Chapter 20
The *Mainport Planning Suite*: Planning Support Software for Studio-Based Planning

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20.1 Introduction

The main ports in the Netherlands, such as the Port of Rotterdam (PoR) and Amsterdam Airport Schiphol (AAS), are important for the national economy. Sustainable growth and the commercial success of 'Mainport Holland', located in Europe's most densely populated area, is threatened by a lack of available land, a congested infrastructure, and an increasingly complex social, economic and political reality. To deal with these threats, the main ports are reengineering their planning processes. Instead of making plans based on an extrapolation of current trends, the aim is now to find answers to what-if questions which are applied to concurrent scenarios. 'Mainport planning' is like solving a large jigsaw puzzle, but unlike a conventional jigsaw, the pieces used to solve the puzzle are not available beforehand, and there is no single optimum solution. Solving the mainport planning puzzle is a difficult, lengthy, knowledge and information intensive, multi-actor process.

In this research we have developed the *Mainport Planning Suite* (*MPS*), an innovative planning support system (PSS) which supports user engagement and stakeholder participation in a mainport planning project. The underlying paradigm is what we call studio-based planning. Core to this paradigm is the notion of a studio: a facilitative environment which supports the blend between people, processes and technology. Hence we do not consider planning support as a solely technical challenge but instead we consider it from a process-oriented, multi-actor perspective which can be supported by information and communications technology. The challenge is to bring process and technology together to effectively support mainport planning projects.

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The research method is based on case studies as the main research instrument and design science as the research strategy. Whereas natural scientists and behavioural scientists try to understand reality, design science attempts to create things that serve human purposes. Natural science often consists of discovery and justification. Design science revolves around building and evaluating objects and systems. Hevner *et al.* (2004) stress the complimentary nature of both paradigms, as design relies on using existing theories. They state that design science is proactive with respect to technology, whereas natural sciences, or behavioural sciences, take technology as given. They strongly advocate a research cycle where design science is used to create artefacts aimed at solving specific information problems, based on relevant theory from the field of natural and behavioural sciences.

The relevance of this research became clear in a case study at the PoR (Smits *et al.* 2005). In 2004, the PoR and the Delft University of Technology jointly defined a case study which was focused on improving the effectiveness of port planning by means of planning support technology. We will use this case study to illustrate the ideas presented in this chapter. The PoR is responsible for developing and exploiting about 10,000 acres of the Rotterdam port and industrial complex. Customers of the PoR are, for example, container companies, petrochemical companies, bulk materials companies and distribution centres.

To be able to continuously control the development of the port, planning processes are of increasing importance. In the search for growth opportunities, the PoR continuously faces the scarcity of resources. For instance, the amount of available land within the port industrial complex has substantially decreased over the past few years. Nowadays there are hardly any large and unused areas left. Available land is mainly found in small sizes and widespread and is not always accessible from the waterside. Another issue is the increasingly dynamic, unpredictable and complex environment in which the PoR has to operate. The world is changing fast. Asia is booming, events like 9/11 lead to new requirements regarding safety and security, and new EU regulations increase the complexity of daily operations. Considering the scarcity of resources and the increasingly dynamic, unpredictable and complex environment, the PoR is actively developing more effective port planning processes. The PoR defines port planning as: *"the process of balancing the mutual relations between spatial planning, business development and environmental constraints and opportunities"* (Smits *et al.* 2005). In order to plan and design the port industrial complex taking into account the scarcity of resources, professional port planning is required. During our case study, we focused on a type of planning called area planning which deals with the development of a specified port area for a five to ten year period into the future.

This chapter is structured as follows. In Section 20.2, the concept of studio-based planning is introduced. In Section 20.3, the details of the research approach are elaborated. In Section 20.4, the design of our *MPS* is outlined, followed by the research results and an identification of future trends and future research directions in Section 20.5.

20.2 Studio-Based Planning

This research is based on a longstanding research tradition in Collaborative Business Engineering (CBE) at the Delft University of Technology. Business engineering deals with "*organizational transformation focusing on integral design of both information technology and organizational processes and structures*" (Hammer 1990; Maghnouji *et al.* 2001). In CBE, a combination of simulation models and group support systems (GSS) are used in a dynamic modelling approach (Babeliowsky 1997; Maghnouji *et al.* 2001). Simulation models are used to develop dynamic models of organizational processes and information systems. Simulation modelling tools provide an environment in which one can understand, analyse and improve the business process. Simulation outcomes are usually visualized using animations and graphs which allow the stakeholders to understand the model and communicate about it. GSS are used to assist a group in structuring activities, generating ideas and improving group communications (Hengst and Vreede 2004).

