**EXPLORATORY RESEARCH**

# D6.2 Stakeholders' consultation on system and investigative case studies

**Deliverable 6.2**

**Domino**

| | |
|---|---|
| **Grant:** | **783206** |
| **Call:** | **H2020-SESAR-2016-2** |
| **Topic:** | **SESAR-ER3-06-2016 ATM Operations, Architecture, Performance and Validation** |
| **Consortium coordinator:** | **University of Westminster** |
| **Edition date:** | **24 August 2018** |
| **Edition:** | **01.01.00** |

SESAR
JOINT UNDERTAKING

## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Luis Delgado / University of Westminster | Project member | 20 August 2018 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Graham Tanner / University of Westminster | Project member | 24 August 2018 |
| Gérald Gurtner / University of Westminster | Project member | 24 August 2018 |

### Approved for submission to the SJU By — Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Andrew Cook / University of Westminster | Project coordinator | 24 August 2018 |

### Rejected By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| N/A | | |

### Document History

| Edition | Date | Status | Author | Justification |
|---|---|---|---|---|
| 01.00.00 | 19 July 2018 | Release | Domino Consortium | New document for review by the SJU |
| 01.01.00 | 24 August 2018 | Release | Domino Consortium | Incorporating SJU comments |
|  |  |  |  |  |
|  |  |  |  |  |

Founding Members

EUROPEAN UNION      EUROCONTROL

# Domino

NOVEL TOOLS TO EVALUATE ATM SYSTEMS COUPLING UNDER FUTURE
DEPLOYMENT SCENARIOS

## Abstract

For completeness, this deliverable presents the consultation questionnaire and a summary of the consultation results on the system architecture and the investigative case studies to be modelled in Domino: the feedback has already been incorporated into deliverables D3.1 (Architecture definition) and D3.2 (Investigative case studies description).

The opinions expressed herein reflect the authors' views only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

# Table of Contents

## Executive summary

For completeness, this deliverable presents the consultation questionnaire and a summary of the consultation results on the system architecture and the investigative case studies to be modelled in Domino: the feedback has already been incorporated into deliverables D3.1 (Architecture definition) and D3.2 (Investigative case studies description).

# 1 Introduction

## 1.1 Stakeholders' involvement in Domino

In order to maximise the impact of Domino, it is important to include the involvement of stakeholders and experts from the early stages of the project. This will ensure that the relevant systems are modelled and considered. The feedback provided by experts will help us also to identify the scenarios which bring the higher added value of the project to the community.

Domino has an active Advisory Board composed of ENAV, Harris Orthogon, Deep Blue and members of the consortium of the evoATM project. This Advisory Board is updated with the progress of the project and provides feedback to the different modelling activities.

Besides the value of the Advisory Board, Domino considers a wider reach of experts and stakeholders at different stages in the project. The first of these outreach activities (in addition to the dissemination carried out through the website, blogs and social media) is the consultation on systems, mechanisms and scenarios. This first consultation has been carried out and aimed at obtaining feedback from relevant experts and stakeholders, and not only to disseminate the achievements of the project. The feedback obtained has been used for the definition of the architecture of the project (reported in D3.1, Ref [3]) and the scenarios to be modelled (see D3.2, Ref [4]).

Other planned feedback activities include the workshop that will be conducted in London in spring 2019. These activities ensure that WP6 is not only dissemination but also actively incorporation of feedback by the relevant and wider Air Traffic Management (ATM) community.

## 1.2 Deliverable structure and contents

Note that this deliverable focuses on the information of the consultation. The impact of the feedback obtained has been incorporated into the relevant technical deliverables (D3.1, Architecture definition, and D3.2, Investigative case studies description).

This deliverable is structured as follows:

- Introduction to the deliverable: Introduction to the involvement of stakeholders in Domino and deliverable structure and main contents;

- Stakeholders and experts reached in this consultation;

- Consultation responses and considerations for Domino and other consultation activities;

- Next steps and look ahead;

- Acronyms;

- Annex with the questionnaire.

# 2 Stakeholders and experts

The consultation has been sent to a total of 34 stakeholders and experts and to the members of the Advisory Board. These stakeholders and experts have been selected based on their expertise in ATM and on the different mechanisms that Domino will model. As shown in the Annex, the questionnaire requested specific feedback on the architecture of the ATM system that will be modelled in Domino, the three different mechanisms (4D trajectory adjustment, flight prioritisation and flight arrival coordination) and the scenarios considered to be analysed.

