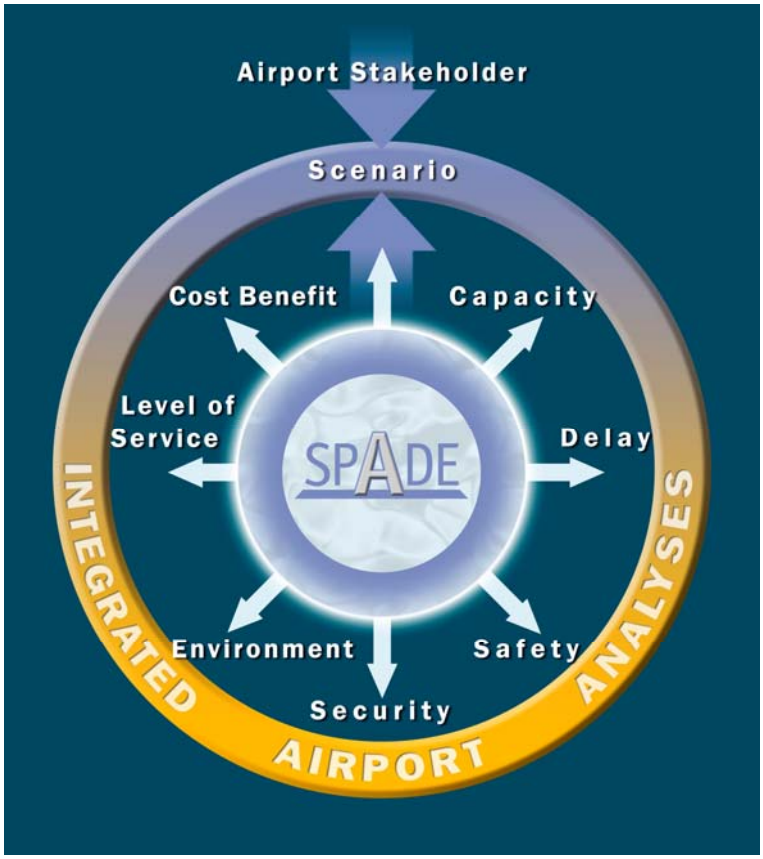
Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

Executive summary

SPADE: Supporting Platform for Airport Decision-making and Efficiency Analysis



Problem area
Within the European Union, air traffic demand is expected to double by the year 2025. Under present conditions, the growing demand and the resulting mismatch between demand and supply of airport services will result in an increase of congestion problems at airports.

This implies that airport stakeholders and policy-makers face challenging decision-making questions with strong interdependencies and often-conflicting objectives in the areas of safety and security, efficiency and service, and environment. The decision-making process to assess these questions involves the

Report no.
NLR-TP-2007-040

Author(s)
M.J.A. van Eenige
T. Muehlhausen

Report classification
Unclassified

Date
December 2007

Knowledge area(s)
Planning, advanced (sensor-) information processing, and control

Descriptor(s)
Airport decision-making
Integrated impact analysis
Total airport

This report is based on a presentation held at the 25th International Congress of the Aeronautical Sciences, Hamburg, Germany, 3-8 September 2006.

deployment of technical expertise in and the assistance of tools capable to answer the particular questions and support interpretations of tool results within the particular context.

Description of work
The objective of the SPADE project is to develop a user-friendly decision-support system for airport stakeholders and policy-makers. This system will provide support in airport development, planning and operations, allowing both integrated impact analyses and trade-off analyses with respect to a variety of performance measures (e.g., capacity, delay, level-of-service, third-party risks, security, environmental impacts, and cost-benefits). For instance, the SPADE system could assist in seeking ways to increase airport utilization in order to accommodate the rising air traffic without undue delays, while improving safety and security, improving efficiency and service, and reducing the burden of operations on the environment.

Results and conclusions
This document presents the SPADE project: its background, the state-of-the-art in airport decision-making tools, its objective, its approach, its use, the results obtained so far, and feedback from key stakeholders on these results.

Applicability
The SPADE system will be applicable to any airport that would like to improve its support for airport development, planning and operations, with integrated impact analyses and trade-off analyses with respect to a variety of performance measures (e.g., capacity, delay, level-of-service, third-party risks, security, environmental impacts, and cost-benefits).
The SPADE system offers a user-friendly layer on top of individual simulation and analytical tools. The system makes direct interaction with the data-intensive tools obsolete, and removes the burden of data transfer and conversion between tools. Furthermore, the central repository inside the system will contribute to the consistency of the results obtained by the different tools.