The research efforts in CBE lead to a richer image of a support environment for planning and decision making as introduced by Keen and Sol (2007) known as decision enhancement studios, or studios in short. Studios are facilitative simulation environments designed to enable executives to rehearse the future. As Keen and Sol explain, rehearsing the future rests on vision, envisioning shared images, collaboration and communication among people scattered across the organization. Studios are not simulation environments in the traditional sense of the word, instead in studios *"tools of technology and the analytic sciences are embedded in the processes and interactions"* (Keen and Sol 2007, p. 12). The concept of a studio can be compared with a television studio: a facilitative environment which merges people, processes and technology. Studio-based planning provides both horizontal and vertical support, i.e. it supports a wide range of stakeholders in the planning process, and it supports the leveraging of information through the different organizational layers. Studio-based planning is also closely related to ubiquitous computing. For example, Russell *et al.* (2005) explain how new ways of interacting with computers can lead to interactive workspaces and smart environments where people can work together in technology-rich spaces. Hence, we argue that studio-based planning focuses on two sides: the organizational, i.e. processes, roles, decision context, *et cetera,* and the technological, i.e. computer visualizations, simulation models, group support, etc.

Figure 20.1 shows the concept of studio-based planning. The studio is not at one location, but is dispersed over meeting rooms and offices in the organization. In that sense, a planning studio differs from a television or recording studio; the meeting rooms are not standard and equipped with tools that support planning. Instead, when a planning team occupies a meeting room they transform the room into a studio. A suite of software services changes a meeting room into a planning studio in a digital way; it offers services, tools, documents, maps, electronic agendas and so forth, through an enterprise information portal which hooks up to the corporate IT infrastructure. It sets up a dynamic network of IT services through which the

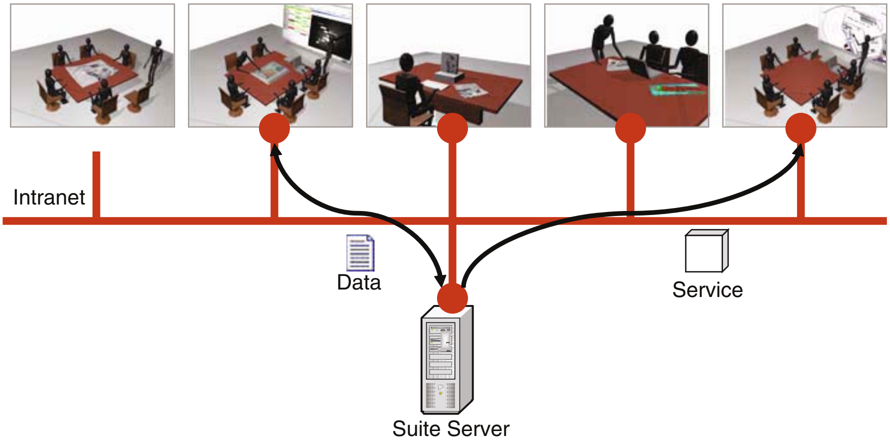

Fig. 20.1 A planning studio schematic

involved actors can access, edit and share information. It offers services for analysis, designing creative solutions, evaluating and choosing preferred solutions.
Studio-based decision support and planning encompasses:

- people: the actors representing a whole scope of disciplines and interdisciplinary dimensions in the context of the problem to be solved;
- process: a process founded in the method of simulation, guiding search towards a solution; and
- technology: suites of interrelated information and communication services, simulation instruments, analytic methods and visualization interfaces.

As Keen and Sol (2007) explain, a suite of software services is the foundation for meshing technology and process. It consists of domain-specific information and communication services, which form building blocks that support recipes for repeatable processes. In a way, a suite is a toolbox for studio-based decision making. A surgeon uses a specific toolbox to operate on a specific patient. Like the surgeon, an executive, planner or expert often faces different problems which require using a specific set of instruments. The choice of instruments will depend on the context, the roles of the involved actors, and possibly, the personal preferences of the managers involved. This is why we focussed this research on the development of a suite to support mainport planning. In the next section the research approach is introduced to explain how the *MPS* was developed.

20.3 Research Approach

This research was conducted in close cooperation with the PoR, enabling the design of the *MPS* in a realistic case study which lasted for about three years. Our focus was to develop a suite of software services to support area planning projects. In area planning, an inter-disciplinary project team of about six to eight experts develops a plan for a specific port area for a target period of five to ten years. This plan provides input to the various departments of the PoR.

The objective of this case study was to explore the needs of mainport planners in practice, which would help to sharpen our insights into the requirements of a suite to support mainport planning. Initially a project team was formed which consisted of four researchers from the University and three managers from the PoR, referred to respectively the TU Delft team and the PoR team. The author participated as one of the four researchers from the TU Delft team. The PoR team members were the first point of contact for gaining more insights into area planning. Regular meetings were held every two or three weeks to present design ideas to the PoR team. Furthermore the PoR Team was responsible for making this project known throughout the PoR's departments involved in area planning. They also provided names of experts who were available for interviews and discussions, and helped in organizing presentations of design ideas to the PoR's departments. In addition, at a later stage, a graduate student from the University was added to the PoR team and given the unique opportunity to participate, mainly as an observer, in a real planning project. The role of the student was that of a business analyst, i.e. to investigate and report on how the current planning process was conducted and to propose ideas for improving the planning process (Schalkwijk 2005).

