Contract number: TREN/04/S/FP6AE/S07.29856/503207
Project acronym: SPADE
Project title: Supporting Platform for Airport Decision-making and Efficiency Analysis
Instrument: Integrated Project
Thematic Priority: Aeronautics and Space

D8.3: Publishable Final Activity Report

Periodic covered: from May 2005 to March 2006    Date of preparation: November 24, 2006
Start date of project: May 1, 2004    Duration: 23 months

Project co-ordinator name: Michel van Eenige
Project co-ordinator organisation name: National Aerospace Laboratory NLR

Revision 1.0

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Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)
Document Identification

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* Type of Deliverable PU-Public, CO-Confidential, or INT-Internal

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<td>Mr. M.J.A. van Eenige</td>
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<td>EC – DG-TREN</td>
<td>Mr. M. Jensen</td>
<td>2006-11-21</td>
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<td>ACI</td>
<td>Airports Council International</td>
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<td>Aena</td>
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<td>AIA</td>
<td>Athens International Airport</td>
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<td>APRON</td>
<td>Aviation Policy Information Resources based on Observatory Networks</td>
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<td>ARC</td>
<td>Airport Research Center</td>
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<tr>
<td>A-SMGCS</td>
<td>Advance Surface Movement, Guidance and Control System</td>
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<td>ASTER</td>
<td>Aviation Safety Targets for Effective Regulation</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<td>AUEB</td>
<td>Athens University of Economics and Business</td>
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<td>BETA</td>
<td>Operational Benefit Evaluation by Testing an A-SMGCS</td>
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<td>CAATS</td>
<td>Co-operative Approach to Air Traffic Services</td>
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<td>CCIT</td>
<td>Chambre de Commerce et d'Industrie de Toulouse – Aeroport de Toulouse-Blagnac</td>
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<td>European Airport Movement Management by A-SMGCS</td>
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<td>EU</td>
<td>European Union</td>
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<td>EUROCONTROL</td>
<td>European Organisation for the Safety of Air Navigation</td>
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<td>Holland Institute of Traffic Technology</td>
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<td>IATA</td>
<td>International Air Transport Association</td>
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<td>Ingenieria de Sistemas para la Defensa de España</td>
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<td>J2EE</td>
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<td>LEONARDO</td>
<td>Linking Existing On Ground, Arrival and Departure Operations</td>
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<td>MAEVA</td>
<td>Master ATM Validation Plan</td>
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<td>NLR</td>
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<td>ONERA</td>
<td>Office National d'Études et de Recherche Aérospatiales</td>
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<td>OPAL</td>
<td>Optimisation Platform for Airports, including Landside</td>
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<td>OPTAS</td>
<td>Optimisation of Airport Systems</td>
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<td>SARS</td>
<td>Severe Acute Respiratory Syndrome</td>
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<td>SICTA</td>
<td>Sistemi Innovativi per il Controllo del Traffico Aereo</td>
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<td>SPADE</td>
<td>Supporting Platform for Airport Decision-Making and Efficiency Analysis</td>
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<td>Total Airport Performance and Evaluation</td>
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<td>TRANSLOG</td>
<td>Transportation Systems and Logistics Laboratory</td>
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<td>TRASTECH</td>
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<td>TU Delft</td>
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<td>TREN</td>
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<td>UML</td>
<td>Unified Modelling Language</td>
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1 Project execution

1.1 Background

Among all different transport modes, air transport has shown by far the largest traffic increase and growth potential during the last two decades. Despite the recent events with the negative impacts on the air transport industry (e.g., the depressed global economy, the terrorist attack of September 11, 2001, the Iraqi Wars, and SARS), analysts generally agree and recent traffic figures provide evidence that the industry starts to recover and air traffic growth rates are likely to return to their previous levels in the medium term. ACI Europe forecasts that international air passenger traffic will increase by an average of 3.6 % per year between 2002 and 2020. Moreover, with the enlargement of the European Union (EU) and the greater travel distances involved, air transport will play an even more important role in the integration of Europe.

Based on the anticipated demand figures, the traffic growth envisaged for the medium to long term future in EU Member States have to be mostly accommodated by a relatively small number of primary hub airports. In parallel, the reorganisation of the European sky under the dictates of the Single European Sky initiative and SESAR initiative will inevitably lead to an expansion in airspace capacity, which should be accompanied by increased capacity on the ground in order to maximise the benefits of the creation of a common air traffic management system in Europe. A direct consequence of the growing demand and the resulting mismatch between demand and supply of air transport and airport services is the increase of congestion problems both in the air and on the ground with considerable externalities and negative consequences reflected on the level of service offered to the travelling public, the efficiency of airport operations, the quality of the surrounding environment, and the safety of the entire air transport system.

The increasing demand and associated externalities, in conjunction with technical, physical and political constraints in providing sufficient capacity, has stimulated vigorous policy discussions toward examining and assessing the traffic implications on various airport performance metrics with focus on capacity and delay, level of service, environmental impacts, safety and security. Stakeholders and policy makers involved in or affected by the airport decision making process are asked to make decisions, draw policy directions, and operate in a quite complicated environmental, institutional, and operational setting. They often face challenging decision making questions with strong interdependencies and often conflicting objectives (trade-offs).
The decision making process and implementation for dealing with the decision making questions involves the deployment of technical expertise or decision support in (cf. Figure 1):

- Knowledge of the problem domain and scope;
- Knowledge of (selecting and using) tools capable of supporting the particular decisions;
- Interpretation of tool results in the particular decision making context; and
- Availability of appropriate data fulfilling the particular decision making and tool requirements.

**Figure 1**: Airport Decision-Making Process

### 1.2 Objectives

In response to the decision making requirements, 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 (both airside and landside) development, planning and operations, allowing integrated impact and trade-off analyses for a variety of performance measures (e.g., capacity, delay, level of service, environment, and safety). It will address a number of important
airport development, planning and operations decisions (or use cases) through pre-structured, pre-specified, and guided, "wizard-type" navigation in a single run and in a back-office routine.

The SPADE Project addresses "Airport Efficiency" (within the Sixth Framework Programme of the European Commission), which is subdivided into two phases. The current phase deals with Phase 1, aiming to develop a complete design of the decision-support system and to implement an early prototype of the system. By means of this prototype, a visual example of the system to potential users is provided. As such, the prototype will be instrumental in presenting what the SPADE consortium expects as a result of Phase 2.

