Step 1 V3 UDPP Validation Report

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Abstract

User driven prioritization process (UDPP) allows airspace users to prioritize their flights given a capacity constraint. The process does not resolve the capacity constraint, but permits airspace users to rearrange their flights according to their own business needs.

Two SESAR solutions have been put through validation: Enhanced ATFM Slot Swapping (solution #56), and UDPP Departure (solution #57). This report summarizes the results of all the exercises that were carried out, and presents overall conclusions and recommendations.

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Executive Summary

Overview

The user driven prioritisation process (UDPP) allows airspace users to prioritize their flights given a capacity constraint. The process does not resolve the capacity constraint, but permits airspace users to rearrange their flights according to their own business needs. Today, airspace users can perform limited swapping of air traffic flow management (ATFM) slots. There are many rules and constraints that must be adhered to for a requested swap to be acceptable.

UDPP work comes under SESAR project 07.06.02, Optimized Airspace User Operations, which is part of OFA05.03.06. Step 1 covers two SESAR solutions: Enhanced ATFM Slot Swapping (solution #56), and UDPP Departure (solution #57). This validation report provides a synthesis of the validation activities carried out, and presents overall conclusions and recommendations. An Annex presents the individual validation and demonstration reports on which the synthesis is based.

Levels of Maturity Achieved

Seven concept features were validated:

Concept Feature	Current Level of Maturity	Observations / Work Left to Do
AUO-0101-A (Enhanced ATFM Slot Swapping)		
Pre-Allocated Slot Swap	Early V3[1]	Needs software changes to the Network Manager's (NM's) Enhanced Tactical Flow Management System (ETFMS), and then to be validated in a live trial. This feature has been transferred to the Network Manager for potential further development, validation and deployment.
Multi-Swap	End V3 (type 1); Early V3 (type 2)	There are two types, which are not mutually exclusive. Type 1 permits a flight to swap several times (three was the limit agreed in validation exercises), with each swap subject to a separate swap request. Type 2 permits a given flight to make two or even three consecutive swaps in the same swap request. Type 2 needs software changes to NM's Network Impact Display (NID) tool, and possibly to ETFMS as well, and then needs to be validated in a live trial. The Type 2 feature has been transferred to the Network Manager for potential further development, validation and deployment.
Substitution on Cancellation	End of V3	Validated in a live trial.
Most Penalising Delay	V1	Operational implementation would require the airport delay to be known for each flight. In the current airport collaborative decision making (A-CDM) protocol, flight delay is transmitted for each flight by the airport to NM in the departure planning information (DPI) messages, but there is no indication of the source of such delay, which could well be due to the airspace user itself. Therefore, using that information to determine that the airport has caused the most penalising delay for both flights to be swapped would be wrong and could be inequitable. This feature has been transferred to SESAR2020 as operational improvement step AUO-0108 (Integrated Roadmap Dataset 14) for further development, validation and deployment.
AUO-0103 (UDPP Departure)		
Departure Reference Time Reordering ('Reordering')	V5	The three features have been implemented operationally at Paris Charles de Gaulle (CDG) airport.
First Priority for Departure ('Prioritization')		
Upwards Cascade on Departure		

[1] According to the European Operational Concept Validation Methodology, V1, V2 and V3 are the three sequential phases of validation.

Cancellation ('Substitution')		

Enabler

A prototype was developed to facilitate current ATFM slot swapping and the enhanced swapping features developed in Step 1. The prototype was used in two validation exercises, including a live trial across Europe. The prototype continues to be **used operationally**, even though the ATFM live trial finished in March 2015. This is an **interim solution** during the transition to deployment.

Summary of Benefits and Issues

The following benefits and issues come out of the validation activities that were carried out in Step 1.

ATFM slot swapping:

- The **cost of delay** is reduced by 4900 euros for airspace users, on average, per ATFM slot swap;
- Estimated **annual cost saving** for airspace users in Europe is 7.6M€ (assuming 1500 swaps saving 4900 euros per swap);
- Enhanced ATFM slot swapping features increase the **flexibility** for airspace users to cope with imposed delay by permitting more combinations of flights to swap;
- Using the slot swapping prototype/tool leads to **significant increases in acceptance rate** of swap requests, which may also reduce the workload of both airspace user and the NM operator (because fewer revised requests are needed);
- The swapping prototype/tool is likely to **encourage more swapping** in the future because it corrodes blocking factors such as the time and mental effort required to identify technically viable swaps;
- Validation has shown the users' need for an **automated swap request** function to complement the swap selection function of the prototype/tool;
- No investment costs are foreseen for airspace users. NM would need to use the prototype swapping tool to develop and deploy an operational tool. This should require a **relatively modest investment**.

Departure swapping:

- DFlex (the name used to refer to the three departure swapping features) provides **flexibility** to airspace users to cope with imposed delay;
- Typically used to fine tune departures, rather than for exchanging significant delays (this is a difference with ATFM slot swapping);
- DFlex is now **deployed** in full at Paris CDG;
- DFlex is most relevant to Paris CDG, which operates a first scheduled first served principle in the pre-departure sequence. Validation suggests that few other airports in Europe might see a significant benefit from implementing DFlex;
- There is an impact on some flights that are not involved in DFlex actions, but which happen to be in temporal proximity in the pre-departure sequence. The impact is an **increase in average delay**;
- Flights that are subject to a DFlex action see a **reduction in delay**, on average.

Recommendations

ATFM slot swapping:

1) The **Pre-Allocated Slot Swapping** feature should be subject to a live trial to complete its journey to the end of V3 validation. This will require a modification to NM's ETFMS so that deteriorated flights in the 'allocated' status are not automatically promoted back by ETFMS;

2) The **Multi-Swap** feature (type 1) should be deployed operationally, with a maximum of three swaps allowed per flight. NM operators should have a swap counter in ETFMS to log the number of times a given flight has swapped;

3) The **Multi-Swap** feature (type 2) should be subject to a live trial, but first NM's NID tool needs modifying so that all the swaps in the single request are evaluated (and carried out) simultaneously;

4) The **Substitution on Cancellation** feature should be deployed operationally; an improved manual procedure, or even an automated approach should be conceived for deployment to reduce the workload on the NM operator and to remove the unnecessary safety check on the flight to be cancelled;

5) CDM airports should identify and publish the delay caused by the airport itself so that the **most penalizing delay** (airport v arrival / en route) for flights can be calculated. (This may require a modification to the current A-CDM protocol.);

6) The Network Manager should use the **slot swapping prototype** to develop an operational swapping tool for all airspace users in Europe. The '**one-click swap request**' functionality is an essential requirement for this tool. The ATFM live trial report presents other requirements for the tool and should be considered;

7) Once deployed, the swapping behaviour from airspace users and the performance of the slot swapping tool should be monitored to confirm that the performance impacts identified and quantified during validation are realised;

Departure swapping:

8) European CDM airports should **consider a local deployment** of DFlex;

9) Paris CDG to **monitor and publish** the effect that DFlex actions may have on the pre-departure sequence, in a similar but more detailed fashion to that already done for the demonstration project. The monitoring should distinguish between flights involved in a DFlex action, and those impacted, and should also distinguish between different airspace users. The monitoring activity should include the *distribution* of change in delay for flights that are subject to a DFlex action, and, separately, for those that are in temporal proximity[2]. The motivation should be to assure/ensure that equity is achieved for airspace users;

10) The UDPP project should (re)discuss and agree the principles of UDPP, and then based on these principles should **define clear, unambiguous rules** to be able to decide what is equitable or not for future validation exercises.

[2] The DFlex demonstration project has already established rules for this.

1 Introduction

1.1 Purpose of the Document

This document provides a synthesis of the validation activities carried out for the user driven prioritisation process (UDPP) for SESAR Step 1. UDPP work comes under SESAR project 07.06.02, Optimized Airspace User Operations, which is part of OFA05.03.06. An Annex presents the individual validation and demonstration reports on which the synthesis is based [1].

The Network Operations validation strategy [2] and the Integrated Roadmap Dataset 14 [3] have been used to guide this document.

1.2 Intended Readership

This document is written for the stakeholders of UDPP, particularly airspace users, airports and the Network Manager. It will also be of interest to project B.05 and projects 16.06.0x.

1.3 Structure of the Document

Section one gives a short introduction to the document. Section two provides the context to the validation activities. Section three briefly explains how the planned validation exercises were carried out. Section four presents a summary of the results. Section five presents the conclusions and recommendations for the whole of Step 1. Section six presents the individual validation exercise reports for Step 1.

1.4 Glossary of Terms

Refer to the ATM Lexicon [4] for terms used in this document.

1.5 Abbreviations, Acronyms and Terminology

Term	Definition
A-CDM	Airport collaborative decision making
AOBT	Actual off-block time
AOC	Aircraft operations centre
APOC	Airport operations centre
ATC	Air traffic control
ATFCM	Air traffic flow and capacity management
ATFM	Air traffic flow management
ATM	Air traffic management
CASA	Computer assisted slot allocation
CDG	Charles de Gaulle (Airport)
CDM	Collaborative decision making
CTO	Calculated time over. This is the time that a regulated flight is co-ordinated to enter a particular en route regulation.
CTOT	Calculated take-off time
DCB	Demand-capacity balancing

Term	Definition
DFlex	A Demonstration project managed independently from SESAR which is shorthand for 'departure flexibility'.
DOD	Detailed operational description
DPI	departure planning information (a set of messages that are part of the A-CDM protocol)
E-Helpdesk	A web interface that is accessible via the Network Operations Portal that assists airspace users with slot related matters, extensions and air traffic flow and capacity management issues.
EOBT	Estimated off-block time
E-OCVM	European Operational Concept Validation Methodology [5]
ETFMS	Enhanced Tactical Flow Management System
EXE	Exercise
FMP	Flow management position
HP	Human performance. (A human's capability to accomplish tasks and meet job requirements.)
KPA	Key performance area
KPI	Key performance indicator
Model-based simulation	A simulation technique closely related to fast-time simulation
NID	Network impact display. A tool used by NM operators to evaluate the impact of a requested swap before accepting the swap.
N/A	Not applicable
NM	(The) Network Manager
NOK	Not okay (the validation objective has not been fully met)
NOP	Network Operations Portal
OFA	Operational focus area
OI	Operational improvement
OK	Okay (the validation objective has been fully met)
OSED	Operational service and environment definition
PDS	Pre-departure sequencer
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (an agency of the European Commission)
SOBT	Scheduled off-block time
STAM	Short-term ATFCM measure
True Revision Process	This is the regular re-evaluation of CASA's solution to redress under capacity in the European network
TSAT	Target start-up approval time
TTOT	Target time of take-off
UDPP	User driven prioritization process
V1, V2, V3	Maturity levels according to the E-OCVM [5]. V1 denotes an immature concept, whereas a concept that has reached the end of V3 is mature and validated.

2 Context of the Validation

2.1 Concept Overview

The UDPP concept for Step 1 includes two operational improvement (OI) steps: AUO-0101-A, titled Enhanced ATFM Slot Swapping, and AUO-0103, titled UDPP Departure.

Each OI step constitutes several concept 'features', which are smaller, independent operational improvements. The features are described in Table 1 and Table 2. For a detailed explanation of the Step 1 concept refer to the OSED [6].

Feature	Description
Current Situation	• Both flights must be regulated and share the same most penalizing regulation. • Only flights with 'slot allocated' status are permitted to swap. • Swapping is permitted between flights of same airline or same group. • A swap is an exchange of CTOs. • A swapped flight cannot depart ahead of its scheduled departure time (SOBT). • A swapped flight cannot be swapped again.
1/7: ATFM Pre-Allocated Slot Swap	• One flight has 'slot allocated' status, and the other is 'pre-allocated'. (The switch from pre-allocated to allocated occurs when the airspace user receives a slot allocation message two hours before the EOBT).
2/7: Multi-Swap of ATFM Slots	• A swapped flight can be swapped again. Either the flight can be improved in several independent swap requests (**type 1**), or in several consecutive steps in the same swap request (**type 2**).
3/7: Substitution on Cancellation	• An airspace user cancels a flight and immediately fills the vacated slot with another of its flights; • The flight that takes the empty slot must have the same most penalizing regulation; • The empty slot created by the promoted flight is given back to the Network Manager to fill with another flight.
4/7: Most Penalising Delay	• Airspace users can swap two flights that depart from the same CDM airport if the delays generated by the airport exceed the most penalizing regulation delays of the two flights in question.

Table 1: Concept overview for AUO-0101-A (Enhanced ATFM Slot Swapping).

ATFM slot swapping is possible today, as Table 1 indicates. The intention of UDPP Step 1 is to provide airspace users more ways to swap to have more flexibility to react to imposed delay.

Feature	Description
Departures: Current Situation	• There is no common, agreed process for swapping flights at airports in Europe.
5/7: Departure Reference Time Reordering	• An airspace user reorders its flights in the reference time list. (Note, this is possible within a group or within an alliance.) • Constraints such as CTOT, SOBT and TTOT are respected by the pre-departure sequencer (PDS).
6/7: First Priority for Departure	• An airspace user requests the prioritization of one of its flights. • The prioritized flight may be promoted up the reference list to take the place of another of the airspace user's flights. • The airspace users' flight(s) cascade down one rank in the reference list to make way for the prioritized flight. • Constraints such as CTOT, SOBT and TTOT are respected by the PDS.
7/7: Upwards Cascade on Departure Cancellation	• When an airspace user cancels a flight its remaining flights in the A-CDM reference time list are cascaded upwards. • Constraints such as CTOT, SOBT and TTOT are respected by the PDS.

Table 2: Concept overview for AUO-0103 (UDPP Departure).

2.2 Summary of Validation Exercises

Five validation and demonstration exercises were planned for Step 1. A summary of each is given below in Tables 3 to 7. For detailed descriptions of these refer to the validation plan [7].

EXE-07.06.02-VP-727: UDPP Step 1 Benefits Studies	
Leading organization	EUROCONTROL
Validation exercise objectives	To estimate the cost benefits of using the UDPP features in Step1.
Rationale	Cost savings (or more accurately, the reduction in cost liabilities) is the main interest for airspace users when swapping flights.
Supporting DOD / operational scenario / use case	07.02 Network Management DOD [8] / medium to short term operational scenario / use cases UC-NP-27, UC-NP-28 and UC-NP-29.
OFA addressed	OFA05.03.06 (UDPP)
OI steps addressed	AUO-0101-A (Enhanced ATFM Slot Swapping) AUO-0103 (UDPP Departure)
Enablers addressed	None
Applicable operational context	Airspace user operations
Expected results per KPA	Cost-effectiveness – direct and indirect cost savings per swap
Validation technique	Modelling
Dependent validation exercises	This exercise is dependent on EXE-07.06.04-VP-712 providing cost benefit data and the frequency of use of the concept features.

Table 3: An overview of validation exercise EXE-07.06.04-VP-727.