The introduction of new technologies in area planning played an important role in this research. To provide a realistic impression of what studio-based planning means, extensive use was made of prototyping. Working software prototypes were used alongside slideshow presentations, which enabled ideas to be effectively transferred to the experts in the PoR. Throughout this research, prototypes were used in meetings with the PoR team, in interviews and discussions with individual experts, and in presentations for the different PoR departments. The software prototypes went through a number of iterations, partly based on a trial and error approach. Eventually, after about a year, the prototype converged to a more or less stable solution that could be used in an evaluation session.

Together with the PoR team, several ideas for a prototype evaluation were discussed. Ideally, the prototype would be used and evaluated directly in an ongoing area planning project. However, this would impose considerable risks to the continuity of such a project. Therefore it was decided to first evaluate the prototype in a controlled environment. A one-day evaluation session was prepared: a fictitious but realistic area planning meeting in which the different studio-based technologies would be introduced. The time to prepare this evaluation session was considerable, nearly half a year, for a number of reasons. First, a team of area planners was needed to participate in the session. Typically an area planning team consists of people from different departments. The PoR team needed to contact the different departments to find participants for the evaluation session. Second, a realistic storyboard needed to be developed in which the different technologies would be introduced. Third, after a team of participants was set up, they were actively involved in creating realistic content for the artificial area planning meeting. Fourth, based on the inputs of the PoR team, the prototype was fine-tuned for the evaluation session and the prepared content needed to be entered in an electronic database.

In the week before the evaluation session, the participants were asked to complete an online survey about their current way of working. On the day of the evaluation session, the area planners were guided through the storyboard supported by the prototype. Participant feedback was gathered through an electronic survey system, a group discussion, and individual interviews afterwards. Furthermore, the whole session was recorded on video.

After the evaluation of our prototype, it was decided to improve the prototype based on the feedback gathered. The improved prototype was presented to and discussed with the participants during several meetings about a year after the evaluation session, after which this research was concluded. In the next section, the details of the *MPS* design and prototype are outlined.

20.4 Design of the Mainport Planning Suite

We had the unique opportunity to develop a prototype *Mainport Planning Suite* in close cooperation with its intended end users. We extensively researched how area planning in the PoR is conducted in practice, by having interviews and discussions with experienced area planners and by observing area planning projects in progress.

20.4.1 The Area Planning Process

Area planning is a process in which the actors, the area planners, play different roles depending on their field of expertise and their contribution to the planning process. For example, roles that can typically be identified are project leader, domain expert, analyst, and facilitator. Area planning involves expertise in domains such as infrastructure engineering, geographical information systems, economics, strategic planning, environmental issues. Furthermore, area planning projects can last for about ten months, during which the project goes through several stages. First a project team is formed; then the area is analyzed and opportunities and constraints are inventoried. A number of workshops are scheduled to discuss alternative planning solutions for the area, and finally a final report, the area plan, is written.

Area planning is an iterative process in which the people work both individually in their offices, and together in multi-disciplinary team meetings. During this process a wide variety of information is used and produced. A common denominator throughout an area planning project is the use of geographic maps. A map of the area provides a common frame of reference to all involved area planners. Furthermore, paper maps are used as writing pads to sketch and communicate design ideas.

20.4.2 Challenges on Area Planning

During our investigation, a number of challenges in area planning came to light, both with respect to the planning process and the planning content. With respect to the planning process it was observed that, due to the duration of an area planning project, it is difficult to manage and keep track of the abundance of information and resources involved. The information is of many kinds and maintained by different individuals and departments. For example, geographic maps are prepared by the drawing department. During a meeting, area planners make sketches and annotations on the map, and after the meeting, the map is stored in the office of one of the area planners. When, after ten months, the area plan is written, it turns out to be difficult to find out when the map was made, who annotated it, and what was discussed in that particular meeting.

With respect to the content, it was clear that information of many different kinds needed to be integrated, compared and evaluated. Often changes in the area over time and the transition to the future situation are considered to be important, but it is difficult to incorporate dynamic effects and alternative scenarios in the planning process. Furthermore, creating an integral view on all the relevant aspects leads to an information overload.

20.4.3 Overview of the Design

The *MPS* was designed as a web-based solution, because of the fact that area planners work both asynchronously at their offices and synchronously in meetings (Chin 2007). The web-based solution requires the area planners to login to the project web-portal using a web browser. After logging in they are assigned a role based on their function in the area planning project. A distinction in roles makes it possible to assign functionalities to area planners which match their information needs.

Figure 20.2 shows a selection of the main software services provided by the *MPS*. Each of these services supports a different activity in the problem solving cycle (Sol 1982). We focused on the activities which fall inside the shaded box, because these are the activities which are conducted by multi-disciplinary planning teams, while the other activities are more mono-disciplinary in nature. The supported activities are analysis, finding solutions, *ex ante* evaluation and choice. A *Map* service was designed to support analysis because, in mainport planning, geographic maps are commonly used to analyze mainport areas. The *Sketchbook* service represents a digital sketchbook, or scrapbook to keep track of, compare and view alternative planning solutions. *Matchbox* is a visualization tool which helps multi-disciplinary teams in evaluating alternative solutions. Finally, *Aspect Explorer* is a tool which helps multi-disciplinary teams in choosing a preferred alternative solution. In the following sections each of the suite's services is explained in more detail.