Nationaal Lucht- en Ruimtevaartlaboratorium, National Aerospace Laboratory NLR

Anthony Fokkerweg 2, 1059 CM Amsterdam,
P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
Telephone +31 20 511 31 13, Fax +31 20 511 32 10, Web site: www.nlr.nl

Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

NLR-TP-2007-040

SPADE: Supporting Platform for Airport Decision-making and Efficiency Analysis

M.J.A. van Eenige and T. Muehlhausen[1]

[1] Deutsches Zentrum für Luft- und Raumfahrt

This report is based on a presentation held at the 25th International Congress of the Aeronautical Sciences, Hamburg, Germany, 3-8 September 2006.

Customer	NLR
Contract number	----
Owner	NLR
Division	Air Transport
Distribution	Unlimited
Classification of title	Unclassified
	December 2007

Approved by:

Author	Reviewer	Managing department
6/5	21/5/08	

Summary

SPADE is a project within the Sixth Framework Programme of the European Commission. Its aim is to develop a user-friendly decision-support system for airport stakeholders and policy-makers. This system will provide support in airport (airside and landside) development and planning, allowing trade-off analyses for a variety of performance measures. It will allow airport decision-makers to focus on the question at hand rather than dealing with the technicalities related with the use and integration of tools.

Contents

SPADE: SUPPORTING PLATFORM FOR AIRPORT DECISION-MAKING AND EFFICIENCY ANALYSIS

Michel J.A. van Eenige*, Thorsten Muehlhausen**
***National Aerospace Laboratory NLR, ****German Aerospace Center DLR**

Keywords*: airport decision-making, integrated impact analysis, total airport*

Abstract

SPADE is a project within the Sixth Framework Programme of the European Commission. Its aim is to develop a user-friendly decision-support system for airport stakeholders and policy-makers. This system will provide support in airport (airside and landside) development and planning, allowing trade-off analyses for a variety of performance measures. It will allow airport decision-makers to focus on the question at hand rather than dealing with the technicalities related with the use and integration of tools.

1 Introduction

A major challenge in the Strategic Research Agenda for European Aeronautics is that airport utilisation will be able to accommodate rising traffic (at a rate of approximately 3.7 % per annum according to EUROCONTROL's forecasts [1]) without undue delays, while preserving safety, improving efficiency and service, and reducing the burden on the environment.

Under present conditions airport constraints limit the ability to meet this increase in air traffic demand. Hence, this increase will result in an increase in congestion at airports, with negative consequences reflected on the level of service offered to passengers, on the efficiency of airport operations, on the quality of the surrounding environment, and on air transport risk and safety.

In addition, in a vision for the year 2020 ambitious aims have been set (cf. [2]), e.g.:

- Punctuality: 99 % of all flights arriving and departing within 15 minutes of the published timetable, in all weather conditions;
- Time spent in airports: no more than 15 minutes in the airport before departure and after arrival for short-haul flights, and 30 minutes for long haul;
- Reduction in perceived noise to one half of current average levels;
- Five-fold reduction in the average accident rate of global operators.

This implies that airport stakeholders and policy makers have to solve challenging airport decision-making questions with strong interdependencies and often conflicting objectives in order to accommodate the growth in air traffic and to reach the other aims.

This paper presents the project SPADE (Supporting Platform for Airport Decision-making and Efficiency Analysis), in which a user-friendly decision-support system is developed to assist airport stakeholders and policy-makers in their complex decision-making task.

The outline of this paper is as follows. Section 2 describes both the problems decision-makers face when using tools and the state-of-the-art. Section 3 states the objective of the SPADE project and Section 4 presents the approach taken in SPADE to achieve this objective and, hence, overcoming the problems mentioned in Section 2. Section 5 shows the current results of the SPADE project, including a preliminary impression of the envisaged system to be developed. Initial feedback on these results provided by key stakeholders is presented in Section 6. Finally, Section 7 gives some conclusions.

