Towards a Passenger-Centric ATM system

Research Challenges and Horizons for Deployment

June 2018

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Executive summary

The European high-level vision on transport depicts a passenger-centric system that takes travellers from their origin to their destination in a seamless, efficient, predictable, resilient and environmentally-friendly way. In contrast with this high-level vision, air transport in general, and ATM in particular, have often lacked a passenger-oriented perspective, with performance indicators and decision criteria not necessarily taking into account the ultimate consequences for the passenger.

Digital transformation opens new opportunities to overcome these issues. The possibility to consolidate information from heterogeneous sources in real time and provide this information to the passenger in a meaningful and actionable manner will help passengers to make more informed choices. Simultaneously, the same technologies that enable the provision of more accurate information to the passenger offer the opportunity to collect large data samples on travel behaviour and get new insights on the interaction between the passenger and the ATM system.

Though research in this domain is still relatively scarce, in the past few years several European projects have investigated how to incorporate the passenger perspective into the planning and management of the air transport system. The research avenues opened by these projects unlock promising opportunities to build an ATM system that puts the passenger at the centre. It is our view that such passenger-centric vision should be included in the updated European ATM Master Plan that will be launched in 2018, so that SESAR Wave 2 projects can properly address these opportunities, which span from short-term opportunities for the uptake of results by SESAR Industrial Research to opportunities in the medium- to long-term that could be initially explored through SESAR Exploratory Research. In the short-term, we identify two clear opportunities: (i) the development of new decision support tools for airport planning and management that take into account ground access/egress, landside processes and airside processes in an integrated and synergistic manner; and (ii) the development of passenger-centric performance indicators more comprehensive assessment of new operational concepts and solutions in terms of their ultimate consequences for the passenger. As for medium- to long-term research, we propose three research topic that would significantly contribute to realise the vision of a future passenger-centric ATM system: (i) the development of advanced bidirectional (push/pull) information systems that help the passenger to make more informed decisions from journey planning through to journey execution and real-time re-planning; (ii) the integration of the passenger perspective into ATM collaborative decision-making processes; and (iii) the analysis of the role of ATM in the future European intermodal transport system.

1. Towards a passenger-centric ATM system: the role of digitalisation

The European Commission's 2011 White Paper on Transport [1] emphasises the need for a multimodal, passenger-centric transport system, able to provide seamless door-to-door travel and facilitate better modal choices. In line with these objectives, the long-term vision for the European aviation sector outlined in the Flightpath 2050 report [2] envisages an **air transport system thoroughly integrated with other transport modes, with the ultimate goal of taking travellers and their baggage from door to door predictably and efficiently while enhancing passenger experience and rendering the transport system more resilient against disruptive events**. The report highlights the role of aviation as an enabler of socioeconomic development, drawing attention to the key role of the ATM system in realising this vision, and defines five high-level goals:

1. European citizens are able to make informed mobility choices and have affordable access to one another, taking into account: economy, speed, and tailored level of service.
2. 90% of travellers within Europe are able to complete their journey, door-to-door, within 4 hours.
3. Flights arrive within 1 minute of the planned arrival time regardless of weather conditions.
4. An air traffic management system is in place that provides a range of services to handle at least 25 million flights a year of all types of vehicles.
5. A coherent ground infrastructure is developed including airports, vertiports and heliports with the relevant servicing and connecting facilities, also to other modes.

In contrast with this high-level vision, **air transport in general, and ATM in particular, have often lacked a passenger-oriented perspective**, with performance indicators and decision criteria not necessarily taking into account the ultimate consequences for the passenger. The reason for this is twofold:

- the passenger is only able to consume pieces of information from different sources which provide partial (and often inconsistent) views of the different legs of the trip;
- information about passenger needs, preferences and behaviour is scarce, due to the fact that traditional data collection methodologies (e.g., passenger surveys) are expensive, time-consuming, and often limited in accuracy and validity.