1.3 State-of-the-art
A number of research projects in the airport domain have been funded by the European Commission during the last few years. These projects have four major research directions: i) airport capacity & efficiency optimisation, ii) validation and evaluation of ATM concepts, iii) development of safety and security standards, rules, and best practices, and iv) technology development in terms of airside, airspace, landside, and ground equipment (Figure 2). Among the major and most relevant projects in this field, the following can be listed:

- **TAPE:** The “Total Airport Performance and Evaluation” project was funded by the European Commission (DG VII). Its objective was the development and validation of a decision support system for airport performance evaluation and strategic planning.

- **OPTAS A + B:** The main objectives of the "Optimisation of Airport Systems A+B" projects funded by the European Commission (DG VII) projects were: i) to evaluate a suite of airside and landside simulation tools to conduct a set of case studies to evaluate the potential capacity impacts of a range of initiatives likely to be introduced at European airports in the future, and ii) to develop a fast runtime, high level modelling tool which integrates the airside and landside components of an airport.

- **OPAL:** The objective of the “Optimisation Platform for Airports, including Landside” project, funded by the European Commission (DG TREN), was to develop an integrated, distributed simulation platform for modelling, evaluating and optimising airport airside and landside operations, independently or in conjunction.

- **LEONARDO:** The fundamental objective of the “Linking Existing ON ground, Arrival and Departure Operations” project, funded by the European Commission (DG TREN), is to demonstrate the feasibility of integrating existing arrival, departure and ground management tools for air transport operation. This project aims at the integration of concepts and technologies allowing not only the sharing of information between the arrival, departure and ground
movement tools, but also co-ordination, taking into account requests and constraints from their "neighbours" tools.

- **ASTER**: The major objective of the “Aviation Safety Targets for Effective Regulation” project, funded by the European Commission (DG TREN) was to develop a method and tools to define target levels of safety for the total air transport system and to support the identification of optimal safety improvement measures (through regulation) to achieve the target level of safety.

- **MAEVA**: The project titled “A Master ATM European Validation Plan”, funded by the European Commission (DG TREN), aims to define an overall validation strategy for the pre-EATMS (pre European ATM System) for the 5th Framework Programme validation projects, generating a validation master plan.

- **CAATS**: The project titled “Cooperative Approach to Air Traffic Services”, funded by the European Commission (DG TREN), aims to define a co-ordinated, co-operative European approach to ATM research and technical support in the domains of safety, human factors and validation for ATM projects within the 6th Framework Programme.

- **BETA**: The main objective of the “Operational Benefit Evaluation by Testing an A-SMGCS” project, funded by the European Commission (DG TREN), was threefold: i) the implementation of mature A-SMGCS (Advanced Surface Movement Guidance and Control System) elements and the creation of industrial rules for integration, ii) the generation of operational procedures adapted to the new technology potential, and iii) the user operational benefit validation.

- **EMMA**: The objective of the “European Airport Movement Management by A-SMGCS” (EMMA) project, funded by the European Commission (DG TREN) in continuation of the BETA project, is the development, demonstration, and evaluation of a surface movement guidance and control system for airports.

- **THENA**: The main objective of the "Thematic Network on Airport Activities" project, which is funded by the European Commission (DG TREN), is to create and develop an environment of co-ordination and collaboration, in order to increase the visibility and transparency of airport related research activities, as well as to identify new research needs and possibilities.

- **APRON**: The objective of the “Aviation Policy information Resources based on Observatory Networks” project, funded by the European Commission (DG TREN), is threefold: i) to identify and validate the requirements of the policy formulation process, ii) to integrate and harmonise the existing information collected from the various individual sources, and iii) to establish a physical communication network (airport observatory) that will enable the exchange of data between airport and air transport stakeholders.
The above listed research projects mainly address modelling issues (e.g., TAPE, OPTAS, LEONARDO, OPAL), validation / evaluation issues (e.g., MAEVA, CAATS), safety and security issues (e.g., ASTER, CAATS), and technology development issues (e.g., BETA, EMMA). Furthermore, a number of horizontal research activities (e.g., APRON, THENA, CAATS) have been conducted with the purpose of co-ordinating research activities and integrating research results and related airport data on a collaborative environment in the sense of an airport observatory network. The SPADE project capitalises on work performed within the framework of the aforementioned research projects. In addition, SPADE works closely together with on-going research projects by exploiting results and data that have been (will be) produced by these projects in all related directions (i.e., safety, security, validation / evaluation, technology development, horizontal and co-ordinated research activities). In that respect, although the core research activities and focus of SPADE are positioned under the category of airport capacity optimisation and modelling, it will develop research synergies and will fully consider the following aspects (cf. Figure 2):

1. specifications and methodologies for validation / evaluation analysis;
2. safety and security standards that have been determined through previous and on going research work;
3. regulatory / policy constraints and issues;
4. collected and harmonised airport data and results of studies performed through horizontal research activities in the airport domain.

Figure 2: State-of-the-Art Review ("Research Map" in the Airport Domain in Europe)
1.4 Approach
The development of the SPADE system is based on the concept of use cases. In the context of the SPADE Project, a use case is a “wizard-type”, integrated use of a set of tools assisting airport-domain experts in addressing a widely arising airport planning or design problem without requiring familiarity with the tools themselves. The wizard thus provides a pre-structured modelling environment which embeds the computational intelligence and familiarity of tool experts. The ultimate objective of use cases is to help airport-domain experts analyse the various airport performance trade-offs involved in each case (e.g., capacity, delay, level-of-service, safety, security, environmental impacts, and cost-efficiency) and provide appropriate decision support. This concept enables the user to perform the analysis under consideration through "pre-structured" and built-in, "wizard-type" navigation aids in a single run by shielding the user from the complicated model and tool world: enabling him or her to focus on the real question to be addressed. The system will integrate a specific set of use cases.

![Figure 3: SPADE concept](image)
The activities in Phase 1 can be subdivided into two main streams. The first stream deals with the development of a complete system design and the second stream with the development of an early prototype.

The development of a complete design of the system follows the standard lifecycle and consists of 5 major and sequential activities:

1. Elicitation of use cases. Stakeholders involved in airport planning, operations and development process are identified to systematically elicit their decision-support requirements through interviews and a workshop. Moreover, the system's decision-support framework is specified in terms of the use cases that will be provided.

