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**Designing a Decision Enhancement
Studio to support the complex logistic
planning process of pipe supply**

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Designing a Decision Enhancement Studio to support the complex logistic planning process of pipe supply

PREFACE

Over the past 6 months I performed my Master Thesis project at Heerema Marine Contractors. This Master Thesis project is the final project for my master Systems Engineering, Policy and Management.

During this research project, the aim was to give insight in how the effect of decisions in Heerema's logistic planning process for pipe-lay projects can be acquired. Using the design science perspective, the goal was to acquire that desired insight by intervening in the process by implementing a support system. Due to time constraints the result of my Master Thesis Project is a promising concept for the support system, evaluated by prototypes. The project as a whole is still unfinished.

These results would never be achieved without good supervision. Within Heerema I would like to thank my coach ir. C. Berends for his support during the stages of my project. Next I would like to thank ir. F. Lange for giving me the opportunity to perform this project and his support on writing the business case. Especially I would like to thank everybody that contributed to my interviews and questions.

From the TU Delft I would like to thank dr.ir. G. Kolfshoten for supporting me during the project. Finally I would like to thank dr. J.H. Slinger and prof.dr.ir. A.Verbraeck for their advice.

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TERMINOLOGY AND ABBREVIATIONS

In this chapter the most used terminologies and abbreviations are defined to acquaint the reader with their meaning.

Terminology

<i>Actor</i>	An actor is a stakeholder that is directly involved in pipe-lay projects. Some actors are involved in the decision making on the logistics planning process, while other actors fulfill other tasks in pipe-lay projects.
<i>Analyst</i>	The analyst/ researcher is the person who designs the support system by neutral observation of the current process and the desires of actors. This will be done in co-operation with the client Heerema Marine Contractors. The author of this report has the role of the analyst.
<i>DES</i>	Decision Enhancement Studio (DES) refers to a facilitative environment where decision enhancement is achieved. It helps decision makers in using appropriate simulation models, information systems, analytic methods and tools in their decision process (Keen and Sol, 2007).
<i>Decision maker</i>	The decision maker is an actor that is responsible for certain decisions in the logistics planning process.
<i>Logistics</i>	Logistics is about efficient and effective inventory management. Logistics focuses on the organization, planning, steering and execution of flows of goods, information and money.
<i>Logistic plan</i>	In this study the logistic plan consists of the exact information on what should be loaded when and where on a barge (barge lay-out) and when the barge should leave the yard.
<i>Process</i>	The course of actions taken to fulfill a certain task is termed the process. This research focuses on the logistic planning process. The aim of this process is to develop a logistic plan.
<i>Prototype</i>	The prototype can be an initial execution of the support system. In this study it refers to an incomplete execution of the support system, with the intention to show certain functionalities of the suggested support system.
<i>Stakeholder</i>	Stakeholders have less influence on the decisions to take than actors, however they are concerned with the outcomes. An example is the client of pipe-lay projects.
<i>Support system</i>	The system giving an overview of- or insight into the effect of choices on the logistic plan process of pipe supply.

System The aspects considered relevant to involve in the research are inside the scope of the research. The scope defines the system to study. The scope is described in chapter 4.1.

Abbreviations

EPIC	Engineering, Procurement, Installation and Commissioning
HMC	Heerema Marine Contractors B.V.
IT	Information Technology
PE	Project engineer
Planning T&I	Planning Transport and Installation
PM	Project manager
PPD	Pipeline Production Department
SADT	Structured Analysis and Design Technique
SIP	Sub sea Infrastructures and Pipelines department
TAM	Technology Acceptance Model
QESH	Quality, Environment, Safety and Health

Pipe sections:

SJ	Single Joint (1 section)
DJ	Double Joint (2 sections)
QJ	Quad Joint (4 sections)
HJ	Hex Joint (6 sections)
MJ	Multi Joint (more than 1 section)

SUMMARY

Logistic planning process characteristics and research objective

The design of a logistic plan for pipe and structure transport for deepwater pipe-line projects lacks transparency. There are causes for this lack of transparency: the decisions are based on intuition and 'rules of thumb', lack of time to generate more alternative plans, based on incomplete information, and situated in a complex environment since there are many departments and uncertainties or risks involved (e.g. weather conditions, breakdown, etc.). The process is experienced as a frustrating task, due to recurrence of calculations. This is caused by the dynamics of the information: tender specifications are often incomplete and the design of the construction is further developed during the logistic planning process, causing revisions.