EXE-07.06.02-VP-725: UDPP Departure Performance Assessment	
Leading organization	EUROCONTROL
Validation exercise objectives	To see if the features really do impact delay (punctuality) or cause over-delivery in non-regulated sectors and arrival airports (safety), and if so to determine broadly under what conditions. To determine if swapping ATFM slots leads to inequity amongst airspace users (whether participating in UDPP or not). To determine if runway capacity is unaffected by slot swapping.
Rationale	Slot swapping at airports may introduce perturbations in the network such as over-delivery in some sectors, and under the wrong conditions regulations may not be possible to apply. This could be a safety issue. To have an equitable UDPP process is very important to airspace users, and so this must be assessed. Efficient runway throughput is an important issue for airports, airspace users and the network, and so must be assessed.
Supporting DOD / operational scenario / use case	07.02 Network Management DOD [8] / medium to short term operational scenario / use cases UC-NP-27, UC-NP-28 and UC-NP-29.
OFA addressed	OFA05.03.06 (UDPP)
OI steps addressed	AUO-0103 (UDPP Departure)
Enablers addressed	None
Applicable operational context	Airports and the wider network.
Expected results per KPA	Safety – could be affected negatively under 'extreme' conditions, but otherwise there will be no significant effect. Equity – non-participating airspace users will not be disadvantaged. The features operate fairly for participating airspace users. Punctuality (delay) – reactionary delay reduced.
Validation technique	Model-based simulation
Dependent validation exercises	None

Table 4: An overview of validation exercise EXE-07.06.02-VP-725.

EXE-07.06.02-VP-726: UDPP Slot Swapping Performance Assessment	
Leading organization	EUROCONTROL
Validation exercise objectives	To see if the features really do impact punctuality (delay) or could cause over-delivery (safety), and if so to determine broadly under what conditions. To determine if swapping ATFM slots leads to inequity amongst airspace users (whether participating in UDPP or not).
Rationale	The number of empty ATFM slots may be affected by certain factors such as the frequency of swaps and the timing of swaps. To have an equitable UDPP process is very important to airspace users, and so this must be assessed.
Supporting DOD / operational scenario / use case	07.02 Network Management DOD [8] / medium to short term operational scenario / use cases UC-NP-27, UC-NP-28 and UC-NP-29.
OFA addressed	OFA05.03.06 (UDPP)
OI steps addressed	AUO-0101-A (ATFM Slot Swapping Enhancement)
Enablers addressed	None
Applicable operational context	The en route part of the network
Expected results per KPA	Safety – could be affected negatively under 'extreme' conditions, but otherwise there will be no significant effect. Punctuality (delay) – reactionary delay reduced. Equity – non-participating airspace users will not be disadvantaged. The features operate fairly for participating airspace users.
Validation technique	Model-based simulation
Dependent validation exercises	None

Table 5: An overview of validation exercise EXE-07.06.02-VP-726.

Exercise "DFlex" (A SESAR Demonstration Project)	
Leading organization	Air France
Validation exercise objectives	To confirm the technical and operational feasibility of the three UDPP departure features, and to measure the impact on performance.
Rationale	This trial has been agreed under the DFlex demonstrator contract and is not under the management of SESAR project 07.06.04, although the concept to be demonstrated falls under the Step 1 UDPP concept.
Supporting DOD / operational scenario / use case	07.02 Network Management DOD [8] / medium to short term operational scenario / use cases UC-NP-27, UC-NP-28 and UC-NP-29.
OFA addressed	OFA05.03.06 (UDPP)
OI steps addressed	AUO-0103 (UDPP Departure)
Enablers addressed	None
Applicable operational context	Airports and the wider network.
Expected results per KPA	Flexibility (for airspace users) – improved significantly. Cost Effectiveness – improved. Equity – non-participating airspace users will not be disadvantaged. The features operate fairly for participating airspace users. Capacity (Airport) – will not be affected significantly. Safety – will not be significantly affected.
Validation technique	Live trial
Dependent validation exercises	None.

Table 6: An overview of the DFlex demonstration exercise.

EXE-07.06.04-VP-712: ATFM Live Trial	
Leading organization	EUROCONTROL
Validation exercise objectives	To confirm the operational feasibility of the ATFM features together in an operational environment. To measure some aspects of performance – see the key performance areas in this table below. Some of the impacts on performance that were measured in V2 will also be confirmed.
Rationale	This exercise has three parts: • Issues and benefits analysis workshop; • human-in-the-loop simulation; • live trial. The issues and benefits workshop and the human-in-the-loop trial serve as preparation for the live trial.
Supporting DOD / operational scenario / use case	07.02 Network Management DOD [8] / medium to short term operational scenario / use cases UC-NP-27, UC-NP-28 and UC-NP-29.
OFA addressed	OFA05.03.06 (UDPP)
OI steps addressed	AUO-0101-A (ATFM Slot Swapping Enhancement)
Enablers addressed	None
Applicable operational context	NM operations
Expected results per KPA	Cost-effectiveness – will change, depending on the stakeholder. Flexibility – will increase significantly for participating airspace users. Equity – non-participating airspace users will not be disadvantaged. The features operate fairly for participating airspace users. Punctuality – delays for the most important flights are reduced.
Validation technique	Workshop; human-in-the-loop simulation; live trial.
Dependent validation exercises	None

Table 7: An overview of validation exercise EXE-07.06.04-VP-712.

To illustrate which concept elements were to be validated in which activity, refer to Table 8.

OI Step	UDPP Feature	V2			V3	
		EXE-07.06.02-VP-727 (UDPP Step 1 Benefits Studies)	EXE-07.06.02-VP-726 (ATFM Slot Swapping)	EXE-07.06.02-VP-725 (Departure Swapping)	DFLEX (Demonstration)	EXE-07.06.04-VP-712 (Human-in-the-loop trial, and live Trial)
AUO-0101-A	1/7: Pre-Allocated Slot Swap	✓	✓	-	-	✓
	2/7: Multi-Swap of ATFM Slots	✓	✓	-	-	✓
	3/7: Substitution on Cancellation	✓	✓	-	-	✓
	4/7: Most Penalising Delay	✓	✓	-	-	✓
AUO-0103	5/7: Departure Reference-Time Reordering	✓	-	✓	✓	-
	6/7: First Priority for Departure	✓	-	✓	✓	-

	7/7: Upwards Cascade on Departure Cancellation	✓	-	✓	✓	-

Table 8: Relevant concept features per validation exercise.

3 Conduct of Validation Exercises

3.1 Exercises Preparation

Each validation exercise was prepared in accordance with that described in the validation plan [7]. Deviations from the planned preparatory activities are summarised in section 3.3.

3.2 Exercises Carried Out

Table 9 summarises the validation exercises that were carried out.

Exercise	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-07.06.02-VP-727 UDPP Step 1 Benefits Studies	2013	May 2014	2013	Oct 2014
EXE-07.06.02-VP-725 UDPP Departure Performance Assessment	Cancelled			
EXE-07.06.02-VP-726 UDPP Slot Swapping Performance Assessment	Autumn 2014	Spring 2015	Autumn 2014	April 2015
DFlex (A SESAR Demonstration Project managed by Air France)	26/03/2013	10/04/2014	01/05/2014	13/06/2014
EXE-07.06.04-VP-712: Issues and Benefits Analysis Workshop Human-in-the-loop Simulation ATFM Live Trial	 03/03/2014 24/03/2014 01/12/2014	 03/03/2014 26/03/2014 11/03/2015	 04/03/2014 April 2014 Dec 2014	 18/03/2014 June 2014 April 2015

Table 9: Validation exercises carried out in Step 1.

3.3 Deviations from the Planned Activities

3.3.1 Deviations with Respect to the Validation Strategy

No known deviations from the validation strategy occurred.

3.3.2 Deviations with Respect to the Validation Plan

Table 10 indicates the major deviations between the validation plan and that which was carried out in a validation exercise. For complete descriptions of the deviations refer to the individual validation reports in section six.

Exercise	Major Deviations
EXE-07.06.02-VP-727 UDPP Step 1 Benefits Studies	None
EXE-07.06.02-VP-725 UDPP Departure Performance Assessment	The exercise did not take place.
EXE-07.06.02-VP-726 UDPP Slot Swapping Performance Assessment	Significantly reduced scope due to workload and technical difficulties, which resulted in: - fewer validation objectives being attempted; - fewer concept features being assessed.
DFlex (A SESAR Demonstration Project managed by Air France)	None
EXE-07.06.04-VP-712: Issues and Benefits Analysis Workshop Human-in-the-loop Simulation ATFM Live Trial	 The workshop had no deviations. The human-in-the-the-loop simulation had no reference scenario. The live trial was extended from 31/01/2015 to 11/03/2015 to collect more data.

Table 10: Major deviations from the UDPP validation plan.

4 Results from the Exercises

4.1 Summary

The very large but useful Table 11 presents all the validation objectives that were planned for each exercise, summarises the results per objective, and finally presents a judgement as to whether or not the validation objective has been met (OK or NOK). For a validation objective's status to be **OK** all the success criteria must met (except ones that are indicated as no longer being relevant). If one or more relevant success criteria are not met the status of a validation objective is labelled **NOK** (not okay). Text in red indicates a success criterion or indeed part of a criterion that has not been met.

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-07.06.02-VP-727	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0301	Total time spent by the Network Manager is measured.	Criterion not relevant.	OK
EXE-07.06.02-VP-727	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0302	Delays for an airspace user's most important flights goes down.	This is self evident! (The entire point of swapping is to reduce the delay of important flights.)	
EXE-07.06.02-VP-727	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0303	Average cancellation notice to passengers, APOC, ATC and NM improves (increases).	Criterion not relevant.	
EXE-07.06.02-VP-727	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0304	A swap saves the airspace user money.	Slot swapping is estimated to have saved airspace users about 7.6M euros in 2013.	
EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0001	Performance - Safety	CRT-07.06.04-VALP-S1V2.0101	The over-delivery is low and infrequent enough to be operationally acceptable to project members and stakeholders.	Exercise cancelled due to insufficient time and resources.	NOK
EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0004	Performance - Punctuality	CRT-07.06.04-VALP-S1V2.0401	Empty air traffic flow management (ATFM) slots do not increase.	Exercise cancelled due to insufficient time and resources.	NOK
EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0004	Performance - Punctuality	CRT-07.06.04-VALP-S1V2.0402	Departure punctuality improves.	Exercise cancelled due to insufficient time and resources.	

EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0004	Performance - Punctuality	CRT-07.06.04-VALP-S1V2.0403	Reactionary delay of the network is less.	Exercise cancelled due to insufficient time and resources.	
EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0005	Performance - Equity	CRT-07.06.04-VALP-S1V2.0501	On average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do swap are unaffected.	Exercise cancelled due to insufficient time and resources.	NOK
EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0005	Performance - Equity	CRT-07.06.04-VALP-S1V2.0502	On average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do not swap are unaffected.	Exercise cancelled due to insufficient time and resources.	
EXE-07.06.02-VP-725	OBJ-07.06.04-VALP-S1V2.0009	Applicability of DFlex concept to all CDM airports	CRT-07.06.04-VALP-S1V2.0901	The capabilities provided by the features can be achieved at CDM airports that don't use 'first scheduled first served' in the algorithm of the pre-departure sequencer.	Exercise cancelled due to insufficient time and resources.	NOK
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0001	Performance - Safety	CRT-07.06.04-VALP-S1V2.0101	The over-delivery is low and infrequent enough to be operationally acceptable to project members and stakeholders.	Not assessed – insufficient time and resources available.	NOK
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0004	Performance - Punctuality	CRT-07.06.04-VALP-S1V2.0401	Empty air traffic flow management (ATFM) slots do not increase.	Not assessed – insufficient time and resources available.	NOK
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0004	Performance - Punctuality	CRT-07.06.04-VALP-S1V2.0402	Departure punctuality improves.	Not assessed – insufficient time and resources available.	
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0004	Performance - Punctuality	CRT-07.06.04-VALP-S1V2.0403	Reactionary delay of the network is less.	Results show that reactionary delay can be reduced by slot swapping.	
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0005	Performance - Equity	CRT-07.06.04-VALP-S1V2.0501	On average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do swap are unaffected.	Not assessed – insufficient time and resources available.	NOK
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0005	Performance - Equity	CRT-07.06.04-VALP-S1V2.0502	On average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do not swap are unaffected.	Not assessed – insufficient time and resources available.	
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0007	Duration of ATFM Slot reservation	CRT-07.06.04-VALP-S1V2.0701	Empty ATFM slots are not created (by maintaining the reservation too long).	Not assessed – insufficient time and resources available.	NOK
EXE-07.06.02-VP-726	OBJ-07.06.04-VALP-S1V2.0010	Eligible pre-allocated flights	CRT-07.06.04-VALP-S1V2.1001	A consensus is reached between airspace users and NM on an appropriate maximum value.	Not assessed – insufficient time and resources available.	NOK

DFlex	OBJ-07.06.04-VALP-S1V2.0002	Performance - Airport Capacity	CRT-07.06.04-VALP-S1V2.0201	Runway throughput is not made worse by the feature.	No deleterious effect on runway throughput according to the DFlex demonstration report.	OK
DFlex	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0301	Total time spent by the Network Manager is measured.	Criterion not relevant.	NOK
DFlex	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0302	Delays for an airspace user's most important flights goes down.	Mean delay on prioritized flights was 6.5 minutes, compared to 17 minutes before the DFlex action.	
DFlex	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0303	Average cancellation notice to passengers, APOC, ATC and NM improves (increases).	Criterion not relevant.	
DFlex	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0304	A swap saves the airspace user money.	Not assessed.	
DFlex	OBJ-07.06.04-VALP-S1V2.0006	Performance - Flexibility	CRT-07.06.04-VALP-S1V2.0601	Airspace users have more options to swap.	All three features were used, and give airspace users more swapping/prioritization actions.	OK
DFlex	OBJ-07.06.04-VALP-S1V2.0006	Performance - Flexibility	CRT-07.06.04-VALP-S1V2.0602	The feature is used by airspace users.	Confirmed: all three features were used. However, it is unclear how may DFlex actions there were in the trial. The report says 1319 flights were 'involved in[3]' a 'reorder' action, 56 flights involved in a 'prioritize' action and 1489 flights involved in a 'substitution' action.	
DFlex	OBJ-07.06.04-VALP-S1V2.0006	Performance - Flexibility	CRT-07.06.04-VALP-S1V2.0603	The ratio of requested to accepted swaps is high.	Rejection rate for 'reordering' was about 9%. There are insufficient data available for the 'prioritization' action. 'Substitutions' are carried out automatically.	

[3] The objective of a single DFlex action is to purposefully affect at least two flights, which is the nature of any prioritization. However, 'involved in' could refer only to flights that are intentionally affected by the DFlex action, or, all flights that are intentionally and unintentionally involved. The report is unclear on this.

DFlex	OBJ-07.06.04-VALP-S1V3.0005	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0501	There are no unacceptable knock-on effects in operations. That is: (1) the pre-departure sequence remains stable; and (2) CTOTs are respected in the pre-departure sequence the first time the sequence is re-calculated following a swap; and (3) SOBTs are respected in the pre-departure sequence the first time the sequence is re-calculated following a swap.	(1)The pre-departure sequence is reported as stable; (2) the report suggests that some CTOTs are not respected; and (3) criterion not relevant.	NOK
DFlex	OBJ-07.06.04-VALP-S1V3.0005	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0502	The performance benefits identified in V2 are broadly confirmed. That is: (1) the over-delivery of non-regulated sectors is low and infrequent enough to be operationally acceptable to project members and stakeholders; and (2) on average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do swap are unaffected; and (3) on average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do not swap are unaffected.	(1) criterion not relevant; (2) not the case. Aeroports de Paris report that, on average, flights ***involved*** in a DFlex action experience a ***reduction*** in the total delay; and (3) Aeroports de Paris report that, on average, flights ***not involved*** in a DFlex action experience an ***increase*** in delay as a result of a DFlex action.	
DFlex	OBJ-07.06.04-VALP-S1V3.0005	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0503	The users find the concept to be usable and acceptable. That is: (1) airspace users are able to swap flights when they need to; and (2) from the point of view of the airspace user, the expected/desired outcome of the swap matches the actual outcome of the swap; and (3) it is sufficiently easy to select a suitable swap; and (4) it is sufficiently easy to submit a swap request.	(1) confirmed; (2) it was reported that the 'substitution' feature was not meeting airspace users' needs, and so needs to be reworked; (3) 'prioritization' is easier as it requires less experience of CDM compared to reordering. It was found easier to reorder multiple flights by reordering pairs of flights; and (4) not specifically discussed in the report, but the features are available via a mobile phone app, or Aeroports de Paris' website or via in-house software in the case of Air France.	