The mechanisms considered in Domino are targeted at airlines and Air Navigation Service Providers (ANSPs) operators, therefore these have been particularly considered in the consultation process.

In total the consultation has been sent to:

- 11 airlines;

- 2 airlines' associations;

- 1 airport;

- 1 airport association;

- 2 ANSPs;

- 1 NM;

- 4 system engineering companies;

- 3 research institutions.

A total of eight responses has been obtained, which corresponds to the typical size of a full focus group in market research studies.

Note that feedback to Domino is not limited to this consultation activity but is followed up with further interactions with stakeholders and experts, from inside and outside the Advisory Board. The different experts reached in this consultation will be updated on the project evolution and invited to the workshop that will be organised in spring 2019. Further feedback for modelling and validation purposes is already agreed with some members of the Advisory Board.

Founding Members

EUROPEAN UNION    EUROCONTROL

# 3 Consultation responses and considerations for Domino

## 3.1 Domino architecture

The different respondents agreed that the architecture of Domino presented to them covers all the most relevant systems.

Domino already considers traffic to-from the European Civil Aviation Conference (ECAC) region and the importance of intercontinental traffic has been signalled by one of the reviewers. This is particularly relevant when Air Traffic Flow Management (ATFM) initiatives can be applied to these flights coming to Europe (e.g. assigning target times of arrival to flights to Heathrow).

The nature of traffic and the airspace structure (e.g., free routes) should also be considered when modelling the cruise phase, which might require more detail on the definition of its impact on traffic.

Systems that were out of scope for Domino (such as Airport-Collaborative Decision Making (A-CDM)) might need some degree of modelling as they have been pointed out as relevant on turnaround operations. However, ground operations such as parking stand assignment are currently out of scope of the project.

Experts agree that the degree of freedom of the flight agent to operate autonomously (i.e., independently of the Flight Operation Centre (FOC)) should be limited. Airlines' procedures and strategies (e.g., to minimise cost/delay) could vary, but pilots are expected to follow their airline's defined policies. One airline, however, confirmed that their pilots have some degree of freedom to implement some of the mechanisms (e.g., dynamic cost indexing) even though pro-active behaviour should be kept limited. This information will be used when defining the possible implementation of the mechanisms. Note that one expert also mentioned the inefficiency due to the airline not filing the optimal flight plan and the crew then asking for directs.

## 3.2 Mechanisms

### 3.2.1 4D Trajectory adjustment

There is a consensus that the use of re-routing and flight level 'capping' along with dynamic cost indexing covers all the main tactical strategies of airlines to recover part of their delay. However, the importance of buffers has been made relevant as the delay should be considered with respect to the

planned schedules. This has some important consequences on the model, since buffers are set strategically and Domino's model is considering a pre-tactical/tactical environment. The implications of the buffers are discussed in D3.2 more in detail. The cost of missing curfews should also be considered as it might have a big impact on the delay recovery strategy carried out by the airline (including potential cancellations).

It has also been indicated that it would be interesting to incorporate the Air Traffic Control (ATC) planning for flows at a longer time-frame than for short-haul flights. When considering modifications to the trajectory to deal with delay all operating costs (including route charges) should be considered, as indicated by one of the experts.

## 3.2.2  Flight prioritisation

Most of the experts agree that allowing slot swapping at any time (even when ATFM regulations are not in place) could be useful as it provides more flexibility for the airspace users. However, there is a need of clarification on how such as system would work (for example, how to define slots when there is no regulation in place). Moreover, this could have an impact on the parking stands at the airports, which are out of scope of Domino.

The use of a credit system for slot swapping is seen as a challenging but interesting idea. Other issues such as equity should then be considered.

Testing the possibility of a centralised market to trade slots is relevant and considerations of interactions between airlines, alliances and competitors of high relevance. It will be considered in Domino but is related to more strategic views and thus will have to be limited (because Domino is set in a pre-tactical/tactical environment).

## 3.2.3  Flight arrival coordination

For the arrival coordinator, the possibility of a centralised system which considers the airport's available information to reduce reactionary delay is received with scepticism by most of the experts. The main reason being that crucial information is owned by the airline, and other parameters such as passenger connectivity or the allocation of ground resources can have a significant impacts on reactionary delay. However, this could be used as a first step to test a more advance flight arrival coordination procedures.

