



ACCESS Final Project Report

Document information

Project Title	ACCESS
Project Number	E.02.29
Project Manager	Nommon
Deliverable Name	Final Project Report
Deliverable ID	D1.10
Edition	01.00.00
Template Version	03.00.00

Task contributors

Nommon, Advanced Logistics Group (ALG), University of Valladolid-INSISOC, University of Trieste

Abstract

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

Authoring & Approval

Prepared by		
Name & Company	Position & Title	Date
██████████ / Nommon	Project Contributor	07/12/2015
██████████ / Nommon	Project Contributor	07/12/2015
██████████ / ALG	Project Contributor	07/12/2015
██████████ / UVA-INSISOC	Project Contributor	07/12/2015
██████████ / UNITS	Project Contributor	07/12/2015

Reviewed by		
Name & Company	Position & Title	Date
██████████ / Nommon	Project Contributor	10/12/2015

Approved for submission to the SJU by		
Name & Company	Position & Title	Date
██████████ / Nommon	Project Leader	10/12/2015

Document History

Edition	Date	Status	Author	Justification
00.00.01	07/12/2015	Draft	Nommon	New Document
00.01.00	10/12/2015	Submitted to EUROCONTROL for approval	Nommon	Content update after internal review
00.02.00	15/12/2015	Submitted to EUROCONTROL for approval	Nommon	Addition of estimated costs in section 4
01.00.00	22/01/2015	Submitted to EUROCONTROL for approval	Nommon	Integration of comments from EUROCONTROL and SJU

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Table of Contents

PUBLISHABLE SUMMARY	4
1 INTRODUCTION.....	8
1.1 PURPOSE OF THE DOCUMENT.....	8
1.2 INTENDED READERSHIP.....	8
1.3 INPUTS FROM OTHER PROJECTS.....	8
1.4 GLOSSARY OF TERMS.....	8
2 TECHNICAL PROJECT DELIVERABLES	9
3 DISSEMINATION ACTIVITIES.....	12
3.1 PRESENTATIONS/PUBLICATIONS AT ATM CONFERENCES/JOURNALS	12
3.1.1 <i>Publications at ATM conferences/journals</i>	12
3.1.2 <i>Presentations at ATM conferences/workshops</i>	14
3.2 PRESENTATIONS/PUBLICATIONS AT OTHER CONFERENCES/JOURNALS.....	15
3.2.1 <i>Publications at non-ATM conferences/journals</i>	15
3.2.2 <i>Presentations at non-ATM conferences/workshops</i>	16
3.3 WEB PRESENCE	16
3.4 DEMONSTRATIONS.....	18
3.5 EXPLOITATION PLANS.....	18
3.5.1 <i>Nommon</i>	18
3.5.2 <i>ALG</i>	18
3.5.3 <i>UVA-INSISOC</i>	18
3.5.4 <i>UNITS</i>	19
4 TOTAL ELIGIBLE COSTS.....	20
5 PROJECT LESSONS LEARNT	21
6 REFERENCES.....	22

List of tables

Table 1 - List of Project Deliverables	11
Table 2 - List of Publications at ATM conferences/journals.....	13
Table 3 - Presentations at ATM conferences/workshops	14
Table 4 - Publications at non-ATM conferences/journals	15
Table 5 - Publications at non-ATM conferences/journals	16
Table 6 Overview of Billing.....	20
Table 7 Overview of Effort and Costs per project participant	20
Table 8 - Project Lessons Learnt	21

List of figures

Figure 1. ACCESS website	16
Figure 2. Location of ACCESS website visitors	17

Publishable Summary

Introduction to the project and problem statement

Several studies funded by the European Commission along the last decade have concluded that the current European Regulation for airport slot allocation, which retains and develops the principles of the IATA slot allocation process, is neither consistent with an economically efficient use of capacity nor with the facilitation of fair competition at congested airports. Both issues were acknowledged by the European Commission in the proposal for a new slot regulation included in the Airport package adopted on 1st December 2011, which recommended the introduction of market-based mechanisms as a means to provide the right economic incentives to favour a more efficient use of the available capacity, as well as higher flexibility for airlines to adapt their slot portfolio to their business objectives and planning constraints. However, market mechanisms also imply a number of risks, ranging from the potentially negative impact on airline operating costs and the resulting network effects, to market imperfections, exercise of market power, or market failures. Moreover, experiences with market mechanisms in other sectors have shown that different market designs and implementation details can lead to very different outcomes. There is therefore a need for a comprehensive assessment of different slot allocation systems.

Project objectives and research questions

The main goal of ACCESS has been to develop a framework for the evaluation of slot allocation mechanisms, allowing the assessment of their impact on network performance as well as on each of the involved stakeholders.

The project has tackled the following research questions:

- What is the improvement margin of the current airport slot allocation system? How can the shortcomings of the current system be eliminated or mitigated by using market-based mechanisms?
- How are different market-based mechanisms used in other sectors? Which of these mechanisms could be suitable to tackle the problem of strategic airport capacity allocation?
- How can we define a comprehensive set of indicators allowing the assessment and comparison of different market designs, taking into account both their impact on network performance and the costs and benefits for the involved stakeholders?
- How can we implement the proposed framework into a simulation tool allowing us to test the proposed market-based mechanisms in different scenarios and assess their potential impact at European level?
- What are the main levers, barriers, constraints and requirements for the implementation of those solutions identified as potentially beneficial?