DFlex	OBJ-07.06.04-VALP-S1V3.0006	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0601	There are no unacceptable knock-on effects in operations. That is: (1) the pre-departure sequence remains stable; and (2) CTOTs are respected in the pre-departure sequence the first time the sequence is re-calculated following a swap; and (3) SOBTs are respected in the pre-departure sequence the first time the sequence is re-calculated following a swap.	(1)The pre-departure sequence is reported as stable; (2) the report suggests that some CTOTs are not respected; and (3) criterion not relevant.	NOK
DFlex	OBJ-07.06.04-VALP-S1V3.0006	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0602	The performance benefits identified in V2 are broadly confirmed. That is: (1) the over-delivery of non-regulated sectors is low and infrequent enough to be operationally acceptable to project members and stakeholders; and (2) on average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do swap are unaffected; and (3) on average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do not swap are unaffected.	(1) criterion not relevant; (2) not the case. Aeroports de Paris report that, on average, flights ***involved*** in a DFlex action experience a ***reduction*** in the total delay; and (3) Aeroports de Paris report that, on average, flights ***not involved*** in a DFlex action experience an ***increase*** in delay as a result of a DFlex action.	
DFlex	OBJ-07.06.04-VALP-S1V3.0006	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0603	The users find the concept to be usable and acceptable. That is: (1) airspace users are able to swap flights when they need to; and (2) from the point of view of the airspace user, the expected/desired outcome of the swap matches the actual outcome of the swap; and (3) it is sufficiently easy to select a suitable swap; and (4) it is sufficiently easy to submit a swap request.	(1) confirmed; (2) it was reported that the 'substitution' feature was not meeting airspace users' needs, and so needs to be reworked; (3) 'prioritization' is easier as it requires less experience of CDM compared to reordering. It was found easier to reorder multiple flights by reordering pairs of flights; and (4) not specifically discussed in the report, but the features are available via a mobile phone app, or Aeroports de Paris' website or via in-house software in the case of Air France.	

DFlex	OBJ-07.06.04-VALP-S1V3.0007	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0701	There are no unacceptable knock-on effects in operations. That is: (1) the pre-departure sequence remains stable; and (2) CTOTs are respected in the pre-departure sequence the first time the sequence is re-calculated following a swap; and (3) SOBTs are respected in the pre-departure sequence the first time the sequence is re-calculated following a swap.	(1)The pre-departure sequence is reported as stable; (2) the report suggests that some CTOTs are not respected; and (3) criterion not relevant.	NOK
DFlex	OBJ-07.06.04-VALP-S1V3.0007	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0702	The performance benefits identified in V2 are broadly confirmed. That is: (1) the over-delivery of non-regulated sectors is low and infrequent enough to be operationally acceptable to project members and stakeholders; and (2) on average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do swap are unaffected; and (3) on average, the placings of airspace users in the pre-departure sequence or ATFM slot list who do not swap are unaffected.	(1) criterion not relevant; (2) not the case. Aeroports de Paris report that, on average, flights ***involved*** in a DFlex action experience a ***reduction*** in the total delay; and (3) Aeroports de Paris report that, on average, flights ***not involved*** in a DFlex action experience an ***increase*** in delay as a result of a DFlex action.	
DFlex	OBJ-07.06.04-VALP-S1V3.0007	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0703	The users find the concept to be usable and acceptable. That is: (1) airspace users are able to swap flights when they need to; and (2) from the point of view of the airspace user, the expected/desired outcome of the swap matches the actual outcome of the swap; and (3) it is sufficiently easy to select a suitable swap; and (4) it is sufficiently easy to submit a swap request.	(1) confirmed; (2) it was reported that the 'substitution' feature was not meeting airspace users' needs, and so needs to be reworked; (3) 'prioritization' is easier as it requires less experience of CDM compared to reordering. It was found easier to reorder multiple flights by reordering pairs of flights; and (4) not specifically discussed in the report, but the features are available via a mobile phone app, or Aeroports de Paris' website or via in-house software in the case of Air France.	
DFlex	OBJ-07.06.04-VALP-S1V3.0012	Human Performance	CRT-07.06.04-VALP-S1V3.1201	Appropriate and sufficient evidence is collected in accordance with the HP Guidance Material for V3.	No human performance assessment carried out.	NOK
DFlex	OBJ-07.06.04-VALP-S1V3.0013	Human Performance	CRT-07.06.04-VALP-S1V3.1301	Appropriate and sufficient evidence is collected in accordance with the HP Guidance Material for V3.	No human performance assessment carried out.	NOK

DFlex	OBJ-07.06.04-VALP-S1V3.0014	Human Performance	CRT-07.06.04-VALP-S1V3.1401	Appropriate and sufficient evidence is collected in accordance with the HP Guidance Material for V3.	No human performance assessment carried out.	NOK
DFlex	OBJ-07.06.04-VALP-S1V3.0015	Human Performance	CRT-07.06.04-VALP-S1V3.1501	Appropriate and sufficient evidence is collected in accordance with the HP Guidance Material for V3.	No human performance assessment carried out.	NOK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0301	Total time spent by the Network Manager is measured.	Time spent by NM to evaluate swap requests was no worse than outside the trial period.	OK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0302	Delays for an airspace user's most important flights goes down.	This is self evident! (The entire point of swapping is to reduce the delay of important flights.)	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0303	Average cancellation notice to passengers, APOC, ATC and NM improves (increases).	Criterion not relevant.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0003	Performance - Cost-Effectiveness	CRT-07.06.04-VALP-S1V2.0304	A swap saves the airspace user money.	Questionnaire responses show that swaps can save several thousand euros.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0006	Performance - Flexibility	CRT-07.06.04-VALP-S1V2.0601	Airspace users have more options to swap.	The prototype swapping tool presents all the swapping options clearly to airspace users, whereas today this has to be worked out ‘by hand’.	OK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0006	Performance - Flexibility	CRT-07.06.04-VALP-S1V2.0602	The feature is used by airspace users.	The multi-swap and the substitution on cancellation features were used during the trial, although the cancellation feature was used only three times.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0006	Performance - Flexibility	CRT-07.06.04-VALP-S1V2.0603	The ratio of requested to accepted swaps is high.	Acceptance rate of swap requests using the swapping prototype was 95%.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0008	Maximum Number of Swaps Permitted	CRT-07.06.04-VALP-S1V2.0801	The majority of airspace users accept three swaps as the limit per flight.	Several airspace users made three swaps for a given flight. Whilst most reported that three swaps was sufficient, one airspace user swapped flights more than three times and wanted this to be allowed. (NM have ruled out the possibility to swap more than three times.)	OK

EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V2.0010	Eligible pre-allocated flights	CRT-07.06.04-VALP-S1V2.1001	A consensus is reached between airspace users and NM on an appropriate maximum value.	The human-in-the-loop trial showed that 210 minutes was insufficient and that 600 minutes was much better for situational awareness and for providing more swapping opportunities. However, the optimum look-ahead time was not assessed explicitly. (Note, this concept feature was not part of the live trial.)	NOK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0001	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0101	There are no unacceptable knock-on effects in operations. That is ATFM slot lists remain stable.	Not assessed.	NOK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0001	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0102	The performance benefits identified in V2 are broadly confirmed. That is: (1) on average, the placings of airspace users in the ATFM slot list who do swap are unaffected; and (2) on average, the placings of airspace users in the ATFM slot list who do not swap are unaffected; and (3) average reactionary delay is reduced for the swapped pair of flights.	Not assessed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0001	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0103	That is: (1) airspace users are able to swap flights when they need to; and (2) from the point of view of the airspace user, the expected/desired outcome of the swap matches the actual outcome of the swap; and (3) it is sufficiently easy to select a suitable swap; and (4) it is sufficiently easy to submit a swap request; and (5) from the point of view of the flow controller it is sufficiently easy to assess a swap request, and to make the swap.	Airspace liked this feature when it was available in the human-in-the-loop trial. However, currently the feature is not feasible without NM's ETFMS (Enhanced Tactical Flow Management System) being modified such that deprioritized flights don't have to be frozen. A change request has been prepared, but was not implemented for the trial.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0002	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0201	There are no unacceptable knock-on effects in operations. That is ATFM slot lists remain stable.	Criterion not relevant because the slot allocation algorithm (CASA) has not changed.	OK

EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0002	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0202	The performance benefits identified in V2 are broadly confirmed. That is (1) on average, the placings of airspace users in the ATFM slot list who do swap are unaffected; and (2) on average, the placings of airspace users in the ATFM slot list who do not swap are unaffected; and (3) average reactionary delay is reduced for the swapped pair of flights.	Criterion not relevant.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0002	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0203	The users find the concept to be usable and acceptable. That is (1) airspace users are able to swap flights when they need to; and (2) from the point of view of the airspace user, the expected/desired outcome of the swap matches the actual outcome of the swap; and (3) it is sufficiently easy to select a suitable swap; and (4) it is sufficiently easy to submit a swap request; and (5) from the point of view of the flow controller it is sufficiently easy to assess a swap request, and to make the swap.	Airspace users liked this feature, and used it a lot during the live trial. With the swapping prototype it is easy to identify swaps.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0003	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0301	There are no unacceptable knock-on effects in operations. That is ATFM slot lists remain stable.	Criterion not relevant because the slot allocation algorithm (CASA) has not changed.	NOK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0003	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0302	The performance benefits identified in V2 are broadly confirmed. That is: (1) on average, the placings of airspace users in the ATFM slot list who do swap are unaffected; and (2) on average, the placings of airspace users in the ATFM slot list who do not swap are unaffected.	Criterion not relevant.	

EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0003	Operational Feasibility	CRT-07.06.04-VALP-S1V3.0303	The users find the concept to be usable and acceptable. That is: (1) airspace users are able to swap flights when they need to; and (2) from the point of view of the airspace user, the expected/desired outcome of the swap matches the actual outcome of the swap; and (3) it is sufficiently easy to select a suitable swap; and (4) it is sufficiently easy to submit a swap request; and (5) from the point of view of the flow controller it is sufficiently easy to assess a swap request, and to make the swap.	This features was used in the live trial on three occasions. From NM's point of view, swap requests based on this feature required more time to process because a manual suspension was needed. Operational implementation would need a better manual process or an automated approach to reduce workload and to remove the need for the safety check on the flight to be cancelled.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0801	Operating methods for NM and airspace users in normal operating conditions, or in abnormal operating conditions, or in degraded operating conditions are defined and are clear and consistent to end users.	Confirmed: procedures were prepared and approved with all participants for the live trial.	NOK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0802	Operating methods can be followed in an accurate, efficient and timely manner.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0803	The potential for airspace user or for NM human error is reduced to a tolerable level according to airspace users and NM operators.	Confirmed: the swapping prototype reduces erroneous swap requests compared to today.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0804	Any errors made by end users and how recovery was achieved have been captured and assessed.	Confirmed	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0805	Actions made by NM operators and airspace users are timely.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0806	The workload of NM operators and airspace users is acceptable.	Confirmed, except for the substitution on cancellation feature in which extra work was required. There was no evidence that the availability of the swapping prototype increased the number of swap requests.	

EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0807	NM operators and airspace users confirm their trust in the concept and any new procedures.	NM operators trust all the concept features, but want to see an improved procedure for the substitution on cancellation feature.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0808	NM operators and airspace users confirm they have a sufficient level of situational awareness when choosing or assessing swaps.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0809	Any relevant safety requirements are identified.	None identified.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0008	Human Performance	CRT-07.06.04-VALP-S1V3.0810	Any relevant security requirements are identified.	None identified.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0901	The task allocation between the human and the machine is consistent with automation principles.	Not assessed.	NOK
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0902	The changes to the task allocation between the human and the machine support human performance.	Confirmed: the swapping prototype makes it easier for the human to do his job.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0903	The transition from automatic to manual modes and vice versa, human-intended or failure induced, can be performed by the humans in a timely, efficient and accurate manner.	Not specifically tested, but since this has no safety impact it should not be an issue.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0904	The level of workload induced by the allocation of tasks between the human and the machine is acceptable.	Confirmed: the swapping prototype reduces the mental workload of airspace users in identifying a swap.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0905	Airspace users have an adequate mental picture of the slot swapping tool.	Airspace users in the trial reported that they understand the swapping prototype.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0906	The level of trust in automated functions (by NM operators and airspace users) is appropriate.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0907	The information provided by the slot swapping tool is accurate enough for identifying and requesting beneficial swaps.	Confirmed.	

EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0908	The information provided to the NM operator is timely and accurate enough for evaluating the impact of a requested swap and for accepting/declining the request.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0909	The information provided by the slot swapping tool is timely for identifying and requesting beneficial swaps.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0910	The information provided to NM and airspace users satisfies their information requirements.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0911	Input devices, visual displays, alarms and alerts, and workstations adhere to human factors' principles.	Not assessed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0912	The usability of the user interface is acceptable to airspace users and to NM operators.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0913	The user interface design of the slot swapping tool reduces human error as far as possible.	Confirmed.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0914	The changes to the design of the user interface used by NM operators reduces human error as far as possible.	Criterion not relevant because there were no changes to NM's user interfaces.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0915	The design of the slot swapping tool supports a sufficient level of operational awareness according to airspace users.	Confirmed	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0916	The design of the user interface used by NM operators supports a sufficient level of situational awareness.	Criterion not relevant because no changes to NM's user interfaces were made.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0009	Human Performance	CRT-07.06.04-VALP-S1V3.0917	The user interface design supports a sufficient level of team situational awareness.	Criterion not relevant.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0011	Human Performance	CRT-07.06.04-VALP-S1V3.1101	The changes in roles and responsibilities are acceptable to the NM operator and the airspace user.	Not assessed.	NOK

EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0011	Human Performance	CRT-07.06.04-VALP-S1V3.1102	How job satisfaction of the NM operator and the airspace user may be affected by the concept has been considered.	NM operators reported that they had no objections in seeing the concept features deployed. By implication, job satisfaction should not be adversely affected. No explicit assessment was made for airspace users.	
EXE-07.06.04-VP-712	OBJ-07.06.04-VALP-S1V3.0011	Human Performance	CRT-07.06.04-VALP-S1V3.1103	The need for a change in staffing for NM or airspace users has been considered.	Not assessed.	

Table 11: The extent to which validation objectives in Step 1 have been completed (OK means achieved, NOK means not achieved).