2 State-of-the-art

The airport decision-making process for dealing with the aforementioned questions can and often needs to be supported by the deployment of (analytical or simulation) tools. Currently, the available tools can jointly address all airport elements and flows (i.e., at the airport airside and in the airport terminal), can jointly support different levels of decision making (i.e., strategic, operational, and tactical) and can jointly analyse nearly all types of performance measures (e.g., capacity, delay, level of service, third-party risk, security, environmental impacts, and cost-efficiency). However, each tool is only suited for a specific element, flow, decision-making level, or performance measure, so that tools have to be used in combination for conducting a total airport performance analysis.

In previous European research projects (like TAPE and OPAL) pre-selected tool combinations communicated and interacted in order to perform total airport performance analyses. Nevertheless, the outcomes of these projects lack a harmonised, integrated and fully-automated computing environment for executing the various tools and for presenting their integrated results. Also Preston Aviation Solutions and IATA have recently made some integrated airport modelling efforts, which resulted in Preston Airport Solutions Suite and Total AirportSim, respectively. However, these consider only a limited and pre-specified number of simulation tools. The interested reader is referred to [3] for more details on the state-of-the-art.

Thus, there does not yet exist a single tool that covers the entire range of airport elements and flows, of decision-making levels, and of types of airport performance measures in an integrated manner, implying that these tools still have to be used in combination to conduct total airport performance analyses.

3 Objective

At present conducting a total airport performance analysis by using tools in combination requires a broad range of capabilities from airport stakeholders and policy-makers. In particular, they require:

- Knowledge of the airport domain and scope;
- Knowledge of selecting airport (analytical or simulation) tools;
- Knowledge of using the selected airport tools;
- Integration of the results from selected airport tools;
- Interpretation of the integrated results.

However, airport stakeholders and policy-makers are mainly interested in defining the airport decision-making question (based on their airport domain expertise) and in obtaining an integrated view of the analysis and results.

The objective of SPADE is to develop a user-friendly decision-support system for airport stakeholders and policy-makers, using existing analytical and simulation tools for airport performance modelling. See Figure 1 for a graphical impression. This system will provide support in airport development and planning both at the airside and in the terminal, allowing trade-off analyses for a variety of measures of airport effectiveness. It will allow airport decision-makers to focus on the question at hand rather than dealing with the technicalities related with the selection, use, and integration of (analytical or simulation) tools.

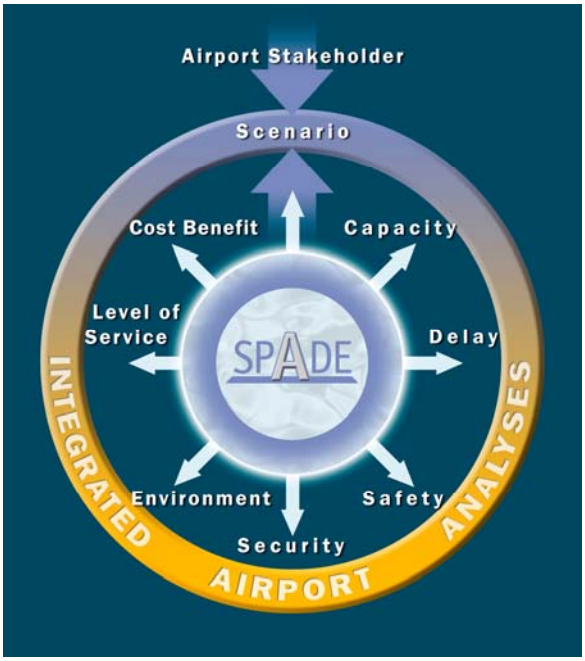


Fig. 1. Objective of SPADE.

SPADE is a project within the Sixth Framework Programme of the European Commission. It is subdivided into two phases. The first phase (May 2004-March 2006) dealt with the development of a complete design of the system and with building an early prototype to demonstrate the SPADE concept and to solicit feedback from experts and key stakeholders on this concept. The second phase (June 2006-May 2009) deals with the actual implementation and validation of the system.

The SPADE project is lead by NLR and the following organisations participate: IATA (Canada); ONERA and CCIT (France); ARC and DLR (all Germany); AUEB-RC/TRANSLOG and AIA (all Greece); CFR, SICTA and TRASTEC (all Italy); AAS, ECORYS, Incontrol, NLR, TU Delft, and HITT (all The Netherlands); and Aena, INECO, Isdefe and Polar (all Spain).

