composition 1)	**Reference**	1,2246 (SD:1,0937)	4,27
	Trials	1,2879 (SD:1,1767)	4,69
Composition 2)	**Reference**	1,2354 (SD:1,1139)	4,46
	Trials	1,3074 (SD:1,1615)	4,6
Composition 3)	**Reference**	1,3278 (SD:1,1605)	4,67
	Trials	1,3407 (SD:1,2268)	4,68
Composition 4)	**Reference**	1,3553 (SD: 1,164)	4,76
	Trials	1,2341 (SD: 1,189)	4,33

Table 6: Traffic density results for UJ Sector

Only composition 4) shows the expected behaviour, but for composition 1) to 3) the expected slight decrease for the defined indicators cannot be observed.

However, it has to be noted that the observed changes for composition 1) to 3) are rather small (<0,08 aircraft per airspace volume), so it can be questioned if these changes are interpretable.

Flight path diversity

CPR data was used for this analysis.

The results listed here were calculated with an in-house DLR software application (EWMS) which is capable of calculating various performance indicators and that was used here to analyse the flight path diversity in the UJ sector for the peak time period.

The Flight path diversity indicator has a value from 0 (zero diversity) to 1 (max diversity) and is one means to quantify traffic complexity, based on flight trails.

The following table shows the results for CDG arriving traffic transiting the UJ sector (hypothesis: COP sequencer used in UJ sector leads to less bunching and less vectoring and other path stretching manoeuvres inside the UJ sector.

Therefore, this indicator should show a slight decrease). The same dataset compositions as for traffic density were used.

		Average flight path diversity (value from 0 to 1) / Standard deviation (SD)
Composition 1)	Reference	0,8497 (SD: 0,059)
	Trials	0,8561 (SD: 0,059)
Composition 2)	Reference	0,8505 (SD: 0,056)
	Trials	0,8436 (SD: 0,067)
Composition 3)	Reference	0,8549 (SD: 0,054)
	Trials	0,8745 (SD: 0,048)
Composition 4)	Reference	0,8446 (SD: 0,057)
	Trials	0,8675 (SD: 0,055)

Table 7: Flight path diversity results for UJ Sector

Only composition 2) shows the expected behaviour, but for composition 1), 3) to 4) the expected slight decrease for the defined indicators cannot be observed.

However, it has to be noted that the observed changes for all four compositions are rather small, so it can be questioned if these changes are interpretable and the sensitivity of this metric is sufficient to measure the effect of the COP sequencing benefits.

It has to be noted that flight path diversity as complexity indicator also increases when more direct routings that are deviating significantly from the standard routing are instructed by ATCOs.

An indication whether this is the case or not is the estimated fuel consumption, in detail when a decrease is measured there more and earlier direct routings within the UJ sector are likely, leading to a more expeditious but not necessarily less complex traffic.

<u>Level dispersion at IAF:</u>

The level dispersion at the IAF couldn’t be computed for the COP Sequencer UJ trials.

J.3.1.1.1.5.2 Qualitative Assessment

<u>Questionnaire results related to E-TMA capacity:</u>

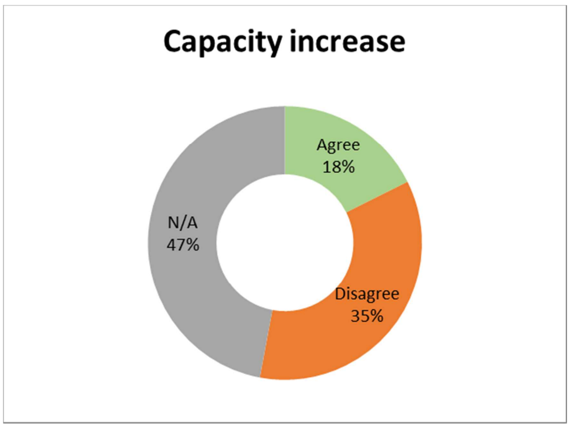


Fig. 39: Impact on capacity increase assessed by Paris FMP

Out of the 34 questionnaires filled by Paris FMP during EXE-VLD-07-002, 18% of Paris FMP assess the concept may enable an increase of capacity, 35% disagree with this and 47% have no opinion.

Note that the answer "disagree" does not mean that there was a capacity decrease (it just means "no increase").

Indeed, during interviews with Paris FMP, a few of them outlined when iAMAN was inoperative due to technical failure, they had to implement an ATFCM regulation on LFFF UJ sector when detecting a high traffic load, as they regularly do to cope with traffic load & complexity.

If they would have had an iAMAN functional at this time, they wouldn't have implemented an ATFCM regulation on LFFF UJ sector.

Questionnaire results related to ATCO workload:

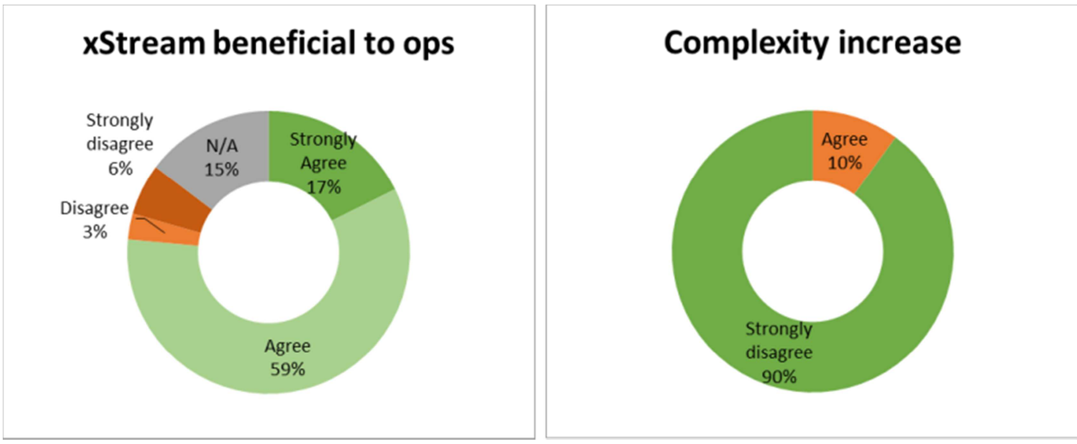


Fig. 40: Impact on complexity & on operations assessed by Paris ATCO

COP Sequencer UJ concept was beneficial to operations for 76% of the ATC and 90% assess complexity didn't increase during the trials. 9% of Paris ACC ATCO disagree it was beneficial, and 10% of them assessed it brought a complexity increase when Paris FMP requested flights to slow down based on an unreliable arrival sequence fed by inaccurate ETOs (for instance, when Paris FMP asked for speed reductions more than 30 minutes before the hotspot, which was not recommended during the trials).

Other subjective feedback related to ATCO workload:

During post-trial interviews, many ATCOs (around 10) assessed the trials helped them dealing with the sequencing of arrivals and allowed to decrease the complexity of the hotspot (i.e. by reducing the need of giving radar vectors to increase miles-in-trails between arrivals to match the required parameters by the LOA).

Questionnaire results related to ATCO situation awareness:

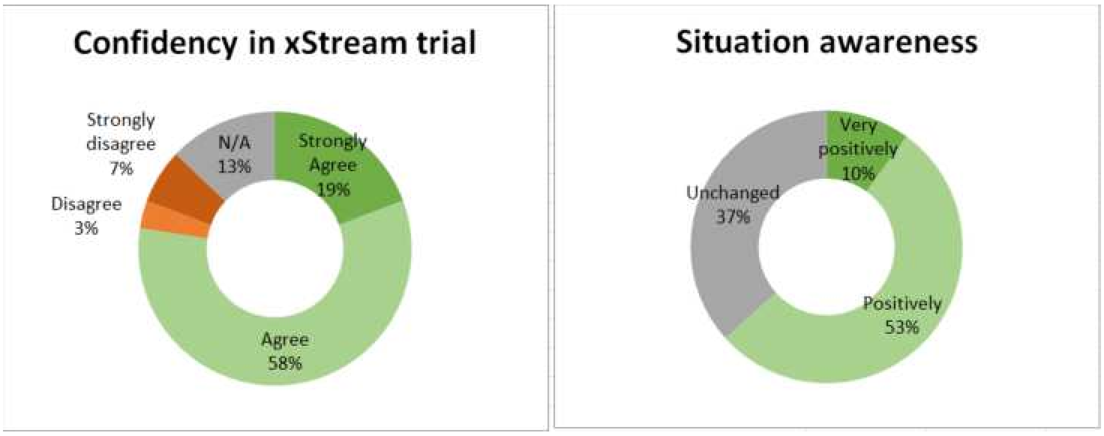


Fig. 41: Impact on confidence & situation awareness assess by Paris ATCO

COP Sequencer UJ concept was felt as increasing positively by 63% of the ATCO their situation awareness on the UJ sector, and the ATCO were confident in the trials by 77% in regards of the traffic situation. 10% of ATCO assessed they had no confidence in COP Sequencer UJ trials when the flights were reduced based on an unreliable arrival sequence fed by inaccurate ETOs (for instance, when Paris FMP asked for speed reductions more than 30 minutes before the hotspot, which was not recommended during the trials).

Impact on en-route ACC:

- Enroute sectors were not regulated due to XMAN requests and didn't report issues regarding complexity or capacity during EXE-VLD-002 UJ scenario.

J.3.1.1.2 Results impacting regulation and standardization initiatives

During planning EXE-VLD-07-002, a reduction of Mach 0.04 was decided as the standard Mach number reduction to be applied for CDG arrivals when in cruise.

This reduction was accepted by a wide variety of all the flight crews operating flights to CDG, from medium-bodies (B737NG or A320 series) to wide-bodies (B777 series or A330/340 series).

This trial supports this magnitude of Mach number reduction for XMAN operations.

However, some aircraft types are more difficult to change Mach number-wise such as Boeing 737-300 or RJ85/Bae146.