Digital transformation opens new opportunities to overcome these issues, **by enabling a bi-directional information flow between the passenger and the transport system**. Realising the vision of a passenger-centric ATM system requires an integrated approach to two different, yet complementary, research areas:

- Modern information and communication technologies provide the means to **consolidate information from heterogeneous sources in real time and provide this information to the passenger**. Research is needed to devise the best combination of data sources and data fusion approaches required to provide the passenger with an accurate picture of the whole door-to-door trip, as well as to design interfaces able to present this information in a meaningful and actionable manner, so that passengers can make informed choices from journey planning through to journey execution and real-time re-planning.
- The same technologies that enable the provision of more accurate information to the passenger offer the opportunity to **collect large data samples on travel behaviour and get new insights on the interaction between the passenger and the ATM system**. The increasing sensorisation of the built

environment and the proliferation of personal mobile devices allow us to collect rich information that can be fed back to the air transport system to improve passenger experience and make a more efficient use of resources. The potential of these new data sources is huge, but it also comes with a number of research challenges. We have more data, but increased sample size often comes at the expense of noisy or biased data. Additionally, new data do not always include information about the underlying behavioural drivers, which have to be inferred from the observed behaviour. The ability to blend and analyse data from multiple sources is of paramount importance to tackle these challenges.

1.1 Recent research advances

Though research in this domain is still relatively scarce, in the past few years several European projects have investigated how to incorporate the passenger perspective into the planning and management of the air transport system. A brief overview of some of these initiatives is provided below.

META-CDM. The objective of the META-CDM (Multimodal, Efficient Transportation in Airports – Collaborative Decision Making) project [3] was to define the future of Airport Collaborative Decision Making with the passenger as the centre of attention. The project examined the coherence and co-ordination of the many systems that are part of delivering the traveller through an airport, both in everyday operation and during disruptive events. This was done by considering both airside and landside CDM and their effectiveness. One important application of this study is the analysis of the ability of alternative transport modes and communication to minimise personal disruption during crisis situations, making the passenger door-to-door journey as short and efficient as possible.

TRIMODE. TRIMODE (Transport Integrated Model for Europe) [4] is developing a network and assignment model considering all transport modes in Europe as well as their interconnection with intercontinental transport, covering in detail all freight and passenger movements. Together with the tool, a database is also being developed so as to make available a consistent dataset including model parameters, validation data, and projections for alternative scenarios.

DORA. The goal of DORA (Door to Door Information for Airports and Airlines) [5] is to design and establish an integrated information system that helps passengers to optimise their travel in the door-to-kerb and kerb-to-door segments. The information system created within the project supports the reduction of the overall time needed for a typical European air trip, including the time required for the transfer to and from the airports. To ensure this, the DORA app provides a single point of visualisation of the overall trip, relieving travellers from the need to collect information manually from different heterogeneous sources (public transport schedules, ticketing, maps, etc.). It also provides time-optimised route recommendations for accessing the airport and time-optimised routing within the airports, leading the passengers through terminals to the right security checkpoints and departure gates.

DATASET2050. DATASET2050 (DATA-driven approach for Seamless Efficient Travelling in 2050) [6] tackles the analysis of EU door-to-door trips with at least one air transport segment. DATASET2050 estimates a variety of metrics for the different phases of the trip (door-kerb-gate-gate-kerb-door) and compares them with the goals established in different strategic documents, particularly with the Flightpath 2050 4-hour door-to-door challenge. The main focus is put on analysing how European transport supply (capacity, connections, business models, regulations, intermodality, processes and infrastructure) adapts to the evolution of the demand profile (demographics, passenger expectations, etc.) for the current, 2035 and 2050 transport scenarios.

Mobility4EU. Mobility4EU [7] aims to deliver a vision for the European transport system in 2030 and a roadmap to implement that vision, including recommendations for research and innovation. The project intends to assess the influence of societal trends on transport demand and supply, as well as to create a portfolio of promising technical and organisational transport solutions. To achieve these objectives, Mobility4EU has set a participatory framework involving all relevant actors from inside and outside the transport sector: international, European and national stakeholders representing users, including specific groups and communities that are vulnerable to exclusion, technology suppliers, policy makers, transport service providers, and research organisations.