4.2 Results on Concept Clarification

4.2.1 Key Performance Indicators in UDPP

The SESAR work programme has selected a set of 'top priority' key performance indicators (KPIs), typically one KPI per KPA, to measure the performance benefits and disbenefits of operational concepts [9]. The UDPP project has adopted SESAR's recommended KPIs for the punctuality and predictability KPAs, because they are relevant to the project. For the other KPAs (see Table 12) the project has had to create its own relevant KPIs. This is not only acceptable practice under SESAR [9], but is common sense too!

By way of example, the UDPP project uses the KPI 'airspace user direct costs', instead of the SESAR recommended 'reduction of direct air navigation service cost per flight'. Both KPIs fall under the cost-effectiveness KPA, because they both measure cost.

4.2.2 Results per KPA per Concept Feature

Table 12 summarizes the validation results per concept feature per relevant key performance area (KPA). Not all KPAs are relevant to every concept feature. To help interpret the table, the following colour code has been applied:

Green, **orange, blue** or **red** – an impact was expected on the KPA according to the benefit mechanisms in the validation plan [7]; green – the impact was measured and is broadly as expected, orange – the impact was not measured; blue – the impact was measured and *may* be significantly different to that expected; and, red – the impact was measured and *is* significantly different to that expected.

White – no impact was predicted by the benefit mechanisms in the validation plan [7], and no measurements were taken.

Benefit mechanisms are included in Appendix A, and have been updated following the results from the validation exercises in Step 1. These represent the current best understanding of how the concept features impact performance.

<table>
<tr><th rowspan="2">KPA</th><th colspan="7">Concept Feature</th></tr>
<tr><th>1/7: Pre-Allocated Slot Swap</th><th>2/7: Multi-Swap of ATFM Slots</th><th>3/7: Substitution on Cancellation</th><th>4/7: Most Penalising Delay</th><th>5/7: Departure Reference-Time Reordering</th><th>6/7: First Priority for Departure</th><th>7/7: Upwards Cascade on Departure Cancellation</th></tr>
<tr><td>Airport Capacity</td><td>N/A</td><td>N/A</td><td>N/A</td><td rowspan="9">Early validation activities (such as [10]) led to the conclusion that, whilst this concept feature still has merit, validation cannot continue until the delay caused by the airport is made available to NM.</td><td colspan="3">No deleterious effect on runway throughput.</td></tr>
<tr><td>Cost-effectiveness</td><td colspan="3">Cost of delay reduced by 4900 euros per swap, on average, for airspace users.</td><td colspan="3">Delays for most important (prioritized) flights are reduced, so this implies a cost reduction. The benefits study did not estimate with confidence the average cost saved per swap, although it did present three approaches for making such a calculation, each with its own problems/limitations [11].</td></tr>
<tr><td>Punctuality</td><td colspan="2">The anticipated improvements in reactionary delay and departure punctuality were not assessed.</td><td>N/A</td><td colspan="3">The anticipated improvements in reactionary delay and departure punctuality were not assessed.</td></tr>
<tr><td>Equity</td><td colspan="3">The anticipated non-impact on placings in the slot list was not assessed.</td><td colspan="3">Although not a formal validation objective, results from the DFlex demonstration show that flights not directly participating in a DFlex action receive, on average, an increase in delay as a result of the DFlex action. And, flights subject to a DFlex action receive a delay reduction, on average.</td></tr>
<tr><td>Flexibility</td><td colspan="3">All three features were used and appreciated by airspace users in the human-in-the-loop simulation or live trial. The acceptance rates from NM operators were comparable with the current operational feature (i.e., a single swap) in the human-in-the-loop simulation.</td><td colspan="3">All three features were used in the DFlex demonstration, and give airspace users more swapping/prioritization actions. The rejection rate for the reordering feature is 9%, so quite good; substitutions are accepted automatically; no results were available for the prioritization feature.</td></tr>
<tr><td>Predictability</td><td colspan="2">The anticipated improvement in block-to-block variability was not assessed.</td><td>N/A</td><td colspan="2">The anticipated improvement in block-to-block variability was not assessed.</td><td>N/A</td></tr>
<tr><td>Safety</td><td>N/A</td><td>N/A</td><td>The anticipated non-impact on over delivery in non-regulated sectors was not assessed.</td><td colspan="2">The anticipated increased chance of over delivery in non-regulated sectors was not assessed.</td><td>N/A</td></tr>
<tr><td>Human Performance</td><td colspan="3">Generally, human performance has been well considered in EXE-07.06.04-VP-712 and results suggest that there is no significant adverse impact on human performance.</td><td colspan="3">No evidence that a human performance assessment was carried out.</td></tr>
</table>

Table 12: Validation results per concept feature per relevant KPA.

4.2.3 Impacts on Regulation and Standardisation Initiatives

None.

4.3 Analysis

4.3.1 ATFM Slot Swapping (AUO-0101-A)

4.3.1.1 The Extent to Which the Features are Validated

At the start of the UDPP Step 1 project, there were four ATFM slot swapping features. It later became clear that the validation of the **Most Penalizing Delay feature** could not continue. Implementing this feature in the current ETFMS system would require the airport delay to be known for each flight. In the current A-CDM protocol, flight delay is transmitted for each flight by the airport to NM in the DPI (departure planning information) messages, but there is no indication of the source of such delay, which could well be due to the airspace user itself. Therefore, using that information to determine that the airport has caused the most penalising delay for both flights to be swapped would be wrong and could be inequitable.

The **Pre-Allocated Slot Swap feature** showed merit in the human-in-the-loop simulation [12], and was appreciated by airspace users. However, it was not included in the ATFM live trial [13] because necessary software changes to NM's ETFMS were not implemented due to budgetary constraints.

The **Multi-Swap feature** was initially predicated on the idea that a flight could swap several times, with each swap subject to a separate swap request (now referred to as **type 1**). Later, a new idea was proposed that would allow a given flight to make two or even three consecutive swaps in the same swap request (**type 2**). Both types were assessed in the human-in-the-loop simulation [12], and both were seen to provide merit to airspace users. However, there were some concerns with the type 2 multi-swap. First and foremost, airspace users were apprehensive that the first swap in the enchainment might be accepted by NM, but the second or third swaps might not, which could leave the airspace user in a worse position than had the swap request not been submitted at all. This phenomenon was indeed observed during the simulation. NM also raised two concerns: one about the time needed to assess a type 2 request, and the other about the latter swaps in the type 2 request 'going out of date' due to natural changes in operations (which was indeed observed, although rarely). If NM's safety checking tool (NID) could be modified so that a safety assessment of all swaps in the enchainment could be carried out at the same time, all concerns would be overcome. **Type 2 multi-swapping has a useful advantage**, which is that sometimes it is possible to swap two flights in a regulation that would otherwise be impossible to swap.

Only the type 1 Multi-Swap feature was available in the ATFM live trial. It was used extensively by airspace users. A maximum of three swaps per flight (either promoted or deteriorated) was permitted, which was mostly respected by the airspace user participants, and deemed a sufficient limit by most, and certainly by NM! The report [13] recommended that this feature should be deployed operationally. A swap counter to log the number of times a flight has been swapped would be useful for NM operators to keep a record of the number of swaps made by a flight.

The **Substitution on Cancellation feature**, has evolved from what was originally described as '*reservation* on cancellation'. Reservation on cancellation would have allowed airspace users to cancel flights and keep the slots for use in future, without specifying which flight would fill the slot. The idea of such a reservation was uncomfortable to NM, which argued that airspace users don't own slots and therefore should not be able to reserve them. Thus, the concept evolved. *Reservation* would have afforded airspace users with more flexibility than *substitution*.

In the ATFM live trial the Substitution on Cancellation feature was used few times. Airspace users are understandably reluctant to cancel flights, and so infrequent usage should not be unexpected. Before operational deployment, **an improved manual procedure or even an automated approach** should be conceived to reduce the workload on the NM operator and to remove the unnecessary safety check on the flight to be cancelled.

In summary, the type 1 Multi-Swap and Substitution on Cancellation features have reached the end of V3 validation and deployment is recommended. The type 2 Multi-Swap and Pre-Allocated Slot Swap features need software changes to NM's systems and should be subject to a future live trial before a deployment decision can be taken. At the time of writing these two concept features have been transferred to the Network Manager for potential further development, validation and deployment. Much work is required and political discussions had if the Most Penalizing Delay feature is to be validated to the end of V3; the feature has been transferred to SESAR2020 and rebadged as OI step AUO-0108.

4.3.1.2 ATFM Slot Swapping Prototype/Tool

An ATFM slot swapping prototype was developed for the human-in-the-loop simulation and live trial. It has been **extensively tested** and has shown to be **robust and accurate** during several months in an operational environment. At the time of writing it continues to be available to the participants of the live trial as an interim measure prior to deployment. The recommendation is that NM develops and deploys a similar tool based on this prototype, which be made available to all airspace users.

The prototype identifies and presents suitable candidate swaps to airspace users. The prototype is highly configurable, and makes the whole process of identifying swaps much easier than it is currently. In the long run the tool may encourage airspace users to submit more swap requests and benefit from the flexibility afforded by swapping.

A **significant increase in acceptance rate of swap requests** was observed by virtue of the prototype. Invalid swap requests are those that don't adhere to the swapping rules or request procedure, and the prototype did very well at preventing these from reaching NM operators. The acceptance rate increased from 73% (the current process) to 95% in the ATFM live trial [13]. So why not 100% acceptance? Well, one reason is given in the next paragraph, but the first reason is that some of the rejected requests were valid but failed NM's safety check. (Safety checks are the responsibility of the NM operator, and not the responsibility of a prototype/tool used by airspace users.)

The live trial identified some useful enhancements to the prototype which are detailed in the live trial report [13], and should be considered for operational deployment. However, one of them is so important that it deserves mention here. In the trial, the prototype only *identified* suitable swappable pairs, and requesting a swap had to be done 'manually' using the normal procedure via NM's E-Helpdesk. The live trial clearly showed that, **if the tool can be developed to also *submit* swap requests, the acceptance rate of these requests will increase further**. This improvement would not only help NM operators by filtering out any remaining invalid requests, but would also likely encourage more slot swapping by corroding a procedural barrier that puts off potential users.

Everything being equal, a higher acceptance rate translates as a (modest) improvement in **workload** for the NM operator. This, however, might be more than offset in the future if swapping becomes more widely used because of automation and more flexibility.

The indications are that the development and deployment of an ATFM slot swapping tool by NM would require **relatively modest investment**. No investment costs are foreseen for airspace users.

4.3.1.3 Cost-Effectiveness

Anecdotally, ATFM slot swapping saves airspace users a lot of money. Airspace users have privately given examples of costs saved in the past to UDPP project members. These are invariably special cases, when the saving was memorably high. The cost saved per swap depends on many factors, and so to estimate the overall financial benefit to the airspace user community it's important to know the average cost saved per swap. These data are certainly not published by airspace users, and indeed may not even be known.

In 2014 a UDPP human-in-the-loop simulation [12] collected information about slot swapping, including the reasons why swaps were requested, and how much money was saved per swap. It was a simulation and not real operations, but nonetheless it was a sincere attempt to collect these data, and it has given a starting point for understanding and quantifying the financial benefits for the airspace user community in Europe. Using these data, the UDPP benefits study [11] estimated the **average cost saved per ATFM slot swap to be 4900 euros**. Soft costs such as brand reputation were not part of this estimate.

Knowing that the Network Manager made 1548 ATFM slot swaps in 2013, the **estimated cost saving for the airspace user community in 2013 is 7.6 M€** [11]. Again, soft costs such as reputation were excluded.

An attempt to refine these cost estimates with data from the ATFM slot swapping live trial failed. Generally speaking, operational persons in the trial going about their operational work were reluctant (or indeed unable) to provide cost information about their swaps. Of the 282 swap requests made in the trial, only 17 swap questionnaires were returned with details of the costs saved per swap, which is a small sample. The **average cost saved for the 17 was 4600 euros**, which is (surprisingly and quite satisfyingly) close to the estimate from the human-in-the-loop simulation / benefits studies.

The live trial provided a deeper into the reasons for swapping, thanks to the fact that it was real operations and due to the inclusion of more airspace users, notably KLM. KLM are an enthusiastic user of ATFM slot swapping, and were responsible for about three quarters of swap requests during the live trial. KLM are subject to lots of arrival regulations at Schiphol Amsterdam airport, and often submit swap requests due to late incoming aircraft from previous flights. Given that KLM are responsible for a significant number of swap requests, any future cost-benefits study should work closely with KLM in particular.

Every airspace user is different, has different methods of working and coping with delay, different corporate cultures. These factors – and others – all influence the use of ATFM slot swapping. Bearing this in mind it would be folly to make a serious attempt to estimate the number of swaps that might be expected at a given point in the future. However(!) under the assumption that the financial saving varies linearly with the number of ATFM slot swaps made, it would be easy to forecast the cost benefit to the airspace user community for a given number of swaps in a future year. If the multi-swap and substitution on cancellation features are deployed operationally – as is recommended – and if the excellent slot swapping identification and request tool for airspace users is developed and deployed by NM, **ATFM slot swaps could increase significantly**.

With regard to investment costs, none are foreseen for airspace users. NM would need to develop and deploy the slot swapping tool, but this should be a **relatively modest investment**.

The benefit mechanisms [7] show the expectation that NM's workload will increase because there will be more swap requests to assess. (Each swap request must be assessed to ensure the swapping rules are observed, and the swap is safe.) Analysis of the data from the ATFM live trial [13] did not show that the number of swaps increased over the trial period. This should not be a surprise because there are cultural and other barriers that dampen the appetite for submitting swap requests, and the increase in swapping behaviour is likely to be observed over the longer term. Thus, the logical argument that NM workload will increase remains, although currently it is unsubstantiated by the validation process.

The ATFM live trial showed that the slot swapping prototype significantly reduces the submission of swap requests that don't adhere to the swapping rules or request procedure. **This *may* reduce the**

workload of the NM operator by reducing the frequency of repeat requests (the first being an invalid and rejected request, the second a valid request), although this was not explicitly examined.

4.3.1.4 Flexibility

UDPP Step 1 is primarily about giving airspace users more flexibility (more control) over how to cope with imposed delay. Slot swapping is already possible today, of course, but the aim of UDPP Step 1 is to provide airspace users more opportunities to swap flights via the four concept features.

A significant improvement in flexibility also comes from the important slot swapping prototype which was developed for the human-in-the-loop simulation and the ATFM live trial. The tool encourages airspace users to swap by reducing the cognitive demands to identify a suitable, viable swap (a viable swap is one which adheres to the swapping rules). The tool is highly configurable, and can even **identify viable swaps between different airspace users** if set up to do so. (In the ATFM live trial there were five swaps between airspace users belonging to the same airline alliance, and one swap between airspace users of rival alliances!)

4.3.1.5 Equity

Given that NM's slot allocation algorithm, CASA, has not been modified and that NM's process for swapping has not really changed, UDPP Step 1 should not affect the degree of fairness that exists today. However, that's the logical argument, and was not tested in a validation exercise.

4.3.1.6 Predictability and Punctuality

A model-based simulation [14] had been planned to investigate the network effects caused by ATFM slot swapping. This exercise took place but was significantly reduced in scope due to lack of time and resource. This has affected the measurement and understanding of how ATFM slot swapping may affect predictability (block-to-block variability), punctuality (departure punctuality, reactionary delay) and safety.

Very minor improvements in predictability and punctuality were predicted by the benefit mechanisms for the Multi-Swap and Pre-Allocated Slot Swap features [7]. (Given that validation of the Most Penalizing Delay feature has been stopped it won't be included here in the discussion). Given the positive nature and extent of the expected impacts it is not so important that measurements have not been made.