2. Specification of the system. This concerns the system's components, the use cases (from the first activity) and their implementation in the system, and the airport data model for all data to be managed.

3. Assessment of the functional specifications of the system against the use cases. Any area where the specification does not cover the use cases is identified, and any enhancement required is implemented.

4. Design of the system. This concerns the system and its components, including the mechanism for the integration of tools, based on the system specification and possible enhancements.

5. Assessment of the system's design against the functional specification. This includes the carrying out of the relevant corrections and enhancements to the design.

The second stream of activities concerns the development of an early prototype. This prototype addresses two use cases identified in the activity above. The early prototype shows computational capabilities and certain functionality, and shows the validity of the concepts behind the system. It is a software implementation with the external appearance of the system, but not necessarily using a common platform sharing modules in an integrated environment or using an architecture like the final system.

Section 1.7 provides more details of the approach and the associated activities.

1.5 Results
The first main result is the complete design of the SPADE system. This design (together with the lessons learnt in the development of the early prototype) constitutes the basis for the actual realisation of the system in Phase 2.
The second main result is the early prototype, addressing two use cases and using real airport data. This prototype provides a visual example of the system to potential users and serves its key purpose of showing the validity of the concepts behind the system. The early prototype is instrumental in presenting what the consortium expects as a result of Phase 2.

The results are elaborated in Section 1.7. With these results the SPADE Project (i.e., Phase 1) has accomplished its objectives, constituting the starting point for conducting the activities in Phase 2.

1.6 Consortium

The activities in the SPADE Project were conducted by a consortium consisting of 17 organisations from 7 different counties, which was co-ordinated by NLR. These organisations are listed in the table below.

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<th>Participant short name</th>
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<td>1</td>
<td>Nationaal Lucht- en Ruimtevaartlaboratorium (National Aerospace Laboratory NLR) Anthony Fokkerweg 2 1059 CM Amsterdam The Netherlands</td>
<td>NLR</td>
<td>The Netherlands</td>
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<td>Main technical point-of-contact: Mr. Michel van Eenige</td>
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<td>2</td>
<td>Aeropuertos Españoles y Navegación Aérea Josefa Varcarcel 30 28027 Madrid Spain</td>
<td>AENA</td>
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<td>Deutsches Zentrum für Luft- und Raumfahrt Lilienthalplatz 7 38108 Braunschweig Germany</td>
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<td>Germany</td>
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<td>Research Centre of the Athens University of Economics and Business - Transportation Systems and Logistics Laboratory Evelpidon 47A &amp; Lefkados 33 11362 Athens Greece</td>
<td>AUEB-RC/TRANSLOG</td>
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<td>International Air Transport Association 800 Place Victoria H4Z 1M1 Montreal Canada</td>
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<td>Airport Research Center Bismarckstrasse 61 52066 Aachen Germany Main technical point-of-contact: Mr. Michael Laubrock</td>
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<td>Chambre de Commerce et d'Industrie de Toulouse - Aeroport de Toulouse-Blagnac P.O. Box 103 31703 Blagnac France Main technical point-of-contact: Mr. Vicent Pimenta</td>
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1.7 Activities performed and results achieved
As mentioned in Section 1.4 the activities in the SPADE Project have been subdivided into two main streams:

- Development of complete system design:
  - Elicitation of use cases;
  - Specification of system;
  - Evaluation of specification;
  - Design of system;
  - Design validation.

- Development of early prototype:
  - Prototype implementation;
  - Prototype validation;
  - Feedback.

The associated activities conducted and the results obtained are described in the next subsections: the development of the complete SPADE system design in Section 1.7.1 and the development of the early prototype in Section 1.7.2. Results have also been laid down in publicly available project deliverables as listed in Section 2.2, to which references are made below.

1.7.1 System design
1.7.1.1 Elicitation of use cases
The first step in the development of a design for the SPADE system was to systematically and consistently elicit user requirements and use cases. (A SPADE use case is a "wizard-type", integrated use of a set of tools assisting airport-domain experts in addressing a widely arising airport
planning or design problem without requiring familiarity with the tools themselves.) To this end a methodology was applied consisting of two parallel activities:

- **Demand-side survey**
  
  The SPADE Consortium identified and classified a list of relevant airport stakeholders who are involved in strategic and operational/tactical policy making, and developed a questionnaire for a survey of these stakeholders. Using this questionnaire, the SPADE Consortium held interviews with the identified stakeholders to obtain information of their needs and wishes concerning the SPADE system, and to obtain a list of potential use cases. The surveyed stakeholders were:
  
  - airports: Amsterdam Airport Schiphol, Athens International Airport, Brussels International Airport, Cologne Airport, Frankfurt Airport, Madrid-Barajas Airport, Milan-Malpensa Airport, Naples International Airport, Toulouse-Blagnac Airport;
  
  - airlines: Air France;
  
  - air traffic service providers: Aena (Spain), ENAV (Italy), LVNL (Netherlands);
  
  - governmental institutes: DGL (Netherlands), RIVM (Netherlands), Ministry of Transport (Netherlands);
  
  - international organisations: EC, EUROCONTROL.

  The SPADE Consortium assessed the outcomes of the interviews and presented the results of this assessment at a Workshop in Toledo to airport stakeholders:
  
  - airports: Amsterdam Airport Schiphol, Athens International Airport, Barcelona Airport, Brussels International Airport, Düsseldorf Airport, Frankfurt Airport, Madrid-Barajas Airport, Toulouse-Blagnac Airport;
  
  - airlines: IATA;
  
  - air traffic service providers: Aena (Spain), Spanish Civil Aviation Authority;
  
  - governmental institutes: Hessen Ministry of Economics, Transport and Development (Germany);
  
  - international organisations: EC, EUROCONTROL.

  In this workshop the airport stakeholders gave feedback on the list of potential use cases and prioritised the use cases.