Furthermore, flights departing airports close to the horizon or in-horizon (e.g. departures from Milano, Geneva, Zurich, Lyon, Basel-Mulhouse) were impossible to act upon because they were still on the ground or in climbing phase and their speed can vary from using IAS or Mach numbers, and their estimated time over the Metering Fixes and their ETA can vary during climb until reaching their cruising flight level.

The implementation of the XMAN requests towards the upstream ACCs was very successful (close to 90%) because only the limited number of requests per peak was distributed to the upstream ACCs (6 per peak max, average of 1,8 requests per peak).

Speed re-acceleration observed in buffer ACC outlines the XMAN status needs to be shared along the sectors crossed by the flight.

J.3.1.2 Analysis of Scenario Results per Demonstration objective

J.3.1.2.1 OBJ-VLD-01-001 Results

This objective was to show that xStream operational improvements are respecting the current level of safety in air traffic management.

The corresponding success criterion is fulfilled when the safe management of traffic by ATC is not compromised and new procedures do not cause critical incidents.

No safety occurrences were reported in Paris ACC, Zurich ACC, Reims ACC, Geneva ACC or Milano ACC according to post trial feedback.

Qualitative analysis & feedback from operational staff confirms that the safe management of traffic was never compromised in neither of these ACCs.

This objective can be considered fulfilled.

J.3.1.2.2 OBJ-VLD-02-001 Results

This objective was to show that xStream operational improvements provide a better predictability and punctuality of air traffic in TMA / terminal sectors.

The corresponding success criterion is fulfilled when differences between planned / predicted and actual traffic flow at prominent points or at the runway are reduced.

According to the quantitative results, the arrival sequence was measured to be slightly improved in terms of predictability for the CDG arrivals during EXE-VLD-07-002 UJ scenario.

According to the qualitative feedback of Paris FMP, the prediction of the arrival sequence in the E-TMA was improved with the used of iAMAN fed by NM data, which was reliable enough to be used in the COP Sequencer targeted horizon of 20 to 30 minutes before the peak.

This objective can be considered fulfilled.

J.3.1.2.3 OBJ-VLD-03-001 Results

This objective was to show that xStream operational improvements provide benefits in terms of environmental sustainability of air traffic.

The corresponding success criterion is fulfilled when fuel efficiency of air traffic is increased while emissions (and noise pollution) are reduced.

According to the calculation done during EXE-VLD-07-002 UJ scenario, fuel consumption was decreased by up to 12% on average for the flight portion within LFFF UJ sector when the COP Sequencer trial was activated, in comparison with comparable traffic presentation & load values.

This objective can be considered fulfilled.

J.3.1.2.4 OBJ-VLD-05-001 Results

This objective was to show that ATC capacity usage in TMA is optimized by xStream operational improvements.

The corresponding success criterion is fulfilled when Traffic load, ATC workload or complexity in terminal sectors is reduced.

According to quantitative results, traffic density is decreased by up to 9% on average when COP Sequencer concept is activated, compared to comparable days during EXE-VLD-07-002 UJ scenario.

According to qualitative results, feedback from Paris ATCOs dealing with the arrival sequence during EXE-VLD-07-002 UJ scenario didn't feel an increase of complexity and reported a decrease in complexity & ATC workload on many occasions. Some Paris FMP also reported the concept could enable a capacity increase in the future.

This objective can be considered fulfilled.

J.3.1.2.5 OBJ-VLD-05-002 Results

This objective was to show that available en-route sector capacity allows the application of xStream operational improvements.

The corresponding success criterion is fulfilled when Traffic load, ATC workload or complexity in en-route sectors do not exceed available capacity.

According to feedback obtained from the participating upstream ACCs to the COP Sequencer UJ trials, no ATFCM regulation nor other capacity reduction has been caused by EXE-VLD-07-002 UJ scenario, and with a 89% rate of XMAN action implementation in the upstream ACCs, the application of the measures didn't cause major ATC workload or complexity issues.

This objective can be considered fulfilled.

J.3.1.3 Unexpected Behaviours / Results

During EXE-VLD-07-002 UJ scenario unexpected behaviours or results as follows were noticed:

- <u>Unreliable estimates</u>: on a few occasions, the estimated times over at the Metering Fixes could "jump" and have sudden different values even during the targeted horizon, when the ETOs are supposed to be stable. This occasional unreliability had an important effect on the stability of the arrival sequence and could lead to the wrong choice of flight selection for XMAN action. This estimate unreliability could come from strong winds enroute, or technical limits in NM B2B for flight profile updates (CPR) maybe due to the data feed from different RDPS.

- <u>Aircraft re-acceleration in buffer ACC</u>: as shown in Fig. 26: the COP Sequencer UJ horizon needs the arrivals to be reduced 20 to 30 minutes before LFFF UJ sector, that can be 2 ACCs before reaching Paris ACC. For instance, flights reduced in Zurich ACC fly through Reims ACC before reaching Paris ACC UJ sector, and flights reduced in Milano ACC fly through Geneva ACC before reaching Paris ACC UJ sector. 15% of the flights reduced in these 2 ACCs were given free speed in the buffer ACC and therefore it decreased the benefits of the XMAN action.

- <u>Refusal of XMAN actions by flight crews</u>: on 4 recorded occasions, flight crews refused to comply with the initial M0.04 reduction request. Eventually they refused to reduce due to flight performance or they only accepted a reduction of M0.02 or M0.03.

- <u>ATFCM regulation bunching assistance</u>: on 2 occasions, EXE-VLD-07-002 UJ scenario helped Paris FMP to smooth an arrival peak following the appearance of a bunching of arrival traffic during a LFPGARR1 ATFCM regulation or after a removal of this regulation.

- <u>Ability to accelerate the first arrivals of a bunch</u>: in order to optimize the arrival sequence, Paris FMP operators indicated the ability to accelerate the first arrival of a sequence would be useful in order to optimize the arrival sequence. However, this type of action didn't occur during the trials.

J.3.1.4 Confidence in the Demonstration Results

J.3.1.4.1 Level of Significance / Limitations of Demonstration Exercise Results

EXE-VLD-07-002 UJ scenario was applied during the busiest CDG arrival peaks flying through UJ sector during the day. Paris FMPs were properly trained on the concept and on iAMAN tool so they could pick the most relevant flights to be reduced upstream in order to mitigate the complexity in the E-TMA.

A checklist was prepared for Paris FMP operators so the concept is properly applied, and an operational instruction was issued to Paris ACC ATCOs working the UJ sector was notified of the trials.

However, on a few occasions, some busy peaks couldn't be trialled in case Paris Supervisor didn't want the trial to be run or in case an ATFCM regulation activated beforehand had already smoothed the arrival peak.

J.3.1.4.2 Quality of Demonstration Exercise Results

Qualitative assessment was recorded with the use of questionnaires distributed to Paris FMP that actually used iAMAN to activate the COP Sequencer concept during EXE-VLD-07-002 UJ scenario.

Questionnaires were distributed and were filled by 20 different FMP operators. The output was of 34 FMP questionnaires in total.

Questionnaires were also distributed to Paris ATCOs who handled the arrival sequence on the arrival sector impacted by the XMAN actions, 34 questionnaires were returned.

Quantitative assessments for TMA throughput, ASMA, flight path diversity and fuel consumption were made between EXE#7-UJ-P3-1-2018 (solution composed of 8 peaks) and the reference dates (composed of 39 peaks), with comparable traffic throughput and comparability checked passed as described in Annex E.

However, TMA throughput in UJ sector is increased probably because targeted peaks during EXE#7-UJ-P3-1-2018 had more bunches than in reference solutions, since the COP Sequencer trials were activated only during high peaks of arrivals.

However, in spite of a higher TMA throughput in UJ during EXE#7-UJ-P3-1-2018 compared to reference solution, the ASMA managed to be slightly decreased.

J.3.1.4.3 Significance of Demonstration Exercise Results

EXE-VLD-07-002 UJ scenario targeted the busiest CDG arrival peaks in 2018 and 2019.

Paris FMP operators were properly trained on the concept and the tool and could apply the COP Sequencer concept during busy periods to help the ATCOs mitigate its workload.

Paris FMP could ask for XMAN actions on the ACCs delivering the majority of the flows to the UJ sector (Zurich, Milano and Geneva), and in spite of the non-participation of Marseille ACC and some technical failure of iAMAN during some planned trial days, 95 flights could have been asked to be reduced upstream, with a 89% implementation rate.

Therefore, the demonstration exercise results should be considered as solid.

J.3.2 TE Scenario

One trial period in 2019 was conducted while focussing on different traffic peaks. They are assumed not to be fully comparable to each other due to different daytimes and traffic picture, which is why they have been analysed separately. The following table gives an overview on performed trial periods.

Internal ID(s)	Start Date	Stop date	Target peak (LT)	Days
EXE7#2-TE-P2-1-2019	March 22, 2019	April 16, 2019	P2: 7h40-9h00	Everyday excl. weekends
EXE7#2-TE-P5-1-2019	March 22, 2019	April 16, 2019	P5: 16h00-17h40	Everyday excl. weekends

Table 8: Trial periods for EXE-VLD-07-002: COP sequencer for the TE sector

In order to keep the complexity and clarity of this document at a reasonable level the results presented below are the results collected during trial period 22nd March 2019 to 16th April 2019 for Peak 2 (EXE7#2-TE-P2-1-2019), based on the comparability & visibility of benefits, and the number of speed advisories given.

The justifications are provided in the following table.

Internal ID(s)	Number of trial dates	Number of flights with requested XMAN actions	Remarks
EXE7#2-TE-P2-1-2019	11	33	Successful trial, good visibility of benefits
EXE7#2-TE-P5-1-2019	7	15	Successful trial, but benefit is less visible due to lower number of speed advisories given; some comparability problems due to weather issues

Table 9: Main Outcomes for EXE-VLD-07-002: COP sequencer for the TE sector

The first outcomes of the COP SEQ TE trials are:

- Trials had been activated on 18 arrival peaks.
- Main peak addressed had been P2 (61%) ahead of P5 (39%),
- 48 flights in total were requested for speed reduction by Paris FMP to upstream ACCs
- Trials had been activated when no ATFCM regulation was activated (67%), during LFFTE3 ATFCM regulations were activated (28%) and also when LFPGARR1 ATFCM regulations were activated (5%)

Paris FMP operators found some opportunities to activate the trials in 2019 for the following reasons:

- To lower complexity if LFFTE3 regulation was not effective enough to de-bunch the arrival flows,
- Mitigate bunching during a LFPGARR1 regulation,
- Lower complexity in case no LFFFTE3 regulation was activated,
- Undetected bunching appearing late in LFFF TE sector.