Explanation of approach and methodology

Approach. ACCESS has addressed the problem of airport slot allocation from the perspective of agent-based modelling and simulation. An agent-based model is a computer model consisting of a set of software objects, the agents, interacting within a virtual environment. The agents, often with a one-to-one correspondence with the real world actors, react to and act on their environment and on other agents trying to achieve their goals. Due to the complexity of the combinatorial assignment problems underlying primary slot auctioning and secondary slot trading, agent-based computational economics provides a particularly suitable framework to undertake a rigorous and formal study of different alternatives for market design, allowing the modelling and exploration of features (such as bounded rationality, evolutionary behaviour or asymmetry of information) that are not properly captured by classical approaches from economics and operations research.

Research methodology. The project started by analysing the current mechanism for slot allocation in Europe and the alternatives proposed in the literature, with particular focus on market-based mechanisms. The conclusions of this analysis served as a basis to formalise different possible designs for market approaches to airport slot allocation, and to propose a set of performance areas and indicators for a sound comparative evaluation of different slot allocation mechanisms. The proposed performance framework was refined thanks to a stakeholder workshop involving around 100 delegates from airlines, airports, slot coordinators, regulators, consultants and research organisations. We then built a test environment including a stylised model of the air transport network and a set of behavioural models of the air transport stakeholders, and defined a number of relevant simulation scenarios. A second stakeholder workshop was used to evaluate the realism of the modelling assumptions and the relevance of the proposed scenarios. Finally, and made use of the newly developed models and tools to assess the impact of market-based slot allocation and compare it to the current system.

Highlights and key results

Review of slot allocation mechanisms. Airport coordinators allocate slots in a two-stage process. The first stage is called primary slot allocation. The second stage, called secondary allocation, involves the exchange and transfer of slots among airlines trying to obtain more suitable slots. Airport slot allocation at EU airports is governed by Regulation 95/93 and its respective amendments. The main criterion applied is historical precedence: airlines can earn historic rights (grandfather rights) to a series of slots, provided they operate the slots as allocated by the coordinator at least 80% of the time during a season (use-it-or-lose-it rule). Different mathematical optimisation approaches have been proposed to improve the current system, with the aim to better accommodate airlines' preferences. As an alternative, some researchers have advocated the use of auctions as a more efficient means to allocate slots; the allocation of slots is a combinatorial allocation problem, so combinatorial auctions, where participants can bid for several items, should be used. Secondary slot allocation can also take different forms: slot exchanges and transfers without monetary compensation, slot exchange with monetary compensation, and slot buy-sell, either in the form of bilateral trading or in an organised market.

Performance framework. We have proposed a comprehensive performance framework encompassing six performance areas: economic efficiency; equity and distributional aspects; access and competition; flexibility, resilience and adaptability; interoperability; capacity and

delay. Particularly relevant is the analysis of the distribution of costs and benefits among the different stakeholders: while secondary trading should in theory improve the position of all the stakeholders, as both the seller and the buyer will only carry out a transaction if it increases their utility, this is not the case for other potential reforms, such as auctions. Incumbent airlines, for example, oppose slot auctions because they would reduce the utility they are currently obtaining from grandfather rights. Generally speaking, mechanisms that could potentially increase social welfare may raise distributional issues if they do not include appropriate compensation mechanisms.

ACCESS simulation platform. The inputs of the simulation environment are the particular combinations of primary and secondary slot allocation mechanisms to be studied. A set of exogenous variables are considered to take into account different elements that affect the model without being affected by it, such as the evolution of passenger demand. The core of the simulation model is composed by an agent-based model comprising four types of agents: (i) the slot allocation coordinator, (ii) airports, (iii) airlines, and (iv) passengers. The output data are a set of indicators influenced by the slot allocation mechanisms, intended to facilitate the evaluation and comparison of different mechanisms, including the prediction of the resulting schedule and the surplus obtained by the different stakeholders.

Simulation experiments. We have applied the developed model to evaluate the impact of primary slot allocation through a combinatorial price-setting auction. The simulation illustrates how the proposed auctioning mechanism allows the balancing of capacity and demand in a decentralised manner, without the need for airlines to disclose sensitive information. The available capacity is allocated to those airlines able to make best economic use of it, and the economic value of each slot emerges from the auctioning process. After analysing slot auctioning in detail, we have performed several simulation experiments to compare the auction-based slot allocation with the current administrative slot allocation mechanism based on grandfather rights. The simulation shows that the auction yields a more efficient use of airport capacity, increasing the number of flights, the number of passengers, and the total social welfare. However, the extra surplus is not homogeneously distributed among all stakeholders: while some airlines improve their profit, the surplus of the airline that enjoyed grandfather rights in the baseline scenario is reduced. This can be interpreted as the combination of two effects: first, with the auction the incumbent airline loses the grandfather rights and therefore its privileged access to its preferred slots; additionally, the fact that the auction leads to a more efficient allocation of capacity helps the other airlines get better slots, thus rendering them more competitive and allowing them to capture part of the market share originally belonging to the incumbent airline in the administrative allocation scenario.

Policy implications. Although the construction of a more complex and realistic model calibrated with real data would be necessary to provide more conclusive evidence, the simulation experiments conducted within ACCESS suggest that market mechanisms have significant potential for enabling a more efficient use of scarce capacity at busy airports. However, the implementation of market-based mechanisms such as an auction-based market for primary slot allocation and/or a centralised secondary market for airport slots, also poses several challenges that need to be faced. From the technological point of view, such mechanisms would require a centralised platform to receive all airline slot bids and compute the allocation, and each aircraft operator would also require ad-hoc software tools to set up its bids. From the regulatory point of view, it would require a modification of the roles and responsibilities of the current stakeholders involved in the process, including the creation of a new European institution on airport coordination, and the consequent reduction of airport coordinators responsibilities.