- **Supply-side analysis**
  
  The SPADE Consortium prepared a list of state-of-the-art decision-support tools (building on results obtained in the EC projects APRON and OPAL) and a structured template for a systematic description of these tools. Using the template, each of the identified tools was described, addressing its capabilities, integration constraints and requirements, as well as its potential contribution to the SPADE system.
The final activity in the elicitation of use cases was to match and analyse the demand-side survey (which resulted in a prioritised list of potential use cases for the SPADE system) and the supply-side analysis (which resulted in a list of state-of-the-art airport decision-support tools) with the purpose of determining existing tool combinations that can be used and integrated in order to perform the elicited use cases. This resulted in a list of 18 use cases for possible implementation in the SPADE system. These use cases were subdivided into so-called "strategic" use cases and so-called "operational" use cases in order to indicate that the former provide decision-support for a medium- or long-term time horizon through the use of macroscopic, low level-of-detail tools and that the latter provide decision-support for a short- to medium-term time horizon through the use of microscopic, high level-of-detail tools. These use cases are listed in Table 1.

<table>
<thead>
<tr>
<th>Strategic/Operational</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Expanding airport landside infrastructure</td>
</tr>
<tr>
<td>Strategic</td>
<td>Airside infrastructure development</td>
</tr>
<tr>
<td>Strategic</td>
<td>Airport capacity management</td>
</tr>
<tr>
<td>Strategic</td>
<td>New equipment, technology or procedures</td>
</tr>
<tr>
<td>Strategic</td>
<td>Sharp traffic increase</td>
</tr>
<tr>
<td>Strategic</td>
<td>Change in operating conditions</td>
</tr>
<tr>
<td>Strategic</td>
<td>Identification of capacity bottlenecks and shortages</td>
</tr>
<tr>
<td>Operational</td>
<td>Impact of fleet characteristics</td>
</tr>
<tr>
<td>Operational</td>
<td>(Re-)allocation of flights</td>
</tr>
<tr>
<td>Operational</td>
<td>Impact of new airport equipment and procedures</td>
</tr>
<tr>
<td>Operational</td>
<td>Analysis of impact of new procedures</td>
</tr>
<tr>
<td>Operational</td>
<td>Weather forecast in capacity</td>
</tr>
<tr>
<td>Operational</td>
<td>Airport capacity determination</td>
</tr>
<tr>
<td>Operational</td>
<td>New security devices and/or procedures</td>
</tr>
<tr>
<td>Operational</td>
<td>Taxing methodology</td>
</tr>
<tr>
<td>Operational</td>
<td>Airport capacity versus airside factors</td>
</tr>
<tr>
<td>Operational</td>
<td>Resources workload and its impact on airport capacity</td>
</tr>
<tr>
<td>Operational</td>
<td>Trade-off airport capacity versus environmental capacity/airport performance</td>
</tr>
</tbody>
</table>

Table 1: Elicited use cases

More details on the user requirements and use case elicitation methodology can be found in the public SPADE D1.1 deliverable [1]. The public SPADE D1.2 deliverable [2] provides more details on the demand-side and supply-side analyses, and on the elicited use cases and their descriptions. The proceedings of the Toledo Workshop can be found in the public SPADE D1.3 document [3].

**1.7.1.2 Specification of system**

The next step in the development of a design of the SPADE system was the specification of the SPADE system based on the identified and described use cases. Before actually specifying this system, the SPADE Consortium identified possible specification methodologies and software tools.
The consortium selected Unified Process and UML (Unified Modelling Language) as the mechanism for the specification, and Rational Rose as the software tool.

The first specification activity was a description of the SPADE system architecture. Following the Unified Process, a list of requirements was prepared in several iterations. This list was subdivided into use/user related requirements and technical related requirements. In addition to these requirements, the SPADE Consortium identified so-called design considerations. These considerations concerned SPADE system’s capabilities that are desirable or nice to have, but that depend on the selected use cases. Therefore, at this stage of the project, no final decision on these considerations was made. The aim was to include or to consider as many as possible in the specification phase and to make a final decision during subsequent activities.

Based on the description of the system architecture, the SPADE Consortium decided to apply an approach based on four components:

- Input component;
- Computational component;
- Output component;
- Airport data model.

But before developing a specification for each of these components, the use cases as selected above were specified. More specifically, UML diagrams were developed and implemented in accordance with the Unified Process for each of the selected use cases.

After the specification of the use cases, global methods were assigned to each of the four components, and interfaces between components were identified. The SPADE Consortium specified these methods and interfaces in detail through UML diagrams in accordance with the Unified Process. For each of these components, the specification activity was split into a general part valid for all use cases and a use case specific part.

The specification methodology has been described in the public SPADE D2.1 deliverable [4]. The specification of the SPADE system has been laid down in the public SPADE D3.3 deliverable [8].

1.7.1.3 Evaluation of specification

The third step in the development of a design of the SPADE system was to perform a formal evaluation of the specification of this system. More precisely, the SPADE Consortium compared the functional system specification against the use cases elicited in order to ensure conformance to the
latter, to identify any area of non-conformance, and finally to propose and implement the required corrective actions in the form of updates or enhancements of the use case specifications.

The SPADE Consortium prepared a generic evaluation template that was customised to the context of the specific use case. By filling-in the customised template for the corresponding use case, each use case was evaluated. When evaluating the use cases, the SPADE Consortium partners who were responsible for the specification of the use case were not assigned to perform its evaluation.

The filled-in templates identified use case specifications that did not conform to the conceptual descriptions of these use cases (as provided in the elicitation activities described above). For these cases of non-conformance, the SPADE Consortium took corrective actions: implementation of enhancements and updates of the use case functional specifications along with the necessary documentation that should be used in the design activities.

The evaluation methodology has been described in the public SPADE D3.1 deliverable [6]. The update of the specification of the SPADE system has been laid down in the public SPADE D3.3 deliverable [8].

1.7.1.4 Design of system

With the updated or enhanced functional specification as a basis, the next activity was the design of the overall SPADE Platform. To this end the SPADE Consortium first focused on the architectural design of the SPADE system, which was translated into a Rational Rose model, and it selected J2EE as the technology for the architecture and J2SE as back-up solution.

After the architectural design of the SPADE system, the SPADE Consortium applied an object-oriented philosophy to the design of the four components (viz. input component, output component, computational component, and airport data model), which resulted in an iterative process:

1. Use cases
   The use cases were included in the aforementioned Rational Rose model: for each use case its (components') specification was mapped onto the design classes in this model and additional classes were defined whenever necessary.

2. Components
   For each design class all components mapped onto this class were analysed. See also Figure 4 for a high-level design.