On the contrary, COP Sequencer trials hadn't been activated due to:

- Weather (strong winds),
- Low traffic demand,
- Traffic already delayed by upstream ATFCM regulations.

The overall recorded data for EXE-VLD-07-002 TE scenario is listed below:

- 48 flights total were requested to be reduced by Paris FMP to upstream ACCs during 18 peaks
- Average number of requested XMAN action per peak: 2,7,
- Maximum number of requested XMAN action per peak: 6,
- Acceptation rate: 98% implemented; 2% unknown;

Note: The acceptation rate was calculated according to FlightRadar24 data (when flight was observed in the upstream sector) or Mode S data observed by Paris FMP when entering TE sector.

- Metering Fixes for arrivals concerned by XMAN action: 72% via VEDUS / 28% via MOPIL
- Upstream ACCs where XMAN actions were implemented: 58% in KUAC / 42% in MUAC
- Reaccelerated flights in E-TMA: 6% of the flights were re-accelerated in TE sector when in contact with Paris ACC ATCO because they finally were #1 in the arrival sequence or the ATCO changed his/her sequencing strategy.

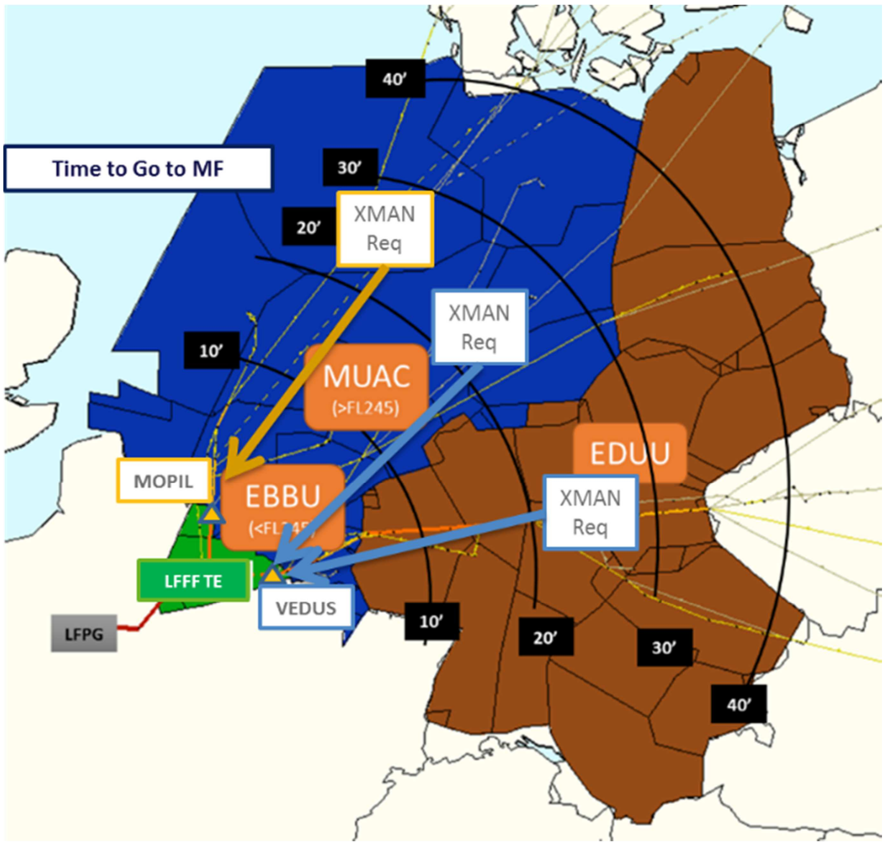


Fig. 42: Average position of XMAN requests in MUAC & KUAC

- Average notice of XMAN request before Metering Fix: 25 minutes (see Fig. 42:)
- Average distance of XMAN request from Metering Fix: 185 NM
- Average distance of XMAN request from CDG runway: 280 NM
- Average flight parameters before XMAN reduction request: Mach 0.79 / Ground speed 450 kts / FL370
- Average flight parameters after XMAN reduction request: Mach 0.75

J.3.2.1 Summary of Scenario Results

See main document chapter 4.1.2.2.2.

J.3.2.1.1 Results per KPA

In this section, the quantitative assessment is based on the results collected during trial period 22nd March 2019 to 16th April 2019 for Peak 2 (EXE7#2-TE-P2-1-2019), based on the comparability & visibility of benefits, and the number of speed advisories given.

In this section, the qualitative assessment is based on:

- 17 questionnaires filled by Paris FMP who analysed the arrival sequence and requested the XMAN actions to the upstream ACCs;
- 18 questionnaires filled by Paris ATCO who tactically managed the arrival sequence in the TE sector after XMAN actions were requested to the upstream ACCs.

J.3.2.1.1.1 KPA Safety

J.3.2.1.1.1.1 Quantitative Assessment

<u>Number of Incident Reports:</u>

- No incidents were reported in connection with the trials in Paris ACC, MUAC or KUAC.

J.3.2.1.1.1.2 Qualitative Assessment

<u>Questionnaire Results related to Safety:</u>

- Paris ATCO feedback:

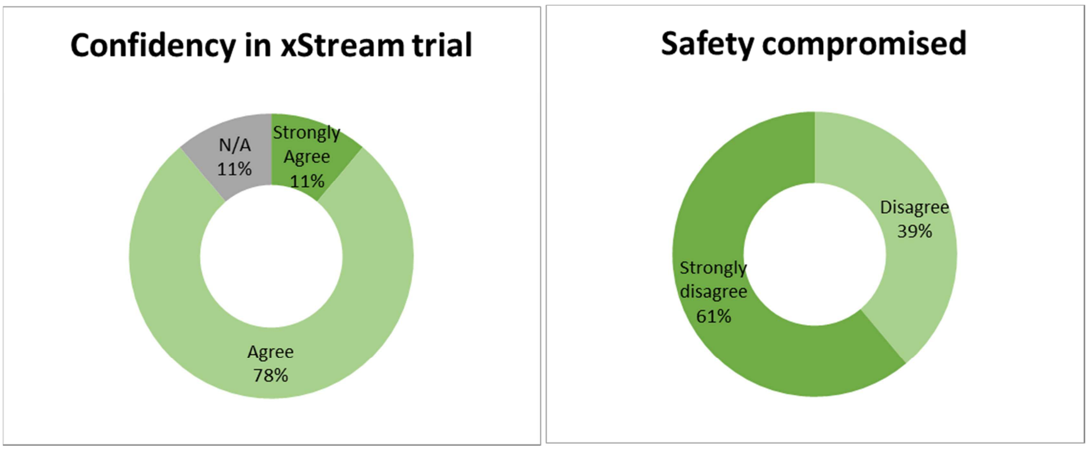
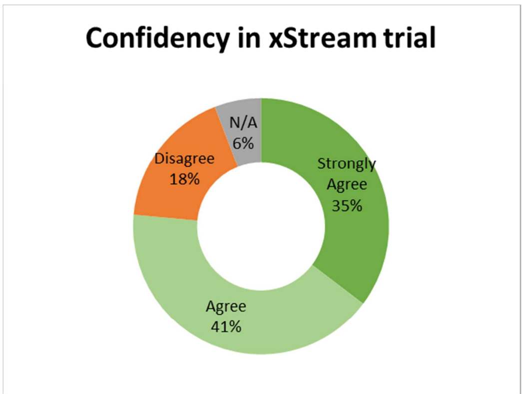


Fig. 43: Confidence & safety questionnaires results from Paris FMP

Paris FMPs who were running the trials had a good confidence in the trials (89%) and assessed safety was never compromised.

- <u>Paris FMP feedback</u>:



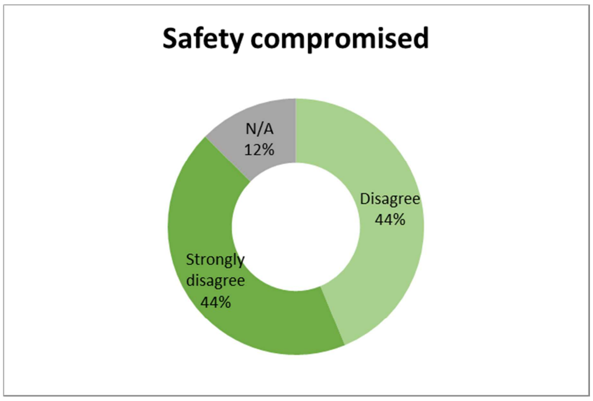


Fig. 44: Confidence & safety questionnaires results from Paris FMP

Paris FMP that were running the trials had a good confidence in the trials (76%) and assessed safety was never compromised. 18% of Paris FMP that filled the questionnaires didn't have confidence in the trials because they were not sure if the predicted arrival sequence in iAMAN was accurate or not.

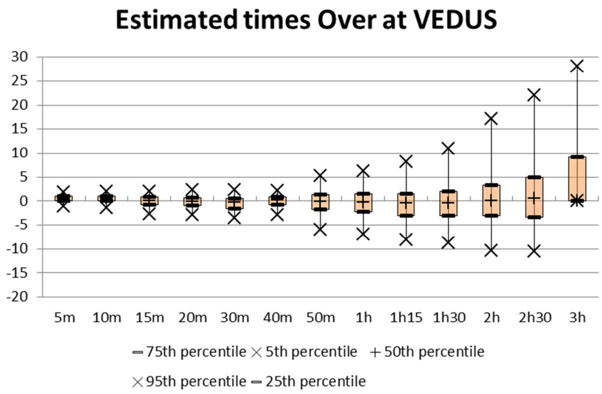
However, an inaccurate predicted arrival sequence is not considered to be an immediate safety problem.