Future steps based on the outcomes of the project

ACCESS has demonstrated the potential of the proposed modelling approach to conduct a comprehensive analysis of different slot allocation mechanisms, opening interesting lines of future research:

- Different model extensions can be envisaged to enhance the realism of the model and the variety of issues that can be explored, in particular a more realistic airport model including airport costs and non-aeronautical revenues, as well as a more complex airline behavioural model. For example, airline agents could be endowed with learning capabilities, so that they are able to improve their estimation of future profits from the observed behaviour of their competitors in previous seasons. Behaviours other than utility maximisation (e.g., anticompetitive practices) could also be explored.
- It would also be interesting to compare the outcome of slot auctioning with the slot allocation obtained by solving the equivalent optimisation problem, in order to evaluate the ability of auctions to yield an optimal (or nearly optimal) solution according to different optimisation criteria (e.g., maximisation of social welfare).
- The execution of simulations testing different combinations of primary and secondary slot allocation mechanisms along several seasons would allow the exploration of crucial medium-term and long-term effects of different slot allocation mechanisms, such as their impact on schedule continuity and thus on the operational stability and economic viability to airlines and airports, as well as their ability to adapt to abrupt changes in demand and other exogenous variables.

Conclusion

The simulation framework and the computational experiments developed by ACCESS have enabled a more comprehensive understanding of the benefits and risks of market mechanisms for airport slot allocation, providing the basis for more realistic models able to inform future policy developments in this area. The proposed analytical framework and modelling techniques also have a significant potential for tackling other relevant air transport and ATM policy questions, such as the allocation of ATFM slots.

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 and 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

The target audience of this document comprises:

- EUROCONTROL and SJU, in order to provide them with a comprehensive view of the project results, both from a technical and
- Research community and aviation stakeholders concerned with airport slot allocation (Publishable Summary), in order to provide them with an overall view of the main results and conclusions of the project.

1.3 Inputs from other projects

Not used.

1.4 Glossary of terms

Not used.

2 Technical Project Deliverables

Number	Title	Short Description	Approval status
D1.1	Performance of the Current Slot Allocation Process and Stakeholder Analysis Report	<p>D1.1 describes the main characteristics of the current airport slot allocation process, identifies its main shortcomings, discusses how these shortcomings could be eliminated or mitigated by using market-based mechanisms, and analyses the potential impact of different slot allocation mechanisms on the different air transport stakeholders. The document includes the following contents:</p> <ul style="list-style-type: none"> • Description of the current slot allocation process. • Discussion of the performance of the current system and the perspectives for reform. • Stakeholder analysis. • Discussion of the way forward proposed by the European Commission and the potential role of market-based mechanisms. • Stakeholders' preferences and position regarding market-based mechanisms. 	Approved
D2.1	Review of Auction-based Markets	<p>D2.1 identifies and analyses theory and practice of auction markets to elaborate a set of recommendations to be used as starting point for the design of an auction market for airport slot allocation. Experiences with real auction markets across several domains are discussed, as well as the expected impact of this kind of markets on airport slot allocation. The document includes the following contents:</p> <ul style="list-style-type: none"> • Review of markets and auctions: principles, classification, relevance to the slot allocation problem. • Case studies: auction markets in air transport, CO₂ emission rights market, bus dock allocation in bus stations, electricity markets, radio electric spectrum allocation markets, and commercials' slot allocation. • Conclusions, recommendations and principles of design. 	Approved
D2.2	Market-based Mechanisms for Airport Slot Allocation: Formalisation and Assessment Criteria	<p>D2.2 describes and formalises the slot allocation mechanisms that will be simulated by ACCESS — describing the flow of information among stakeholders, the decision points, the solution of the slot allocation problem, or how to start up, configure and operate the system, among other aspects — and outlines a performance framework for the comparative evaluation of different slot allocation mechanisms along six performance areas: economic efficiency; equity and distributional aspects; access and competition; flexibility, resilience and adaptability; interoperability; capacity and delay. The document includes the following contents:</p> <ul style="list-style-type: none"> • Terminology, concepts and definitions relevant to slot allocation mechanisms. • Overview and classification of slot allocation mechanisms. • Description of stakeholders and their role within different slot allocation mechanisms. • Formalisation of slot allocation mechanisms, including a graphical process representation. • Performance framework for the assessment and comparison of slot allocation mechanisms. 	Approved

