Final Project Report WP-E

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Abstract

The final report of the FLITE project provides a publishable summary of the results. In addition it lists all deliverables, dissemination activities, eligible costs, deviations, bills and lessons learned.

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This deliverable consists of SJU foreground.

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Publishable Summary

The SESAR operational concept was conceived as a direct response to the need for an efficient European air transport system, within the context of a significant rate of increase in air travel. The impact of this increase is that traditional Air Traffic Management (ATM) methods have struggled to satisfy efficiency demands, resulting in delays and associated negative impacts on the economy, safety and environment. Based on the historical variation of airline passenger kilometre growth and research by the IPCC and Airbus among others, air travel is expected to more than double by 2025 from the level in 2005. In order to satisfy future demands, the EC set the targets of a 3-fold increase in air traffic movements whilst reducing delays, improvement in safety performance by a factor of 10, reduction of 10% in the impact of aviation on the environment and a 50% reduction in the cost to users of the provision of ATM services. These SESAR targets address the short- and medium-future, by exploiting the state-of-the-art aircraft, airport infrastructure and underpinning technologies.

In the long term however, more complex air travel scenarios are expected to emerge in order to satisfy societal needs. The future vision of air travel in Europe expressed in Flightpath 2050 is to provide door-to-door transport within Europe capped at 4 hours (90%) and to execute all flights with delays not exceeding 1 minute under all weather conditions. The vision further includes dynamic network reconfiguration, 24 hour efficient airport operations and coherent ground infrastructures, including vertiports and heliports. The achievement of this vision will require fundamental changes in the air transport system. The question addressed in this project is “What will the ATM operational concept and system architecture in the post-SESAR timeframe (2020 to 2070) look like and what changes are required to be implemented in SESAR to ensure a smooth transition?” In order to address these questions, the FLITE project has:

- evaluated future air travel scenarios and identified the stakeholders and their competences
- evaluated whether the SESAR operational concept and underpinning technologies and infrastructure are able to accommodate these scenarios, and identified gaps
- determined the ability of existing analysis tools to deal with the gaps, and identified their limitations
- developed enhanced analysis tools for simulating future scenarios from an operational perspective
- analysed the operational, technological and infrastructure requirements for the future scenarios
- specified the system requirements for the post-SESAR “FLITE ATM system”, providing guidelines to support the identification of a framework for a high-performing European transport system, where 90% of passengers within Europe are able to complete their door-to-door journeys within 4 hours.

The FLITE project has identified key deficiencies at three levels from an operational perspective: gate-to-gate, airport transit and airport access. Furthermore, a number of associated technological challenges were identified.

Operational deficiencies and solutions

From a gate-to-gate perspective, a key issue is the anticipated runway and TMA capacity shortage, which already manifests itself at the busiest European airports. While solutions such as airport (including runway) expansion appear to be the obvious choice, new satellite airports in the vicinity of hubs linked with seamless high-speed terrestrial connections offer a

significant potential to address the capacity-demand imbalance in real time for the busiest airports. Seamless intermodal transport was therefore identified as a key enabler of the “post-SESAR” air transport. At another level, runway capacity can also be enhanced through the use of larger aircraft, a tendency that is already observed at present, as well as through the use of threshold offsets with variable glideslopes. In the TMA, it was found that current separation standards cannot be maintained if EC 2050 targets are to be met. This is not only due to the significantly larger density of aircraft expected in that time-frame, but also the integration of different types of air vehicles with significantly varying operational performance capabilities into the same airspace. This integration is expected to become a necessity in order to provide the required seamlessness and meet the future performance targets with respect to travel times. Such integration is not foreseen by SESAR. FLITE studies have shown that with conventional approaches, such integration results in significant delays due to the variability in time-slots required for these different air vehicle types in order to keep them safely separated. This is not only due to different approach speeds, but also differences in wake-turbulence categories. FLITE has shown that a viable solution is to separate air vehicle types by altitude in the TMA, and by approach procedure during the approach phases. Novel scenario-based approach procedures generated in real-time (rather than being fixed) for conventional HTOL air vehicles, accounting for the performance of surrounding air vehicles (including on the surface), environmental conditions and the instantaneous approach procedures of such vehicles, will serve as key enablers to the optimisation of throughput efficiency. This will eliminate wake-vortex and delays resulting from differences in time-slot requirements between different air vehicles as the key limiting factors of capacity deficiency. These novel procedures will not only optimise operations for any given prevailing environmental conditions and consequently lead to the lowest possible emissions for the given scenario, but they will also generally reduce the number of holdings and thereby contribute towards eliminating the associated unnecessary emissions. Furthermore, the average increase in the approach altitude will provide the additional benefit of reducing the perceived noise footprint. Additionally, new VTOL approach procedures into hub airports will be required. These will not only alleviate runway capacity, but also allow for a much better utilisation of TMA airspace by significantly increasing the number of available approach procedures into the airport.