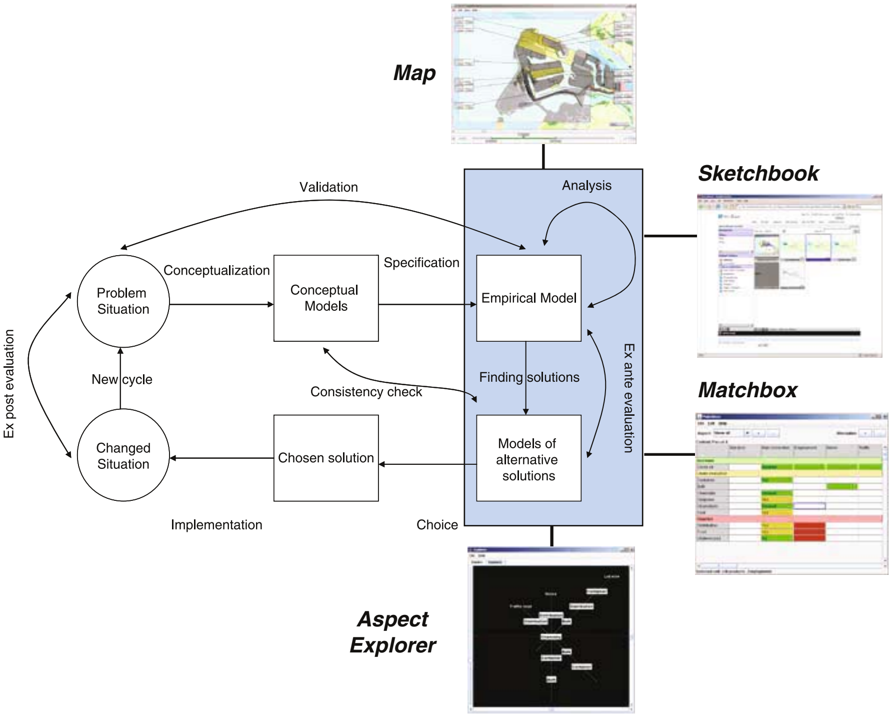

Fig. 20.2 *MPS* services and their relation to the stages and activities in problem solving

20.4.3.1 *Map* Service

During our case study at the PoR, it was observed that geographic maps are commonly used in area planning projects. During project meetings the team members use paper maps to analyse the port area and sketch design ideas. The disadvantage of using paper maps is that these are not properly documented and archived. The paper maps are produced by the PoR's drawing department on request of the area planning team. The drawing department is responsible for managing all geographic material that is used in the PoR. However, the paper maps used in area planning meetings tend to end up in the offices of the individual team members, because these are not 'official' maps. Yet, these maps contain important sketches and annotations. The *Map* service was designed specifically to address the needs of mainport planners. In close cooperation with experts in the PoR, the concept of an interactive map viewer was iteratively rethought and redesigned. The *Map* service is a web-based interactive viewer for both static and animated geographic maps as is shown in Fig. 20.2.

The Map service is meant to be a lightweight creativity tool instead of a full GIS system. The problem with the advanced GIS systems that we observed in the PoR, was that mainport planners were not trained to use these advanced systems. Hence, GIS analysts had to produce ready-to-use paper maps for planning meetings.

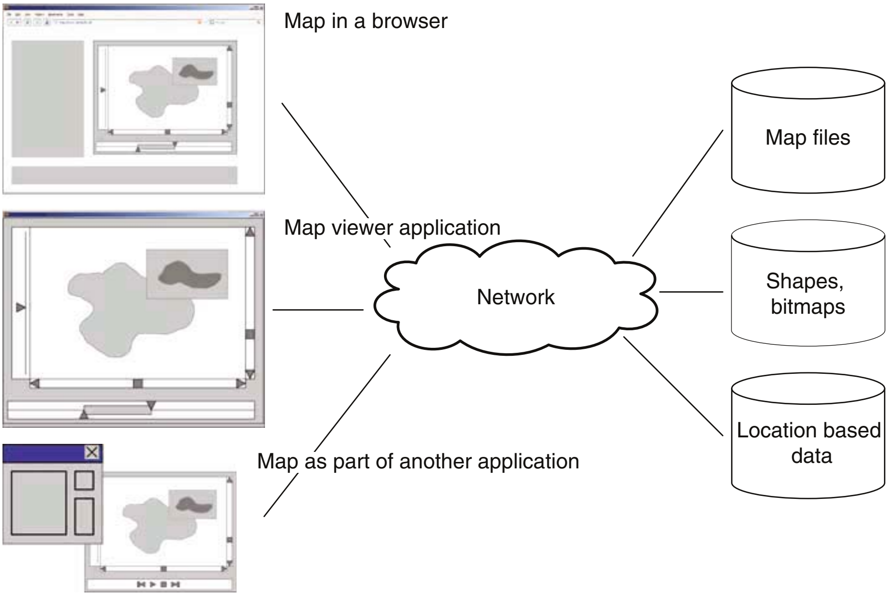

Fig. 20.3 Using *Map* in different ways to visualize and interact with distributed information