Number	Title	Short Description	Approval status
D3.1	Simulation Framework Specification	D3.1 contains the technical specification of the ACCESS simulation environment, including: <ul style="list-style-type: none"> • Functional requirements (including theoretical models and algorithms). • Non-functional requirements. • System architecture (software and hardware requirements). 	Approved
D3.2	Simulation and Analysis Toolset	D3.2 describes the ACCESS simulation platform and analysis tools. The document includes the following contents: <ul style="list-style-type: none"> • Functional design. • Technical design. • User manual. 	Approved
D4.1	Definition of the Simulation Scenarios	D4.1 defines the simulation scenarios to be used in the simulation experiments. The definition of each scenario includes: <ul style="list-style-type: none"> • Airports and airlines considered. • Time horizon of the simulation. • Evolution of exogenous variables (passenger demand and fuel prices). 	Approved
D4.2	Report on the Simulation Results	D4.2 describes the results of the simulation experiments conducted in the frame of ACCESS for different slot allocation mechanisms and simulation scenarios. The document includes the following contents: <ul style="list-style-type: none"> • Overall view of the ACCESS simulation platform. • Description of the simulation scenarios. The simulation experiments focus on a simplified yet realistic scenario composed of four airports and four airlines • Analysis of combinatorial price-setting auctions for primary slot allocation and guidelines for optimising the auction design • Comparison between the current administrative system and the allocation resulting from slot auctioning, discussing the impact of each mechanism on different stakeholders as well as at network level. 	Submitted
D5.1	Contribution to SID 2013	D5.1 includes: <ul style="list-style-type: none"> • The paper <i>Airport slot allocation: performance of the current system and options for reform</i>, which proposes a set of performance metrics for a comprehensive evaluation of slot allocation mechanisms. • A poster with general information about the project. 	Approved
D5.2	Intermediate Report on Communication and Dissemination	Compilation of the dissemination material (brochures, publications, posters, presentations...) produced during the first half of the project.	Approved
D5.3	Contribution to SID 2014	D5.3 consisted in the paper <i>Agent-Based Pilot Model for Alternative Primary Airport Slot Allocation with Price-Setting Auctions</i> , which presents the simulation of a simplified auction at two airports.	Approved

Number	Title	Short Description	Approval status
D5.4	Final Report on Communication and Dissemination	Compilation of the dissemination material (brochures, publications, posters, presentations...) produced throughout the project.	Submitted
D5.5	Policy Recommendations on Market-based Mechanisms for Airport Slot Allocation	Policy recommendations about market-based mechanisms for airport slot allocation. The document includes the following contents: <ul style="list-style-type: none"> • Discussion of technical and regulatory challenges • Further research needs. • Considerations about the transition from the current system to a market-based system. 	Submitted

Table 1 - List of Project Deliverables

3 Dissemination Activities

3.1 Presentations/publications at ATM conferences/journals

3.1.1 Publications at ATM conferences/journals

Authors	Title	Publication	Abstract	Ref.
ACCESS Consortium	ACCESS Position Paper: Application of Agent-Based Computational Economics to Strategic Slot Allocation. State-of-the-art and Future Challenges	ACCESS project website, 1/05/2013	The paper provides a description of the project: problem statement, project objectives, and scientific/technical approach. This Position Paper has proven useful to provide people interested in the project with more detailed technical information than that currently available in the website.	[1]
ACCESS Consortium	ACCESS Working Paper 1: Performance of the current airport slot allocation process and stakeholder analysis report'	ACCESS project website, 22/01/2014	The document analyses the current system in terms of rules, actors, interactions and performance outcomes, identifies a number of options for reform, and discusses the expected impact for different stakeholders.	[2]
ACCESS Consortium	ACCESS Working Paper 2: Review of Auction-Based Markets	ACCESS project website, 15/02/2014	The document identifies and analyses theory and practice of auction markets to elaborate a useful set of recommendations to be used as starting point for the design of an auction market for airport slot allocation. Experiences in real auction markets across several domains are discussed, as well as the expected impact of this kind of markets on airport slot allocation.	[3]
ACCESS Consortium	ACCESS Working Paper 3: Market-based mechanisms for airport slot allocation: formalisation and assessment criteria	ACCESS project website, 12/05/2014	The paper describes and formalises the slot allocation mechanisms that will be simulated by ACCESS — describing the flow of information among stakeholders, the decision points, the solution of the slot allocation problem, or how to start up, configure and operate the system, among other aspects — and outlines a performance framework for the comparative evaluation of different slot allocation mechanisms along six performance areas: economic efficiency; equity and distributional aspects; access and competition; flexibility, resilience and adaptability; interoperability; capacity and delay.	[4]
ACCESS Consortium	ACCESS Working Paper 4: ACCESS Simulation Framework Specification	ACCESS project website. 27/11/2015	The paper contains the technical specification of the ACCESS simulation environment, encompassing functional requirements (including theoretical models and algorithms), non-functional requirements, and system architecture (software and hardware requirements).	[5]