3. Technology translation
After the analysis of the design classes associated with the four components (airport data model, computational component, input component, and output component) the outcomes were translated in terms and terminology of the selected technology J2EE and in the Rational Rose model. More specifically,

- The outcomes of the analysis of the design classes associated with the input component (i.e., input views and action controllers) were translated in terms and terminology of the selected technology J2EE. For the input and output component it was important to ensure the same look and feel among all use cases.
- The outcomes of the analysis of the design classes associated with the output component (i.e., output views and action controllers) were translated in terms and terminology of the selected technology J2EE. For the input and output component it was important to ensure the same look and feel among all use cases.
- The outcomes of the analysis of the design classes associated with the computational component (i.e., action handlers, business processes, and tool wrappers) were translated in terms and terminology of the selected technology J2EE.
- The outcomes of the analysis of the design classes associated with the airport data model (i.e., transfer object, business domains, and data object) were translated in terms and terminology of the selected technology J2EE.

One of the reasons for following the steps above was risk mitigation. Although the J2EE technology was selected as the preferred technology, some doubts on the maturity and applicability of this technology for use within the SPADE Project existed. Therefore, in the first two steps of the design process, a logical design was made, which consisted of a decomposition of the functionality of the system in packages and classes, without making assumptions on the underlying technology. In the third step, the technology was added to the design. In case of a necessity to abandon the J2EE technology, and replace it with J2SE technology, only this step would have to be repeated.

The resulting design consists of a general part, dealing with general functions such as login and use case selection, and common classes for the basic component connections, from which use case specific classes may inherit. These common classes ensure that the basic structure of all use case implementations will be the same, and that new use cases may be added to the system more easily.

The design methodology and the system design have been described in the public SPADE D4.1 deliverable [9].
1.7.1.5 Design validation

The last activity in the development of a design of the SPADE system was to perform a formal validation of this system's design. More specifically, the SPADE Consortium assessed the design in order to identify any areas where this design did not appropriately support the provision of the specified functionality as well as to carry out the relevant corrections, updates, and enhancements in the system design.

The SPADE Consortium prepared a generic validation methodology, including necessary supporting material such as assessment attributes and metrics, validation techniques, and templates to be used in the validation process. The consortium used the supporting material to perform and document the validation, hereby assessing whether the system design can successfully realise the specified system functionality and identifying any instances where improvements are required.

In cases where the SPADE Consortium concluded that the design did not adequately meet the functional specifications, it updated and enhanced the system design accordingly. The updates and enhancements of the system design resulted in a new version of the Rational Rose model.
The validation methodology has been described in the public SPADE D6.1 deliverable [13]. The update of the design of the SPADE system has been laid down in the public SPADE D6.3 deliverable [15].

1.7.2 Prototype
1.7.2.1 Implementation of prototype

In parallel to the specification and design of the SPADE system, the SPADE Consortium developed an early prototype of this system. The aim of this prototype was to validate the SPADE concept, to demonstrate certain system functionality, and to have a means to obtain feedback from airport stakeholders in an early stage in the system development. As such the intention of the early prototype was to be a software implementation with the external appearance of the system, but neither to use an architecture like the final system, nor to share modules in an integrated environment. The prototype provides a visual example of the envisaged system.

Using real airport data the early prototype was based on the implementation of two use cases; one operational and one strategic:

- Operational use case: Assessment of a change in fleet characteristics
  This use case analyses the impact of possible changes in fleet characteristics (e.g., aircraft type, city pair, airline, or flight schedule) on the airport operations, especially in terms of airside and landside capacity, efficiency, environmental impact, and cost/benefit analysis. Different aspects of the operation are addressed. For an airport (and companies working at airports) it is important to have sufficient capacity and resources available at the right time and place in order to handle the flights, passengers, luggage, and cargo in an efficient and smooth way. Knowing how the characteristics of the fleet, changing continuously on hourly, daily and seasonal basis, will affect the airport operation to ensure a good tactical approach to get the maximum benefit from a given infrastructure. Typical end users include airport and airline decision makers.

- Strategic use case: Airport capacity management.
  This use case provides decision support to the following generic types of frequently arising airport planning questions: i) impact assessment of changes in the physical airside and/or landside infrastructure of the airport, ii) impact assessment of changes in operational procedures or standards (e.g. security levels, service times, service discipline) or requirements (e.g. separation minima) and iii) impact assessment of changes in the traffic distribution, mix or volume. It provides decision support to an aggregate (macroscopic) level for strategic decision making purposes, by covering both airside and landside simultaneously. It captures the trade-off involved between capacity, delays, and level of service. Among the typical users of this use case
one could see high-level airport decision makers, civil aviation authorities, national slot co-ordinators, and slot co-ordination committees.

The first activity in the development of the early prototype was the development of a methodology for the realisation of the prototype. To this end the SPADE Consortium determined the requirements based on the specific contents of the selected use cases. Further, it decided what middleware and airport model database to use.

Following the methodology, the SPADE Consortium designed, implemented and tested generic components and use case specific components:

- **Operational use case**
  This use case integrated the following tools:
  - TRAFGEN: traffic generator;
  - ESTOP: runway occupancy planner;
  - RAMSPlus: fast-time airside simulation (aircraft flows); exchangeable with TAAM;
  - TAAM: fast-time airside simulation (aircraft flows); exchangeable with RAMSPlus;
  - ED-PAX/-BAX: fast-time landside simulation (passenger flows);
  - INM: noise model around the airport;
  - CBM: cost benefit model for both airside and landside.

  The design and implementation of the use case specific components were based on J2EE, using JBoss as the application server, and on MySQL for the relational database model; see [10] for an impression of the implementation.

- **Strategic use case**
  This use case integrated the following tools:
  - FLASH: flight schedule generator;
  - MACAD: airport capacity and delay analysis tool;
  - SLAM: landside capacity and delay tool.

  The design and implementation of the use case specific components was based on J2SE.

The methodology for the development of the early prototype has been laid down in the public SPADE D5.3 deliverable [12]. Figure 5 shows the main screen of the early prototype, enabling the user to define his study and to select the use case; see [11] for an impression of the implementation.
1.7.2.2 Validation of prototype

After the implementation and testing, the early prototype was validated extensively by airport stakeholders. In this validation, requirements that were defined in the methodology for the development of the early prototype were evaluated. To this end the SPADE Consortium prepared a template and a questionnaire to be filled-in by these stakeholders.