1.2 Opportunities for the SESAR programme

Despite the opportunities brought about by digitalisation, so far SESAR has devoted very limited resources to investigate the relationship between the passenger and the ATM system. **BigData4ATM** (Passenger-centric Big Data Sources for Socio-economic and Behavioural Research in ATM) [8] is the only project funded within SESAR Exploratory Research Call 1 that is focused on the passenger. The project has explored the potential of geopositioned data coming from smart personal devices (mobile phones, smart cards, etc.) to extract relevant information about passengers' behaviour and inform ATM decision making processes. BigData4ATM has shown the usefulness of these emerging data sources for the definition of passenger-centric indicators able to capture the ultimate consequences of ATM performance on the passengers. Through a set of case studies, the project has addressed questions such as airport accessibility and intermodal capabilities, the current level of achievement of the Flightpath 2050 4-hours-door-to-door goal, the characterisation of passenger choices during the different legs of the door to door journey, and the passengers' reactions to ATM disruptions.

The research avenues opened by BigData4ATM, and more generally by the emerging research threads described in section 1.1, unlock promising opportunities to build an ATM system that puts the passenger at the centre. It is our view that **such passenger-centric vision should be included in the updated European ATM Master Plan** that will be launched in 2018, so that SESAR Wave 2 projects can properly address these opportunities. In the remaining of this document, we suggest a number of research topics that would contribute to realise this vision. Depending on the level of maturity of the enabling concepts and technologies, the proposed research topics have been classified into two broad categories: short-term opportunities for the uptake of results by SESAR Industrial Research, and opportunities in the medium- to long-term that could be initially explored through SESAR Exploratory Research:

1. **Opportunities for the uptake of results by SESAR Industrial Research**:
    - Decision support tools for airport planning and management.
    - Passenger-centric performance indicators.
2. **Opportunities for new research topics to be addressed by SESAR Exploratory Research**:
    - Advanced bidirectional passenger information systems.
    - Enhanced CDM processes informed by passenger-centric performance metrics.
    - Analysis of the role of ATM in the future European intermodal transport system.

The next two sections discuss in more detail each of the proposed research topics.

2. Uptake of results by SESAR Industrial Research

2.1 Decision support tools for airport planning and management

Background and motivation. In recent years, airports have begun to undertake projects aiming at improving the knowledge of passenger behaviour inside the airport. A variety of technologies, such as Bluetooth/WiFi beacons, cameras with image processing software, analysis of boarding pass scanners, etc. allow the airport to characterise and anticipate the passenger itinerary in the kerb-to-gate segment. At the same time, many airports make use of transport and traffic simulation models to evaluate the performance of the ground transport system and the behaviour of travellers in the access/egress. However, the solutions for the monitoring and prediction of passenger behaviour outside (door-to-kerb/kerb-to-door) and inside the airport (kerb-to-gate/gate-to-kerb) are usually based on data sources and predictive models that are completely disconnected from each other. This prevents airports from having a comprehensive picture of the full door-to-door passenger journey, which leads to suboptimal allocation of resources. This has been acknowledged by some airports, which have recently launched pioneering projects to overcome this problem[1]. Excessive resources lead to an unnecessary increase of operational costs, while insufficient resources can produce bottlenecks that degrade passenger experience (e.g., long queues at the security check-points), reduce airport non-aeronautical revenues (e.g., less time spent in the shopping area) and can even propagate to the airside (e.g., departure delays caused by late passengers).

Challenges. The proposed projects would address the development of decision support tools for airport planning and management based on a comprehensive view of the door-to-door passenger journey that takes into account ground access/egress, landside processes and airside processes in an integrated manner. These tools should integrate different data sources and modelling approaches in order to provide an earlier and more accurate picture of the number and type of passengers that arrive to/depart from the airport under different conditions (different days, different times of the day, nominal vs abnormal conditions, etc.) and assess their impact on different airport resources (e.g., check-in counters, security control, boarding gates, etc.), so as to spot/predict capacity-demand imbalances and recommend corrective actions. As an example, historical and real-time information on ground transport services and scheduled flight departures could be proposed to feed predictive models of passenger arrival rates. The results of these models could then be fed into models of passenger mobility inside the airport. Particularly relevant is the role of the data collected from smart phones and other personal mobile devices, which provide rich information on passenger behaviour with an unprecedented level of detail. The newly developed solutions should be evaluated in a real-life environment in collaboration with an airport.