The mainport planners had no easy way of passing their annotated paper maps and design sketches back into the system. The Map service was designed to support the distinction between providers of maps and users of these maps, and to provide a relatively easy way of processing and displaying 'unofficial' maps. The distinction between providers and users of maps makes it possible to formalize the use of unofficial maps that are created by the mainport planners. Sketches and annotated maps are passed to the GIS analysts who can further process and archive the maps. Hence, instead of ending up in desk drawers, the annotated maps and sketches are made an integral part of the total collection of maps in a planning process, and they are managed by the GIS analysts. Furthermore, the Map service is a web-based tool. It makes geographic information available to mainport planners who work dispersed over the mainport's organization and who require web-based access to, visualization of and interaction with completely different types of information. Finally, the Map service is designed with the animation of temporal information in mind. While cartographic material usually consists of static images, data sets with a time-axis are not uncommon in mainport planning. The Map service provides functionality for binding layers of geographic information to time intervals. Hence the Map service can be used to display how a mainport changes over time geographically, and to display the animation of simulation outcomes directly on a map.

Figure 20.4 shows one specific example of how the *Map* service can be used in area planning, and especially how the Map service can be used to display temporal information. An area planning team may be interested to know which other projects overlap in terms of time and location within the area they are planning for. In this example, the *Map* service displays project boundaries for a certain time interval,

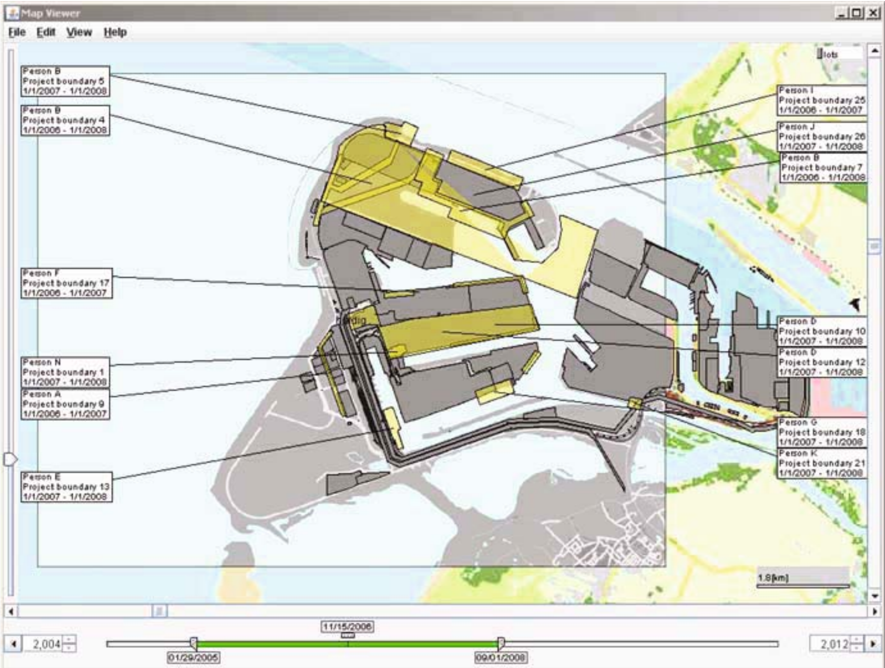

Fig. 20.4 Example of the *Map* service with contents of labels purposefully blurred

within a specific port area. The labels indicate the name of these projects, contact information and the time-span. The slider below the map represents a timeline that is used to manually select a time interval. When a time interval is selected, the map is automatically updated by displaying the corresponding project boundaries and labels. The selected time interval can also be dragged along the timeline to animate changes on the map over time.

On request of the PoR the contents of the labels contains only fictitious information. Furthermore this is just an example of one of the uses of the *Map* service. The same *Map* service has the flexibility to display totally different types of information when a planning team requires this for their specific planning project.

20.4.3.2 Sketch Book

The *Sketchbook* is meant to support indexing, filtering, viewing and interacting with information used and produced during a mainport planning process. In mainport planning, an abundance of information is used and produced. A substantial amount of information exists in the form of images such as geographic maps, diagrams, and graphs. Other forms of multi-media may also be used such as photographs, movies and animations. Typically, the available information is stored in distributed databases which fall under the responsibility of different departments and individuals.

It is not easy to manage and work with the abundance of information used and produced in mainport planning.