No other report indicating safety issue was received from the upstream ACCs implementing speed reductions.

J.3.2.1.1.2 KPA Predictability and Punctuality

J.3.2.1.1.2.1 Quantitative Assessment

Time difference actual – planned:



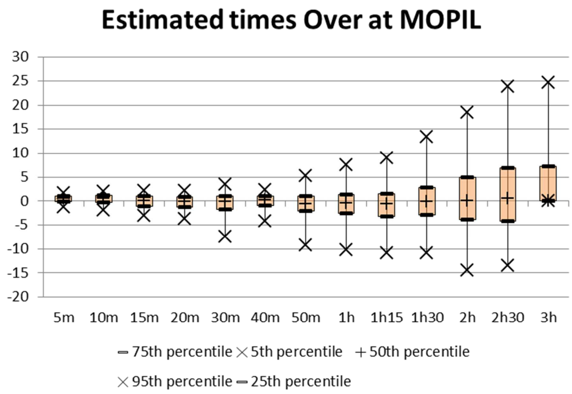


Fig. 45: Precision of Estimated Times Over the Metering Fixes feeding TE sector, in minutes during trials

iAMAN data was assessed compared to the predicted times over the Metering Fixes and the actual times over or maximum 10 NM abeam the Metering Fixes VEDUS or MOPIL.

According to Fig. 45: 30 minutes before the different Metering Fixes, ETOs predictability is:

- +0,2 mins / -1,6 mins for 50% of the flight
- +3 mins / -5 mins minutes for 90% of the flights

The most reliable horizon for the arrival sequence compatible with the COP Sequencer concept remains the horizon 20 to 30 mins before the arrival peak.

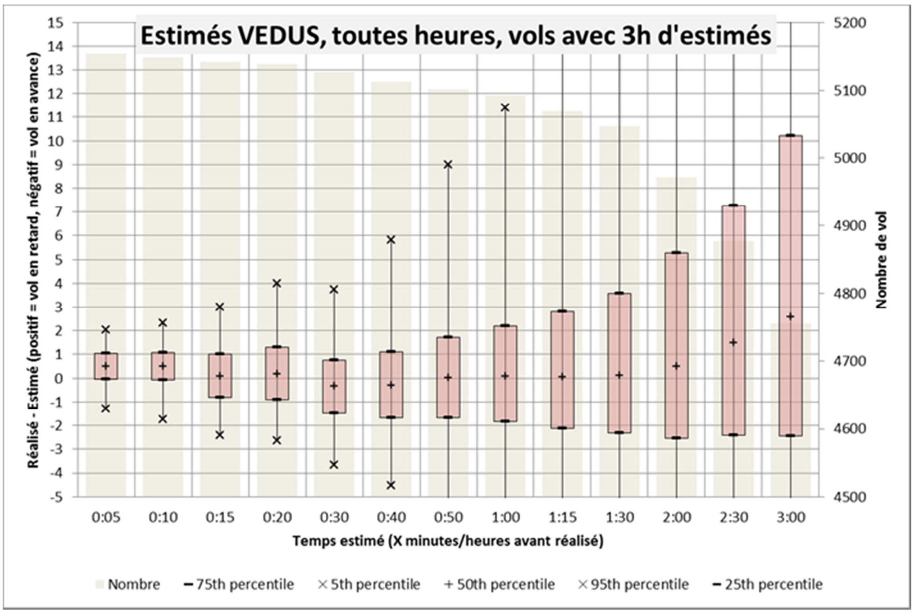


Fig. 46: Precision of Estimated Times Over VEDUS, feeding TE sector, in minutes during baseline

No obvious difference was observed between baseline and the trials in the targeted horizon.

Landing sequence predictability:

CPR and iAMAN scheduler data was used for this analysis.

The results were calculated with an in-house DLR software application which was developed especially for xStream performance assessment and calculates the number of sequence jumps from the mentioned data.

All days between 1st March and 30th April 2019 that were no originally planned trial days excluding weekends were used as reference (25 days).

Due to data quality (mainly data gaps in the scheduler data), 3 of 25 reference datasets and 0 of 18 trial datasets are useable for analysis. For this indicator not enough samples are available to draw conclusions.

J.3.2.1.1.2.2 Qualitative Assessment

Paris FMP felt the arrival sequence was more much predictable during the EXE-VLD-07-002 TE scenario trials with the use of iAMAN tool showing the forecast peaks fed with NM data. This is shown by the questionnaire related to confidence during the trials as shown in Fig. 44:

J.3.2.1.1.3 KPA Environment

J.3.2.1.1.3.1 Quantitative Assessment

Fuel consumption:

CPR data was used for this analysis. The results listed below were calculated with an in-house DLR software application which estimates the fuel consumption of aircraft flight trajectories based on BADA version 3.13. The results are therefore specific to the aircraft type.

To get reliable results, a certain number of flights of the same aircraft type must be contained in the datasets to average outliers.

For this reason, the 10 most frequent aircraft types were considered for the analysis, i.e. A319, A320, A321, A332, A333, A388, B738, B77W, E170, E190. In total, 65.6% of all flights were performed with one of these aircraft types. The shares of these aircraft types are visible in Fig. 47: .

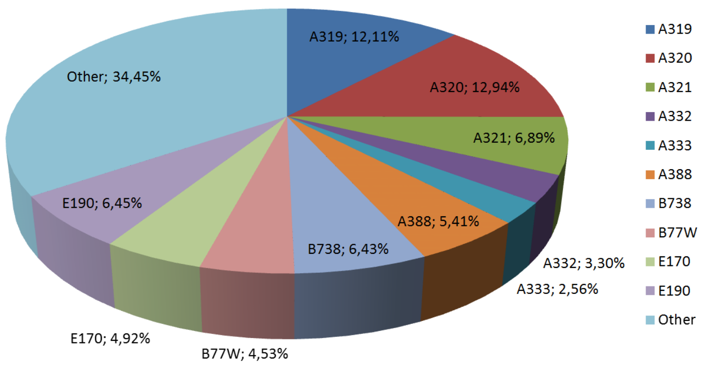


Fig. 47: Average aircraft type shares of the traffic during trial and reference datasets

As the results are an estimation based on BADA 3.13 data, which is not or just marginally considering most influencing factors for fuel consumption (actual aircraft weight, weather, engine types, etc.), the actual fuel consumption values (kg) are not meaningful.

Therefore, only the relative difference compared to the baseline datasets is written down below (average relative fuel savings within TE sector).

The hypothesis is that the COP sequencer used in TE sector leads to a reduction of fuel burn, which is directly connected to a reduction of gas emissions.

As result of the fuel calculation for these aircraft types, considering all traffic within all planned trial datasets (18 days) and comparing them to all reference datasets (non-trial days between 01st March and 30th April excluding weekends, 25 days), the average fuel saved per flight for the leg within the TE sector according to the performed analysis equals **3,94%.**

When only considering all trial and reference datasets which passed comparability checks as described in appendix E, the average fuel saved per flight for the leg within the TE sector according to the performed analysis equals **8,39%**.

When only comparing all days where speed advisories were given (11 datasets) and comparing them to datasets between 01st March and 30th April without speed advisories but with a comparable traffic throughput (28 datasets), the average fuel saved per flight for the leg within the TE sector according to the performed analysis equals **3,16%.**

When additionally considering the results of the comparability checks as described in appendix E, the average fuel saved per flight for the leg within the TE sector according to the performed analysis equals **12,49%**.

CDG arrivals in TE sector fly through the E-TMA airspace during around 7.9 minutes. According to Standard Inputs for EUROCONTROL Cost Benefit Analyses - Edition 8, this represents a fuel consumption of 300 kg for the most common aircraft type (A320 family).

A 12% saving represents a saving of fuel consumption of around 36 kg per arrival, and a reduction of 114 kg of CO_2 gas emissions.

J.3.2.1.1.3.2 Qualitative Assessment

None

J.3.2.1.1.4 KPA Cost Efficiency (not required by DEMO objectives but covered)

J.3.2.1.1.4.1 Quantitative Assessment

Additional ASMA Time:

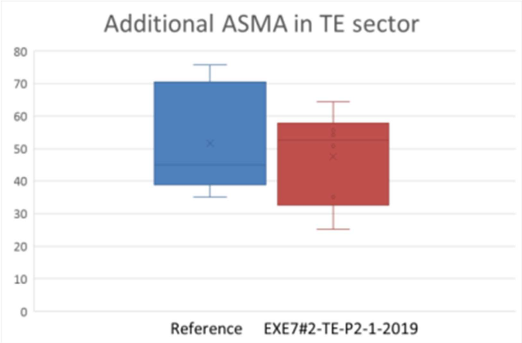


Fig. 48: Additional ASMA time in TE sector for CDG arrivals during EXE#7-TE-P2-1-2019 and reference period

According to calculated additional ASMA time in LFFF TE sector, a slight reduction of additional ASMA could be measured between the reference solution and EXE7#2-TE-P2-1-2019 (from an average of 68s to an average of 58s).

Number of holding patterns flown in TMA:

No holding patterns were measured during reference and EXE#7-TE-P2-1-2019.

Flown distance between TOD and IAF:

Flown distance between TOD & IAF couldn't be computed in this scenario this the majority of the CDG arrivals are already descending while entering & crossing the TE sector.

J.3.2.1.1.4.2 Qualitative Assessment

Subjective feedback related to Cost Efficiency:

AU Costs:

- According to the questionnaires filled by Paris ATCOs and post trials interviews, some Paris ACC ATCOs declared the speed reductions implemented upstream allowed them to avoid giving radar vectors, or just to give minimal radar vector to build the arrival sequence to CDG and therefore optimize the flights trajectories during the sequencing in the Extended TMA.