4 Approach

A classical approach to achieve the SPADE objective is the 'bottom-up' approach. In this approach, one starts with the performance indicators of interest, then selects and integrate appropriate tools, and finally investigates what questions can be addressed by these tools; cf. Figure 2.

In SPADE the opposite approach is followed: the 'top-down' approach. More specifically, SPADE first investigates what type of questions the SPADE system should support and then selects tools to address the appropriate performance measures; see Figure 2. This approach has led to the modelling concept of use cases.

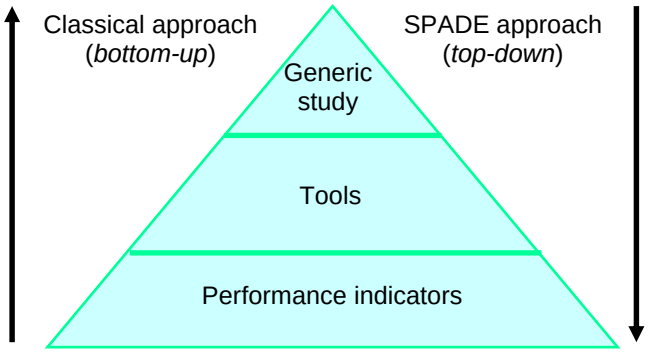


Fig. 2. Classical approach and SPADE approach.

4.1 Concept of use cases

The SPADE system is built and based on the modelling concept of use cases. A use case can be considered as a generic airport study in the form of decision-making questions supported by the system. More specifically, a use case can be considered as a "super / umbrella / generic" airport study, consisting of a collection of specific and corresponding airport decision-making questions. An example of a use case is 'Examine ways of improving or expanding airport infrastructure'. Specific airport decision-making questions corresponding to this use case could be 'What is the effect of a change in runway configuration' and 'What is the effect of a new check-in'.

The SPADE project has defined about 15 use cases. In the definition of use cases key airport stakeholders were involved in different stages. Firstly, a list of airport decision-making questions was extracted from them by means of structured interviews. Secondly, they commented, reformulated, and prioritised the questions in this list in a workshop. Finally, the prioritised list of questions was processed, resulting in a list of prime candidate use cases for implementation.

Key stakeholders involved in the elicitation and prioritisation of use cases included the European Commission, EUROCONTROL, national government (German and Dutch), air navigation service providers (Aena, ENAV, LVNL, Spanish CAA), airlines (Air France and IATA), and, of course, airports (Amsterdam, Athens, Barcelona, Brussels, Cologne, Düsseldorf, Frankfurt, Madrid, Milan, Naples, and Toulouse). Examples of important use cases are:

- Examine ways of improving or expanding airport airside or airport terminal infrastructure;
- Assessment of infrastructure or demand-management measures to cope with a sharp traffic volume increase;
- Identification of airport bottlenecks;
- Assessment of the impact of changes in fleet characteristics on airport operations;

- Assessment of the impact of new equipment or procedures (e.g., security, baggage handling, gate allocation) on airport operations;
- Assessment of the impact of a change in the flight schedule.

Within the context of the SPADE project, a use case is not merely a generic airport study, consisting of a collection of airport decision-making questions. Firstly, a use case also encapsulates an appropriate (pre-selected) "suite" of tools. Secondly, the data of a baseline or reference scenario is available for this use case too.

The pre-selection of tools for a use case does not exclude the use of alternative tools for assessing the generic airport study associated with the use case. A requirement of the SPADE system is to enable the integration of any tool provided that this tool possesses the required capabilities (e.g., those concerning with input and output). For the purpose of the development, implementation and demonstration only, a specific suite of tools that is available to the SPADE consortium has been selected within the SPADE project. Anyway, the user of the SPADE system does not have to interact with the encapsulated tools directly.

The availability of data for a baseline or reference scenario will enable the user to only modify the parameters relevant to the airport study.

In a summary, a use case is characterised by:

- generic airport study;
- collection of specific airport decision-making questions;
- encapsulation of an appropriate suite of tools;
- availability of default data corresponding to a baseline scenario.

As will be elaborated later, a use case will enable the development of a system that can be used through "pre-structured modelling paths", built-in, "wizard-type" navigation aids in a single run by shielding the user from the complicated tool world and enabling him to focus on the real question he wants to address.