User-Driven Prioritisation Process (UDPP) principles could be used to create the prioritisation of arrivals considering an advanced implementation of the mechanism. Most experts agree on maintaining a consistent prioritisation based on the pre-tactically declared preferences by airlines, unless conditions have significantly changed.

Another expert has pointed out the possibility of using temporal margins to define the flight prioritisation in addition to UDPP. Time windows are explored in other projects such as ADAPT and could also be considered in Domino.

Founding Members

EUROPEAN UNION   EUROCONTROL

## 3.3 Scenarios - combinations of mechanisms

There is a consensus that the scenarios considered in Domino are adequate. The only extra consideration is the importance of the uptake by stakeholders which has been deemed relevant by three of the experts. This feedback has been used to further refine and prioritise the scenarios in D3.2.

Finally, the modelling of Trajectory-Based Operations (TBO) by considering a conjoint deployment of the three mechanisms considered in Domino seems adequate, according to the feedback. The need for strong coordination between Airspace Users (AU) and the Network Manager (NM) has been pointed out. One of the experts recommends the review of the outcome of the PARTAKE project to enhance how flights can be prioritised in Domino operations. This will be done during the development phase of the model.

## 3.4 Insights from consultation used in D3.1 and D3.2

We finish by showing briefly how the consultation has been used in the technical deliverables D3.1 (Architecture definition) and D3.2 (Investigative case studies description). Indeed, in the text of these two deliverables, we added some insert boxes, where relevant, to discuss how the consultation was integrated into the concepts developed in the deliverables. We copy these inserts here to illustrate how they were used.

### 3.4.1 In D3.1: Architecture definition

**Insights from consultation**

It is still an open question whether or not the flight should be a pro-active agent, with a dedicated objective function, or a simple 'processor' guided mechanically by other agents. The feedback from the consultation is also divided on the subject, even if the balance seems to be in favour of a passive flight, but at least points out that in the current situation, it is very dependent on the airline culture. The model will thus likely include the possibility for the flight to have a more complex objective function, but we will first start with a simple entity.

**Insights from consultation**

One expert has reminded us that the airlines usually have very comfortable buffers, particularly on long-haul flights, which means that they are able to recover some delay in such cases. In fact, buffers introduce some slack in the system by allowing elasticity in the arrival times, as explained in Section 2. As a consequence, we expect that 4D trajectory adjustments are performed more often and have more impact when the buffers are smaller. The same expert also pointed out that the 4D adjustments are mainly short- and medium-term solutions, but that ANSPs work on longer-term solutions whereby for instance the departure times are updated when updates on weather are available.

Other experts mentioned the importance of curfews and crew. Domino cannot take crew factors into account, since it has no data available to calibrate the model. Concerning curfew, there might be a possibility for Domino to get some data on this, but most probably the model will feature a simplified approach with a fixed curfew for every airport in Europe. This will be considered regarding the expected cost of delay at the end of the day.

One expert pointed out that re-rerouting is a complex operation because of route charges. Since Domino will not feature a geographical model *per se*, we must take care of not introducing a strong bias one way or another (towards smaller route charges or reduced times).

**Insights from consultation**

Some answers in the consultation pointed out that the ATCOs should be more present in the model. In the previous description, they are just considered as creating *ad hoc* distributions of delay (positive and negative) for the en-route phase. It is out of the scope of Domino to consider detailed controllers able to separate planes. However, Domino can include some high-level agents (for instance at the NAS level) computing their own dynamic load and modifying the probability for the flights to have a direct for instance, or to have their changes of trajectories such as speed variations cleared.

Similarly, systems such as CDM have been suggested as relevant for the model. For now, Domino will consider CDM within the flight prioritisation and arrival coordinator but assume it is implemented as A-CDM at the airports and not considered as an explicit system in the model.

**Insights from consultation**

Some experts pointed out during the consultation that a centralised market with real money, or other kinds of credits, is definitely a road to explore. Others have pointed out how averse some actors are to any kind of monetisation of the slots. Domino will try to shed some light on the potential benefits and drawbacks of more market-oriented solutions. In any case, several experts have pointed out how much the equity among airlines is important and should be preserved.

