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Title

D1.1 UDPP Assessment Framework: Indicators and Metrics

Keywords

UDPP, Assessment Framework, KPA, KPI, metrics

Summary

The purpose of the present document is to define an assessment framework for the evaluation of the performance of the different flight prioritisation and trajectory allocation mechanisms proposed in the scope of the ENGAGE Catalyst Fund project "Exploring Future UDPP Concepts through Computational Behavioural Economics". The proposed framework is based on a combination of desk research and consultation with different ATM stakeholder representatives.

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Distribution

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1. Introduction

1.1 Scope and objectives

The goal of the ENGAGE Catalyst project 'Exploring Future UDPP Concepts through Computational Behavioural Economics' is to develop new modelling approaches enabling the study of User Driven Prioritisation Process (UDPP) mechanisms. To this end, the project adopts the paradigm of computational behavioural economics. The purpose of this document is to define a set of relevant indicators and metrics allowing a comprehensive assessment of the impact of the different flight prioritisation and trajectory allocation mechanisms that will be proposed and simulated in the scope of the project. The proposed framework looks for maximum alignment with the SESAR Performance Framework, focusing on those Key Performance Areas (KPAs) that are considered more susceptible of being influenced by the application of different flight prioritisation mechanisms, but also adds some specific KPAs and KPIs that are considered relevant for the problem under study. Particular attention is paid to KPAs that have received less attention in previous studies, but are however considered essential for the evaluation of flight prioritisation mechanisms, such as equity and robustness against unexpected Airspace User (AU) behaviours.

1.2 Document structure

The document is structured as follows:

- Section 1 introduces the document explaining its aim and scope, includes a list of acronyms and abbreviations, and describes the structure of the report.
- Section 2 presents an overall view of the SESAR Performance Framework. The different KPAs considered are listed and explained, as a necessary step to identify which KPAs are relevant for the purpose of the present project.
- Section 3 proposes a set of KPAs and KPIs for the assessment of the flight prioritisation mechanisms that will be analysed within the project.

1.3 List of acronyms

Acronym	Definition
AOBT	Actual Off-Block Time
ATM	Air Traffic Management
ATFM	Air Traffic Flow Management
ATFCM	Air Traffic Flow and Capacity Management
ANS	Air Navigation Services
AU	Airspace User
FPFS	First Planned First Served
FPL	Flight Plan
ICAO	International Civil Aviation Organisation

Acronym	Definition
KPA	Key Performance Area
KPI	Key Performance Indicator
SESAR	Single European Sky ATM Research
SES	Single European Sky
SOBT	Scheduled Off-Block Time
UDPP	User Driven Prioritisation Process

2. The SESAR Performance Framework

The SESAR Performance Framework[1] describes the performance-driven development approach applied within the SESAR programme with the goal of ensuring that the programme develops the operational concept and technical enablers needed to meet the performance ambitions described in the ATM Master Plan. The SESAR Performance Framework is composed of:

- the performance management process,
- a set of Key Performance Areas (KPAs), Key Performance Indicators (KPIs) and Performance indicators (PIs) for the purpose of measuring performance and tracking the achievement of targets.

The SESAR Performance Framework is intended to support the development and deployment of operational changes and enabling technologies. The KPAs and KPIs included in the SESAR Performance Framework reflect this, and are consequently different from the KPAs/KPIs used in the regulatory arena (SES Performance Scheme) and from those used by ANSPs for ANS performance monitoring and management. The selection of KPAs uses as reference the set of KPAs defined in ICAO framework, with a number of refinements to support SESAR requirements. The KPAs included in the SESAR Performance Framework are: Safety, Security, Environment, Capacity, Predictability/Punctuality, Cost Efficiency, Flexibility, Civil-Military Cooperation and Coordination, Human Performance and Access/Equity. The following table summarises scope of each KPA and the associated operational focus areas.