4.2 Use of SPADE system

The concept of use cases has been applied to develop a user-friendly airport decision-support system that shields the user from technicalities related to the use of (different) tools in combination. The global use of the SPADE system can be described by considering the process flow diagram in Figure 3.

Upon login, the SPADE system presents the list of available use cases to the user. The user then selects the use case of his interest. For this use case, he selects the specific airport decision-making question, the reference scenario, the performance indicators of interest, and modifies parameters associated with the use case (and airport decision-making question). At this stage, the user has completely specified the use case and scenario (recall that a data for the

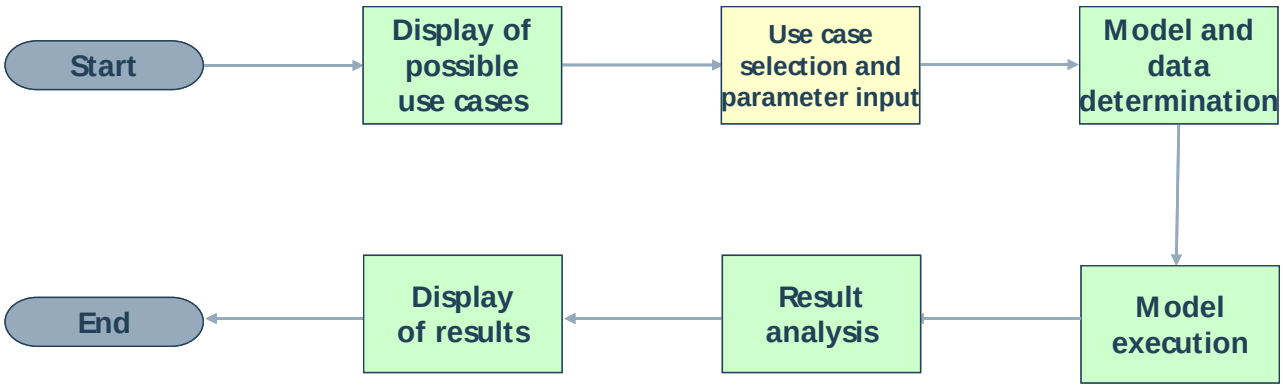


Fig. 3. SPADE process flow diagram.

reference scenario are already available). Then, the system activates the different tools in the correct order and interchanges data between them, in order to perform the computations. Once the computations have been performed, the SPADE system presents the integrated results to the user, enabling him to assess these and to conduct a new study.

A more detailed description of the envisaged use of the SPADE system is provided in the next section, as part of the description of the early prototype as developed with the first phase of the SPADE project.

5 Results

As mentioned in the Introduction, the SPADE project consists of two phases. The first phase has been completed in March 2006 and the second phase has started recently.

Up to now, the SPADE project has produced two main results. The first result is a complete design of the SPADE system. This design, of which a high-level view is depicted in Figure 4, has been developed applying the MVC approach and using UML and J2EE technology.

The second main result is an early prototype of the SPADE system. The aim of this early prototype is to demonstrate the validity and feasibility of the SPADE concept and to solicit feedback from experts and key stakeholders on this concept and the first thoughts about the envisaged system. The early prototype has partially implemented two use cases. One addresses airport capacity management and the other changes in fleet characteristics. Next the early prototype is elaborated to further clarify the use of the SPADE system. In this elaboration, the user will select the use case on fleet characteristics, and in particular the airport decision-making question on the effect of a change in aircraft type for a specific airline.