**Insights from consultation**

For Level 2, some experts have mentioned the fact that priorities should be drawn at least from cost minimisation, and ideally from the pre-tactical ones given to the (extended) UDPP system plus some updates given by the airlines during the flight. It seems indeed logical for the airlines to prioritise their flights in general and that this same priority is used throughout the execution phase (even if it can slightly evolve). This idea will be explored in one of the scenarios (see D3.2), whereby when the flight prioritisation mechanism is implemented, both will interact and thus be in synergy. There might be some unforeseen issues with joint implementations, however. In order to do this, Domino will need to align the concept of 'priority' in both mechanisms. Also, in E-AMAN the airlines have to prioritise all their flights, whereas with UDPP, they do not have to put any priority if there is no regulation. The model will need to be able to derive an overall priority for each flight, which is not a trivial task.

It is worth noting that one expert has also mentioned a simple 'stick to plan' objective for the prioritisation. In other words, the AUs is charged with asking for the best flight plan for itself before departure and the E-AMAN simply tries to stick to it. Another expert has also pointed out that the focus should be more on the ground process rather than on the sequence of arrival to avoid reactionary delay, for instance.

Several experts have noted that focusing on the reactionary delay at Level 1 should be enough. One of them noted that: "This may work out of hub only, i.e., in the hub, carrier may use tail swap to minimize disruption and allocate 'on-time' departures for the right flights".

### 3.4.2  In D3.2: Investigative case studies description

**Insights from consultation**

One expert mentioned that it would be very important for airlines to have only one point of contact to deal with all the prioritisation process. This is in line with the joint implementation that we suggest, even if strictly speaking there could be one point contact, but still several independent prioritisation processes going on.

**Insights from consultation**

Several experts think that the level of uptake is important, but it is not clear if they think that it is because the gains can be non-linear or for another reason. Another parameter which was suggested by the experts was the weather. Testing different weather is certainly interesting, but since Domino plans to use increased levels of delay, we believe that the weather variable can be adequately captured like this.

**Insights from consultation**

One expert has explicitly mentioned that level 1 implementations should be tested independently. This will be indeed done during the development phase, but without in-depth analysis.

## 3.5  Other consultation activities

As described previously, besides the consultation, other feedback activities have been conducted with members of the Advisory Board. In particular, a set of teleconferences has been carried out with Harris Orthogon to help us on the understanding of the current Extended-Arrival Manager (E-AMAN) system and its potential evolution. Similar contacts have been performed with members of the project evoATM to help us with the definition of the systems to be modelled, the Agent-based modelling (ABM) approach and to synchronise the activities between the two projects. EUROCONTROL's expertise has been extensively drawn upon from within the consortium.

Founding Members

EUROPEAN UNION    EUROCONTROL

# 4 Next steps and look ahead

The feedback obtained in this consultation has been considered during the definition of the architecture, mechanisms and scenarios as reported in D3.1 and D3.2. The modelling activities carried out in WP4 will also benefit from the information obtained.

As described previously, further feedback will be obtained during the modelling/validation activities of the model by interacting with the Advisory Board members.

Finally, once the initial results are obtained, the wider ATM community and experts will be invited to the spring 2019 workshop of Domino, in London. The invitation to this workshop will be extended, among others, to all the entities contacted for the current consultation process.

# 5 References

[1]   Domino project, 2017. Grant Agreement 783206, Ref. Ares(2017)6114973 - 13/12/2017.

[2]   Domino project, 2018. Deliverable 1.1 - Project Management Plan.

[3]   Domino project, 2018. Deliverable 3.1 - Architecture definition.

[4]   Domino project, 2018. Deliverable 3.2 - Investigative case studies description.