ANSP Cost:

- Paris FMPs received training during their planned FMP courses & multiple refresher courses in Paris ACC. They also received training on iAMAN during their planned FMP shift and performed the trial days during planned FMP shifts. Therefore EXE-VLD-07-002 implied no extra cost for the ANSP. No additional staff needed to be recruited for performing the trials

J.3.2.1.1.5 KPA Capacity

J.3.2.1.1.5.1 Quantitative Assessment

TMA Throughput:

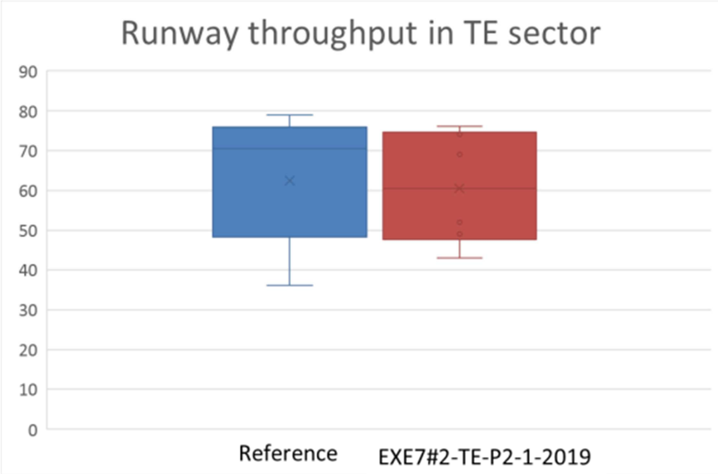


Fig. 49: TMA throughput between EXE#7-UJ-P2-1-2019 (blue) and reference solution (red)

TMA throughput in TE sector is similar during EXE#7-UJ-P2-1-2019 compared to reference solution.

Traffic Density:

CPR data was used for this analysis.

The results listed here were calculated with an in-house DLR software application (EWMS) which is capable of calculating various performance indicators and that was used here to analyse the flights per airspace volume (=TE sector) as a function of time.

Here, the following indicators where calculated:

- Average traffic density and standard deviation,
- Average traffic density maximum of the peak.

The following table shows the results for the measured indicators for CDG arriving traffic transiting the TE sector (hypothesis: COP sequencer used in TE sector leads to less bunching and a slight decrease in the above mentioned indicators).

In total, four different dataset compositions were analysed again:

1) All planned trial days (18 days) are compared against all non-trial days between 1st March 2019 and 30th April 2019 (25 days).
2) Is a subset of composition 1) containing most comparable datasets following the comparability checks described in appendix E (11 trial days, 7 reference days).
3) Only those trial days where XMAN actions were actually performed are compared to all other days between 1st March 2019 and 30th April 2019 with a comparable traffic throughput (11 trial days, 28 reference days).
4) Is a subset of composition 3) containing most comparable datasets following the comparability checks described in appendix E (6 trial days, 12 reference days).

		Average traffic density (flights per volume) / Standard deviation (SD)	Average traffic density maximum of the peak (flights per volume)
Composition 1)	**Reference**	2,372 (SD: 1,575)	6,48
	Trials	2,206 (SD: 1,388)	5,44
Composition 2)	**Reference**	2,131 (SD: 1,406)	5,50

	Trials	2,118 (SD: 1,356)	5,00
Composition 3)	Reference	2,337 (SD: 1,484)	5,93
	Trials	2,257 (SD: 1,401)	5,71
Composition 4)	Reference	2,128 (SD: 1,427)	5,50
	Trials	2,252 (SD: 1,318)	5,00

Table 10: Traffic density results for TE Sector

The expected slight decrease for the defined indicators is visible for compositions 1)-3). For composition 4) an increase is observed, but due to the low sample size (6 trial days in this composition) this result may be unreliable.

Flight path diversity:

CPR data was used for this analysis.

The results listed here were calculated with an in-house DLR software application (EWMS) which is capable of calculating various performance indicators and that was used here to analyse the flight path diversity in the TE sector for the peak time period.

The Flight path diversity indicator has a value from 0 (zero diversity) to 1 (max diversity) and is one means to quantify traffic complexity, based on flight trails.

The following table shows the results for CDG arriving traffic transiting the TE sector (hypothesis: COP sequencer used in TE sector leads to less bunching and less vectoring and other path stretching manoeuvres inside the TE sector. Therefore, this indicator should show a slight decrease).

The same dataset compositions as for traffic density were used.

		Average flight path density (value from 0 to 1) / Standard deviation (SD)
Composition 1)	Reference	0,5528 (SD: 0,033)
	Trials	0,5218 (SD: 0,044)
Composition 2)	Reference	0,5450 (SD: 0,037)
	Trials	0,5205 (SD: 0,041)
Composition 3)	Reference	0,5557 (SD:0,023)
	Trials	0,5083 (SD: 0,046)
Composition 4)	Reference	0,5350 (SD: 0,043)
	Trials	0,5102 (SD: 0,047)

Table 11: Flight path diversity results for TE Sector

All four compositions show the expected behaviour.

Level dispersion at IAF:

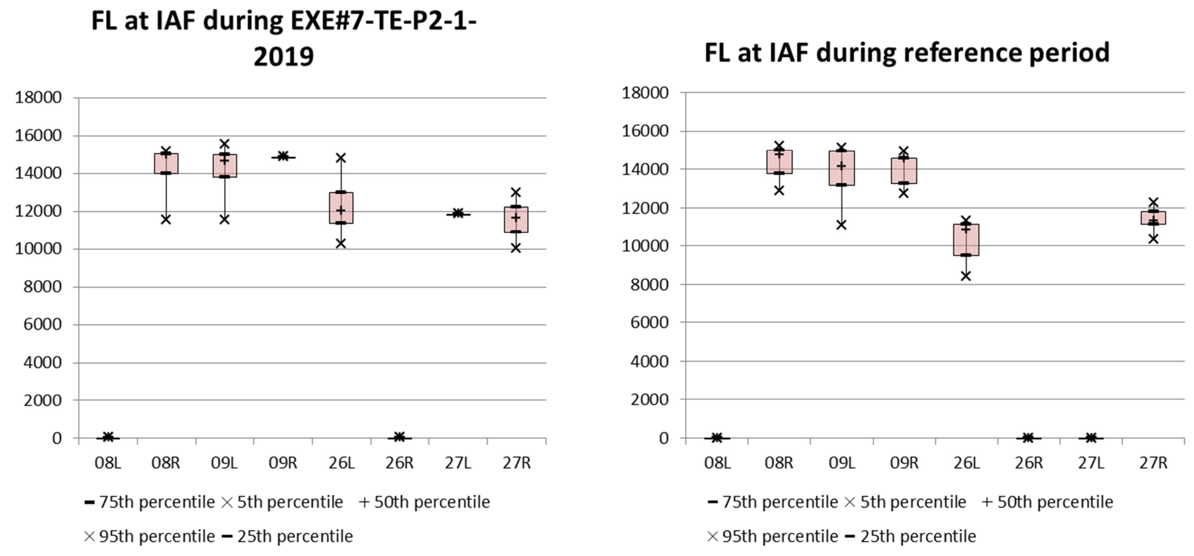


Fig. 1: Level dispersion at IAF (LORNI) during EXE#7-TE-P2-1 and reference period

When Paris-CDG is facing East (runway 08L,08R,09L or 09R in use), the arrivals should cross the IAF at FL150. When Paris CDG is facing West, (runway 27L, 27R, 26L, 26R), the arrivals should cross the IAF at FL110.

According to the analysis, when facing East, the actual flight level of the arrivals is very similar. When facing West, the flight level of the arrivals in slightly more compliant with the LOA during the reference period compared to EXE#7-TE-P2-1.

J.3.2.1.1.5.2 Qualitative Assessment

Questionnaire results related to E-TMA capacity:

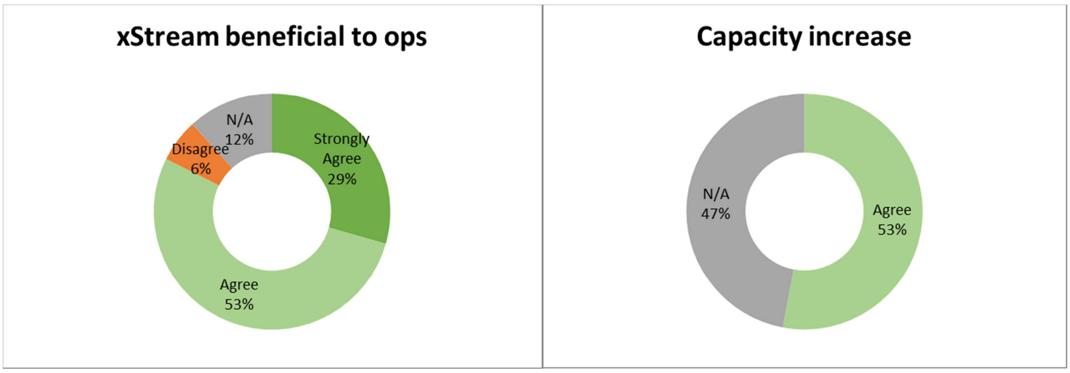


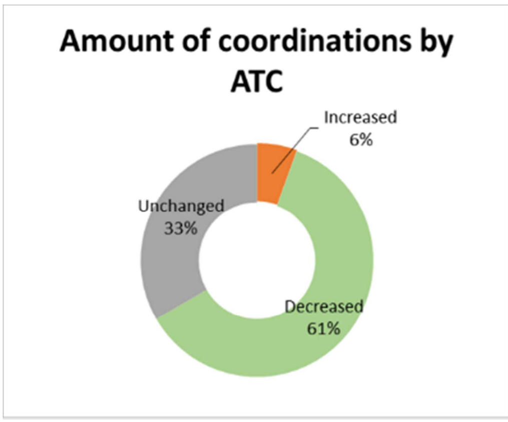
Fig. 2: Impact on E-TMA capacity assessed by Paris FMP

Paris FMPs assessed the trials were beneficial to OPS (82%) – many feedback about the complexity being decreased in the sector.