Several types of validation activities with different end-users were considered, each with their own questionnaires:

- Generic end-user validation (at workshops where limited exposure to the prototype was possible);
- Detailed end-user validation (dedicated visits to end-users);
- Technical assessment (prototype designers from consortium).
Several sessions with end-users in Athens International Airport, Madrid-Barajas Airport, and Malaga Airport were organised to bring the prototype under the attention of potential end-users of the system. Respondents were requested to fill-in the template and questionnaire, and to provide comments / clarifications to their responses. The consolidation of the individual assessment results and the determination of the end result of the assessment for each requirement were performed with the use of the mode value (i.e., the most frequently observed value identified in the completed templates) for each requirement. The validation was carried out in two ways:

- **Usability**: the identified stakeholders filled-in usability questionnaires to enable the SPADE Consortium to validate the prototype against usability standards;
- **Technical**: taking advantage of the technical knowledge gathered by the technical people involved in the prototype's design, a formal technical validation was performed for the prototype.

In addition to these sessions, two workshops were organised and Amsterdam Airport Schiphol, Brussels International Airport, and Aéroports de Paris were visited for a wider validation.

In general the validation feedback obtained was positive; see also Section 1.7.2.3. Lessons learnt and suggestions made by airport stakeholders during the validation exercise shall be incorporated into SPADE Phase 2. The results of the validation have been described in the public SPADE D5.3 deliverable [12].

### 1.7.2.3 Feedback on prototype

The SPADE Consortium presented and demonstrated the early prototype to various airport stakeholders through visits and two workshops (one in Brussels and one in Malaga). The participating airport stakeholders included:

- airports: Amsterdam Airport Schiphol, Asturias Airport, Athens International Airport, Brussels International Airport, Düsseldorf Airport, Frankfurt Airport, Lisbon Airport, Madrid-Barajas Airport, Malaga Airport, Milan-Malpensa Airport, Oslo Airport, Aéroports de Paris;
- airlines: IATA;
- air traffic service providers: Aena (Spain), Belgocontrol (Belgium), ENAV (Italy), NATS (United Kingdom), Spanish Civil Aviation Authority;
- governmental/research: MIT (United States of America);
- international organisations: EC, EUROCONTROL.

The visits and workshops were an appropriate and effective means for the SPADE Consortium to collect feedback on the SPADE Programme. In general airport stakeholders 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.

The SPADE Consortium collected all this feedback for use in Phase 2 of the SPADE Programme. This feedback has also been laid down in the public SPADE D5.3 document [12].

1.8 Intentions for use and impact
The main intention for use of the results of Phase 1 of the SPADE Programme is their use (as a starting point) in Phase 2 (i.e., the SPADE-2 Project) for the actual implementation of the SPADE system. Section 1.9 elaborates on this latter phase.

In the mean time the results of the SPADE Project are intended to interest airports and their stakeholders in the SPADE system, hereby further customising the system to their needs (e.g., needs related to the types of questions to be addressed and to the user interaction). This interest is and will be raised by presentations by the SPADE Consortium at various forums; for instance:

- interactions with related projects (e.g., CAATS) and EUROCONTROL;
- participation in conferences and exhibitions, e.g.,
  - Airport Operations Conference & Exhibition;
  - Dresden Conference of Traffic and Transportation Science;
  - Transportation Research Board Annual Meeting;
  - European SIMMOD User Group Meeting;
  - ATRS World Conference;
  - Aeronautics Days 2006;
  - Congress of the International Council of the Aeronautical Sciences;
  - IFAC Symposium on Control in Transportation Systems.
• organisation of workshops;
  ▪ SPADE Toledo Workshop;
  ▪ SPADE Brussels Workshop;
  ▪ SPADE Malaga Workshop.

• papers:
  ▪ Greek Logistics & Management Journal;
  ▪ Air Traffic Control Quarterly.

• visits to airports, e.g.:
  ▪ Aéroports de Paris;
  ▪ Amsterdam Airport Schiphol;
  ▪ Athens International Airport,
  ▪ Brussels International Airport;
  ▪ Madrid-Barajas Airport;
  ▪ Malaga Airport.

Also SPADE brochures, news letters, and the public SPADE web-site contribute to raising general awareness of the SPADE Programme and its intentions. All publicly available information and results of the SPADE Project can be accessed through the public project website (http://spade.nlr.nl).

The major argument to interest airports and stakeholders in the SPADE system is its strong and positive impact on two major key strategic aspects:

1. The improvement of the airport decision-making process quality through an integrated and systematic impact analysis of, e.g., capacity, delay, safety, noise, environment, and security.
2. The homogenisation and rationalisation of this process at a European level through addressing a standard set of questions or use cases related to airports. What changes from airport to airport is, of course, the airport data as well as a relatively limited number of assumptions that underlie the analysis.

In addition to these key strategic aspects, the SPADE Programme also responds to societal needs. For instance:

• The SPADE system will solve one of the major problems airport stakeholders face in working with information and software supporting tools: their complexity. In practice, the decision maker is interested in obtaining an insight and in examining alternative (even approximate) solutions and “what-if” scenarios into particular problems. Existing tools require substantial familiarity and prior knowledge to tackle their use, to build scenarios addressing the study objectives, and to
prepare the appropriate data sets pertaining to the given study and scenario. The SPADE Programme will create a true operation cushion between the "world and language" of users and the "technicalities" of the tools, and it can isolate the user from necessarily dealing with the peculiarities of tool design and be transparent to the user.

- The SPADE system will exhibit the capability of supporting airport-modelling decisions and identify potential sources of inefficiency of the airport operations. In effect, it is expected to boost the efficiency of total airport operations, thus reducing delays and the resulted "out-of-pocket" cost suffered by the various airport users, while indirectly improving employment and working conditions of the airport and air traffic management personnel. As a matter of fact, an improvement in the airport operations (e.g., reduction of delays, better slot management, demand smoothing, and reduction of congestion) will be, in turn, reflected on the working conditions in terms of the workload and anxiety related to airport personnel involved especially in critical safety activities.

- The SPADE system will support the improvement of safety and security of the air transport by a capability of performing specific safety / risk assessment analysis for particular airports. Safety considerations and formal procedures ensuring or monitoring the fulfilment of air transport safety standards are drawing the increasing attention of policy makers and aviation stakeholders. It is within the scope of the SPADE Programme to provide the user with the capability of performing specific safety / risk assessment analysis for particular airports. The main objective of this functionality will be to assist the user in a flexible and user-friendly manner to assess the risk levels and monitoring the safety of airport operations contributing to the improvement of the safety level within the airport borders and the residential area around the airport vicinity.