Anticipating on the future challenge of Heerema; performing pipe-lay projects in to them new regions with harsh weather conditions and ultra deep complex pipe constructions, their intuition and 'rules of thumb' might lack the guarantee of success. Therefore Heerema needs overview of- and insight into the effect of decisions they make in the logistic planning process. Consequently the research question is: *How can overview of- and insight into the effects of decisions, with respect to the pipe/structure-logistic planning process for pipe-lay projects, be achieved?*

Research method

Within the selected paradigm: design science. The solution space is narrowed down to designing a support system, which fits the paradigm, as this paradigm is focused on intervening in a situation and measure the results of that intervention. The research approach of Hevner et al (2004) is applicable. This method stimulates to rigorously select appropriate knowledge and methods, which is as well relevant to improve the logistic planning process. Since the aim is to design a support system, the research method of Takeda (1990) was used which consists of the following steps:

- First, a profound analysis of the current situation was accomplished; using explorative interviews, observation of current tools and processes (awareness of problem).
- Secondly, from this analysis the requirements for the support system were derived.
- Thirdly, from the literature the methods and techniques applicable to the support system were identified based on these requirements (suggested support system).
- Fourthly, this suggested design was developed in an iterative manner using prototypes.
- And finally, each prototype was evaluated by the experts and users, which have led to revisions in the requirements.

Research results

The first result is the list of requirements, which are derived from the profound analysis of the current situation and desires. According Keen and Sol (2007) effective decision support rests on usefulness, usability and usage of the system. The requirements are defined within these three basics to stimulate effective support:

Usefulness The support system must visualize information in such a way an objective decision between alternative logistic plans can be made, therefore the system must give insight in the project criteria (net-profit) and predictability. The support system must integrate the dynamics in information supply (varying from incomplete, to very detailed information). And the system must show the effect of uncertainties and risks on the project results.

- Usability** The support system must be as flexible to be usable for different projects (90% of the projects). To streamline the process, the system must enhance dealing with different perspectives (multi-actor), the system must stimulate the development and comparison of alternative logistic plans and must be transparent and intuitive in usage, otherwise the risk occurs that the actors do not use the system in the right way or not at all.
- Usage** To promote the use of the system the system must remain practical, show the prior conditions, and generate accurate output. The system must support the complete design phase; therefore the system must be open for creative solutions and provide and connect different calculation tools. To stimulate usage, the system must be easy to use to the actors (Davis, 1989).

Design specifications

The requirements formed the basis for the design of the support system. As the support can vary from group support (multi-actor) to basic calculation support, consequently different tools could be chosen. Since there is no one tool that fits all these requirements, a Decision Enhancement studio is designed, in which a suite containing different decision tools is available. Figure 1 shows the designed process and the tools connected to that.