6% estimated the trials were not beneficial to OPS because the reduced flight upstream was wrongfully chosen due to unreliable ETOs.

53% of Paris FMPs think this concept can bring capacity increase to the sector, 47% assess it’s too soon to decide.

Questionnaire results related to ATCO workload & complexity in E-TMA:



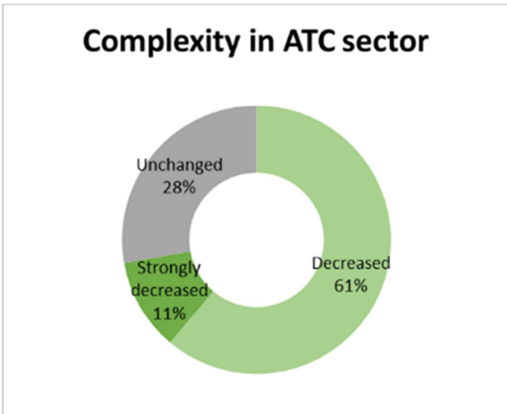


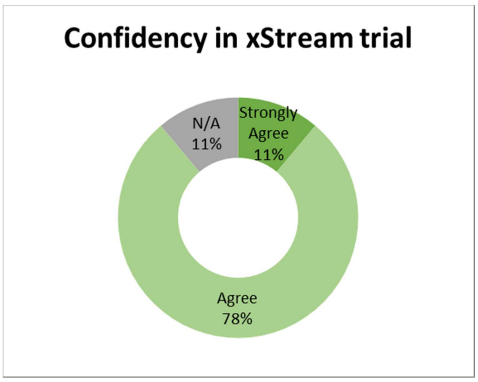
Fig. 3: Impact on situation awareness by ATCO

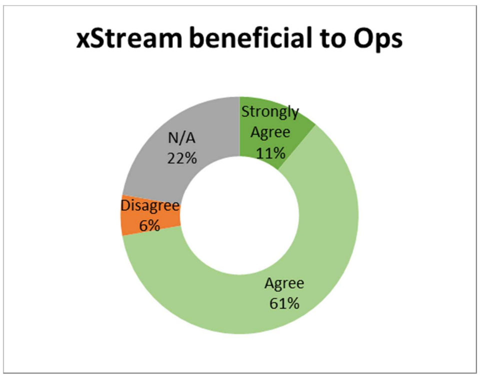
- 67% of ATCOs saw their situation awareness increase
- 61% of ATCOs assess the trials helped them to decrease the coordination with other ATS units: usual ATC coordinations about speed on transfer between Paris ATCO and MUAC ATCO were useless thanks to Paris FMP XMAN requests. Only 6% of Paris ATCO assessed coordinations increased because they were not sure the flights were actually reduced upstream.
- 72% of ATCOs who handled the arrival sequence felt complexity was decreased for the ATC sector.

Other subjective feedback related to ATCO situation awareness:

Majority of ATCOs assess the trials have been beneficial to ATC Operations (72%). 22% assess it's too difficult to evaluate the benefits.

Majority of ATCO had confidence in xStream trials (89%). Only 6% disagree on benefits when ATC felt the concept was unhelpful to OPS (1 occurrence).





- Impact on enroute ACC:

Enroute sectors were not regulated due to XMAN requests and didn't report issues regarding complexity or capacity during EXE-VLD-002 TE scenario.

J.3.2.1.2 Results impacting regulation and standardization initiatives

Trials had brought successful results to operations in Paris ACC either for FMP either for ATCO.

During planning EXE-VLD-07-002, a reduction of Mach 0.04 was decided as the standard Mach number reduction to be applied for CDG arrivals when in cruise. This reduction was accepted by a wide variety of all the flight crews operating flights to CDG, from medium-bodies (B737NG or A320 series) to wide-bodies (B777 series or A330/340 series).

This trial supports this magnitude of Mach number reduction for XMAN operations.

The implementation of the XMAN requests towards the upstream ACCs was very successful (close to 100%) because:

- Only a limited number of requests per peak was distributed to the upstream ACCs (6 per peak max, average of 2,7 requests per peak)
- XMAN requests were transmitted electronically from Paris FMP E-AMAN tool directly to MUAC CWP

This trial demonstrates the efficiency of direct electronic links for XMAN requests to the CWP and the need of normalizing arrival service sequence sharing with partners.

However, the work needs to be continued especially on the following topics:

- Improving ETOs,
- XMAN feedback,
- Electronic coordination of airborne delays & speed advisories.

J.3.2.2 Analysis of Scenario Results per Demonstration objective

J.3.2.2.1 OBJ-VLD-01-001 Results

This objective was to show that xStream operational improvements are respecting the current level of safety in air traffic management.

The corresponding success criterion is fulfilled when the safe management of traffic by ATC is not compromised and new procedures do not cause critical incidents.

No safety occurrences were reported in Paris ACC, MUAC, KUAC.

Qualitative analysis & feedback from operational staff confirms that the safe management of traffic was never compromised in neither of these ACCs.

This objective can be considered fulfilled.

J.3.2.2.2 OBJ-VLD-02-001 Results

This objective was to show that xStream operational improvements provide a better predictability and punctuality of air traffic in TMA / terminal sectors.

The corresponding success criterion is fulfilled when differences between planned / predicted and actual traffic flow at prominent points or at the runway are reduced.

According to the qualitative feedback of Paris FMP, the prediction of the arrival sequence in the E-TMA was improved with the use of iAMAN fed by NM data, which was reliable enough to be used in the COP Sequencer targeted horizon of 20 to 30 minutes before the peak.

This objective can be considered fulfilled.

J.3.2.2.3 OBJ-VLD-03-001 Results

This objective was to show that xStream operational improvements provide benefits in terms of environmental sustainability of air traffic.

The corresponding success criterion is fulfilled when fuel efficiency of air traffic is increased while emissions (and noise pollution) are reduced.

According to the calculation done during EXE-VLD-07-002, fuel consumption was decreased by up to 12% for the portion of the flight within the LFFF TE sector when the COP Sequencer trial was activated, in comparison with comparable traffic presentation & load values.

This objective can be considered fulfilled.

J.3.2.2.4 OBJ-VLD-05-001 Results

This objective was to show that ATC capacity usage in TMA is optimized by xStream operational improvements.

The corresponding success criterion is fulfilled when Traffic load, ATC workload or complexity in terminal sectors is reduced.

According to quantitative results, traffic density is decreased by 4% when COP Sequencer concept is activated, compared to comparable days during EXE-VLD-07-002 TE scenario. Flight path diversity measure reports a decrease by 5%.

According to qualitative results, 72% of Paris ATCOs dealing with the arrival sequence during EXE-VLD-07-002 reported a decrease in complexity & ATC workload on many occasions. 53% of Paris FMP also reported the concept could enable a capacity increase in the future.

This objective can be considered fulfilled.

J.3.2.2.5 OBJ-VLD-05-002 Results

This objective was to show that available en-route sector capacity allows the application of xStream operational improvements.

The corresponding success criterion is fulfilled when Traffic load, ATC workload or complexity in en-route sectors do not exceed available capacity.

According to feedback obtained from the participating upstream ACCs to the COP Sequencer TE trials, no ATFCM regulation nor other capacity reduction has been caused by EXE-VLD-07-00 TE scenario, and with a 98% rate of XMAN action implementation in the upstream ACCs, the application of the measures didn’t cause major ATC workload or complexity issues, with the trials planned with a limited number of XMAN action and no other XMAN action planned for other airport arrivals

This objective can be considered fulfilled.

J.3.2.3 Unexpected Behaviours / Results

During EXE-VLD-07-002 TE scenario unexpected behaviours or results as follows were noticed:

- Planner ATCO workload reduction:

With Paris FMP requesting XMAN actions upstream to MUAC and KUAC, this led to the lesser need of ATCO to ATCO coordinations between Paris & MUAC regarding speed instruction on handoff from MUAC LUX sector Paris TE sector

- Unreliable ETOs:

On a few occasions, the estimated times over at the Metering Fixes could “jump” and have sudden different values even during the targeted horizon, when the ETOs are supposed to be stable. This occasional unreliability had an important effect on the stability of the arrival sequence and could lead to the wrong choice of flight selection for XMAN action. This estimate unreliability probably came from strong winds enroute or direct routings given in the upstream ACC

- Aircraft re-acceleration in TE sector:

When the ETOs were inaccurate when there were strong winds enroute, the XMAN actions taken by Paris FMP could be counterproductive and lead to a re-acceleration of the flights when entering TE sector

- ATFCM regulation bunching assistance:

On 2 occasions, EXE-VLD-07-002 TE scenario helped Paris FMP to smooth an arrival peak following the appearance of a bunching of arrival traffic during a LFPGARR1 ATFCM regulation or after a removal of this regulation.

J.3.2.4 Confidence in the Demonstration Results

J.3.2.4.1 Level of Significance / Limitations of Demonstration Exercise Results

EXE-VLD-07-002 TE scenario was applied during the busiest CDG arrival peaks flying through TE sector during the day.

Paris FMPs were properly trained on the concept and on iAMAN tool so they could pick the most relevant flights to be reduced upstream in order to mitigate the complexity in the E-TMA.

A checklist was prepared for Paris FMP operators so the concept is properly applied, and an operational instruction was issued to Paris ACC ATCOs working the TE sector were notified of the trials.

As planned, a maximum of 5 arrivals per ACC were requested to be slowed down during CDG arrival peaks.

This was enforced by Paris FMP. The XMAN requests to MUAC were made using an electronical coordination between iAMAN and MUAC CWP.

The XMAN requests to KUAC were made using phone coordination. Both led to a good implementation rate of speed reductions.

However, on a few occasions, some busy peaks couldn't be trialled in case Paris Supervisor didn't want the trial to be run or in case an ATFCM regulation activated beforehand had already smoothed the arrival peak.

At no time there were limits due to ATCO workload in MUAC or KUAC.