Impact. The new tools will enable more efficient planning and real-time management of airport resources, avoiding situations of insufficient or excessive resource allocation and improving passenger experience.

[1] See, e.g., the project recently launched by the Auckland Airport to combine passenger flow data with information about road traffic: https://www.internationalairportreview.com/news/64632/auckland-road-traffic-data-maximise-capacity

2.2 Passenger-centric performance indicators

Background and motivation. Performance orientation is one of the key elements of the Single European Sky and of its technological pillar, SESAR. By setting down EU-wide and local targets, as well as performance monitoring and corrective actions, the SES Performance Scheme aims to drive performance improvements in European aviation. The SESAR Performance Framework supports the management process for all ATM actors, providing a single, common reference and methodology to assess the performance benefits of SESAR solutions. However, the Key Performance Indicators included in the SES Performance Scheme and the SESAR Performance Framework do not directly capture the passenger perspective. For example, similar values of flight-centric delay metrics, such as average delay per flight, can correspond to very different delay statistics when analysed from the perspective of the passenger.

Challenges. The proposed projects would define new passenger-centric metrics allowing the assessment of the time-efficiency and the predictability of the door-to-door passenger journey and the quality of the passenger experience. The projects would build on recent research on the use of new data sources for the detailed characterisation of the passenger journey. As an example, information on air transport delays could be merged with data on passenger door-to-door itineraries and travel times obtained from new sources of geopositioned data to evaluate different aspects related to the quality and efficiency of the passenger journey, including, but not limited to, the contribution of ATM to the achievement of the Flightpath 2050 4-hour door-to-door target, the impact of flight delays on door-to-door travel times, the integration of the air transport with the ground transport system, and the resilience of the transport network in the presence of ATM disruptions. The topic would cover the definition of new indicators, as well as the development of reliable and robust methodologies for the monitoring of such indicators.

Impact. The new indicators and metrics will result in a more comprehensive assessment of new operational concepts and solutions in terms of their ultimate consequences for the passenger and will contribute to the integration of the passenger perspective into ATM strategic decision-making processes.

3. New topics for SESAR Exploratory Research

3.1 Advanced bidirectional passenger information systems

Background and motivation. Multimodal travel planning is a key element of the European Commission's strategy for the future of transport. In the past few year, numerous European projects have addressed the development of multimodal journey planners that aim to provide comprehensive door-to-door information, in order to allow the traveller to make well-informed travel decisions. In parallel, some other projects have developed applications to guide the passengers through airport terminals. However, in the context of air transport, significant opportunities remain largely unexploited. The reason for this is twofold: (i) despite the synergies between them, the two abovementioned research areas are highly disconnected; (ii) the integration of real-time information about the air transport system into passenger information systems is still very limited. In this context, ATM information systems may have an interesting role to play, by properly filtering, processing and sharing data (e.g., data available through SWIM, such as flights status, delays, information on airport operations, etc.) that would be of great value to optimise the passenger journey.

Challenges. The proposed projects would address the development of a new generation of push/pull passenger information systems. Information between the system and the passenger will flow in the two directions: (i) the system will provide an accurate and permanently updated picture of the full door-to-door journey that allows the traveller to make informed choices along the whole journey. To this end, historical and real-time information of a varied nature (such as supply and demand information on ground transport modes, waiting times at the airport facilities and information on delayed flights) will be fed into predictive analytics models and recommendation algorithms; (ii) in parallel, the proposed systems will allow the passive collection of passenger trajectory data and the provision of user-submitted information (e.g., incident reporting), which will be fed back into the system to enrich and update the information and recommendations offered to other travellers. Example use cases could be real-time journey re-planning by the passenger (e.g., by delaying the arrival to the departure airport or booking a certain transport service at the destination airport in situations of heavy delay) or the provision of specific recommendations aimed to modify passenger behaviour so as to smoothen airport processes and manage scarce resources (e.g., warning messages about the risk of arriving late to the gate, recommendation to use of a certain security check-point, etc.).