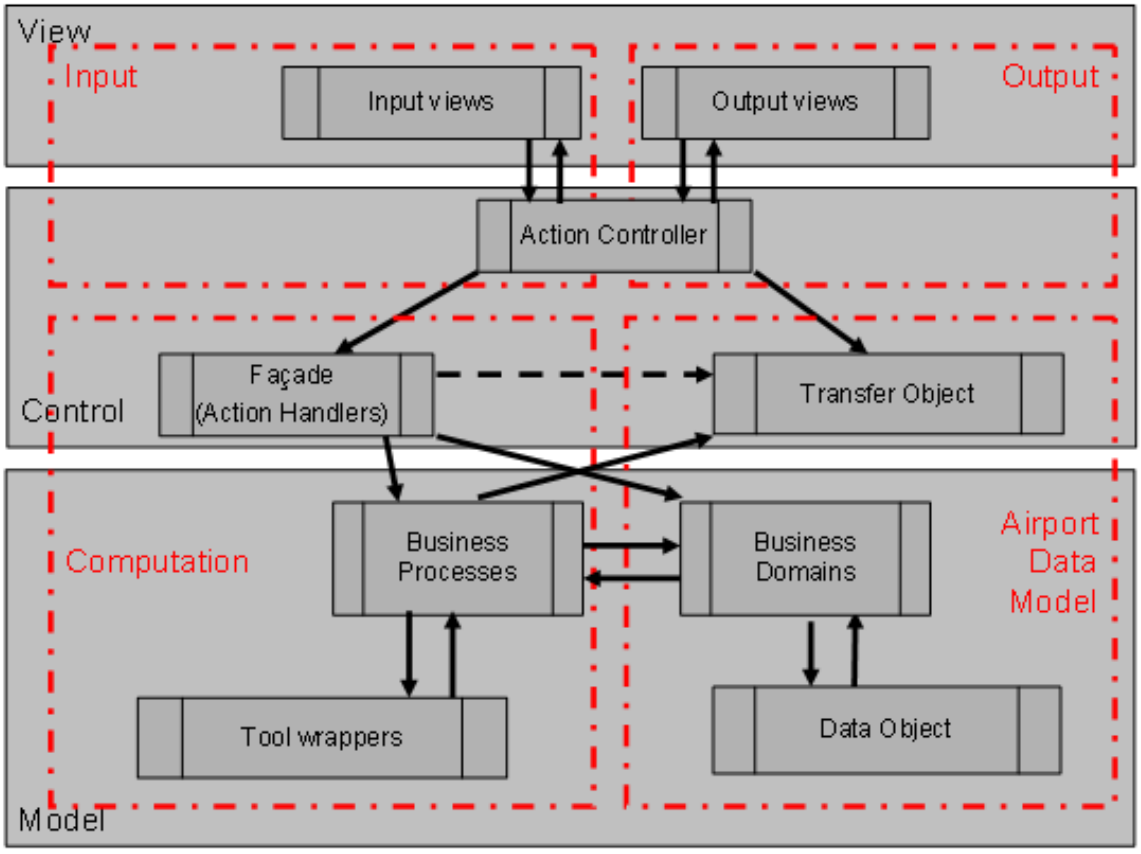


Fig. 4. High-level system architecture.

The user of the SPADE system will communicate via common dialog boxes, which do not differ from the use of known MS-Windows or Linux tools. Therefore, each user should be familiar with the use of this system without a long period of vocational adjustment.

After logging in to the SPADE system the user can specify the study, he wants to perform. One integral part is the selection and specification of the desired use case (see Figure 5), where the use case on fleet characteristics is selected. Depending on the selected use case, different performance indicators and types of questions can be selected. In this case, performance measures addressing landside, airside and cost-benefit, and the question on a change in aircraft type are selected.

In the next step the user has to set a limited number of parameters in the reference or baseline scenario, which are necessary for this specific analysis.

Once the parameters are set, the SPADE system controls the run of the required tools: 'back-office routine' (see Figure 6).

When all computations by the different tools associated with this use case are finalised, the user receives overview figures (see Figure 7). He has also the option to get a more detailed view of the results and to use them for a new and more detailed study of the same question.