The model-based simulation [14] did, however, demonstrate that ATFM slot swapping can be used to reduce reactionary delay. It also suggested that there may be significant, unused swapping potential for airspace users.

Only the benefit mechanism for the Substitution on Cancellation feature included the safety KPA, and the prediction was that there would be no effect on safety [7]. So, given this expectation, it is again not so important that measurements have not been made.

4.3.1.7 Human Performance Issues

An **issues and benefits analysis workshop** [10] took place prior to the human-in-the-loop simulation and ATFM live trial. The workshop brought together several technical and operational experts to assess the four ATFM slot swapping concept features in a structured way. Results from the workshop helped to plan follow-on validation activities by ensuring that what needed to be measured was identified, and indeed measured. This type of workshop also provided a 'formal' chance to document any concerns with the concept, and to identify possible mitigations.

During the human-in-the-loop simulation and thereafter the ATFM live trial a significant part of the data collection centred on **measuring human performance**. Many of the success criteria were

achieved for the three human performance-related validation objectives for exercise EXE-07.06.04-VP-712 (see Table 11). The overall impression should be that human performance has been well assessed.

4.3.2 Departure Swapping (AUO-0103)

4.3.2.1 Cost Effectiveness

The DFlex demonstration at Paris Charles de Gaulle (CDG) airport did not attempt to estimate the cost-benefits of departure swapping to airspace users [15]. When asked how much money was saved per departure swap airspace users were unable to say[4]. It may be that those making swapping decisions are unaware of the cost benefits, but are making their decisions on other criteria. A cost-benefits study [11] did, however, attempt to estimate the costs saved due to departure swapping using ground delay cost per minute. Given the large uncertainty in the estimate, no figure is repeated here. The study concluded that a better estimate could be produced, but this would be a sizeable piece of work and would take the form of a new exercise.

4.3.2.2 Flexibility

The principle aim of DFlex – Departure FLEXibility – is to provide flexibility to airspace users to be able to optimize their operations at an airport when subject to delay.

The four airspace users that took part in the demonstration at Paris CDG airport were Air France, HOP*!,* Delta and FedEx. The participants reported the following [15]:

- **Departure Reference Time Reordering;** (also known as **'Reordering'**) a useful feature, which is easier to do on pairs of flights than multiple flights. If multiple flights need to be reordered it can be done by reordering several pairs of flights. Reordering requires "a minimum of A-CDM expertise" to evaluate the pre-departure sequence. Reordering can be time consuming, and seems to benefit from having someone dedicated to this task. Whilst no what-if simulation is possible, it is possible to undo an action if the impact of a DFlex action is unfavourable to the airline concerned.
- **First Priority for Departure;** (also known as **'Prioritization'**) requires less expertise than reordering because it just requires the flight to prioritize to be identified. However, the effects of prioritizing can be unpredictable.
- **Upwards Cascade on Departure Cancellation;** (also known as **'Substitution'**) needs reworking because this concept feature currently only works when flights are cancelled within three hours of the departure.[5]

With the exception of the Upwards Cascade on Departure Cancellation, much of the swapping occurs in the last few minutes before departure, and seems to be used to **fine tune departures** rather than to exchange large numbers of minutes of delay (which is in contrast to ATFM slot swapping.) Participant airspace users were appreciative of the flexibility afforded by the DFlex concept.

4.3.2.3 Equity

According to Table 10 in the DFlex report [15], flights that are not subject to a DFlex action (i.e., reordering, prioritization or substitution) can sometimes be impacted. In other words, flights that are not swapped, but happen to be nearby in temporal terms[6] to the swapped flights in the pre-departure sequence can be affected by the swap. By considering the TSATs of these impacted flights

[4] Asked by Steve Kirby during a DFlex progress meeting on 14/5/2014 at Air France HQ, Paris.

[5] However, since the DFlex report was written, this feature has now been deployed at Paris CDG along with the other two feaures.

[6] "Flights are considered as impacted flights if one minute before the DFlex action their TTOT is within the 30 minutes before or after the TTOT of the flight associated to a DFlex action." [15]

immediately before and after a DFlex action, some impacted flights had more delay and some less, but on average **impacted flights accrued more delay**.

The total amount of accrued delay in the DFlex trial depends on how delays are counted. The DFlex report presented two approaches. The first approach counts all delays greater than zero minutes, and gives a value of about 29 hours of extra TSAT delay during the course of the trial period (about one year)[7]. Using this approach, 19% of flights temporally close[3] to the DFlex action are impacted by a delay [15].

The second approach counts all delays that are greater than five minutes. At Paris CDG, the departure procedure permits -5/+5 minutes of tolerance about the TSAT. By taking into account only deteriorations that are greater than five minutes, the extra TSAT delay is about five hours. Using this approach, only 2% of flights temporally close[3] to the DFlex action are impacted by a delay [15].

With either approach, some flights that are *not* subject to a DFlex action but just happen to be close temporally are impacted, and the average delay is *increased* for these flights. **Contrast this with flights that *are* subject to a DFlex action, which experience a *reduction* in delay, on average**. Increases and reductions of delay "come from CTOT and pre-departure sequencer behaviour" [15].

It is not clear from the report how many impacted flights accrued delay, and so the average delay cannot be calculated. Flights that accrued delay may, of course, have belonged to the same airspace user that made the DFlex action, but others may not. Are the delays spread over many flights, perhaps giving only a few seconds of increased delay per flight? Or, are only a few flights affected, with each receiving a greater delay? These questions are not answered in the DFlex report. **More analysis of the data** from the trial might lead to a better understanding of the extent to which other flights and airspace users are affected by the accrued delay.

So, is the DFlex concept as demonstrated at Paris CDG equitable? The DFlex report [15] concludes that "Flexibility can be given to airlines without impacting operations and capacity and with respecting equity among airlines." Meanwhile, the UDPP OSED [6] presents a set of principles and rules to apply to departure swapping that are borrowed from Step 2 UDPP work. One of these principles says "Airspace users have the right not to participate in UDPP without prejudice." There is no definition of what is, or is not, prejudicial.

4.3.2.4 Predictability and Punctuality

The DFlex demonstration project focussed on the airport without considering the wider effects on the network. It reports that **departure punctuality improved for prioritized flights** (where punctuality is defined as |AOBT-SOBT|<15 minutes), the SESAR-endorsed definition of punctuality was not used (punctuality defined as |AOBT-SOBT|<3 minutes). This makes it hard to incorporate results into the work and analysis by sub-work package B5.

According to the benefit mechanisms in the validation plan [7] reductions in delay for improved flights should be offset by increases in delay for deteriorated flights, i.e., delays are swapped, but total delay for the airspace user concerned should stay the same. On first inspection of Table 10 in the DFlex report [15], it appears that DFlex actions actually reduced the total TSAT delay at Paris CDG. The amount of saved delay depends on how the delay is calculated, but the report implies that between 12 and 32 hours of delay may have been saved during the trial period (about one year). However, studying the table more closely, significant delay reduction comes from the Upwards Cascade on Departure Cancellation feature, which is understandable because cancellations reduce congestion and delay! If the data for this feature are stripped out, the change in total TSAT delay varies between a reduction of 16 hours and an increase of 8 hours, depending on how the delay is calculated! Thus, **the effect that DFlex may have on total TSAT delay is inconclusive**, unfortunately.

A model-based study intended to investigate the network-wide effects of DFlex actions at one then several airports. Unfortunately, this exercise did not take place, due to lack of time and resource. Very

[7] It has been suggested that the data from the 'first' phase of the DFlex trial should be excluded from the analysis because it was a period of learning for those making departure swaps. However, from the point of view of analysing how the pre-departure sequencing algorithm reacts to swaps, data from the first phase are as equally valid as those from the second phase.

minor improvements in predictability (block-to-block variability) and punctuality (departure punctuality and reactionary delay) were predicted by the benefit mechanisms for the three DFlex concept features [7]. Given the positive nature and extent of the expected impacts it is not so important that measurements have not been made.

4.3.2.5 Safety

Regarding the safety KPA, a theoretical deterioration in safety was predicted in the benefit mechanism [7], but no attempt has been made to measure this. The causal link between DFlex and a reduction in safety runs as follows: the features ('Reordering' and 'Prioritization' only) lead to more opportunities to swap slots which lead to more opportunities for non-regulated sectors to have traffic volume counts higher than the maximum threshold.

Experience from the DFlex trial [15] shows that departure swapping happens close to departure, and so, potentially, sectors could be caught out by a sudden over-demand of flights. The benefit mechanisms suggest that affected sectors might be able to split at short notice to cope, or, to be regulated if there is sufficient time, or, to apply a short-term ATFCM measure (STAM) to mitigate the risk.

4.3.2.6 Human Performance

No human performance assessment was documented.

4.3.2.7 Implementing DFlex at Paris CDG

Following the end of the DFlex demonstration project, all three DFlex features have been implemented operationally at Paris CDG[8], and DFlex is now therefore available to all airspace users.

The cost-benefits study [11] shows that airspace users with many flights (for example, Air France), or with few flights that are concentrated in a narrow time window (for example, FedEx) are the biggest potential beneficiaries of departure swapping.

The study further showed that (with certain assumptions) the number of departure swaps is unlikely to be linearly related to the percentage presence that an airspace user has at Paris CDG. In fact, it suggests that an airspace user may need a presence of at least 10% to begin to use departure swapping (Reordering or Prioritization), and 20% to use departure swapping on a significant scale. Thus, airspace users with a small percentage footprint at Paris CDG and whose flights are spread through the day are unlikely to be able to benefit much from DFlex.

4.3.2.8 Implementing DFlex at Other Airports

Implementing departure swapping at other airports in Europe is recommended by the DFlex demonstration report, which provides the following advice:

- Airports in Europe that have a pre-departure sequencer should consider deploying DFlex;
- To get **maximum benefits from DFlex the pre-departure sequencer should operate on a 'first scheduled first served' basis**, like Paris CDG;
- The Departure Reference Time Reordering feature will provide less benefit than at Paris CDG if the airport uses either the 'first planned first served' or 'best planned first served' principles for the pre-departure sequencer;
- To use the Upwards Cascade on Departure Cancellation feature the pre-departure sequencer should include all the departure traffic of the day of operations (Paris CDG currently uses a three-hour window before departure, whereas other CDM airports use as little as 20 minutes).

[8] Email communication from Melanie Grandmère (Air France) to the author, received 27/08/2015.

The cost-benefits study [11] also considered the question of implementation at other CDM airports. It did so by extrapolating the results from Paris CDG to nine other CDM airports in Europe[9]. This analysis took into account factors such as the delay profiles at these airports, the number of movements per year, and the fraction of the airport's movements belonging to the dominant airline at each airport. The analysis concluded that, with the exception of Frankfurt, there was unlikely to be a significant demand for DFlex departure swapping.

Both studies [11][15] concluded that **departure swapping will most benefit Paris CDG**. However, other CDM airports may wish to examine carefully the use and potential benefits of DFlex at their own locations.

4.3.3 Unexpected Behaviours/Results

An unexpected result was the potential breach of equity for departure swapping, as discussed in §4.3.2.3.

4.4 Confidence in Results from the Validation Exercises

4.4.1 Quality of Results

Whilst the trends and tendencies reported in the model-based simulation that investigated the network effects of ATFM slot swapping are likely to be correct, the results in terms of numbers are likely to be unreliable. This is not unusual for a parametric study.

The estimated average cost saved per ATFM slot swap 'feels' high at 4600-4900 euros (to the author at least), although the number is supported by a live trial, albeit based on a small sample.

The results are generally reliable for the ATFM live trial.

The results from the DFlex demonstration are not always presented clearly using a systematic approach. For example, results were reported separately by airspace user participant, per phase of trial (there were two phases), for different periods. Another issue is that sometimes results are not always analysed or explained as well they might. For example, why does departure swapping increase average delay for impacted flights, on average, and reduce delay on average for flights subject to a DFlex action? A further example: why do DFlex actions affect the total TSAT delay at the airport?

4.4.2 Significance of Results

The ATFM slot swapping concept features were evaluated in a Europe-wide live trial spanning three months during winter 2014/15. Thirteen airspace users took part in the trial, and accounted for 90% of all swap requests during the trial period. So, from this numerical point of view the results are representative for the whole of Europe. Traditionally, the winter months see the fewest swap requests, and the summer the most, so it will be interesting to see what happens in summer 2015.

The DFlex demonstration was, of course, another live trial and has high operational significance for the three departure swapping concept features. The results are representative for Paris CDG, where the demonstration took place, but are unlikely to be applicable to other CDM airports in Europe, particularly those which use different pre-departure sequencing principles.

[9] Frankfurt, Munich, London Heathrow, Rome Fiumicino, Dusseldorf, Zurich, Helsinki, Oslo, and Brussels.

5 Conclusions and recommendations

5.1 Conclusions

5.1.1 Validation Activities Carried Out

UDPP Step 1 started with seven concept features, the aim of each to provide more flexibility to airspace users for coping with delay. Four validation exercises and one demonstration were planned. Due to limited time and staff availability, the departure swapping model-based simulation exercise (EXE-07.06.02-VP-725) was cancelled, and the ATFM slot swapping model-based simulation (EXE-07.06.02-VP-726) was severely reduced in scope. However, exercise EXE-07.06.04-VP-712 was very substantial and delivered a human performance assessment [10], a human-in-the-loop simulation [12] *and* a live trial [13].

5.1.2 Levels of Maturity Achieved

Table 13 summarizes the current level of maturity for each concept feature, and what work needs to be done, if any. The 'V' phases are described in the E-OCVM [5].

Concept Feature	Current Level of Maturity	Observations / Work Left to Do
AUO-0101-A (Enhanced ATFM Slot Swapping)		
Pre-Allocated Slot Swap	Early V3	Needs software changes to NM's ETFMS, and then to be validated in a live trial. This feature has been transferred to the Network Manager for potential further development, validation and deployment.
Multi-Swap	End V3 (type 1); Early V3 (type 2)	There are two types, which are not mutually exclusive. Type 1 permits a flight to swap several times (three was the limit agreed in validation exercises), with each swap subject to a separate swap request. Type 2 permits a given flight to make two or even three consecutive swaps in the same swap request. Type 2 needs software changes to NM's NID tool, and possibly to ETFMS as well, and then needs to be validated in a live trial. The Type 2 feature has been transferred to the Network Manager for potential further development, validation and deployment.
Substitution on Cancellation	End of V3	Validated in a live trial.
Most Penalising Delay	V1	Operational implementation would require the airport delay to be known for each flight. In the current A-CDM protocol, flight delay is transmitted for each flight by the airport to NM in the DPI messages, but there is no indication of the source of such delay, which could well be due to the airspace user itself. Therefore, using that information to determine that the airport has caused the most penalising delay for both flights to be swapped would be wrong and could be inequitable. This feature has been transferred to SESAR2020 as operational improvement step AUO-0108 [3] for further development, validation and deployment.
AUO-0103 (UDPP Departure)		
Departure Reference Time Reordering ('Reordering')	V5	The three features have been deployed operationally at Paris CDG.
First Priority for Departure ('Prioritization')		
Upwards Cascade on Departure Cancellation		

('Substitution')		

Table 13: The extent to which the concept features in Step 1 have been validated.