In respect of airport transit, linking the aircraft to other modes of transportation, the SESAR ConOps 2020 focuses exclusively on the airside of transport operations. Passenger handling (airport landside throughput) is not considered an integral part of these operations. This is a key deficiency as landside operations currently incur delays that would prevent 2050 performance targets from being met. FLITE assessed potential solutions which included better connectivity of passengers to the airport network as well as increased levels of automation (including baggage check, customs and security screening) to enhance the smoothness of passenger flow through the airport and thereby reduce the transit time to a level where 4 hour door-to-door operations may be achieved.

A further key limitation that was identified by the FLITE project is the significant travel time of passengers between their home and the airport and vice versa. A number of solutions beyond the SESAR ConOps 2020 are proposed to improve airport accessibility and passenger mobility. In particular, a key solution will be improved seamless high-speed terrestrial connections to key hubs in the city with further key connections to more localised end-destinations. These latter may include autonomous road vehicles as well as Personal Air Vehicles which will have to be synchronised with the high-speed terrestrial connections as well as aircraft arrivals and departures at the hub airport. The integration of airports as part of an overall European transport terrestrial network is not addressed by SESAR. Yet it is one of the core enablers to achieve the efficiency performance targeted for the year 2050 and beyond. As part of this integration, a key solution will be the development of a high-level transport management body responsible for the design of a holistic transport system architecture, mobility performance assessment as well as the supervision of the holistic planning and optimisation of that integrated system in order to deliver the promise of an interoperable, predictable, flexible, accessible, resilient and cost-efficient transport network.

Technology deficiencies and solutions

Technologically, given the inherent complexity of such a holistic integrated transport network and the sheer amount of information involved, the transport network must ultimately evolve from a human centric model to a model where intelligent agents (e.g. the combination of artificial intelligence and automation) have a major role in exchanging and processing vast amounts of information as well as identifying opportunities for action and decision making. New technologies such as remote towers will be key enablers of the FLITE ConOps 2050. New transport management systems with significantly increased levels of automation will be required not only to enable new types of approach procedures and maintain safe separation, but also to increase coordination with vehicles on the ground and between the various transport modes.

New methodologies for designing real-time scenario-based approach procedures will need to be developed. Furthermore, new communication protocols will be key enablers of intelligent data transfer between air vehicles as well as ground vehicles, enabling seamless coordination between these vehicles via advanced automation and novel scenario-based surveillance systems (including wake-vortex surveillance). None of these issues is directly addressed by the SESAR ConOps, which is based on a human-centric approach.

While indications are that most of the technological requirements of the ConOps 2050 can be built upon the SESAR ConOps, the FLITE project has identified that there are a number of deficiencies that may require 'revolution' rather than 'evolution' of the SESAR ConOps. From a holistic perspective, the presence of a significant number of novel air vehicles with short-term business requirements will require a fundamental rethink of the Business Trajectory of the SESAR ConOps. The Business Trajectory concept, which is a key enabler of strategic 4D trajectory planning and management, will need to be complemented by advanced constraint management: operations with large uncertainties, which are expected to be the exception in the SESAR 2020 scenario and are therefore not adequately addressed, will be much more common due to the operational needs of these new classes of stakeholders (including UASs and PAVs) that require on-demand operations. Furthermore, operational uncertainties resulting from uncertainties associated with environmental conditions are expected to be significantly different between air vehicles with very different performance characteristics (e.g. between hypersonic air vehicles and UASs). The core pillar of the ConOps 2050 will therefore need to be a hybrid strategic-tactical trajectory management, where the focus is increasingly on constraint management in addition to strategic optimisation. This will require a fundamental revision to the future approach to trajectory management which is required to be much more flexible than foreseen in the SESAR ConOps 2020.