Founding Members

# 6 Acronyms

ABM: Agent-based modelling

ATM: Air traffic management

A-CDM: Airport Collaborative Decision Making

AMAN: Arrival Manager

ANSP: Air Navigation Service Provider

ATC: Air Traffic Control

ATFM: Air Traffic Flow Management

AU: Airspace User

DCI: Dynamic cost indexing

DMAN: Departure Manager

E-AMAN: Extended Arrival Manager

ECAC: European Civil Aviation Conference

FOC: Flight Operation Centre

H2020: Horizon 2020 research programme

NM: Network Manager

SESAR: Single European Sky ATM Research

TBO: Trajectory-Based Operations

UDPP: User-Driven Prioritisation Process

# 7 Annex: Questionnaire

Dear xxx,

Domino is a Research and Innovation Action running from January 2018 to December 2019. **It aims to develop a set of tools, a methodology and a platform to assess the coupling of ATM systems from a flight and passenger perspective.** The platform will allow system designers to gain insights into the impact of applying new ATM mechanisms. It will provide a view of the impact of deploying solutions in different manners, e.g. harmonised v. local/independent deployment, and information on the criticality of elements in the system and how this might vary for different stakeholders. You can find more information about the project on our website ([www.domino-eu.com](www.domino-eu.com)), in our blogs (where a brief description of the activities and project objectives are presented here) or by e-mailing us at [domino-coordinator@westminster.ac.uk](domino-coordinator@westminster.ac.uk) with any questions.

Domino will use an agent-based model to simulate three mechanisms (**4D trajectory adjustment, flight prioritisation** and **flight arrival coordination**) at three levels of implementation:

- **Level 0**: aiming at representing current operations
- **Level 1**: with some technological and operational improvements c.f. current operations
- **Level 2**: the most more advanced case.

The mechanisms will be implemented individually and jointly, and Domino will be able to assess the impact of them on **how the elements in the system are coupled** and their criticality from a propagation of delay and cost point of view ('domino' effects), both for airspace users and passengers. These mechanisms have been selected such that by implementing them jointly, we are approaching a very similar environment to full Trajectory-Based Operations (TBO).

At this stage of the project, we would appreciate it enormously if you could devote **30 minutes of your valuable time** to give us some feedback on the architecture and mechanisms we are planning to model. Your feedback will be greatly appreciated and treated confidentially. This will help us to define the first set of scenarios to test (the 'investigative' case studies). The results from these scenarios will be presented at a workshop in London in spring 2019, and the scenarios will be modified into 'adaptive' case studies to mitigate some of the issues identified at the network level by Domino.

Below you have the description of the systems we are considering to model and of the three mechanisms. There is no need to provide feedback for all of them but only for the ones you consider relevant. In total there are 12 brief questions. It would be very useful if we could get some input from you, as a reply to this e-mail, by **Friday 15 June**.

Many thanks in advance for your cooperation.

The Domino team

**Domino architecture**

Geographically, Domino will use the full ECAC airspace for the full model; it will focus on the operations of a typical day in 2017 (viz., 01SEP), to which different mechanisms will be added to create the case studies of interest. Domino aims to gain an understanding of the coupling of the elements (systems) in ATM. It is interested in macro-effects arising in the air transportation system during the tactical phase arising from changes of management rules. The list of systems considered in Domino are:

- Flight Operations Centre (FOC)
  - Considers the status of the network of flights and passengers of the airline and decides the strategy to follow to minimise the impact of disruption. For example, prioritising flights if a flight prioritisation mechanism is in place or deciding the actions to take by flights to recover delay.
- Network Manager (NM)
  - Considers network constraints (e.g. congested airspace)
  - Assigns slots and delays to flights (en-route and at airports)
  - If a prioritisation mechanism is in place, manages the coordination between the FOC and UDPP processor.
- UDPP processor
  - If a prioritisation of slots by airlines is in place, the UDPP processor will manage those interactions.
- E-AMAN (arrival manager coordinator)
  - Considers flows arriving at an airport and plans the demand by suggesting speed resolutions
- AMAN (arrival sequencing)
  - Performs the final sequencing of flights to the runway, coordinating with the DMAN in the case of mixed-mode operations
- DMAN
  - Performs the sequencing of departing flights at the runway and coordinates with the AMAN if needed.
- Runway
  - System that represents the capacity in terms of movements (departures and arrivals) that can be handled.
- Terminal
  - Processes the ground activities of the passengers (e.g., uncertainty regarding connections of passengers between flights)
- Flights
  - Interact with the FOC to request trajectory management adjustments (e.g. speed variations)
  - Interact with NM, DMAN, runway, E-AMAN and AMAN, terminal and passengers during their operations
- Passenger
  - Passive units handed from flight to flight, but with priority rules for disruption management applied by the airlines (e.g. premium passengers are re-booked first during disruption)