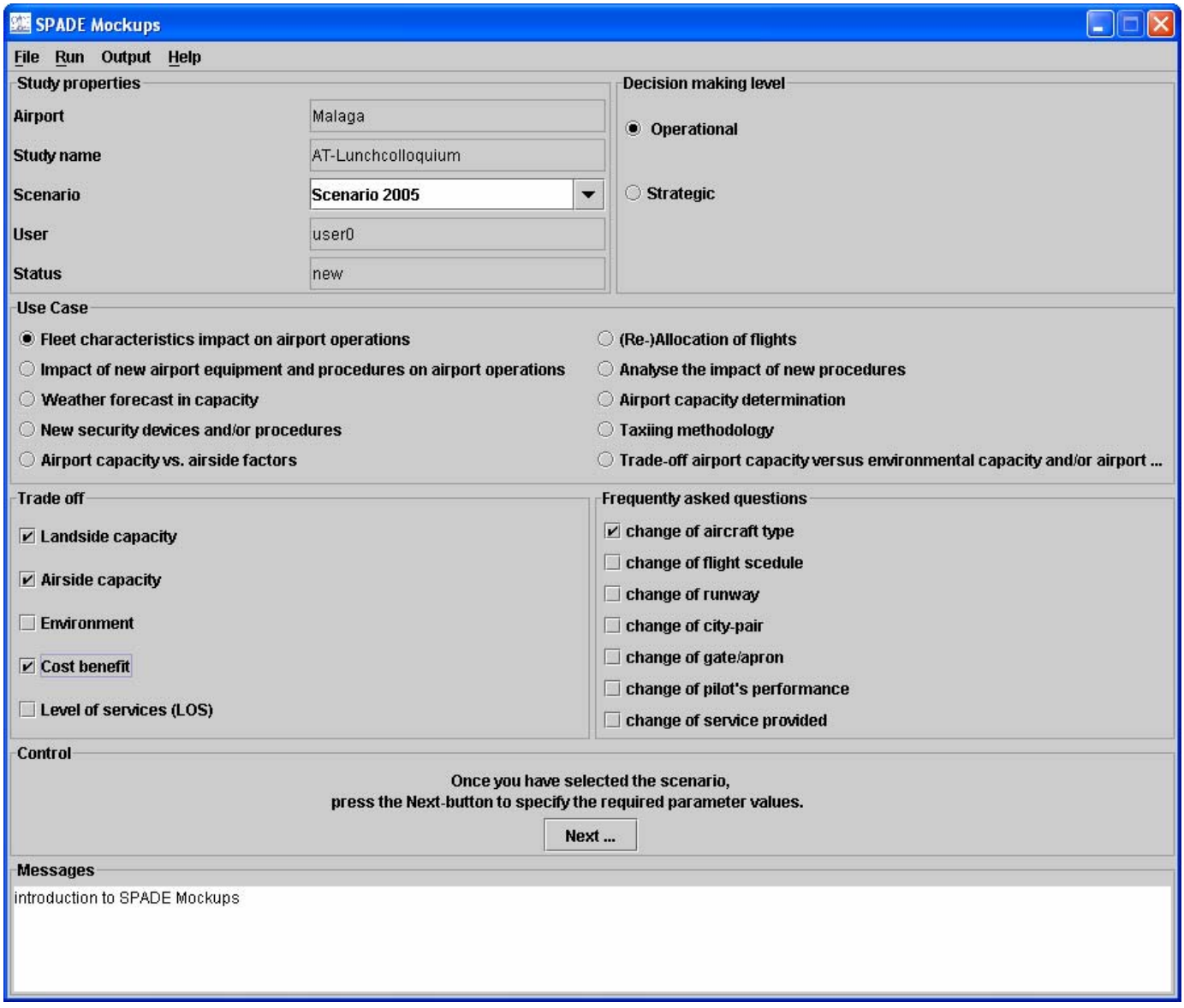


Fig. 5. Selecting use case.