J.3.2.4.2 Quality of Demonstration Exercise Results

Qualitative assessment was recorded with the use of questionnaires distributed to Paris FMP that actually used iAMAN to activate the COP Sequencer concept during EXE-VLD-07-002 TE scenario.

Questionnaires were distributed and were filled by 12 different FMP operators, the output was of 17 FMP questionnaires in total.

Questionnaires were also distributed to Paris ATCOs who handled the arrival sequence on the arrival sector impacted by the XMAN actions, 18 questionnaires were returned.

Quantitative assessments were made using comparable data & traffic loads between the trial dates and the reference dates.

J.3.2.4.3 Significance of Demonstration Exercise Results

EXE-VLD-07-002 TE scenario targeted the busiest CDG arrival peaks in TE sector in 2019, Paris FMP operators were properly trained on the concept and the tool and could apply the COP Sequencer concept during busy periods to help the ATCOs mitigate its workload.

Paris FMP could ask for XMAN actions on the ACCs delivering the majority of the flows to the TE sector (Maastricht & Karlsruhe), and even if only MUAC ATCOs could electronically receive XMAN requests, 48 flights could have been asked to be reduced upstream, with a 98% implementation rate.

Therefore, the demonstration exercise results should be considered as solid.

J.3.3 SKI Scenario

The COP Sequencer SKI scenario ran during the period as described below:

Internal ID(s)	Trial period	Number of trial dates	Number of flights with requested XMAN actions	Remarks
EXE7#2-SKI	15/12/2018 to 31/03/2019 on Saturdays & Sundays	5	10	Very few trials

Table 12: Summary of COP Sequencer SKI scenario

The overall recorded data for EXE-VLD-07-002 SKI scenario is listed below:

- 10 flights total were requested to be reduced by Paris FMP to upstream ACCs during 5 peaks
- Average number of requested XMAN action per peak: 2,
- Maximum of requested XMAN action per peak: 3.
- Acceptation rate: 100% implemented

Note: the acceptation rate was calculated according to FlightRadar24 data (when flight was observed in the upstream sector) or Mode S data observed by Paris FMP when entering UJ sector.

- Metering Fixes for arrivals concerned by XMAN action: 70% via ODEBU / 30% via PEKIM
- Upstream ACCs where XMAN actions were implemented: 80% in Paris ACC (LFFF UK and UZ sectors) / 20% in Brest ACC (LFRR MZ sectors)

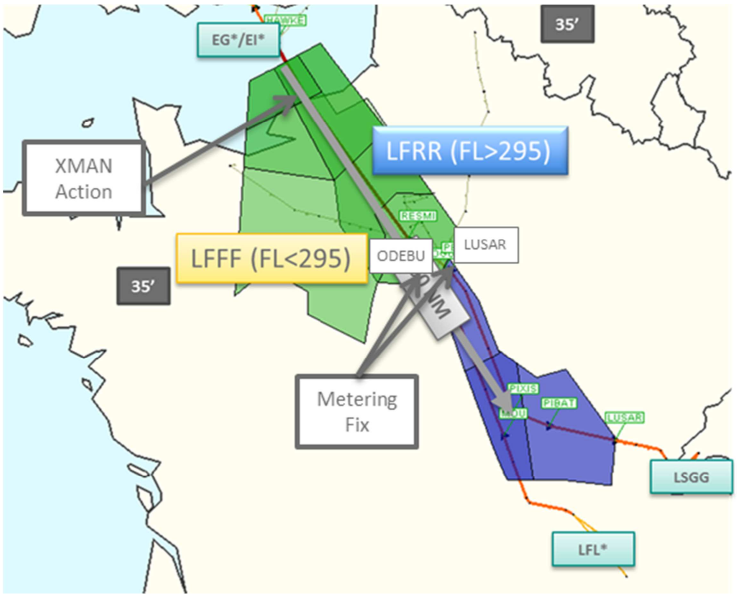


Fig. 4: Average position of XMAN requests in LFFF and LFRR

- Average notice of XMAN request before Metering Fix: 19 minutes,
- Average distance of XMAN request from Metering Fix: 130 NM,
- Average distance of XMAN request from LFLL/LSGG runway: 320 NM,
- Average flight parameters before XMAN reduction request: Ground speed 440 kts / FL290,
- Average flight parameters after XMAN reduction request: Mach 0.75 / Ground speed 450 kts.

For 70% of the XMAN actions, a speed acceleration was requested by Paris FMP to the upstream ACCs in order to optimize the arrival sequence.

The execution of the COP SEQ UJ scenario is detailed on one example, considered as significant from an improvement for Paris ACC operations.

J.3.3.1 Summary of Scenario Results

See Main Document chapter 4.1.2.2.3.

Due to the very few number of actual trial dates (5 days), and little number of flights (10), only qualitative assessment based on 5 direct FMP feedbacks can be made on this scenario.

No questionnaire was filled by Paris FMP and ATCOs during this scenario.

Due to the limited data availability only few EXE-VLD-07-002 objectives can be applied on this scenario. For the proof of concept they are covered in the other scenarios (UJ resp. TE).

J.3.3.1.1 Results per KPA

J.3.3.1.1.1 KPA Safety

J.3.3.1.1.1.1 Quantitative Assessment

Number of Incident Reports:

- No incidents were reported in connection with the trials in Paris ACC, in LMH sector or UZ sector.

J.3.3.1.1.1.2 Qualitative Assessment

- According to feedback from Paris FMP and ATCOs, the trial had no impact on safety.

J.3.3.1.1.2 KPA Predictability and Punctuality

J.3.3.1.1.2.1 Quantitative Assessment

None.

J.3.3.1.1.2.2 Qualitative Assessment

Feedback from Paris FMP running the COP Sequencer SKI trials mentioned the iAMAN in SKI configuration could help anticipate the arrival sequencing in LMH sector.

However, there was a discrepancy between the Air Situation Display and the arrival sequence predicted in iAMAN. For instance, in the figure below, EZY46QG is supposed to be #3 in sequence according to iAMAN, but on the Air Situation Display he's #1 in sequence.

This brought complexity to the work of Paris FMP.

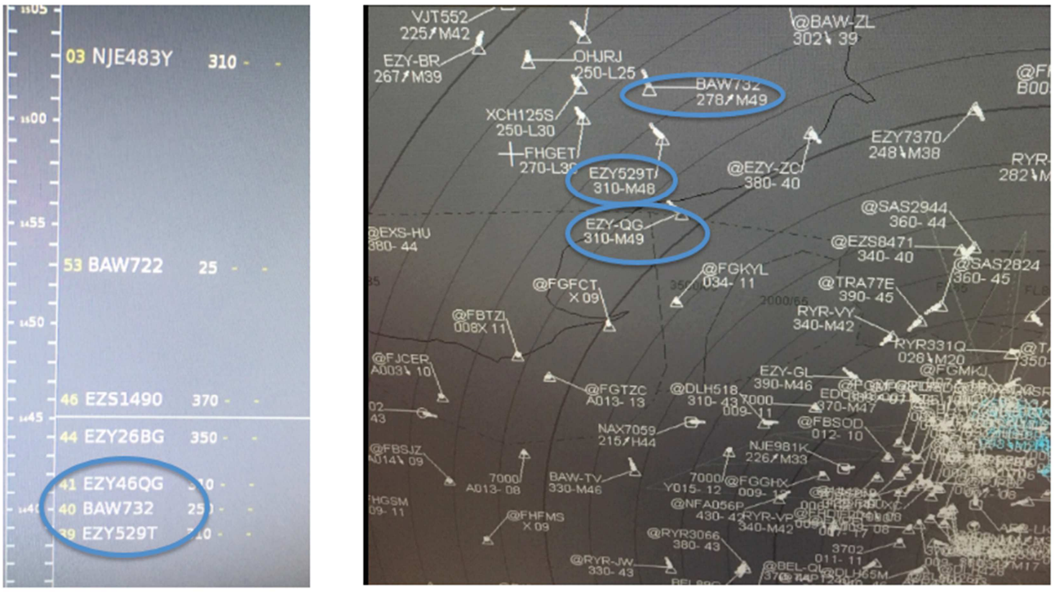


Fig. 5: iAMAN arrival sequence (on the left) and Air Situation Display (on the right) used by Paris FMP during COP Sequencer SKI scenario

J.3.3.1.1.3 KPA Environment

J.3.3.1.1.3.1 Quantitative Assessment

None. Proof of Concept covered by UJ resp. TE Scenarios.

J.3.3.1.1.3.2 Qualitative Assessment

None. Proof of Concept covered by UJ resp. TE Scenarios.

J.3.3.1.1.4 KPA Cost Efficiency (not required by DEMO objectives but covered)

J.3.3.1.1.4.1 Quantitative Assessment

None.

J.3.3.1.1.4.2 Qualitative Assessment

ANSP Cost:

- Paris FMPs received training during their planned FMP course & multiple refresher courses in Paris ACC.
- They also received training on iAMAN during their planned FMP shift and performed the trial days during planned FMP shifts.
- Therefore EXE-VLD-07-002 implied no extra cost for the ANSP. No extra staff needed to be recruited to perform the trials.

J.3.3.1.1.5 KPA Capacity

J.3.3.1.1.5.1 Quantitative Assessment

None.

J.3.3.1.1.5.2 Qualitative Assessment

Qualitative feedback from Paris FMP during post-trial interviews indicates the actions taken upstream were positive in terms of arrival sequence optimisation and mitigation of complexity in LFFF LMH sector.

Impact on en-route ACC:

- Enroute sectors were not regulated due to XMAN requests.
- Only 1 XMAN action couldn't be implemented at the requested time in LFFF UZ sector due to high ATC workload and was only implemented a few minutes later.

J.3.3.1.2 Results impacting regulation and standardization initiatives

In regards to the few peaks trialled, no conclusion can be drawn for regulation & standardization.

J.3.3.2 Analysis of Scenario Results per Demonstration objective

J.3.3.2.1 OBJ-VLD-01-001 Results

This objective was to show that xStream operational improvements are respecting the current level of safety in air traffic management.