KPA	Definition	Operational Focus Areas
Safety	Addresses the risk, the prevention and the occurrence and mitigation of air traffic accidents.	• ATM system safety outcome • Safety management practices and culture
Security	Addresses the risk, the prevention, the occurrence and mitigation of unlawful interference with flight operations of civil aircraft and other critical performance aspects of the ATM system. ATM security also includes the prevention of unauthorised access to and disclosure of ATM information.	• Implementation measures • Effectiveness measures • Impact measures
Environment	Addresses the management and control of environmental impacts, aiming to reduce adverse environmental impacts.	• Fuel Efficiency • Noise impacts • Local Air Quality (LAQ)
Capacity	Addresses the ability of the ATM system to cope with air traffic demand (in number and distribution through time and space). It relates to the throughput of that volume per unit of time, for a given safety level.	• Airspace Capacity • Airport Capacity • Network Capacity • Resilience

[1] SESAR JU (2018b) PJ19.04 Deliverable D4.4: Performance Framework 2018, Edition 01.00.00.

KPA	Definition	Operational Focus Areas
Predictability and Punctuality	Addresses the ability of the ATM system to ensure a reliable and consistent level of 4D trajectory performance.	• On-time operation (Departure Punctuality, Arrival Punctuality, knock-on effects) • Predictability
Cost Efficiency	Addresses the direct gate-to-gate ANS cost and the Airspace User costs.	• Direct gate-to-gate ANS cost • Direct Airspace Users cost • Indirect Airspace Users costs
Flexibility	Addresses the ability of the ATM system and airports to respond to changes in planned flights and mission. It covers late trajectory modification requests as well as ATFCM measures and departure slot swapping.	• Non-scheduled traffic • Trajectory modifications • Military airspace requirements • Impacted trajectories
Civil-Military Cooperation and Coordination	It addresses the impact of ATM on military operation and training activities and how civil-military cooperation contributes to the performance of civil ATM.	• Impact of ATM on military operations • Contribution to Civil ATM performance
Human Performance	Addresses the human capability to successfully accomplish tasks and meet job requirements.	• Human role consistency versus capabilities/limitations • Technical systems support on human actor performance • Team structure and team communication support on human actor performance • HP transition factors
Access and Equity	Addresses the ability of the ATM system to ensure that possible gains raised from a SESAR solution benefit all stakeholders in the same manner and no significant overall detrimental impact on the ATM system is produced.	• Fairness • Access • Transparency

3. Proposed UDPP Assessment Framework

The UDPP assessment framework takes as a starting point the SESAR Performance Framework, complemented with other specific KPAs and KPIs that are considered relevant for the problem under study.

A thematic workshop held in Madrid on 12th November 2019[2] served to gather the inputs from a variety of ATM experts from both industry and academia, which reflected on the perspective of the different ATM stakeholders concerned with UDPP to select a set of KPAs/KPIs allowing a comprehensive assessment of the performance impact of different flight prioritisation mechanisms. During the workshop, several KPAs were sharply discussed and various new metrics were proposed. The SESAR KPAs selected as relevant for the evaluation of flight prioritisation mechanisms are Predictability and Punctuality, Flexibility, Access and Equity, and Cost Efficiency. Additionally, a new KPA, Robustness, was suggested with the intention to capture how well different mechanisms are able to cope with unexpected or 'irrational' airline behaviours. Each of these five KPAs is discussed below, together with the KPIs selected under each KPA.

3.1 Predictability and Punctuality

The impact of different flight prioritisation mechanisms on Predictability and Punctuality is considered relevant for all the stakeholders involved in UDPP. From an airline point of view, it is crucial to measure whether a certain prioritisation mechanism increases the punctuality of its flights. For airports, the importance of measuring predictability and punctuality lies in the fact that higher predictability levels allow the airport to fully utilise its current capacity. Finally, from the Network Manager perspective, improving predictability and punctuality is one of the goals of the ATFCM process.

The metrics proposed in the SESAR Performance Framework are complemented with new indicators to try to capture aspects such as the punctuality from the passenger point of view. On the other hand, some of the metrics considered in the SESAR Performance Framework will not be included in our UDPP Assessment Framework due to the practical limitations to capture such information in the simulation model. The proposed indicators and the associated metrics are included in the following table.