5.1.3 Enabler

A very significant output of the validation process has been the development of the **ATFM slot swapping prototype**, which was used in the human-in-the-loop simulation and the ATFM live trial. Indeed, such was the interest and success of the prototype, it continues to be **used operationally**, even though the ATFM live trial finished in March 2015. This is an **interim solution** during the transition to deployment. The swapping prototype supports the ATFM concept features that are described in Table 13, with the exception of the immature Most Penalizing Delay feature (although during the transition phase prior to deployment the tool is only permitted to support single swaps that can be done today). It is a very significant enabler for providing the airspace user community with the flexibility to cope with imposed delays. The very useful and appreciated **'one click request'** function should be included in the deployment.

The ATFM slot swapping prototype was also observed to increase significantly the **acceptance rate** of swap requests by preventing requests that broke one of the many swapping rules or constraints. This may also reduce the workload of both airspace user and the NM operator (because fewer revised requests are needed).

The swapping prototype/tool is likely to **encourage more swapping** in the future because it corrodes blocking factors such as the time and mental effort required to identify technically viable swaps. This would, of course, affect the workload experienced by NM operators.

No investment costs are foreseen for airspace users to deploy the slot swapping tool. NM would need to develop and deploy an operational tool (based on the prototype). Indications are that this should require a **relatively modest investment**.

5.1.4 Summary of Benefits and Issues

ATFM **slot swapping saves an estimated 4900 euros** for airspace users, on average, per swap. Scaled up to a year, the savings are **7.6M€** (based on 1500 swaps observed in 2013, and each swap saving 4900 euros). Enhanced slot swapping also provides airspace users with more combinations of flights to swap, which improves the **flexibility** with which to react to delay.

Whilst ATFM slot swapping (AUO-0101-A) is necessarily a pan-European deployment, DFlex departure swapping (AUO-0103) would need to be **implemented on an airport by airport basis**. DFlex is most relevant to Paris CDG, which operates a first scheduled first served principle in the pre-departure sequence. **The concept has been fully deployed now at Paris CDG**. Results from the benefits study [11] suggest that few other airports in Europe would see a significant benefit from DFlex implementation.

DFlex undoubtedly provides **flexibility** to airspace users at Paris CDG, most especially to those that have a significant presence at the airport. However, there appears to be an impact on some flights that are not involved in DFlex actions, but that happen to be temporally in proximity. The impact is an **increase in average delay**. Contrast this with flights that are subject to DFlex actions (i.e., flights that are improved and deteriorated), which on average experience a **reduced delay**. It will be up to decision makers and stakeholders at each airport to decide prior to operational implementation if the benefits and possible disbenefits are sufficiently appealing.

5.2 Recommendations

5.2.1 ATFM slot swapping

1) The **Pre-Allocated Slot Swapping** feature should be subject to a live trial to complete its journey to the end of V3 validation. This will require a modification to NM's ETFMS so that deteriorated flights in the 'allocated' status are not automatically promoted back by ETFMS;

2) The **Multi-Swap** feature (type 1) should be deployed operationally, with a maximum of three swaps allowed per flight. NM operators should have a swap counter in ETFMS to log the number of times a given flight has swapped;

3) The **Multi-Swap** feature (type 2) should be subject to a live trial, but first NM's NID tool needs modifying so that all the swaps in the single request are evaluated (and carried out) simultaneously;

4) The **Substitution on Cancellation** feature should be deployed operationally; an improved manual procedure, or even an automated approach should be conceived for deployment to reduce the workload on the NM operator and to remove the unnecessary safety check on the flight to be cancelled;

5) CDM airports should identify and publish the delay caused by the airport itself so that the **most penalizing delay** (airport v arrival / en route) for flights can be calculated. (This may require a modification to the current A-CDM protocol.);

6) The Network Manager should use the **slot swapping prototype** to develop an operational swapping tool for all airspace users in Europe. The '**one-click swap request**' functionality is an essential requirement for this tool. The ATFM live trial report [13] presents other requirements for the tool and should be considered;

7) Once deployed, the swapping behaviour from airspace users and the performance of the slot swapping tool should be monitored to confirm that the performance impacts identified and quantified during validation are realised;

5.2.2 Departure Swapping

8) European CDM airports should **consider a local deployment** of DFlex;

9) Paris CDG to **monitor and publish** the effect that DFlex actions may have on the pre-departure sequence, in a similar but more detailed fashion to that already done for the demonstration project. The monitoring should distinguish between flights involved in a DFlex action, and those impacted, and should also distinguish between different airspace users. The monitoring activity should include the *distribution* of change in delay for flights that are subject to a DFlex action, and, separately, for those that are in temporal proximity[10]. The motivation should be to assure/ensure that equity is achieved for airspace users;

10) The UDPP project should (re)discuss and agree the principles of UDPP, and then based on these principles should **define clear, unambiguous rules** to be able to decide what is equitable or not for future validation exercises.

[10] The DFlex demonstration project has already established rules for this.

6 Validation Exercises Reports

A validation report has been written for each validation exercise. The separate reports are reproduced in an annex [1].

7 References

[1] Step 1 V3 UDPP Validation Report – Annex, Edition 00.01.01, 13/11/2015.

[2] Network Operations Validation Strategy for SESAR Step 1, Edition 02.00.00, 03/03/2014.

[3] Integrated Roadmap Dataset 14.

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

[5] European Operational concept Validation Methodology (E-OCVM), Volume I, Version 3.0, 2010.
https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf

[6] Step 1 V3 UDPP Final OSED, D66, Edition 00.02.00, 30/09/ 2015.

[7] Step 1 UDPP Validation Plan, SESAR Project 07.06.02, Deliverable D64, Edition 00.02.00.

[8] 07.02-D28 Step 1 Release 4 DOD, Edition 00.03.00, July 2015.

[9] Guidance on KPIs and Data Collection Version 1 (2014), deliverable D85, SESAR Project B.05, Edition 00.01.01, 09/12/2014.
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[10] Issues and Benefits Analysis Workshop for EXE-07.06.04-VP-712, Edition 00.00.01, 18/03/2014.

[11] Step 1 V3 UDPP Validation Report (Annex), D67, Edition 00.01.00, 30/09/2015, pp. 38-77 (UDPP Benefits Studies).

[12] Step 1 V3 UDPP Validation Report (Annex), D67, Edition 00.01.00, 30/09/2015, pp. 161-219 (the human-in-the-loop simulation).

[13] Step 1 V3 UDPP Validation Report (Annex), D67, Edition 00.01.00, 30/09/2015, pp. 220-259 (the live trial).

[14] Step 1 V3 UDPP Validation Report (Annex), D67, Edition 00.01.00, 30/09/2015, pp. 4-37 (Slot Swapping Performance Assessment).

[15] Demonstration Report, SESAR Project Number 002.003, Edition 00.01.00, 09/07/2014. See also reference [1].

Appendix A Updated Benefit Mechanisms

Introduction

Seven benefit mechanisms are presented, one per concept feature. The benefit mechanisms were first published in the UDPP Step 1 validation plan [7]. Following the various validation activities that are reported in this report, the benefit mechanisms have been updated to present the current best understanding that the features have on performance.

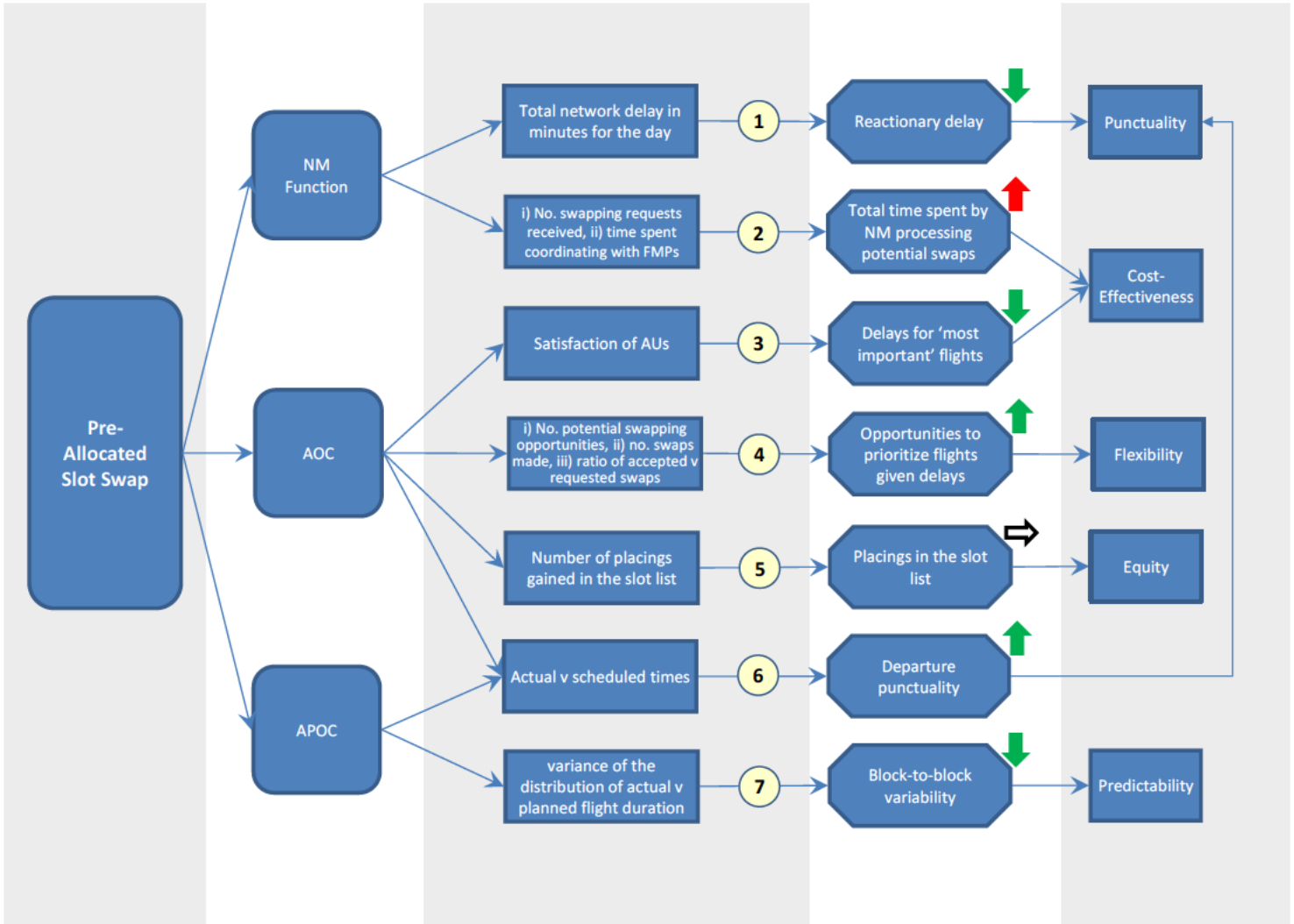
How to Interpret a Benefit Mechanism

There are two parts to each mechanism: the **schematic**, which gives an overall impression of the impacts (i.e. benefits and disbenefits) that are known or expected, and the second part is a set of **detailed notes** that refer to specific branches of the schematic. These are essential for understanding why the impacts are known or expected.

Explanation of Coloured Arrows on the Schematics:

	A beneficial decrease e.g. a reduction in CO_2 emissions (indicator) or a reduction in controller workload (positive impact)
	A detrimental increase e.g. an increase in CO_2 emissions (indicator) or an increase in controller workload (negative impact)
	A beneficial increase e.g. an increase in the number of movements (indicator) or an increase in safety (positive impact)
	A detrimental decrease e.g. a reduction in the number of movements (indicator) or a reduction in safety (negative impact)
	A change in the indicator, a positive or negative impact is expected but with current knowledge the direction is still not clear. Can be coloured to show the main expectation. Where possible an up or down arrow is preferred.

A.1 Feature 1/7: Pre-Allocated Slot Swap



Feature	Impact area	Indicators	Positive/negative impacts	Key performance area

(1) The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users choosing more often to absorb delays with flights with longer turn-around times which leads to reduced reactionary delay for the network [and therefore better punctuality for airspace users and the APOC.]

(2) The feature leads to more opportunities to swap slots which leads to more swaps which leads to more time spent by the NM processing (evaluating and coordinating) swaps.

*(3) **CONFIRMED BY VALIDATION:** The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users reducing the impacts of delay on more of their most important flights.*

*(4) **CONFIRMED BY VALIDATION:** The feature leads to more opportunities to swap because promoted flights can be swapped again by the airspace user - they are not 'frozen'. [There is also a benefit in terms of flexibility for NM because promoted flights will no longer be constraints when recalculating slot lists.]*

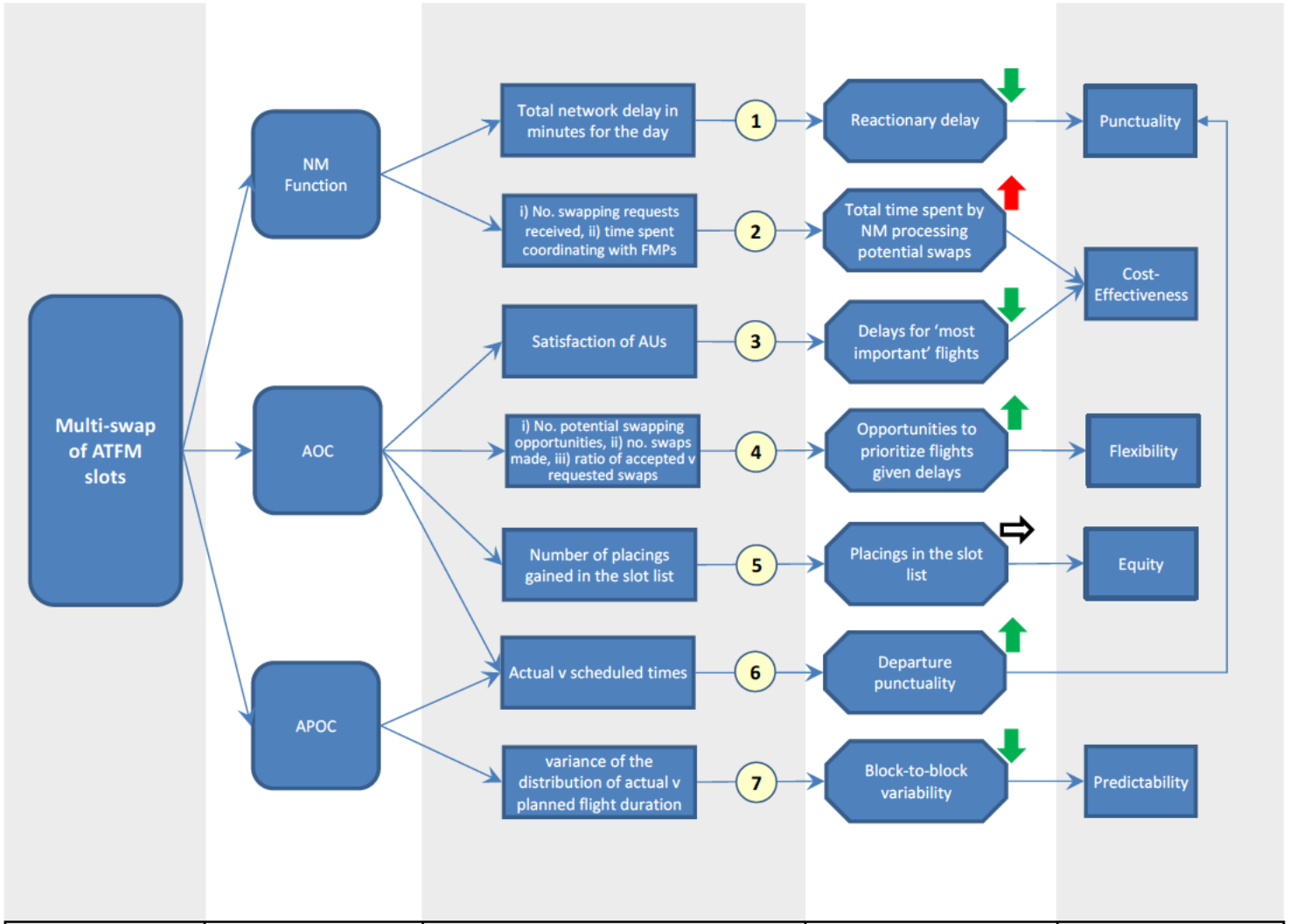
(5) Because the feature swaps slots, this feature should not affect the placings of non-participating flights in the same list. However, there may be unintended changes to placings in other slot lists, but there should be no systematic effect.