Authors	Title	Publication	Abstract	Ref.
ACCESS Consortium	ACCESS Working Paper 5: ACCESS Simulation and Analysis Toolset	ACCESS project website. 30/11/2015	The paper provides a description of the ACCESS simulation platform from different perspectives, including the functional design, the technical design, and the user manual.	[6]
ACCESS Consortium	ACCESS Working Paper 6: Agent-Based Simulation of Different Airport Slot Allocation Mechanisms: Analysis of Results	ACCESS project website. 07/12/2015	The paper provides a description of the results of the simulation experiments conducted in the frame of ACCESS. The simulation experiments focus on a simplified yet realistic scenario composed of four airports and four airlines, and include a detailed analysis of combinatorial price-setting auctions, a set of experiments aimed to optimise auction design (e.g., testing of different price update mechanisms), and a comparison between the current administrative system and the allocation resulting from slot auctioning, discussing the impact of each mechanism on different stakeholders as well as at network level.	[7]
A. Ranieri, N. Alsina, L. Castelli, T. Bolic, R. Herranz	Airport slot allocation: performance of the current system and options for reform. Towards a comprehensive performance framework	Proceedings of the 3 rd SESAR Innovation Days 2013, 28/11/2013	The paper introduces some considerations about the conditions to be met by a performance framework to allow a sound comparative evaluation of different slot allocation mechanisms. It includes a preliminary proposal for a set of performance areas and indicators, and discusses the potential impact of different possible reforms of the slot allocation system.	[8]
M. Ramírez, F. Villafáñez, A. Araúzo, A. López	Agent-Based Pilot Model for Alternative Primary Airport Slot Allocation with Price-setting Auctions	Proceedings of the 4 th SESAR Innovation Days 2014, Madrid, Spain, December 2014	To evaluate the impact of different mechanisms in terms of a comprehensive set of Key Performance Indicators, ACCESS applies a scientific approach based on Auction Engineering to design the Auction Markets, Experiment Design to structure their analysis, and Agent-Based Modelling (ABM) and Simulation as the tool to perform Experimental Economics and test these mechanisms in realistic scenarios. This paper shows how these methodologies are applied in ACCESS, using a specific Combinatorial Auction Market as an example.	[9]
R. Herranz, D. Toribio, M. Ramírez, F. Villafáñez, J.A. Araúzo, D. Poza, N. Alsina, L. Garrigó, L. Castelli, T. Bolic	Price-setting Auctions for Airport Slot Allocation: a Multi-Airport Case Study	Proceedings of the 5 th SESAR Innovation Days 2015, Bologna, Italy, December 2015	In this paper, we present the airport slot allocation simulation model developed by ACCESS and we apply it to the evaluation of primary slot auctioning in a multi-airport scenario. We show how combinatorial price-setting auctions can be used to balance capacity and demand in a decentralized manner, without the need for airlines to disclose sensitive information, so that the available capacity is used by those airlines able to make best economic use of it. The end prices of the auction reveal the economic value of each slot.	[10]

Table 2 - List of Publications at ATM conferences/journals

3.1.2 Presentations at ATM conferences/workshops

Event	Presenter	Title	Abstract
3 rd SESAR Innovation Days 2013, Stockholm, Sweden, 28 th November 2013	A. Ranieri	Airport slot allocation: performance of the current system and options for reform. Towards a comprehensive performance framework	See Table 2, ref. [8]
SATURN/ACCESS Joint Workshop 'Future demand management for Europe – meeting the airport and airspace challenges', London, UK, 20 th March 2014	R. Herranz	New approaches to airport slot allocation: an introduction to the ACCESS project	The presentation provided an overview of the motivation, approach and methodology of the ACCESS project.
4 th SESAR Innovation Days 2014, Madrid, Spain, 26 th November 2014	M. Ramírez	Agent-Based Pilot Model for Alternative Primary Airport Slot Allocation with Price-setting Auctions	See Table 2, ref. [9]
ACCESS Stakeholder Workshop, Barcelona, Spain, 19 th May 2015	R. Herranz	Introduction to ACCESS	The presentation provided an overview of the motivation, approach and methodology of the ACCESS project, as well as of the objectives of the Stakeholder Workshop.
ACCESS Stakeholder Workshop, Barcelona, Spain, 19 th May 2015	David Toribio and Lorenzo Castelli	ACCESS Simulation Platform	The presentation provided an overview of the ACCESS simulation model, in order to gather stakeholders' feedback for the refinement of the modelling assumptions.
ACCESS Stakeholder Workshop, Barcelona, Spain, 19 th May 2015	Laia Garrigó	ACCESS Simulation Scenarios	The presentation provided an overview of the ACCESS simulation experiments, in order to gather stakeholders' feedback for the refinement of the proposed scenarios.
5 th SESAR Innovation Days 2015, Bologna, Italy, 2 nd December 2015	R. Herranz	Price-setting Auctions for Airport Slot Allocation: a Multi-Airport Case Study	See Table 2, ref. [10]

Table 3 - Presentations at ATM conferences/workshops

3.2 Presentations/publications at other conferences/journals

3.2.1 Publications at non-ATM conferences/journals

Authors	Title	Publication	Abstract	Ref.
M. Ramírez, A. Araúzo, F. Villafáñez, A. López	System of Systems Engineering for the Airport Slot Allocation Problem	IEEE 9th International Conference on System of Systems Engineering (SoSE 2014), Adelaide, Australia, June 2014	Airport slot allocation is a combinatorial allocation problem (CAP) involving different complex and autonomous systems. Nowadays, the slots are allocated in a two-stage process: primary allocation is performed according to a set of administrative rules and for each airport independently, while secondary allocation is based on trading mechanisms. Several studies have raised inefficiencies in these processes. To enhance the airport slot allocation, this work proposes the study of the problem from a System of Systems Engineering approach (SoSE), both for the primary and secondary scenarios. Through the application of Auction Engineering and Experimental Economics, a set of market mechanisms is proposed to engineer these SoS. This paper presents their high-level formalisation, that will be implemented in future works and assessed according to a set of pre-established key performance indicators.	[11]
P. Pellegrini, T. Bolić, L. Castelli, R. Pessenti	SOSTA: an effective model for the simultaneous optimisation of airport slot Allocation	Peer-reviewed journal (under review)	This paper introduces SOSTA (Simultaneous Optimisation of the airport Slot Allocation), which is a model that optimally coordinates the airport slot allocations at all Level 2 and Level 3 airports in Europe. It is capable of simultaneously dealing with a whole-day set of requests for airport slots in Europe and of proving the optimality of the final allocation in reasonable computational time. It is an integer linear programming model which considers all existing airport capacity constraints and minimises the deviations between what is requested (by the user) and what is allocated (by the coordinator). SOSTA takes a network perspective, as it explicitly links each flight's departure and arrival slots (when both slots are needed) and considers aircraft rotations by introducing turnaround time constraints. SOSTA is applied on the busiest day of 2013. First, we consider a set of requested slots for which the final IATA allocation is known, showing that SOSTA returns the same final allocation with only a few exceptions. Second, we quantify the potential improvement brought by SOSTA through its simultaneous slot allocation at all airports: we propose instances with an increasing unbalance of demand and capacity, and compare SOSTA's allocation with the one obtained by considering all airports individually. The results support us in the claim that SOSTA can be of benefit to both airport coordinators and airspace users. SOSTA could partially replace and shorten the current (and lengthy) slot allocation process where users need to interact several times with coordinators to build and re-build their schedules. Similarly, it should mitigate the use of the secondary trading when, following the primary allocation, airspace users negotiate and exchange among them the allocated slots to fine-tune their schedules.	[12]