Note that E-AMAN, DCI and UDPP are part of the mechanism modelled in Domino. The model will include several different instances of these systems (e.g. types of flight, types of airline). The following figure represents some of these instances and their interactions:
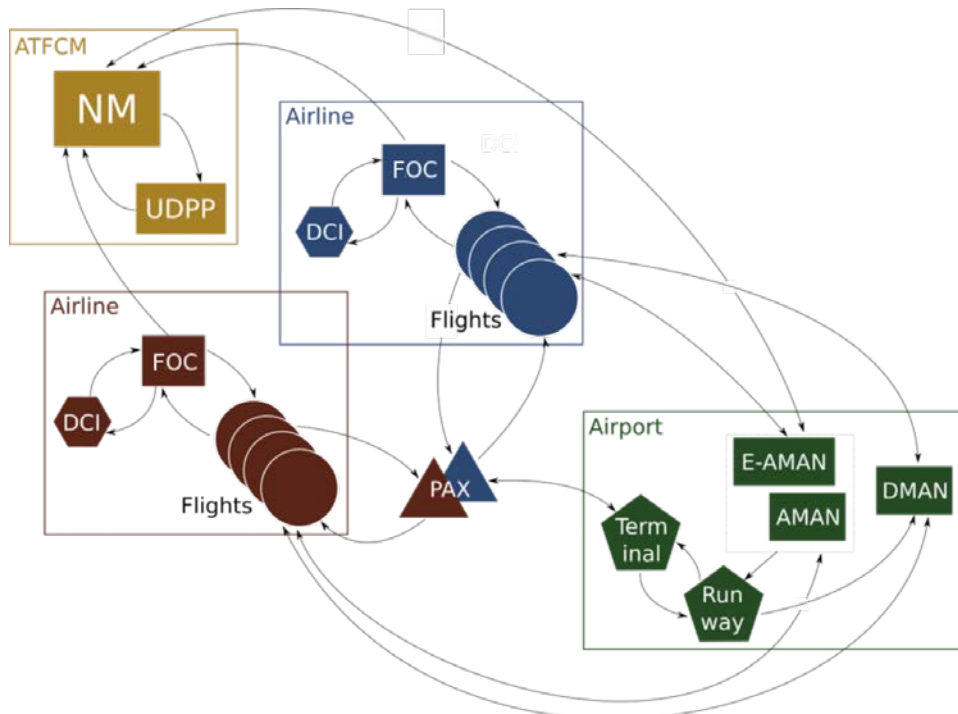


*Questions:*

*Q1. Is there any system that should be considered, but that has been left out?*

*Q2. To what extent should the 'flight'\* have autonomy from the FOC or from the set of rules defined by the airline (e.g., 'recover all possible delay above 15 minutes')? To what extent should it have a pro-active behaviour?*

*\* Conceptually the 'pilot', included within the 'flight'*

## Mechanisms

### 4D Trajectory adjustment

This mechanism includes different delay management strategies from the airline operations point of view. It includes:

- Trajectory management:
    - re-routing/level changes, e.g. changes of route to deal with ATFM delay,
    - dynamic cost indexing, i.e. changes of cost index (e.g. to recover delay)
- Hub management, e.g. waiting for connecting passengers.

Founding Members

Three levels of implementation are planned:

- Level 0
  - Basic delay recovery rules linked to amount of delay incurred; cost index computed before departure; limited waiting for passengers; basic re-routing and level changes used.
- Level 1
  - Dynamic cost indexing for flights, with a simplified in-flight delay and cost estimation based on heuristics and general cost of delay rules
  - Wait for passengers used more widely but with limited rules only
  - Estimation of possibility of re-routing and level changes with respect to dynamic cost indexing
- Level 2
  - Advanced estimation of expected costs due to connecting delayed flights.
  - Optimisation of actions considering the three available techniques (dynamic cost indexing, trajectory modification and wait-for-passenger decisions).

*Questions*

*Q1. Have we introduced the three strategies (DCI, trajectory modification, wait-for-passengers) realistically across the three levels, with Level 0 reflecting 'current' operations?*

*Q2. In particular, have we assumed the right level of ATC/ANSP responsiveness to AU needs across the levels?*

**Flight prioritisation**

The flight prioritisation mechanism collects collaborative decision-making procedures considering airlines' prioritisations of their flights to minimise their expected costs (of delay) in case of capacity-demand imbalance. This includes current ATFM delay assignment, UDPP as currently considered, and other advanced concepts. The three levels of implementation envisioned are:

- Level 0
  - No pre-departure prioritisation of flights by the AU, use of first-planned first-served (FPFS) as performed pre-2017 by the Network Manager when assigning ATFM delay; no slot swapping takes place
- Level 1
  - Pre-departure prioritisation of flights, allowing AUs to reorder several flights in the same constraint among their own slots when they are delayed (UDDP principles); includes Enhanced Slot Swapping (SESAR1)
- Level 2
  - As per Level 1, plus a 'credit' system so that airlines can prioritise flights at a given airport using credits previously earned at the same airport*.