(6) See item (1). Furthermore, if two flights are delayed, and one transfers some of its delay to the other, the prioritized flight could become 'on time', thus punctuality could improve.

(7) Slot allocation and swapping are processes that, in theory, only modify the flight plan's departure time. However, increased slot swapping leads to the most important flights having less or no delay (see item (3)), which may lead to less operational need for these important flights to speed up in flight to arrive closer to the scheduled arrival time, which would lead to better predictability (where predictability is defined as the difference between planned and actual flight duration).

***Note:** it was previously thought that this feature could lead to "foreseen and accepted" over-delivery in regulated and non-regulated sectors, and furthermore to empty slots in regulated sectors. If all reasonable swap requests are accepted by the NM operator, these undesirable outcomes may occur under certain specific conditions. However, provided that the NM operator checks that there is no undesirable impact on regulated and non-regulated sectors before accepting an ATFM swap (using the Network Impact Display tool, and coordinating with FMPs if necessary) there should be no risk of over-delivery or empty slots due to ATFM slot swapping.*

A.2 Feature 2/7: Multi-Swap of ATFM Slots



(1) The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users choosing more often to absorb delays with flights with longer turn-around times which leads to reduced reactionary delay for the network (and therefore better punctuality for airspace users and the APOC).

(2) The feature leads to more opportunities to swap slots which leads to more swaps which leads to more time spent by the NM processing (evaluating and coordinating) swaps.

*(3) **CONFIRMED BY VALIDATION:** The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users reducing the impacts of delay on more of their most important flights.*

*(4) **CONFIRMED BY VALIDATION:** The feature leads to more opportunities to swap because promoted flights can be swapped again by the airspace user - they are not 'frozen'. (There is also a benefit in terms of flexibility for NM because promoted flights will no longer be constraints when recalculating slot lists.)*

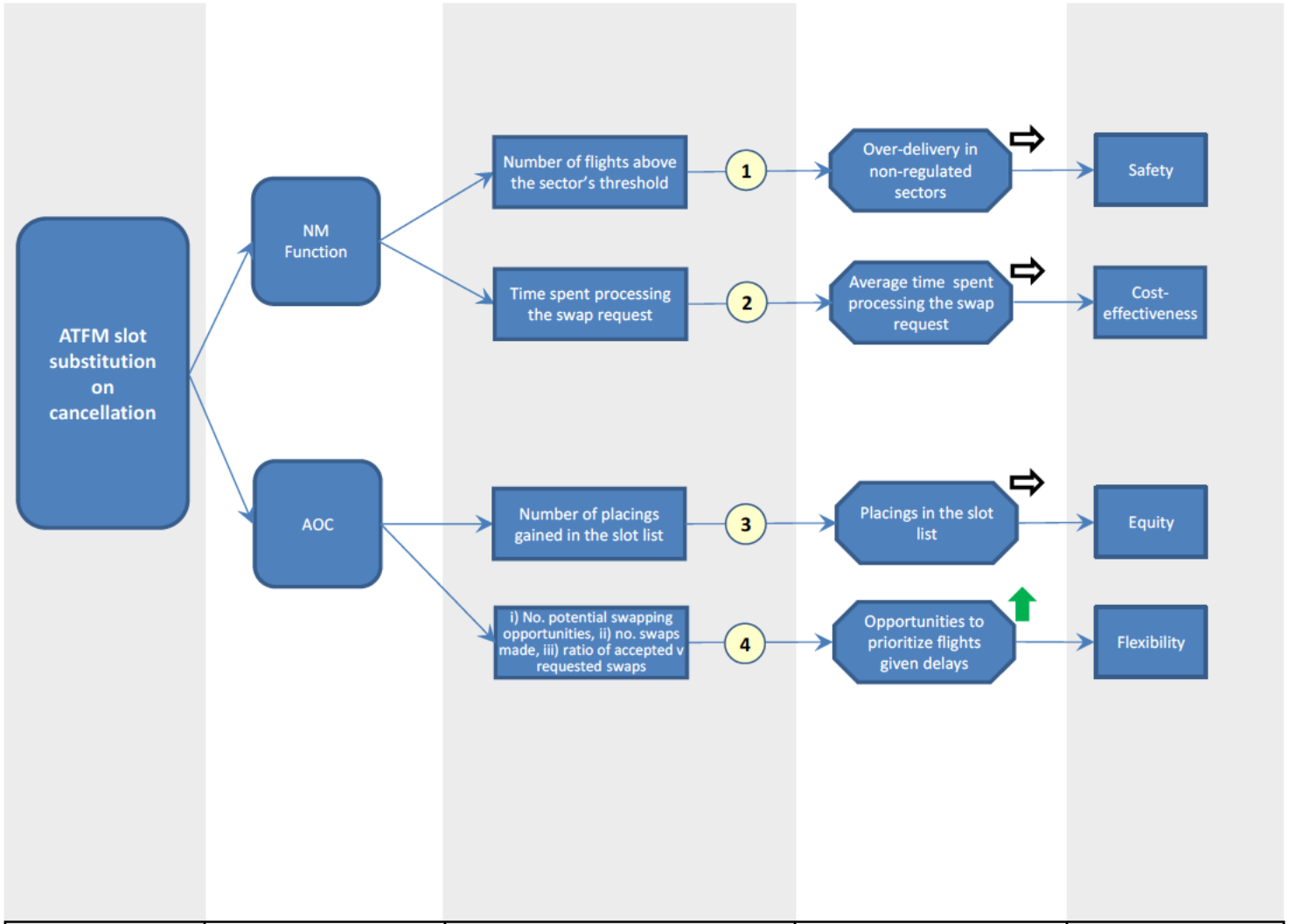
(5) Because the feature swaps slots, this feature should not affect the placings of non-participating flights in the same list. However, there may be unintended changes to placings in other slot lists, but there should be no systematic effect.

(6) See item (1). Furthermore, if two flights are delayed, and one transfers some of its delay to the other, the prioritized flight could become 'on time', thus punctuality could improve.

(7) Slot allocation and swapping are processes that, in theory, only modify the flight plan's departure time. However, increased slot swapping leads to the most important flights having less or no delay (see item (3)), which may lead to less operational need for these important flights to speed up in flight to arrive closer to the scheduled arrival time, which would lead to better predictability (where predictability is defined as the difference between planned and actual flight duration).

***Note:** it was previously thought that this feature could lead to "foreseen and accepted" over-delivery in regulated and non-regulated sectors, and furthermore to empty slots in regulated sectors. If all reasonable swap requests are accepted by the NM operator, these undesirable outcomes may occur under certain specific conditions. However, provided that the NM operator checks that there is no undesirable impact on regulated and non-regulated sectors before accepting an ATFM swap (using the Network Impact Display tool, and coordinating with FMPs if necessary) there should be no risk of over-delivery or empty slots due to ATFM slot swapping.*

A.3 Feature 3/7: Substitution on Cancellation



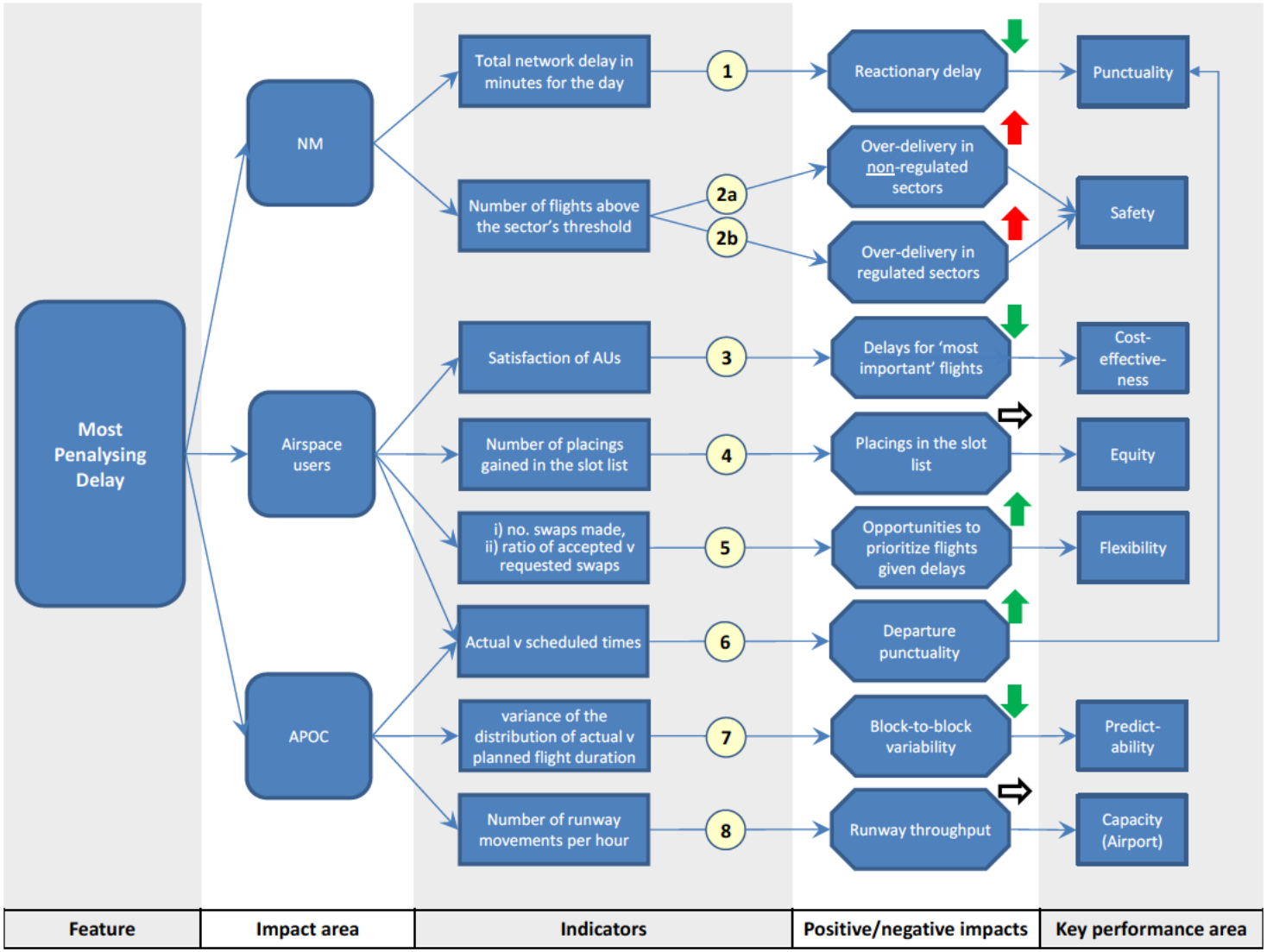
(1) The feature could lead to an over delivery in a non-regulated sector if the substituting flight has to depart shortly after the swap to make its new CTO (affected sectors may be able to split at short notice to cope, or it may be possible to subject the sectors to regulation if there is sufficient time.) and the NM operator fails to carry out a network impact assessment correctly prior to accepting the swap. The latter is very unlikely, of course, but it could be argued that a significant increase in the number of swap requests of this type would increase the chance of this error occurring.

(2) The feature will take no longer to assess than any other type of slot swap requests ***provided that*** *the NM operator does not have to manually suspend or cancel the flight that is to be cancelled.*

(3) This feature will not introduce a new concept, rather it will make something which is possible today via two steps (a swap then a cancellation) easier for the airline. Thus, equity should be no different compared to today. However, given the importance of equity it might be sensible to validate this claim.

(4) ***CONFIRMED BY VALIDATION:*** *This feature will give airspace users an easier alternative to what is already possible today. Today, a swap would be made, followed by the cancellation of the deteriorated flight. However, this concept feature will combine both the swap and the cancellation in one, and forego the safety check on the flight that will be cancelled. This feature gives a more 'flexible' approach for coping with delay because it is a single step and because there is a slightly increased chance it being accepted than the two step alternative. This loose interpretation of 'flexibility' is not aligned to SESAR's recent definition of flexibility [8].)*

A.4 Feature 4/7: Most Penalising Delay



(1) The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users choosing to delay flights that will have longer turn-around times at the next arrival airport (where delays can be better absorbed) which leads to reduced reactionary delay for the network (and therefore better punctuality for airspace users and the APOC at onward airports).

(2a) The feature leads to more opportunities to swap slots which leads to more opportunities for non-regulated sectors to have traffic volume counts higher than the maximum threshold. (Affected sectors may be able to split at short notice to cope, or it may be possible to subject the sectors to regulation if there is sufficient time, or to apply a short-term ATFCM measure (STAM)[11].)

(2b) Similar mechanism to that described in (2a) but concerns regulated sectors. This impact will disappear if the Network Manager can veto a swap at the airport, under the assumption that the Network Manager would not deliberately accept an over-delivery in a regulated sector. The fact that a sector is regulated anyway implies that ETFMS would soon reissue CTOs in reaction to a sudden change in the expected entry times due to a swap at the departure airport[12].

(3) The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users reducing the impacts of delay on more of their most important flights.

(4) On average, airspace users that are not swapping flights will have the same placings in the pre-departure sequence before and after a swap. This is the expectation, and it would be sensible to verify this claim.

(5) This feature will permit airspace users some say in how their delay is apportioned, so flexibility should increase.