Indicator	Unit	Metric	Baseline
% Flights departing within +/- 3 minutes of the scheduled departure time	%	% Departures so that |AOBT – SOBT| < +/- 3 min difference in actual departure time vs. scheduled time due to ATFM causes	SESAR KPI PUN1
Flight departure delay	Minutes/ Flight	Total flight departure delay in minutes divided by the number of flights. This information can be later aggregated, for instance, by airport, by group of airports or by airlines	-
Pax arrival delay	Minutes/ Pax	Total passenger arrival delay in minutes divided by the number of passengers. This information can be later aggregated, for instance, by airport, by group of airports or by airlines	-

[2] The workshop material is available at https://engagektn.com/thematic-challenges.

3.2 Flexibility

The SESAR Performance Framework defines the Flexibility KPA as the ability of the ATM System to respond to changes in planned flights and late FPL request (non-scheduled traffic). Accordingly, the indicators and metrics used to measure flexibility will focus on evaluating how the system is capable of absorbing late FPL requests in the presence of different prioritisation mechanisms. From the AUs' point of view, the flexibility provided by the system in terms of absorbing non-scheduled traffic or late modifications is essential, especially considering that this kind of late FPL requests are often associated with very valuable flights. The level of flexibility provided by different mechanisms also influences the workload of the Network Manager and the airports. Consequently, the Flexibility KPA appears as fundamental to properly assess the impact of different prioritisation mechanisms. The proposed indicators and metrics are shown below.

Indicator	Unit	Metric	Baseline
Average delay for flights with late FPL request	Minutes	Total delay of flights with late FPL request divided by number of flights with late FPL request	Derived from SESAR PI FLX1
% of late FPL requests that are successful[3]	%	Total number of successful late FPL requests divided by the total number of late FPL requests during the day of operations	-

3.3 Access and Equity

Within SESAR's UDPP programme, Equity is considered as a mandatory constraint. SESAR Solutions must not result in inequitable impacts across individuals or groups of AUs. A lack of Equity can arise, for example, when one AU receives an advantage or net gain relative to others. This is an essential requirement from AUs' perspective and is closely related with Access, which refers to the need to offer the same prioritisation possibilities to all involved AUs. This view is aligned with the vision of the Network Manager, which finds it essential that any prioritisation mechanism does not systematically favour or penalise any flight or AU. The proposed indicators and the associated metrics are shown in the table below.

Indicator	Unit	Metric	Baseline
Change in AU's delay or cost compared with other AUs	%	Difference in delay (or cost) of the AU concerned divided by the total delay (or cost) of all the AUs between the Solution Scenario and the Reference Scenario[4]	Derived from SESAR PI EQUI1
Change in AU's delay or cost per flight compared with other AUs	%	Difference in delay (or cost) per flight of the AU concerned divided by the total delay (or cost) of all the AUs between the Solution Scenario and the Reference Scenario	Derived from SESAR PI EQUI1

[3] In the simulation model being developed by the project, which will be documented in deliverable D3.1, flights with late FPL requests are endowed with a maximum tolerance to delay. In the event that the system (with its specific associated prioritisation mechanism) enables the flight to depart within its allowed margin, the late FPL request will be considered as 'successful'.

[4] The Reference Scenario corresponds to the simulation of the current concept of operations, the FPFS mechanism plus a limited swapping capability, which is understood as "equitable".