Conclusions

Based on the outcomes of this project, it is clear that, while the FLITE project has made significant progress towards the development of the post-SESAR concept of operations and the identification of the required technologies, there are a number of significant issues that need to be studied in significant more detail. In particular, it is important to develop an integrated model and software platform of the future intermodal transport system that is able to simulate much more the intricate processes that occur during each of the segments of the door-to-door transport, focussing on the operational deficiencies identified by FLITE and summarised above. The FLITE outputs are expected to be key elements of such platform.

In summary, FLITE has achieved the goals set out in the project plan. FLITE has made significant contributions to the understanding of future air travel scenarios, has identified key issues with respect to the SESAR concept of operations and proposed solutions to ensure seamless transition to the much more integrated intermodal transport system of the future. In the process, FLITE's work has produced 10 deliverables, 4 conference papers and 3 peer-reviewed journal papers and is expected to provide key inputs to future detailed studies of intermodal transport operations, thereby ensuring continued relevance.

1 Introduction

1.1 Purpose of the document

The purpose of this document is to:

- Summarise the technical results and conclusions of the project (Publishable Summary);
- Provide a complete overview of all deliverables;
- Provide a complete overview of all dissemination activities (past and in progress). Where appropriate, provide feedback from presentations. Describe exploitation plans.
- Provide a complete overview of the billing status, eligible costs, planned and actual effort (incl. an explanation of the discrepancies).
- Analyse the lessons learnt at project level.

1.2 Intended readership

SESAR Joint Undertaking, CleanSky, Aircraft manufacturers, Air Navigation Service Providers, Civil Aviation Authorities, (land) transport authorities. All of these stakeholders will have to play an active role in shaping the future intermodal transport system.

1.3 Inputs from other projects

Inputs used from the SJU-WPE TESA project.

2 Technical Project Deliverables

Number	Title	Short Description	Approval status
D0.0	Project plan	Detailed Project Plan (DPP) and kick-off meeting	Approved
D1.1	Conops, KPAs and drivers	Technical report	Approved
D0.1	Progress report1	Management report	Approved
D7.1	SID participation	Poster	Approved
D1.2	Future air travel scenarios	Technical report	Approved
D0.2	Progress report2	Management report + meeting	Approved
D2.1	Operational gaps	Technical report	Approved
D0.3	Progress report3	Management report	Approved
D2.2	Technological gaps	Technical report	Approved
D0.4	Progress report4	Management report + meeting	Approved
D3.1	Description of required tools	Technical report	Approved
D0.5	Progress report5	Management report	Approved
D7.2	SID participation	Poster	Approved
D3.2	Analysis of existing tools	Technical report	Approved
D0.6	Progress report6	Management report + meeting	Approved

D0.7	Progress report7	Management report	Approved
D4.1	Future analysis tool	Technical report	Approved
D0.8	Progress report8	Management report + meeting	Approved
D4.2	Integrated simulation platform	Technical report	Approved
D0.9	Progress report9	Management report + meeting	Approved
D7.3	SID participation	Poster	Approved
D5.1	Scenario analysis results for KPAs	Technical report	Approved
D6.1	Impact analysis	Technical report	Approved
D0.10	Final report	Report + close-out meeting	Submitted

Table 1 - List of Project Deliverables

3 Dissemination Activities

3.1 Presentations/publications at ATM conferences/journals

Provide one paragraph per presentation, mentioning the name of the event, date and place, the title and a short description of the presentation. Add the full reference of the associated paper in 0. Provide an additional paragraph on the feedback, where appropriate.