Sketchbook uses the metaphor of a paper sketchbook or scrapbook. Sketching, drawing up ideas and annotating images are common tasks for designers and mainport planners. In a paper sketchbook, all pages are connected, i.e. one needs to flip the pages to go from one sketch to another. Yet, this is not how designers like to browse through their information (Keller *et al.* 2004, 2006; Lugt 2001; Steenbergen *et al.* 1999). Designers like to create many different perspectives on the same information and they like to combine and compare very different types of information. They put images on the table, stick them to the wall, show them on an overhead projector, use a computer to generate 3D images or do all this simultaneously. They create storylines by putting images behind each other and annotating them. They make choices by comparing images spread out on the table and marking them with sticky notes. They create structure by creating stacks of images in different categories. Designers rip the pages from their sketchbook, but this makes it difficult to keep track of and organize the information in long term mainport planning processes. Furthermore, *Sketchbook* is meant to offer mainport planners the freedom they need to combine and compare information of many types creatively, without the danger of loosing track of information during the mainport planning process. Sketchbook does not have pages in a fixed order, but provides many different viewpoints on information.

The design of *Sketchbook* is shown in Fig. 20.5. Three main sections can be distinguished in the user interface: viewpoints, virtual folders and a content area at the right side. The viewpoints section is used to select a specific view on the data that is shown in the content area. The virtual folders section is used to filter and structure the data, such that a user can select different subsets of data. Although *Sketchbook* looks like a file manager such as those found in the major operating systems, it differs from a file manager in the sense that the data itself can be aggregated from various dispersed file systems. Virtual folders are not directories in a files system but represent queries over possibly a number of directories. The content area displays the selected data using a specified viewpoint. In Fig. 20.5, the data are displayed as little thumbnail images, similar to a file manager. However, *Sketchbook* can, for example, also display the data based on geographical location using a map. The data represents relevant content which is used and produced during a planning project, e.g. maps, photos, simulation models, and images.

For our test session we implemented a web-based version of *Sketchbook* that supported a limited set of viewpoints. It was capable of indexing distributed data such as images, geographic maps, and models. The user could define virtual folders and organize the data in these virtual folders. Furthermore the data could be displayed in different viewpoint implementations. We could display the data as little thumbnails and on a geographic map when it was bound to a geographic location. Consequently we consider our Sketchbook prototype as a working proof of concept. Later on other viewpoints should be implemented to better support the needs that were described above.

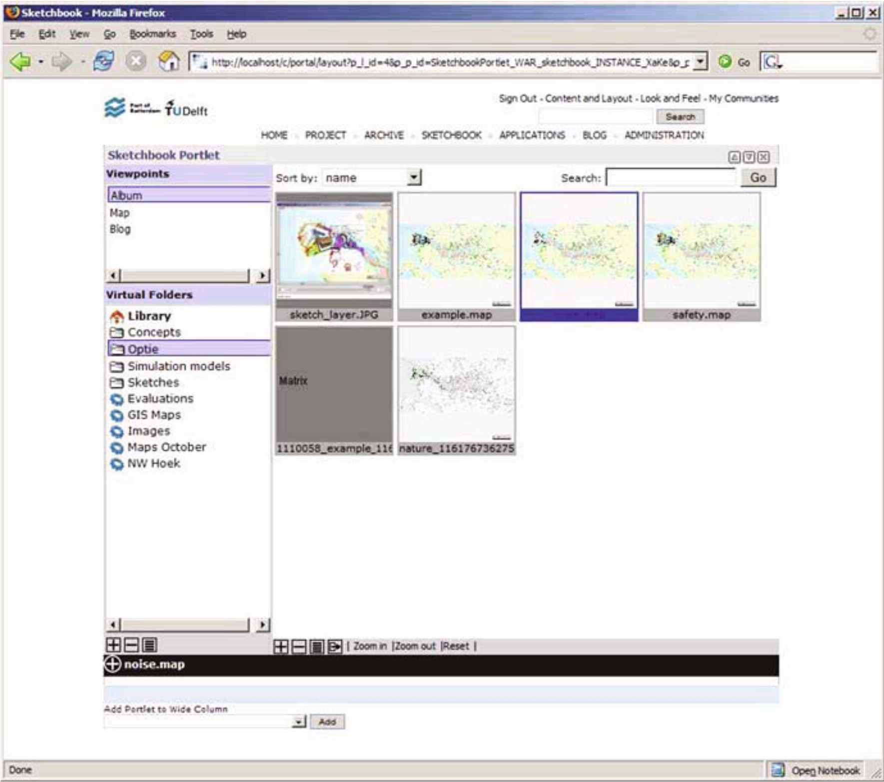

Fig. 20.5 The *Sketchbook* interface

20.4.3.3 Matchbox

Matchbox aims to support the evaluation of alternative solutions in mainport planning. It has been designed in close cooperation with the mainport planners in the PoR and visualizes the status of a multi-disciplinary evaluation process in which numerous aspects need to be compared. *Matchbox* supports different domain experts in the evaluation of a large variety of aspects and alternatives. *Matchbox* supports both quantitative and qualitative considerations in the evaluation of alternative-aspect combinations. The knowledge and information to make an evaluation is related to both possibilities and preferences. In some cases there are hard quantitative constraints which may not be violated by an alternative solution. Sometimes, counter measures can be taken to overcome hard constraints. Yet in other cases, the constraints are more related to what is desirable instead of what is possible (or impossible), i.e. the constraints are more qualitative in nature. *Matchbox* supports a multi-disciplinary team of mainport planners in making a distinction between accepted and rejected alternatives. *Matchbox* visualizes how far an evaluation has progressed and where there are still open issues that need to be addressed.