Table 4 - Publications at non-ATM conferences/journals

3.2.2 Presentations at non-ATM conferences/workshops

Presenter	Title	Event	Abstract
M. Ramírez	System of Systems Engineering for the Airport Slot Allocation Problem	IEEE 9th International Conference on System of Systems Engineering (SoSE 2014), Adelaide, Australia, June 2014	See Table 3, ref. [11]

Table 5 - Publications at non-ATM conferences/journals

3.3 Web presence

A project website (www.access-sesar.eu) was created at the beginning of the project, to provide a unique point of entry to the activities and results of the ACCESS project to the research community, air transport stakeholders, policy makers and general public. The project website is updated regularly, posting the public results from the project (public deliverables as well as papers developed) and publicising the project dissemination activities (e.g. conferences).



Figure 1. ACCESS website

The website is monitored by means of Google Analytics, so that statistics can be easily obtained and analysed to improve the website content.

As of 7 December 2015, the website has had 1725 visits by 1270 different visitors from 86 different countries: Brazil (300), Spain (271), Italy (110), United States (73), Germany (56), UK (54), Belgium (38), France (31), Portugal (22), UAE (19), Switzerland (17), Argentina (15), Austria (14), Greece (14), Mexico (12), Philippines (12), Netherlands (11), Bulgaria (10), Colombia (9), India (9), Australia (8), Chile (8), Israel (8), Romania (8), Japan (7), Serbia (7), Canada (6), Croatia (6), Peru (6), Sweden (5), Hungary (4), Malaysia (4), Tunisia (4), Turkey (4), Bangladesh (3), China (3), Cyprus (3), Ecuador (3), Egypt (3), Norway (3), Thailand (3), Costa Rica (2), Czech Republic (2), Indonesia (2), Jamaica (2), Jordan (2), Cambodia (2), Macedonia (2), Morocco (2), Mozambique (2), Pakistan (2), Poland (2), Puerto Rico (2), Russia (2), South Africa (2), Trinidad & Tobago (2), Ukraine (2), Venezuela (2), Albania (1), Algeria (1), Botswana (1), Côte d'Ivoire (1), Denmark (1), Dominican Republic (1), Finland (1), Gabon (1), Hong Kong (1), Iceland (1), Ireland (1), Lithuania (1), Madagascar (1), Moldova (1), Mongolia (1), Montenegro (1), New Zealand (1), Paraguay (1), São Tomé & Príncipe (1), Saudi Arabia (1), Singapore (1), Slovakia (1), South Korea (1), Suriname (1), Taiwan (1), Uganda (1), Vietnam (1), Yemen (1).