- SESAR Innovation Days 2013: Future Long-term ATM concept, Infrastructure, Technologies and operational Environment – FLITE project scope
- SESAR Innovation Days 2014: The ATM ConOps of the Long-Term Future – Gap Analysis with respect to SESAR.
- ATACCS 2015: ATM research at Imperial College London and its impact on automation
- SESAR Innovation Days 2015: Technologies for Long-Term Future Air Transport Scenarios

3.2 Presentations/publications at other conferences/journals

- Transportation Research Part D: Long-Term Future Air Travel Scenarios: Safety, Definition, Metrics and Modelling Targets, in revision (2016).
- Journal of Air Transport Management: Long-term future air travel scenarios – novel concept of operations (in preparation)
- Transportation Research PartX: Simulation results of long-term future air travel (in preparation)

3.3 Exploitation plans

Describe, per project participant, how the results or lessons learnt from this project will benefit the company or the research community in the future.

- Imperial College London
  - The tools developed within FLITE will form key elements of an integrated multi-modal transport platform, allowing more detailed evaluations of future multi-modal travel scenarios. Such integrated transport platform does not currently exist.
  - The research carried out within FLITE is expected to provide key inputs into standardisation bodies with respect to FMS requirements of the future (RTCA SC227 and EUROCAE WG85) and with respect to navigation system requirements (RTCA SC159 and EUROCAE WG28).
  - FLITE forms the basis for wider research on the efficiency, capacity, safety and environmental impacts of door-to-door operations. This includes research into airport cluster operations and localised environmental impacts.
- ISA Software Paris
  - Traffic Sample: simulation models require traffic samples that contain at least the airport of origin, airport of destination, aircraft performance model, wake turbulence category and departure time. It was challenging to obtain an appropriate traffic sample that represents the anticipated 2050 growth level. We succeeded in producing such traffic sample to meet FLITE simulation

needs and such data is expected to be highly relevant for more advanced simulations of future scenarios.

- Intermodality issue: in our opinion there is no fast-time simulation model capable of simulating European mobility from door to door, including all transport modes. The FLITE outputs are expected to be key elements of such model
- The software and methodology used in the FLITAN transport network simulation modelling may be an interesting product to support other intermodal modelling needs.

4 Total Eligible Costs

This section is based on the Project Costs Breakdown Forms of the eligible costs incurred by project participants.

Date	Deliverables on Bill	Contribution for Effort	Contribution for Other Costs (specify)	Status
Date of invoice	*List of deliverable numbers*	*Requested contribution for effort*	*Requested contribution for travel, licences, logistics etc.*	*Billed or paid*
GRAND TOTAL				

Table 2 Overview of Billing

Company	Planned man-days	Actual man-days	Total Cost	Total Contribution	Reason for Deviation
coordinator					
GRAND TOTAL					

Table 3 Overview of Effort and Costs per project participant

5 Project Lessons Learnt

What worked well?
Project coordination by Eurocontrol was excellent.
Review and approval of deliverables was good and timely.
Despite the many issues encountered during the execution of the project, the consortium lived up to the challenges and succeeded in completing a very ambitious research project.
What should be improved?
Reduction in scope of FLITE project was needed due to the rather short project duration of 30 months, which is generally speaking much too short and should be increased to at least 4 years.
Lack of links with other SESAR projects: more feedback from other SJU stakeholders would have been useful, to better integrate these WP-E projects into the mainstream SJU projects.
Administrative procedures are still too complex.
Better access to relevant data within SESAR is essential.
Better support from SESAR to secure access to external data: e.g. for airport capacity it was virtually impossible to obtain the master plan of major European airports to conduct comparative analyses with respect to future scenarios; the same applied for airport access time data with respect to travel time distributions to major European airports.
Consortium-wise, detailed project plans should be more specific with respect to partner contributions and responsibilities.
Better integration of WP-E projects as part of the SESAR Innovation Days.

Table 4 - Project Lessons Learnt