Indicator	Unit	Metric	Baseline
AU total delay relative to baseline AU total delay	%	Total delay (per AU) in the Solution Scenario divided by the total delay (per AU) in the Reference Scenario	SESAR PI EQUI3
AU delay/cost per flight compared to baseline	%	Delay (Cost) per flight of AU concerned in the Solution Scenario divided by the delay (cost) per flight of AU concerned in the Reference Scenario	SESAR PI EQUI5
Number of flights advantaged and/or disadvantaged	No.	Number of flights impacted (+ or -) by a certain change in terms of cost or delay	SESAR PI EQUI4
Number of AUs that can use the prioritisation mechanism in a hotspot	No.	Number of AUs that can use the prioritisation mechanism in a hotspot	-

3.4 Cost Efficiency

The Cost Efficiency KPA is closely related with the delay airlines face in their operations and how they manage it. From this perspective, it is essential to measure if a certain prioritisation mechanism is able to provide effective tools to decrease the costs associated with the imposed ATFM delays. A mechanism that allows airlines to adjust their operations in a cost-efficient way is also expected to have a positive impact on airports, which can see their income increase due to the greater attractiveness of the system.

The SESAR Performance Framework distinguishes three main focus areas inside this KPA: direct gate-to-gate ANS cost, direct Airspace User costs and indirect Airspace Users Cost. Following the objectives of the project, we will restrict our vision to AUs cost, which refers to cost efficiency obtained by AUs. Additionally, for practical reasons, we will only consider direct operating costs, which are related to handling the aircraft and passengers (fuel, stall expenses, passenger service costs, navigation charges, etc). The proposed indicators and the associated metrics are included in the table below.

Indicator	Unit	Metric	Baseline
Per-flight direct cost	EUR/Flight	Impact on direct costs related to aircraft and passengers: fuel, staff expenses, passenger service costs, navigation charges, strategic delay[5]	Derived from SESAR PI AUC3
Per-flight cost of delay (tactical)	EUR/Flight	Cost of delay[6] of each flight. This can be aggregated by airline	-

3.5 Robustness

The main ambition of this project is to develop a new methodology for assessing UDPP mechanisms following the paradigm of computational behavioural economics. While classical approaches require the use of rigid

[5] Due to the tactical nature of the simulation model being developed, the strategic delay will be considered as given, as the model will take as input a predefined flight schedule. Consequently, the minutes of strategic delay potentially saved by a certain mechanism will not be measured.

[6] Cost of delay calculated based on University of Westminster (UoW) reference values (European airline delay cost reference values report, version 4.1)

assumptions such as perfect rationality and complete information, computational behavioural economics allows these assumptions to be relaxed, which in turn will allow us to test the performance of different UDPP mechanisms in situations where AUs behave in an "irrational" or strategic manner. It is therefore essential to study each potential prioritisation mechanism in the presence of these behaviours in order to detect possible undesired consequences that can go unnoticed in classical approaches.

The robustness of each mechanism will be measured by comparing a baseline "perfectly rational" situation with other simulations where the behaviour of the AUs is modified to simulate "irrational" practices. The metrics belonging to each of the previously selected KPAs are calculated and the difference between the values for both behavioural scenarios is computed. The minimum the difference in the metrics, the greater the robustness of the mechanism. The table below shows how the robustness indicators are developed. For simplification purposes, only one metric per KPA is represented.

Indicator	Unit	Metric	KPA addressed
Change in % of flights departing within +/- 3 minutes of the scheduled departure time	%	Difference [%] between the resultant % of flights departing within +/- 3 minutes of the scheduled departure time computed first in a perfectly *"rational"* scenario and later in a scenario with AUs *"irrational"* behaviours.	Predictability and Punctuality
Change in average delay for flights with late FPL request	%	Difference [%] between the average delay for flights with late FPL requests computed first in a perfectly *"rational"* scenario and later in a scenario with AUs *"irrational"* behaviours.	Flexibility
Change in AU total delay relative to baseline AU total delay	%	Difference [%] between the total delay (per AU) in the solution scheme divided by the total delay (per AU) in the baseline scheme computed first in a perfectly *"rational"* scenario and later in a scenario with AUs *"irrational"* behaviours.	Access and Equity
Change in cost of delay per airline	%	Difference [%] between the cost of delay per airline computed first in a perfectly *"rational"* scenario and later in a scenario with AUs *"irrational"* behaviours.	Cost Efficiency