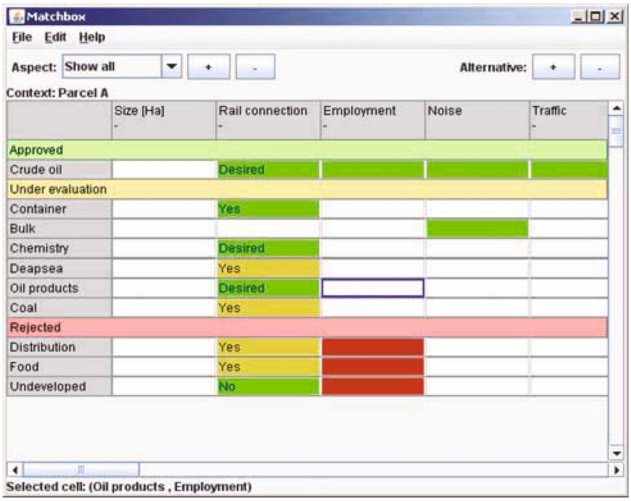

Fig. 20.6 Example screen in *Matchbox*

The design of *Matchbox* will be explained based on Fig. 20.6. Suppose an area planning team made an extensive analysis of a port area, and they came to the conclusion that a land parcel 'A' will be rented to a new customer. Now the team wants to evaluate possible industry types for parcel A. In *Matchbox,* they define the industry types as rows, and they define the different aspects under consideration as the columns. As such they specified a matrix of alternative industry types versus relevant aspects. Next, the individual experts can enter key values in the cells of the matrix. These key values indicate the expected requirements of each alternative-aspect combination. The values can be numeric values, ranges, or textual indicators. Next they compare the key values with the characteristics of land parcel A, and decide if there is a match between the required value and the respective characteristic value. A colour coding is used to visualize the result: green: possible or desirable; yellow: unclear/needs further research; red: impossible/undesirable; and white: not evaluated. An expert can also type 'behind' each cell comments as to why he or she applied a certain colour coding.

After the individual cells are evaluated the planning team can approve or reject alternative solutions. The evaluation of all aspects by a multi-disciplinary team is supported by three distinct categories: approved (alternative solutions that fit the context); under evaluation (alternative solutions that should still be evaluated); and rejected (alternative solutions that are rejected for the specified context). These categories are used to group the available alternatives. In the beginning of the evaluation, all alternative solutions are in the category 'under evaluation'. As the evaluation progresses and more information becomes available, the alternatives are either moved to the 'approved' category or moved to the 'rejected' category. This is done manually by a team member based on the outcome of a mainport planning team negotiation. Finally, no alternative solutions should remain under evaluation. Note that Matchbox only visualizes the status of an evaluation process. No weight factors are used, and no answer is provided by the tool itself.

20.4.3.4 Aspect Explorer

Aspect Explorer has been developed to support making a choice between viable alternative solutions. Whereas the outcome of *Matchbox* is a list of viable alternative solutions, a planning team still has to choose a preferred solution. When there is only a small number of viable solutions and relevant alternatives, the team can probably easily decide which solution they prefer. As the number of alternatives and aspects becomes larger, it becomes more difficult to make a choice among alternative solutions.

The design of *Aspect Explorer* is shown in Fig. 20.7. In essence *Aspect Explorer* is an exact implementation of Spence's neighbourhood explorer. Spence (2001) demonstrated how this visualization concept can be used to make a choice among houses that are for sale without the need to quantify the available information. Two screens are shown in Fig. 20.7. The left screen is used by an individual expert to specify a preference order of alternative solutions when considering a specific aspect. For example, as shown in the figure, a preference can be specified for 'lot size'. In this case the expert has a preference for 'distribution', followed by 'chemistry', 'container' and finally 'bulk' as his/her least preferred alternative. Next, the right screen shows how the alternatives compare based on the different preferences that were specified. The alternative solutions are presented on each axis. The alternative solutions are sorted top to bottom for each aspect with the most preferred alternative on top and the least preferred alternative at the bottom. When sliding one of the alternatives to the centre of the diagram, one can see how it relates to the other alternatives for each aspect.