Impact. The new passenger information systems will help the passenger to make more informed decision about the door-to-door journey and will enhance passenger experience. At the same time, it will enable the collection of detailed information on passenger behaviour and perceptions, which can be of value for the planning and management of the air transport system.

3.2 Enhanced CDM processes informed by passenger-centric metrics

Background and motivation. The System Wide Information Management (SWIM) concept connects different ATM stakeholders (pilots, airports, ANSPs, airlines, meteorology service providers, military operations centres) across all ATM phases (planning, execution, post-execution), with the aim to facilitate information sharing and conflict resolution. However, when making decisions such as flight prioritisation, regulations and re-routing, the passenger is still missing from the picture.

Challenges. The proposed projects would expand the information shared through SWIM (or other information-sharing mechanisms) by incorporating information about passenger needs and behaviour (e.g., flight transfers, ground travel times, queuing bottlenecks, etc.) useful for total airport management and other ATM decision making processes. Real-time information on passenger-centric metrics such as the ones proposed in section 2.2 and data such as those collected through the technologies described in section 3.1, properly processed and aggregated, would allow different stakeholders (airlines, airports, ANSPs, Network Manager) to incorporate the passenger perspective into CDM processes

Impact. The integration of passenger-centric data and indicators into CDM processes will lead to solutions that better take into account the needs of the passengers.

3.3 Analysis of the role of ATM in the future European intermodal transport system

Background and motivation. Information and communication technologies are bringing radical changes in mobility. On the demand side, phenomena like teleworking and e-shopping, for instance, are reducing commuting and shopping trips while increasing leisure and freight trips. On the supply side, ICTs are facilitating new options such as vehicle sharing and demand responsive transport, the emergence of Mobility as a Service (MaaS), and the rapid development of Connected and Autonomous Vehicles (CAVs), which seems to suggest a future in which mobility will be shared, autonomous and electric. Mobility is changing at a much faster pace than we have seen in previous decades, leading to an increasingly uncertain future. Aviation is not an exception: new aircraft technologies, the massive introduction of drones, and new concepts such as urban air mobility are likely to radically change air transport and have profound implications for ATM. Planners and decision makers need to understand these disruptive changes and evaluate the impact of different policies under a range of possible alternative futures.

Challenges. The proposed projects would analyse how new societal trends and emerging transport technologies will change the role of aviation in the future European intermodal transport system, and how these changes will impact on ATM. The characterisation of the current mobility patterns and accessibility levels at European level should serve as a basis to develop different evolution scenarios and explore the two-way interaction between travellers' behavioural changes (changes in the value of travel time, modal preferences, etc.) and new transport options. Will electric aircraft and flying cars open new market niches for aviation in urban, metropolitan and regional transport? How will airports be impacted by the massive adoption of CAVs by passengers arriving in the airports (e.g., drastic reduction of parking space)? How will these technologies interact between each other to deliver an end-to-end transportation service? How will aviation integrate into MaaS ecosystems? The topic would address these questions and their impact on future air travel demand and air traffic patterns, in order to analyse how the ATM system should adapt to this increasingly complex landscape.

Impact. A better understanding of the role of aviation in the future European transport system will help the ATM system to prepare for the future and define the research roadmap required to successfully meet the new challenges and opportunities brought about by the acceleration of technology evolution.

Annex I. References

[1] European Commission, "White Paper: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system", Brussels, 2011.

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[5] DORA: https://dora-project.eu/

[6] Dataset2050: http://innaxis.org/dataset2050/

[7] Mobility4EU: http://www.mobility4eu.eu/.

[8] BigData4ATM: https://www.bigdata4atm.eu

BigData4ATM

Passenger-centric Big Data Sources for Socioeconomic and Behavioural Research in ATM

This project has received funding from the SESAR Joint Undertaking under grant agreement No 699260 under European Union's Horizon 2020 research and innovation programme. Opinions expressed in this work reflect only the authors' view; the SJU shall not be considered responsible for any use that may be made of the information contained herein.

SUPPORTED BY SESAR JOINT UNDERTAKING