**Important note. For all UDPP processes (including slot swaps and use of credits): participation is voluntary; non-participating airlines are never significantly worse off; no airline can make the slot of another airline worse; by 'AU' or 'airline' we also mean within an alliance**

*Questions*

*Q1. In principle, should slot swapping be allowed within an airline at a given airport at any time during the day (i.e. not only when ATFM regulations are in place)?*

*Q2. In principle, should airlines be allowed to earn credits on one day for use on a later day? (This helps lower-volume airlines to accumulate enough useful credits; larger-volume airlines may earn a lot of credits.)*

*Q3. In principle, should airlines be allowed to swap slots with all other airlines, by mutual consent? Should we investigate a free, centralised market for 'buying' slots with credits?*

*\* E.g. BA123 has an ATFM delay of 20 minutes on Tuesday, but freely chooses to accept a delay of 40 minutes, thus earning some credits to use at Heathrow on Wednesday, to reduce a more expensive delay.*

**Flight arrival coordination**

Flight arrival coordination considers the tactical management of arrivals at airports, by sequencing and merging, extending this with planning capabilities. The three levels of implementation considered are:

- Level 0
  - Current principles applied on E-AMAN systems; the flight arrival coordinator tries to minimise the amount of holding delay that will be carried out at the TMA by providing speed advisories for flights during their en-route phase; the AMAN in the TMA is focused on the maximisation of throughput at the runway; no information from the airlines is taken into account when applying this mechanism.
- Level 1
  - The flight arrival coordinator tries to minimise the expected reactionary ('knock-on') delay, considering information from the airport on the expected turnaround of flights.
- Level 2
  - The airspace user provides the prioritisation of their flights when entering the arrival coordinator's planning horizon or the priorities are defined pre-tactically (i.e. flight prioritisation (e.g. UDPP) choices are relayed to the flight arrival coordinator and taken into account when creating the landing sequence).

*Questions*

*Q1. In Level 1 we want to model a more advanced system, which is trying to minimise the delay but that is not as collaborative as in Level 2. Should we consider a different approach rather than the estimation of reactionary delay provided by the airport?*

*Q2. For Level 2 implementation, which approach do you consider should be used to prioritise flights? Providing new prioritisations at the entry of the arrival manager's planning horizon, to use pre-*

*tactically defined priorities (e.g., from UDPP), or a different system to prioritise flights that could be used by the E-AMAN system?*

### Scenarios - combinations of mechanisms

Domino will use the different implementations of the mechanisms to build some scenarios. A baseline will be run of the 'current' situation (a re-run of 01SEP17), with all mechanisms at Level 0. In addition, we plan to run:

- each mechanism implemented at Level 1, with the other two at Level 0 (baseline) [= 3 scenarios]
- each mechanism implemented at Level 2, with the other two at Level 0 (baseline) [= 3 scenarios]
- one 'TBO' scenario - all the mechanisms implemented together (at Level 2), but independently
- one 'TBO+' scenario - all the mechanisms implemented together (at Level 2), with cooperation between them (e.g. E-AMAN could use automatically the priorities previously given by the airspace users to the UDPP processor).

Another possibility is to test different levels of uptake of the technologies by the different stakeholders. For instance, run a scenario where 10% of the airports have an E-AMAN v 100% of them having one.

### *Questions*

*Q1. Is there any other scenario which would be interesting to simulate? How important do you consider it is to model the level of uptake?*

*Q2. In order to model a first approximation of TBO (TBO scenario), where airspace users can provide inputs to the different mechanisms and are actively part of the solution during capacity-demand imbalance, what other service features should be prioritised for consideration?*

### Did we forget anything?

*Do you have any other feedback you would like to provide regarding the architecture, the mechanisms or the scenarios to be modelled?*

**Thank you very much for kindly sparing the time to help us. We will use your feedback in our design process.**

-END OF DOCUMENT-

Founding Members