The corresponding success criterion is fulfilled when the safe management of traffic by ATC is not compromised and new procedures do not cause critical incidents.

This objective has been fulfilled: no incident has been reported during EXE-VLD-02-002 SKI scenario.

J.3.3.2.2 OBJ-VLD-02-001 Results

This objective was to show that xStream operational improvements provide a better predictability and punctuality of air traffic in TMA / terminal sectors.

The corresponding success criterion is fulfilled when differences between planned / predicted and actual traffic flow at prominent points or at the runway are reduced.

No result has been computed for this objective.

J.3.3.2.3 OBJ-VLD-03-001 Results

This objective was to show that xStream operational improvements provide benefits in terms of environmental sustainability of air traffic.

The corresponding success criterion is fulfilled when fuel efficiency of air traffic is increased while emissions (and noise pollution) are reduced.

No result has been computed for this objective.

J.3.3.2.4 OBJ-VLD-05-001 Results

This objective was to show that ATC capacity usage in TMA is optimized by xStream operational improvements.

The corresponding success criterion is fulfilled when Traffic load, ATC workload or complexity in terminal sectors is reduced.

Paris FMP feedback from post-trial interviews indicated the arrival sequence was optimized and eased thanks to upstream actions, therefore this objective has been fulfilled.

J.3.3.2.5 OBJ-VLD-05-002 Results

This objective was to show that available en-route sector capacity allows the application of xStream operational improvements.

The corresponding success criterion is fulfilled when Traffic load, ATC workload or complexity in en-route sectors do not exceed available capacity.

XMAN requests transmitted by Paris FMP to upstream ACCs didn't degrade the sectors' capacity. No ATFCM regulation was implemented to cope with the demands. This objective has been fulfilled.

J.3.3.3 Unexpected Behaviours / Results

Arrival sequence discrepancy:

- Discrepancy was observed between the Air Situation Display and iAMAN on the Paris FMP position. This brought complexity to Paris FMP who ran the COP Sequencer SKI trial.

Acceleration instead of speed reduction:

- To optimize the arrival sequence, Paris FMP asked for acceleration of the arrival to the upstream sectors to debunch the arrival flow in Paris LMH sector and reduce complexity in the sector.

Participation of Brest ACC:

- Even though participation of Brest ACC was not planned, a few measures were coordinated from Paris FMP to Brest FMP, and were successfully applied by Brest ATCOs.

J.3.3.4 Confidence in the Demonstration Results

Only very few feedback from Paris FMP was collected, and no feedback could be obtained from Paris ATCO.

Furthermore, due to the very limited amount of trial days and XMAN actions, no quantitative assessment could have been done.

The confidence in the demonstration results is medium.

J.3.3.4.1 Level of Significance / Limitations of Demonstration Exercise Results

Due to the very limited amount of trial days and XMAN actions, despite the actions being taken during arrival peaks in Paris LMH sector, EXE-VLD-07-002 SKI scenario cannot be considered as significant.

J.3.3.4.2 Quality of Demonstration Exercise Results

Only very few feedback from Paris FMP was collected, and no feedback could be obtained from Paris ATCOs.

Furthermore, due to the very limited amount of trial days and XMAN actions, no quantitative assessment could have been done.

Furthermore only 5 peaks were trialled, which is very low.

J.3.3.4.3 Significance of Demonstration Exercise Results

Due to the very limited amount of trial days and XMAN actions, despite the actions being taken during arrival peaks in Paris LMH sector, EXE-VLD-07-002 SKI scenario results cannot be considered as significant.

J.3.4 Conclusions

J.3.4.1 DSNA conclusions

A summary of COP Sequencer trials running on different scenarios is presented in the table below:

Scenario	Nb of trial days	Nb of XMAN requests	Average XMAN actions per peak	% of total arrival flow eligible to XMAN actions	Way of transmitting XMAN actions	Average notice before MF (mins)	% of confirmed implementation	Average range before MF	Average range before runway
UJ	54	95	1,8	80%	-Phone -Web portal -Email	24	89%	180 NM	350 NM
TE	18	48	2,7	80%	-Phone -Electronic	25	98%	185 NM	280 NM
SKI	5	10	2	40%	-Phone	19	100%	140 NM	320 NM

Table 13: Summary of EXE-VLD-07-002 COP Sequencer trials

Overall, the implementation rate was very high during EXE-VLD-07-002 with an average notice of XMAN actions compliant with the concept (i.e. between 20 to 30 minutes prior the hotspot) using quite reliable ETOs at this horizon.

However, improvements should be made in the future to improve the arrival sequence stability and reliability (via ETOs improvement).

The actions were requested well beyond 200 NM from the runway and the number of XMAN actions requested per peak was compliant with the concept and the Demo Plan.

For XMAN operations, the electronic transmission of XMAN requests clearly brings high benefits in terms of implementation & confidence for the operational actors.

DSNA will work in the coming years on deploying such a link with all the concerned neighbouring ACCs.

Both ATC and FMP feedback from Paris ACC show that the concept is valid, and is an enabler for capacity improvements in Extended TMA.

Main quantitative find as shown in the table below outlines the measured benefits of concepts.

Scenario	Fuel consumption in E-TMA per arrival	Fuel savings per flight during an arrival peak	Average traffic density	% of ATCO estimating COP Sequencer is beneficial to Operations	% of FMP estimating trial may bring capacity increase
UJ	-12%	30 kg	-9%	76%	18%
TE	-12%	36 kg	-4%	72%	52%

Table 14: Main findings for EXE-VLD-07-002

As a matter of fact, performance assessment shows the COP Sequencer concept improves:

- Flight efficiency in E-TMA, measured by fuel savings, CO2 emissions & reduction of additional ASMA time
- Capacity and complexity in E-TMA, measured by the average traffic density.

The trial had no counter effect in terms of safety while Paris ATCOs reported a decrease of complexity, and a decrease of coordination actions.

Finally, operational feedback underlines that the concept is enhancing the following points:

- Confidence in ATM procedures,
- Cooperation with upstream ACCs,
- ATCO situation awareness,
- FMP performance

However, these trials showed all the concerned operational actors (ATCOs, FMPs) need to be properly informed and if necessary trained on the new tools & concept.

J.3.4.2 Skyguide conclusions

Thanks to few and spaced requests, no significant impact on ATCO workload; Zurich FMP had a slight impact on workload but acceptable.

J.3.4.3 MUAC conclusions

The trial was conducted in an extremely smooth way.

The operational concept made sense operationally and was applied by the ATCOs without any problem.

What is very beneficial for sustainable XMAN operations is that the requests to slow down traffic were limited in number and time and made sense to MUAC ATCOs since targeting the last aircraft of a bunch.

J.3.4.4 KUAC conclusions

From KUAC perspective the requested XMAN actions for CDG arrivals didn't have a big influence on the workload of KUAC ATCOs.

Nevertheless, for a permanent arrival management support a system support and the necessary message exchange would be needed.

J.3.4.5 Airspace Users/Air France conclusions on COP Sequencer trials

No negative feedback had been reported from AFR/HOP flight crews.

No specific remarks. Air France supports this procedure and recognizes its benefits as described in the Demo Report.

The flight trials showed that there is very little impact, if any, on the procedures of the airline.

As observed during the trials on a few cases, it is important that the speed instruction is repeated to the pilot consistently in the sectors following the one where it is first implemented, to avoid reacceleration.

The ATCO implementing the advisory needs to inform the pilot of the anticipated arrival steaming purpose of the early speed instruction.

Air France is skeptical of the transmission of other E-AMAN advisories (such as TTL/TTG) directly to the crew; this has not been applied in the WP7 Paris trials, but is mentioned in the xStream ConOps.

Implementation of those advisories directly by the flight crew would not be possible in the current operational procedures.

Furthermore, it would have an impact on the situational awareness of the other ATCOs subsequently taking the flight. This process has to be further described and tested before it can be envisaged in operations.

J.3.5 Recommendations

J.3.5.1 Recommendations for industrialization and deployment

Promote participation of all neighbouring ACCs:

- Comparison between TE and UJ trials showed that it is important that all neighbouring ACCs (except those handling a negligible part of arrival flow) participate in the process. In order to ensure that all ACCs participate in Extended AMAN operation in the coming years, the concept should be further promoted European-wide.

Further deploy automated capability to process E-AMAN requests in ACCs:

- Manual coordination of speed request is feasible for a few flights but time consuming for all the operational actors (FMP, ATCO) and may not be always efficient. In order to ensure that all ACCs develop the ability to process Extended AMAN requests in the most efficient way in the coming years, the ED-254 standard should be further promoted European wide.

Improve ETO/ETA:

- Trials showed the arrival sequence should be stable & reliable enough at the targeted horizon of action to take the most appropriate actions. A better flight trajectory prediction enriched with local TP or ADS-B or ADS-C data, and also taking into account probability of direct routings and weather effects, should be developed.

Comprehensive training:

- As the concept is new for Extended TMA optimization, all operational staff (Supervisors, FMP, ATCO) should be fully trained on the concept and on the tools developed to support the concept.

Allow a possibility to ask for speed acceleration:

- Feedback from FMPs indicate they would like to be able to ask for TTG (Time to Gain), meaning the ability to ask the first flights of an arrival peak to be accelerated upstream in order to optimize the sequence on the whole.

J.3.5.2 Recommendations on regulation and standardization

XMAN feedback

Feedback of Extended AMAN action can be of interest to adapt the arrival management strategy and provide better situation awareness to ATCO and FMP managing TMA and E-TMA, but also for the buffer ACC between the ACC implementing the E-AMAN action and the TMA/E-TMA. ED-254 Standard on Arrival Sequence Service does not deal with this topic. It is recommended that a standard is developed.

XMAN service coordination

Furthermore, the ability to rely on upstream ACCs during the day of operations can be critical for the FMP & Supervisors, therefore the development of a centralized service regrouping airports with E-AMAN procedures & ACCs delivering XMAN service for planning the E-AMAN service delivery is important.

=== End of Appendix J Demonstration Exercise EXE-VLD-07-002 Report ===