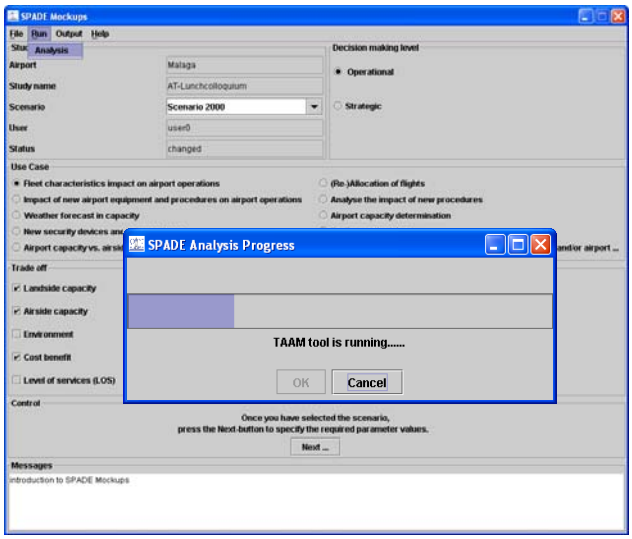


Fig. 6. Performing computations

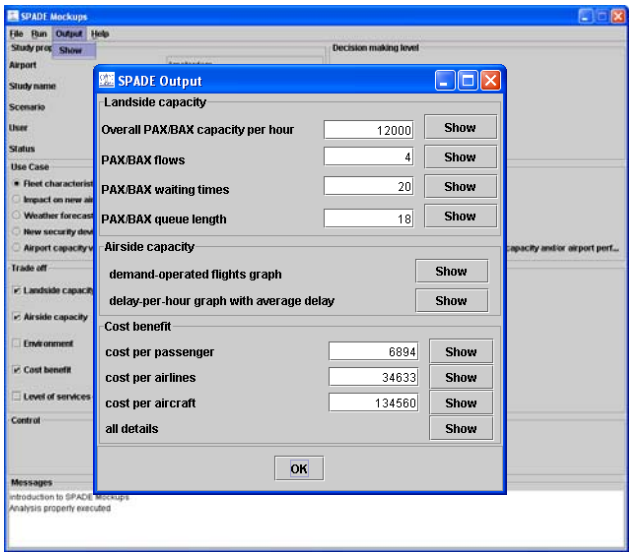


Fig. 7. Inspecting results.

6 Feedback

The early prototype has been presented to key stakeholders at a major SPADE workshop and through visits to airports. The key stakeholders included international bodies (the European Commission and EUROCONTROL), air navigation service providers (Aena, Belgocontrol, ENAV, NATS, and Spanish CAA), IATA, and airports (Amsterdam, Asturias, Athens, Brussels, Düsseldorf, Frankfurt, Lisbon, Madrid, Malaga, Milan, and Oslo).

In this workshop and these visits, key stakeholders in general expressed a positive attitude towards the envisaged SPADE system, although SPADE should pay more attention to clarifying how the system would fit within an organisation and on business models for the exploitation of the system.

In particular, key stakeholders appreciated the use case concept as being more decision (maker) oriented than other systems: no necessity to directly interact with complex and data-intensive tools. Consequently, the system was perceived to be more user-friendly. Moreover, the SPADE system enables the user to follow the complete workflow of tools, enabling the user to monitor the process and ensuring that the system is not an additional black-box. Further, the SPADE system enables the user to perform really integrated impact analysis of total airports: addressing different airport processes with their interrelationships and assessing trade-offs between different performance indicators. Of course, the SPADE system improves the productivity of performing integrated airport studies and reduces errors by the automated connection of tools.

7 Conclusions

The project SPADE is developing a user-friendly decision-support for airport stakeholders and policy-makers, using existing analytical and simulation tools for airport performance modelling. This system will provide support in airport development and planning both at the airside and in the terminal, allowing trade-off analyses for a variety of measures of airport effectiveness.

The SPADE system is based and built on the concept of use cases. Application of this concept will result in a system that enables users to focus on the question at hand rather than dealing with the technicalities related with the selection, use, and integration of (analytical or simulation). The user can use the system through "pre-structured modelling paths", built-in, "wizard-type" navigation aids.

An early prototype of the envisaged system has been presented to key stakeholders. These stakeholders supported the approach followed

and stimulated the consortium to continue its efforts in the development of this system.

The next step in the development of the SPADE system is to actually implement and validate this system, based on the results of the first phase (system design and feedback from key stakeholders on the early prototype), providing a solid base for airport decision-making.

Acknowledgement

European Community financial support for the present study through the European Sixth Framework Programme, Research Projects SPADE (contract number TREN/04/ FP6AE/S07.29856/503207) and SPADE-2 (contract number TREN/06/FP6AE/S07.58054/ 518362), is greatly acknowledged. The present paper does not represent the view of the European Commission, and the authors are solely responsible for the paper's contents.

References

[1] EUROCONTROL, *EUROCONTROL Long-Term Forecast of Flights (2004-2025)*. 2004.

[2] European Commission (Group of Personalities), *European Aeronautics: A Vision for 2020*. 2001.

[3] Zografos K G, Madas M A, Van Eenige M J A and Arnaldo Valdes R. Integrated airport performance analysis through the use of the OPAL platform, *Air Traffic Control Quarterly*, Vol. 13, No. 4, pp. 357-386, 2005.