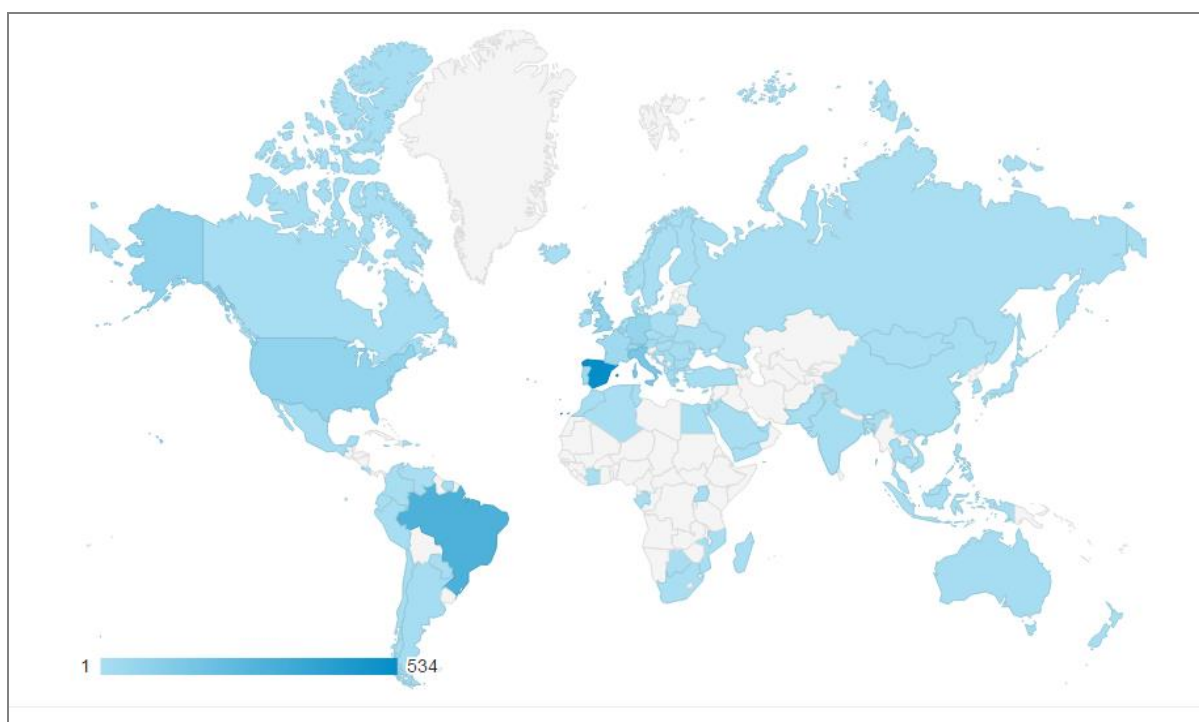


Figure 2. Location of ACCESS website visitors

In addition to the website, a LinkedIn group was created at the beginning of the project. The group is periodically updated, providing general information about the project, deliverables, news, publications, etc. News about the project are also regularly tweeted from the partners' Twitter accounts. As of 7 December 2015, the LinkedIn group has 37 members, mainly from academia and air transport industry. Several expressions of interest have also been received from people who knew about the project from Twitter.

3.4 Demonstrations

A demonstration of the ACCESS simulation platform will be carried out during the ACCESS Final Dissemination Event that will take place at EUROCONTROL HQ in Brussels on 13 January 2016. The simulation platform will be presented to a variety of stakeholders concerned with airport slot allocation (airlines, airport coordinators, EUROCONTROL...) in order to show the functioning of the platform, demonstrate its capabilities, and discuss future applications and room for improvement.

3.5 Exploitation plans

3.5.1 Nommon

At the strategic level, the participation in ACCESS has allowed a start-up company like Nommon to enter the air transport and ATM sector and build a number of links with different stakeholders. This has been of great help for launching other projects in the field, including several new research projects funded under the first SESAR 2020 Exploratory Research call, as well as a number of commercial consulting projects.

At the scientific level, the project has allowed Nommon to increase its knowledge of the aviation sector in general, and of the airport slot allocation problem in particular, and has contributed to the development of new methods for the modelling of the air transport system, leading to a number of scientific publications.

At the policy level, the results of ACCESS will be of value for informing future policy developments in the field of airport slot allocation.

At the innovation level, the work done in ACCESS is expected to open the door for the development of innovative decision support tools and consulting services. The most immediate application is obviously the assessment of different slot allocation policies, but the modelling framework and the techniques developed by ACCESS can also be of value for tackling other ATM related issues, such as the allocation of ATFM slots, which will be explored by Nommon in future projects.

3.5.2 ALG

The participation in ACCESS has allowed ALG to further improve its expertise in the field of air navigation. Although ALG is constantly involved in R&D projects in the ATM community, this project has broadened ALG's view of the current situation of the slot allocation mechanisms.

From a global point of view, the consortium of ACCESS project has gone one step further towards the improvement of the airport slot allocation process.

3.5.3 UVA-INSISOC

The participation in ACCESS has allowed UVA-INSISOC to gain an in-depth understanding of the problem of airport slot allocation, opening an interesting field of application of the two main areas of research and specialisation of UVA-INSISOC, agent-based modelling and auction theory, which can be further explored in the near future.

3.5.4 UNITS

ACCESS has investigated the replacement of the current slot allocation system to allocate airport slots by an auctioning process. Since UNITS' previous research has mainly focused on enhancing the current administrative slot allocation process, UNITS will exploit ACCESS' approach by investigating the role that various economic instruments, such as slot auctions (or congestion pricing, and variants thereof) can play in association with the current administrative mechanism and not as replacement for it. Such instruments are, in fact, viewed as an opportunity to improve and complement the status quo to the benefit of all stakeholders.

From the methodological point of view, ACCESS has formulated and implemented the primary slot auctioning process by means of an agent-based model (ABM), while UNITS' background is on the use of mathematical models (such as mixed-integer linear programming models) to be solved through exact or approximate/heuristics algorithms. Since there is extensive evidence in the literature of the usefulness and efficacy of this latter approach to solve the slot allocation problem, comparisons between ABM and mathematical programming models is certainly a future thread of research for UNITS and the research community as a whole.

4 Total Eligible Costs

Date	Deliverables on Bill	Contribution for Effort	Contribution for Other Costs (specify)	Status
4 December 2013	D0.1, D0.2, D1.1, D2.1	79954.52 €	1310.01 €	Paid
7 May 2014	D0.3, D0.4, D2.2, D5.1	66851.04 €	7193.99 €	Paid
3 November 2014	D0.5, D0.6, D3.1, D5.2	137372.29 €	2040.03 €	Paid
20 July 2015	D0.7, D0.8, D0.9, D3.2, D4.1, D5.3	133283.59 €	3726.66 €	Paid
January 2015 (TBC)	D0.10, D4.2, D5.4, D5.5	137332.31 € (TBC)	4236.18 € (TBC)	To be billed upon approval of deliverables
GRAND TOTAL		554793.75 € (TBC)	18506.87 € (TBC)	