Spence's visualization concept was chosen to support making choices in mainport planning because it provides a shared visual representation that allows for a purely qualitative comparison of alternative solutions. *Aspect Explorer* can be used to show the preferences of domain experts regarding viable alternative solutions in a single

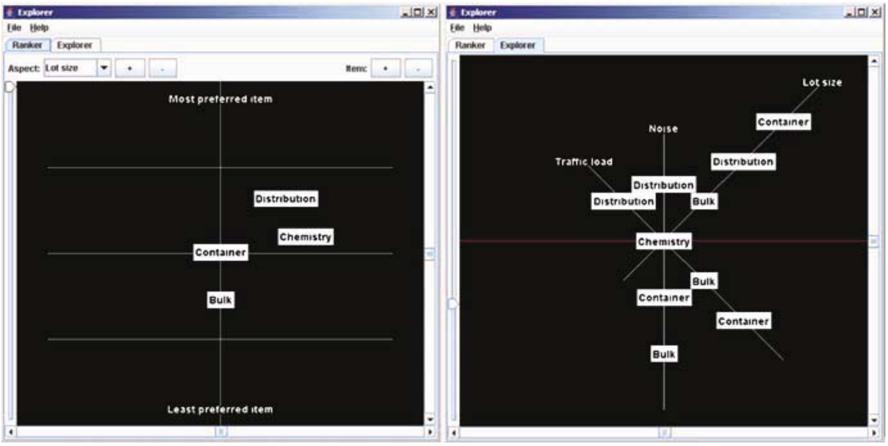

Fig. 20.7 Example interactive screens of *Aspect Explorer*

(interactive) image. The result is that it is possible to show specifically how the mainport planning team as a whole sees the solution space.

20.5 Conclusions and Future Directions

Based on the feedback, the *MPS* was perceived as a useful and innovative contribution to mainport planning (Chin *et al.* 2005, 2006). We conclude, based on the outcomes of the questionnaires, discussions and interviews that the *MPS* is expected to positively contribute to the awareness of the information used and produced in area planning. An *MPS* is expected to change the way of thinking about area planning in the port: it will lead to thinner, more to the point plans which can be updated in a 'rolling manner', i.e. at regular intervals. While planning outcomes are traditionally documented in a static planning report, it is expected that in the future advanced IT systems can be used to dynamically query specific and up-to-date planning data. Experts in the PoR clarified that, in their opinion, an *MPS* will become a 'memory of the organization'. Furthermore the participants of the evaluation sessions said that the *MPS* was also useful in planning projects other than area planning.

Designing an easy to use *MPS* is a balancing act between introducing structure and maintaining creative freedom. On the one hand, a *MPS* should support the structuring and archiving of the information which is used and produced during the planning process, but on the other hand, an *MPS* should also stimulate the creativity needed to find alternative solutions. The participants of the evaluation session said that they felt that the bureaucracy introduced by an *MPS* could potentially harm their creativity. However, the same participants also recognized the need for a more structured and rational approach towards area planning. Thus the support offered by an *MPS* should be carefully tuned to the roles of individual mainport planners, i.e. a secretary should be provided with different services than, for example, a GIS analyst.

Another issue with respect to the ease of use of the *MPS* solution deals with the available hardware. During the evaluation session, laptops and projectors were used to support the area planners. Laptops and PCs are typically designed to support the interaction between a single human and the machine, and not a group of people. To overcome this limitation, projectors were used to present information to the whole team of area planners. However, the participants indicated that they felt that they lost touch with each other, i.e. body language and face-to-face conversations, when watching a projection on the wall. A future trend which may help to overcome these limitations is the recent interest in multi-touch displays. For example, *Microsoft*® recently introduced *Surface*™ computing, which uses a computer in the shape of a coffee table where the table top is a large multi-touch display. Hence, the users do not sit in front of a monitor, but they sit around a display that is integrated in a table. Furthermore the display is touch-sensitive, meaning that users can use their fingers to click on, or drag displayed items. Such new types of human-computer interface will be more suitable for supporting teams of people during complex planning processes.

The iterative design approach, in close cooperation with mainport planners and experts in the PoR, positively contributed to their attitude towards using of the *MPS*. The response team at the PoR could provide quick insights into best practices, open doors to departments that would otherwise remain closed, interest people throughout the organization in studio-based mainport planning, and provide feedback on design ideas and prototype implementations.

Based on this research, a number of future research directions can be identified. First, mainport planning depends, for a substantial part, on data which is produced by computer models, e.g. simulation or analytical models. These models are managed and executed by individual experts inside departments, while during an interdisciplinary team meeting only the outcomes of the models are made available. Modelling in real-time, in a planning meeting, still remains a challenge for future research. Second, it was mentioned earlier that an *MPS* could become a system that, instead of a static planning report, can be queried by different actors for specific and up-to-date information. This raises the question if it is possible to automatically generate useful reports and presentations of the latest planning data available. In other words, it now takes month of work to create a planning report as the outcome of a planning project. Would it be possible to dynamically generate useful reports while planning is being conducted? Third, a structured evaluation session was used to evaluate the *MPS* prototypes, but we did not achieve an institutionalization of the *MPS* in the PoR during this research. Although a substantial amount of new insights were gained from this research, further research is still required to study how an *MPS* can be used on a daily basis, and to evaluate its long-term contribution to mainport planning projects. Finally, several participants at the PoR mentioned that an *MPS* could prove to be useful in projects other than area planning; hence we conclude that further research is needed to investigate the generalizability of the *MPS* solution.

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