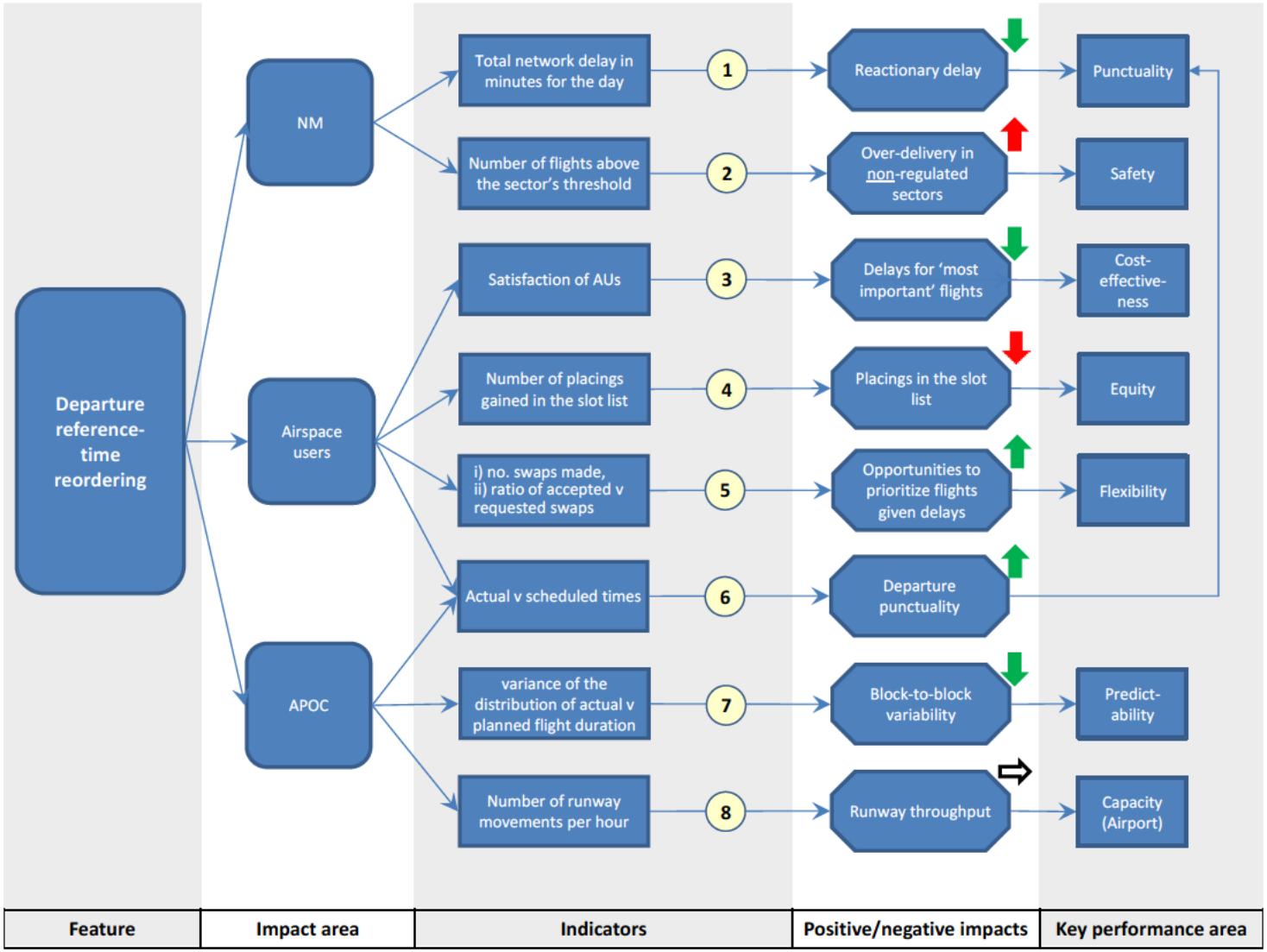
(6) See item (1). Furthermore, if two flights are delayed, and one transfers some of its delay to the other, the prioritized flight could become 'on time', thus punctuality could improve.

(7) Slot allocation and swapping are processes that, in theory, only modify the flight plan's departure time. However, increased slot swapping leads to the most important flights having less or no delay (see item (3)), which may lead to less operational need for these important flights to speed up in flight to arrive closer to the scheduled arrival time, which would will lead to better predictability (where predictability is defined as the difference between planned and actual flight duration).

(8) Runway throughput is unlikely to be affected because reordering happens before the tower calculates the departure sequence. However, under certain very specific conditions (e.g. a very late swap with other conditions) runway throughput could be reduced.

[11] STAM is a new approach to deal with situations where demand exceeds capacity. The approach is to target a few flights that would best alleviate congestion. STAM would, it is hoped, replace regulations in many cases.
[12] The so-called 'True Revision' process is the re-evaluation and subsequent update of slot lists carried out within ETFMS, which is done every five minutes.

A.5 Feature 5/7: Departure Reference-Time Reordering



(1) The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users choosing to delay flights that will have longer turn-around times at the next arrival airport (where delays can be better absorbed) which leads to reduced reactionary delay for the network (and therefore better punctuality for airspace users and the APOC at onward airports).

(2) The feature leads to more opportunities to swap which leads to more opportunities for non-regulated sectors to have traffic volume counts higher than the maximum threshold. (Affected sectors may be able to split at short notice to cope, or it may be possible to subject the sectors to regulation if there is sufficient time, or to apply a short-term ATFCM measure (STAM).)

(3) ***CONFIRMED BY VALIDATION:*** *The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users reducing the impacts of delay on more of their most important flights.*

(4) ***CONFIRMED BY VALIDATION:*** *The DFlex demonstration has shown that flights that don't swap, but that are nearby in a temporal sense to others that do, accrue delay on average.*

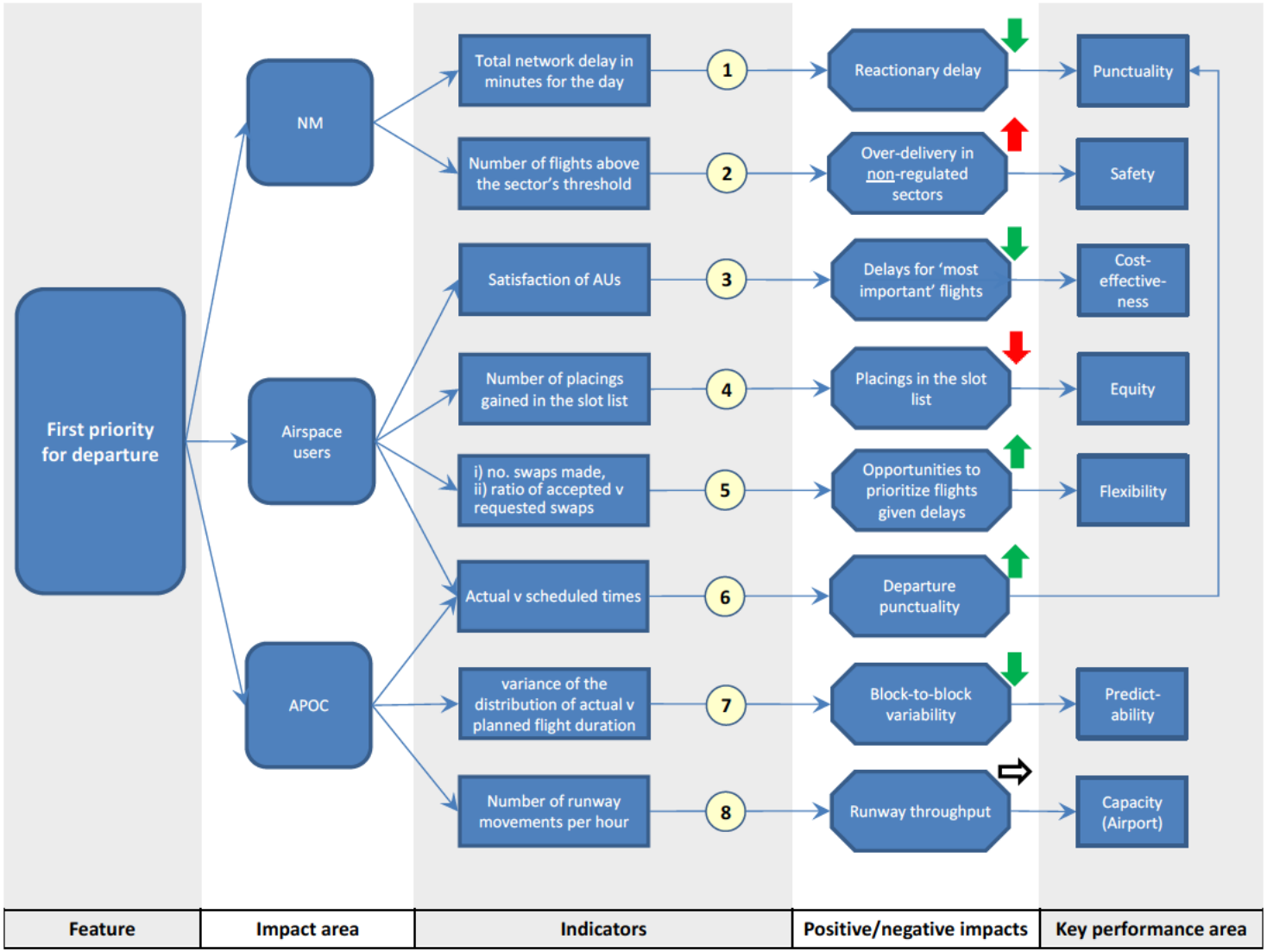
(5) ***CONFIRMED BY VALIDATION:*** *SESAR's definition of the Flexibility key performance area broadly concerns the accommodation of requests of airspace users. As far as this feature is concerned, all requests regarding swaps are accepted provided the swapping rules and constraints are satisfied. This feature will permit airspace users some say in how their delay is apportioned, so flexibility should increase.*

(6) *See item (1).*

(7) *Slot allocation and swapping are processes that, in theory, only modify the flight plan's departure time. However, increased slot swapping leads to the most important flights having less or no delay (see item (3)), which may lead to less operational need for these important flights to speed up in flight to arrive closer to the scheduled arrival time, which would will lead to better predictability (where predictability is defined as the difference between planned and actual flight duration).*

(8) ***CONFIRMED BY VALIDATION:*** *runway throughput is unaffected.*

A.6 Feature 6/7: First Priority for Departure



(1) The feature leads to more opportunities to swap slots which leads to more swaps which leads to airspace users choosing to delay flights that will have longer turn-around times at the next arrival airport (where delays can be better absorbed) which leads to reduced reactionary delay for the network (and therefore better punctuality for airspace users and the APOC at onward airports).

(2) The feature leads to more opportunities to swap which leads to more opportunities for non-regulated sectors to have traffic volume counts higher than the maximum threshold. (Affected sectors may be able to split at short notice to cope, or it may be possible to subject the sectors to regulation if there is sufficient time, or to apply a short-term ATFCM measure (STAM).)

(3) ***CONFIRMED BY VALIDATION:*** *most important flights benefit from reduced delay.*

(4) ***CONFIRMED BY VALIDATION:*** *flights that don't swap, but that are nearby in a temporal sense to others that do, accrue delay on average.*

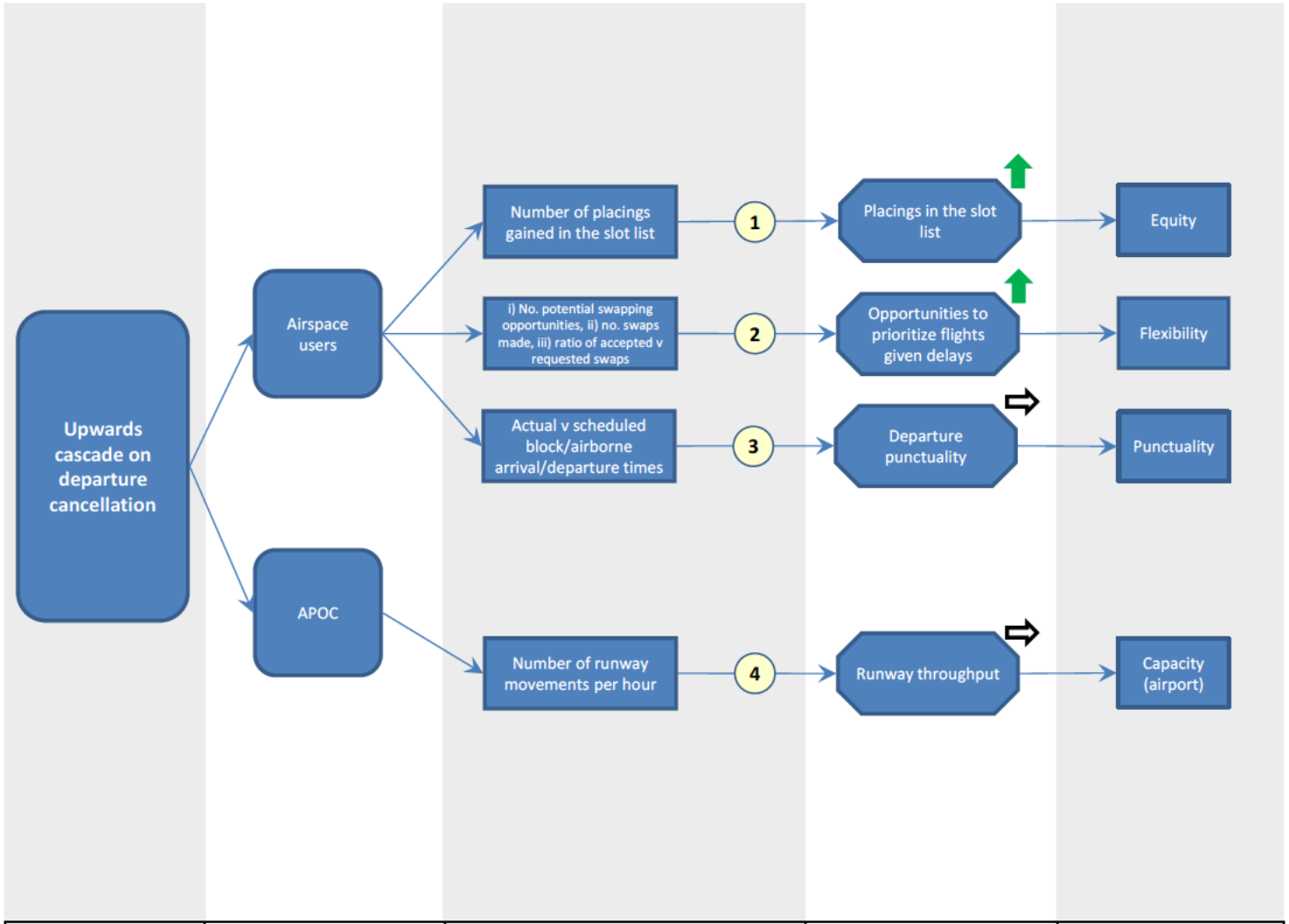
(5) ***CONFIRMED BY VALIDATION:*** *airspace users are better able to cope with delay if using this feature.*

(6) See item (1).

(7) Slot allocation and swapping are processes that, in theory, only modify the flight plan's departure time. However, increased slot swapping leads to the most important flights having less or no delay (see item (3)), which may lead to less operational need for these important flights to speed up in flight to arrive closer to the scheduled arrival time, which would will lead to better predictability (where predictability is defined as the difference between planned and actual flight duration).

(8) ***CONFIRMED BY VALIDATION:*** *runway throughput is unaffected.*

A.7 Feature 7/7: Upwards Cascade on Departure Cancellation



(1) ***CONFIRMED BY VALIDATION:*** *on average, flights impacted by this DFlex action will experience an improvement in placings (and a reduction in overall delay).*

(2) ***CONFIRMED BY VALIDATION:*** *airspace users are better able to cope with delay if using this feature.*

(3) *If this feature didn't exist the pre-departure sequencer would fill the empty slot anyway. The feature just prioritises one airspace user's flights to offset the cancellation. Thus, there should be no difference in average network punctuality at onward airports compared to today's situation (although the punctuality for the airspace user who is subject of the upwards cascade would have improved punctuality compared to today).*

(4) ***CONFIRMED BY VALIDATION:*** *runway throughput is unaffected.*

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