Table 6 Overview of Billing

Company	Planned man-days	Actual man-days	Total Cost	Total Contribution	Reason for Deviation
Nommon (Coordinator)	665	753.5	235565.00 €	167705.54 €	Larger-than-expected effort in the implementation of the simulation platform, particularly in the integration of the airline behavioural model. Reimbursement of travel costs of stakeholder workshop participants (originally included in ALG budget) transferred to Nommon budget.
ALG	417	414.5	297746.17€	148873.08 €	Reimbursement of travel costs of stakeholder workshop participants transferred to Nommon budget.
UVA-INSISOC	534	963	178122.00 €	178122.00 €	Mix of senior/junior researchers different from the one originally planned.
UNITS	244	261	78649.62 €	78600.00 €	Larger-than-expected effort in the definition and implementation of the airline behavioural model.
GRAND TOTAL	1860	2392	790082.79 €	573300.00 €	

Table 7 Overview of Effort and Costs per project participant

Note: The effort and cost figures corresponding to the last invoicing period are estimates, as the costs associated to the Final Dissemination Event and the Project Close-out Meeting are not yet available.

5 Project Lessons Learnt

What worked well?
The proposed research methodology has been effective for mapping and understanding the very complex slot allocation process and has made it possible to build the agent-based modelling framework with sound and credible assumptions.
The early identification of the support required from EUROCONTROL/SJU, in particular the access to EUROCONTROL Slot Analyzer Tool, has ensured access to sufficient data for successful project execution.
The scalable architecture and the use of agile development methodologies have enabled an incremental modelling approach, from a very simple pilot model to the implementation of more complex behavioural models, and will provide the required scalability to further develop the platform beyond the project life.
The mechanisms put in place for internal communication within the Consortium (e.g., project wiki, meetings and conference calls, etc.) have worked in a very satisfactory manner, enabling a fluent exchange of information and close cooperation between the ACCESS partners.
The mechanisms put in place for external communication, stakeholder engagement and dissemination of project results have facilitated a continuous and fluent exchange of information with the research community, industry and policy makers. This has been particularly useful to understand stakeholders' positions and motivations, as well as to gather their inputs and feedback about the proposed approach and to refine and validate our modelling assumptions.
What should be improved?
The lack of available data about initial airlines' slot requests make it difficult to carry out a full calibration and validation of the proposed models.
Further research is needed to refine the airline behavioural model.
To provide more conclusive evidence, the model needs to be tested on larger networks, with a higher number of airlines and airports, and for several consecutive seasons.
Although the effort required to develop a fully calibrated and validated model and to conduct a comprehensive set of policy assessment experiments exceeds the scope of the ACCESS project, an earlier start of the modelling work would have allowed us to go further in the development of the model. We underestimated the complexity of certain tasks, especially the development and implementation of the airline behavioural model. The software development tasks could have been launched earlier in the project, in parallel to the analysis and modelling work, reducing some of the delays caused by such complexity and making it possible to conduct additional simulation experiments.
The project has opened a number of promising research lines. An effort to identify additional sources of funding and new applications of the developed models and tools should be performed to ensure the continuity and further development of such research lines.

Table 8 - Project Lessons Learnt

6 References

- [1] ACCESS Consortium, "Position Paper: Application of Agent-Based Computational Economics to Strategic Slot Allocation. State-of-the-art and Future Challenges", April 2013.
- [2] ACCESS Consortium, "ACCESS Working Paper 1: Performance of the Current Airport Slot Allocation Process and Stakeholder Analysis Report", January 2014.
- [3] ACCESS Consortium, "ACCESS Working Paper 2: Review of Auction-Based Markets", February 2014.
- [4] ACCESS Consortium, "ACCESS Working Paper 3: Market-Based Mechanisms for Airport Slot Allocation: Formalisation and Assessment Criteria", May 2014.
- [5] ACCESS Consortium, "ACCESS Working Paper 4: ACCESS Simulation Framework Specification", November 2014.
- [6] ACCESS Consortium, "ACCESS Working Paper 5: ACCESS Simulation and Analysis Toolset", November 2014.
- [7] ACCESS Consortium, "ACCESS Working Paper 6: Agent-Based Simulation of Different Airport Slot Allocation Mechanisms: Analysis of Results", December 2014.
- [8] A. Ranieri, N. Alsina, L. Castelli, T. Bolic, and R. Herranz, "Airport slot allocation: performance of the current system and options for reform", Proceedings of the 3rd SESAR Innovation Days, Stockholm, Sweden, November 2013.
- [9] M. Ramírez, F.A. Villafañez, A. Araúzo, and A. López-Paredes, "Agent-Based Pilot Model for Alternative Primary Airport Slot Allocation with Price-setting Auctions", Proceedings of the 4th SESAR Innovation Days, Madrid, Spain, November 2014.
- [10] R. Herranz, D. Toribio, M. Ramírez, F. Villafañez, J.A. Araúzo, D. Poza, N. Alsina, L. Garrigó, L. Castelli, and T. Bolic, "Price-Setting Auctions for Airport Slot Allocation: a Multi-Airport Case Study", Proceedings of the 5th SESAR Innovation Days, Bologna, Italy, December 2015.
- [11] M. Ramírez, A. Araúzo, F. Villafañez, and A. López-Paredes, "System of Systems Engineering for the Airport Slot Allocation Problem", Proceedings of the 9th International Conference on System of Systems Engineering (SOSE), Adelaide, Australia, June 2014.
- [12] P. Pellegrini, T. Bolić, L. Castelli, and R. Pessenti, "SOSTA: an effective model for the simultaneous optimisation of airport slot allocation", under review.