- The SPADE system will provide the capability of specifying noise exposure of the area around the airport. This feature of the system enables the user to assess the impacts of alternative enhancements and modifications of the airport infrastructure and the operational procedures that are currently in effect. In effect, it will contribute substantially to the reduction of the residents' disturbance due to the noise exposure produced by aircraft operations. Both of the aforementioned policy issues and social aspects (i.e., delays, slot management, safety, security, noise exposure) are considered to be major concerns of the European Community and they have received high priority for consideration among the objectives of past and on-going RTD (Research and Technological Development) projects.

At a more global level, the SPADE system is expected to fully consider and substantially contribute to the social objectives and needs of the European Community and support the establishment and promotion of the EU policies, as these have been set by the “White Paper on European transport
policy for 2010: time to decide" and other relevant regulations or proposals for regulatory establishments / amendments. Moreover, the SPADE system will allow addressing policy issues and regulatory aspects under the wide spectrum of the quality of life and the level of service provided to passengers, the safety and security dictates, the environmental policy and energy requirements, as well as the employment and working conditions. In summary, the expected SPADE contribution to the policy objectives and societal needs of the European Community are presented in the Table 2.

<table>
<thead>
<tr>
<th>Areas of Policy &amp; Social Interest</th>
<th>SPADE Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety / Security aspects and implications on airport operations</td>
<td>+++</td>
</tr>
<tr>
<td>Environmental concerns (e.g., noise)</td>
<td>+++</td>
</tr>
<tr>
<td>Airport capacity management (delays’ reduction)</td>
<td>+++</td>
</tr>
<tr>
<td>Airport demand management (slot management)</td>
<td>++</td>
</tr>
<tr>
<td>Airport infrastructure / investment planning</td>
<td>++</td>
</tr>
<tr>
<td>Airport pricing / charging system</td>
<td>+</td>
</tr>
<tr>
<td>Airport operational practices / concepts</td>
<td>++</td>
</tr>
<tr>
<td>Air Traffic Management</td>
<td>+</td>
</tr>
<tr>
<td>Collaboration of airport stakeholders</td>
<td>++</td>
</tr>
<tr>
<td>Dissemination of research outcomes</td>
<td>+++</td>
</tr>
<tr>
<td>Commercial exploitation of results</td>
<td>++</td>
</tr>
<tr>
<td>Development of educational / training activities</td>
<td>+++</td>
</tr>
<tr>
<td>Formulation of industry regulation</td>
<td>+</td>
</tr>
<tr>
<td>Consumer / passenger protection</td>
<td>+</td>
</tr>
</tbody>
</table>

*Table 2: Expected SPADE Contributions to the Policy Objectives and Societal Needs of the European Community. (The symbols (+), (++) and (+++) indicate the degree / importance of potential SPADE contribution in the particular areas of policy and social interest.)*

The SPADE Programme also contributes to the state-of-the-art (as described in Section 1.3) by addressing the open research issues and problems:

- Lack of seamless integration between existing tools able to provide airport studies (e.g., capacity, delays, safety, noise). The OPAL platform provides the ability to integrate capacity and delay-oriented models with others analysing the environmental, safety, and cost-benefit impacts of airport operations. However, tools are only partially integrated with respect to selected configurations of tools, which were practically modified to be able to interchange / communicate common data requirements. This, in turn, means that tools should be iteratively run by the user (not an automatic “back-office” procedure where the user only defines / selects a study (and possibly provides input data) and where the system takes care of all necessary computations and data transfers, after which the user in turn can select / inspect the information he / she needs), while the tool results are reported in a fragmented manner without capabilities of performing “trade-off” analyses. The SPADE concept of use cases is a research approach that
will produce a system for studying in a well-structured manner typical types of questions faced by decision makers and assessing trade-offs between airport performance metrics. The SPADE Programme aims to develop a harmonised computing environment and interface that will not require prior knowledge / expertise on the individual tools and their specific functionality, data sets and modelling approach, through built-in use cases.

- Lack of data / input harmonisation to enable interchangeability between integrated models. Within the OPAL project, a superset of the data requirements of the various integrated models was developed; albeit with considerable duplication, redundancies, and without a consensus on the description / modelling of the airport processes. The SPADE Programme capitalises on work performed within the APRON project, and it uses as much as possible standardised and harmonised data and indicators.

- Lack of harmonised / co-ordinated measures of effectiveness describing the performance of the airside and landside airport elements. Similarly, the SPADE Programme exploits the given synergies with the APRON project to set and adopt a standardised reporting system for the various performance metrics that will be provided through the SPADE Programme.

- Existing tools can successfully address all decision making levels and provide decision support to various airport studies, but they practically exhibit limited applicability and usefulness to high-level decision making in airport planning and design, on the grounds that they require in-depth technical knowledge and expertise for using them. In practice, the decision maker is interested in obtaining an insight and examining alternative (even approximate) solutions and “what-if” scenarios into particular strategic problems. Existing tools require substantial familiarity and prior knowledge to tackle with their use, build scenarios addressing the study objectives, and prepare the appropriate data sets pertaining to the given study and scenario. In effect, the capability of the tools to support strategic decision making is limited since they actually fail to deal with the study of essential trade-offs faced by the airport decision makers. The OPAL platform provided a proof of the concept of tool integration, but the issue of a user-friendly, decision support system for a practitioner (as compared to an academician) to assess strategic issues is still pending. This objective and challenging opportunity is tackled by the SPADE Programme through the identification of the set of use cases that should be implemented in order to provide answers to widely arising questions / problems.

Finally, the airport community relies heavily on standards. All technology, procedures and operations are at least standardised and harmonised locally. However, the European dimension of problems faced by airports implies that technology, procedures and operations have to be standardised and harmonised as a minimum at European level.
The SPADE Programme will be developed applying widely spread, commonly recognised, and proven standards and methodologies, guaranteeing a wide applicability of the SPADE results within Europe. Further, this programme will impulse the improvement and solution to problems on standardisation and harmonisation, as faced by airport stakeholders in their decision-making process, through:

- The development of standardised, commonly understood, and well-structured framework for describing and modelling the processes of the entire airport complex (with respect to different flows, actors, and airport elements covered) in order to systematically describe and document the airport system.
- The development of harmonised / co-ordinated measures of effectiveness describing the performance of the airside and landside airport elements.
- The development of data / input harmonisation so that a common database can be interchangeably used between integrated models.

In addition, the SPADE system can contribute to a standardisation of the airport decision-making process within Europe as the commonly accepted platform for airport decision-support at strategic and tactical / operational level.

1.9 SPADE Phase 2 - SPADE-2 Project

The next phase in the development of the SPADE system will be performed in Phase 2 of the SPADE Programme: the SPADE-2 Project. In this project, the SPADE system will actually be implemented, following the design of the SPADE Project, the lessons learnt in the development of the early prototype, and the feedback from airport stakeholders obtained through visits, demonstrations, presentations, and the various workshops.

The SPADE-2 Project is basically organised as follows:

- Transition
  The results and feedback of the SPADE Project are assessed to update and detail the activities to be performed in the SPADE-2 project.
- Implementation, testing and integration of generic system components
  The generic system components, i.e., components that are generic to the system and that may be used by different use cases (viz. input, output and computational component, and the airport data model) are implemented, tested, and integrated.
- Implementation, testing and integration of use cases
Each of the use cases is implemented and tested: its input and output interface, and its computational component. Furthermore, the implemented and tested use cases are seamlessly integrated into the SPADE system.

- Validation
  Any areas where the design and implementation of the use cases and the overall system do not properly support the provision of the functionality specified and the use case requirements are identified, and any correction is carried out.

- Field exploitation
  This activity concerns an operational assessment of the system by airport stakeholders in their real environment, and the determination of the future use and commercial exploitation of the final system.

- Dissemination
  The results of the SPADE-2 Project are disseminated to airports and their stakeholders, but also to other areas, if applicable. The dissemination activities include the organisation of User Group meetings, the maintaining of a website, and the organisation of a world-wide conference.

1.10 Conclusions
The SPADE Project accomplished its objectives, resulting in:
1. Complete design of the SPADE system;
2. Early prototype of the SPADE system.

The SPADE Consortium informed airport stakeholders on the SPADE approach and (intermediate) results. The stakeholders appreciated this approach and suggested to clarify how the system would fit within an organisation and to clarify the business models for exploiting the system. Furthermore, they

- consider the envisaged system as more decision (-maker) oriented than other systems;
- perceive the envisaged system as more user-friendly, since they do not have to interact with data-intensive and complex tools;
- can monitor the complete workflow of tools: the envisaged system does not add a black-box on top of the black-boxes inherent to the underlying tools;
- can perform integrated impact analyses: addressing different airport processes with their interrelationships and assessing trade-offs between different performance indicators;
- can improve their productivity of performing integrated airport studies through the automated connections of tools;
- can reduce errors through the automated connections of tools.
In conclusion, the results of the SPADE Project constitute a sound basis for the actual implementation of the SPADE system in the next phase: the SPADE-2 Project.
2 Dissemination and use

The SPADE Project is the first of two phases in the development of the SPADE system. Therefore the results obtained in this phase cannot be assessed in isolation. Nevertheless, some steps to be performed in the next phase have been identified in order to derive proper business models for this system.

In the first phase several exploitation activities have been conducted:

- Preliminary market analysis of current market situation for SPADE system
  To perform a preliminary market analysis of the current market situation for the SPADE system, the main decision-making requirements faced by airport stakeholders (in terms of policy making, planning, and operations), the software tools currently available in the market addressing these requirements, and the capabilities of the SPADE system in providing airports with alternative solutions to these requirements have been taken into consideration.
  In this analysis, the main target group of users of the SPADE system are categorised into groups:
  - Airport operators;
  - Consultants / modelling experts;
  - Policy makers and international bodies/associations.

- Preliminary list of possible business models for SPADE system
  For the targeted group of users of the SPADE system, an assessment has been performed whether they are potential buyers of the SPADE system (mix of use cases or entire system) or they are potentially making use of the services of the SPADE system without having to purchase the system. Each of these two options will result in a different business model.

- Main aspects for marketing plan of SPADE system
  The overall marketing plan of the SPADE system will include:
  - SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis: describing and analysis external factors (i.e., opportunities and threats) facing the airport management business and internal factors (i.e., strengths and weaknesses of the system);
  - Issue analysis: addressing each issue identified in the SWOT analysis;
  - Objectives: detailing financial and marketing objectives for commercialising the SPADE system for each of the business models;
  - Marketing strategies: defining the marketing mix (product, price, promotion, and place).

These activities will be elaborated and detailed further in Phase 2 of the SPADE Programme.
2.1 Presentations and publications

The SPADE Project has disseminated and published its (intermediate) results at various occasions and through various means:

- SPADE website: [http://spade.nlr.nl](http://spade.nlr.nl);
- SPADE Brochure and Posters (see website);
- SPADE Workshop:
  - Toledo (October 13-14, 2004);
  - Brussels (November 10, 2005);
  - Malaga (February 9-10, 2006).
- SPADE Presentation:
  - Airport Operations Conference & Exhibition (Brussels, October 27-29, 2004);
  - European SIMMOD User Group (Nice, April 7-8, 2005);
  - Conference of Traffic and Transportation Sciences (Dresden, September 19-20, 2005);
  - EUROCONTROL Airport Operations Team (Brussels, October 5-7, 2005 & March 29-30, 2006);
  - Transport Research Board Annual Meeting (Washington, January 22-26, 2006);
  - ATRS World Conference (Nagoya, May 26-28, 2006);
  - Aeronautics Days 2006 (Vienna, June 19-21, 2006);
  - Congress of the International Council of the Aeronautical Sciences (Hamburg, September 3-8, 2006);
  - IFAC Symposium on Control in Transportation Systems (Delft, August 29-31, 2006).
- SPADE Paper:
  - Article in Greek Logistics & Management Journal;
  - Article in Air Traffic Control Quarterly (Volume 13, Number 4, 2005).

2.2 Public deliverables


[3] SPADE D2.2: "Specification" (public version), The final version of this document has been combined with the results of the evaluation into an updated specification as laid down in the public D3.3 document.


[7] SPADE D3.2: "Evaluation Results" (public version), This document has been combined with the public D3.3 document.


[14] SPADE D6.2: "Validation Results" (public version), This document has been combined with the public D6.3 document


The public SPADE website is: http://spade.nlr.nl.