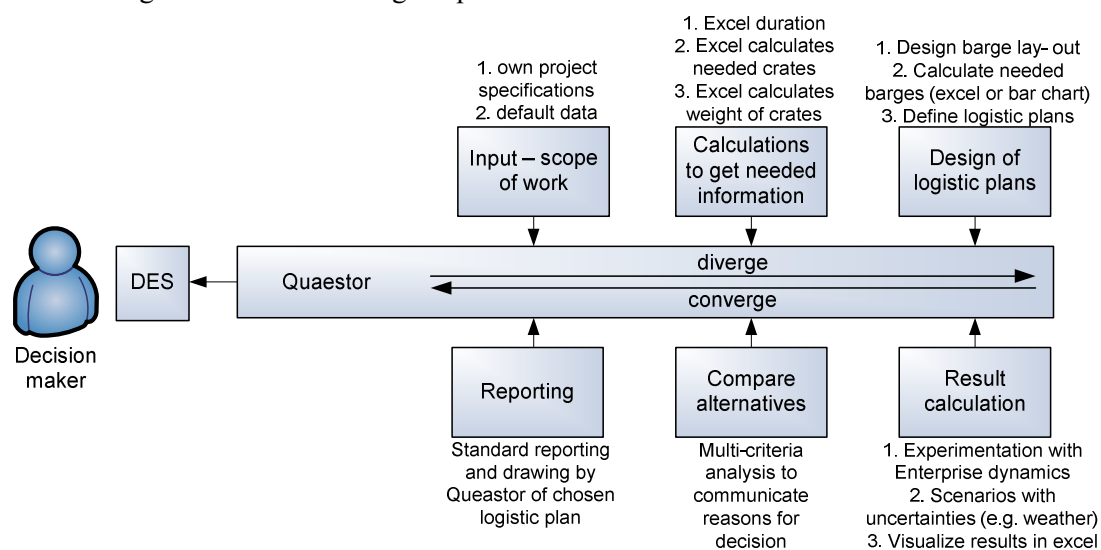


Figure 1 Overview of the Decision Enhancement Studio

Quaestor forms the basis of the support system; this is a knowledge based system that is able to streamline analysis, design and engineering processes (van Hees, 1997). The new process, which diverges (generate plans) and converges (select a plan), is based on goal-oriented focus (Hammer, 1990) to fit the aim of achieving insight in the effects of decisions. All different tools can be connected to Quaestor.

1. *Input*: First the input is defined; this can be based on 'default information' and calculation rules that are available in Quaestor. This can help to deal with generating a robust plan, when the information is incomplete. For example when the dimensions of a structure are unknown, the calculations can be based on average structure size related to the diameter of the pipe. These dimensions can be varied, to test the robustness of the logistic plan.
2. *Calculations*: from the input data, certain information is needed to design a logistic plan (e.g. the number of pipes that fit in a crate, the weight of a loaded crate, etc). The

current calculation spreadsheets and rules are used in Quaestor to accomplish this step for the decision maker. The advantages of using their spreadsheets are: it keeps the calculations transparent, easy to recalculate and easy to adapt to exemptions.

3. *Design logistic plans*: different logistic plans must be designed based on these decisions: type of barge, pipe-lay vessel, yard location and workability, project location, sequence of the pipe-lay and to combine or separate the transport. Different alternatives can be generated and the needed number of barges can be calculated. In Quaestor the constraints on generating a logistic plan are visualized to ensure only realistic plans are designed. For example: a constraint can be the depth of the barge compared to the allowable depth in the yard.
4. *Result calculation*: the estimated results (based on net-profit and predictability) of the logistic plans can be gathered using discrete event simulation. In this type of simulation, the effects of uncertainties and risks can be computed, using imitations of the weather conditions for example. The visualization of the results is important to stimulate objective decision making, therefore the distributions of the duration and the correlation between project cost and duration are visualized as this gives insight in the predictability (Feng et al, 2000).
5. *Compare alternatives*: to communicate the reasoning behind a decision, the alternatives must be compared. When there is no agreement, a multi-criteria decision tool can depict the decision of certain departments based on the weights they allocate to the criteria. This increase the transparency of the reasoning behind the decisions.
6. *Reporting*: fortunately reporting and drawing programs can be connected to Quaestor to automate the standard reporting steps. This will save time, and decrease the frustration recurring tasks caused by revisions in the scope.

Evaluation

The functionality of the support system was evaluated by experts and users. Their reaction was very positive; they would recommend others to use the system assuming it gives accurate information, fits 90% of the projects and can be embedded in the organization. The designed support system is therefore seen as promising, and is recommended to further develop the support system. The main risk is the culture difference between the current way of working (generate and improve one alternative based on intuition) and the designed process (diverge-converge). To accomplish the intended use of the system, the behavior of the users must change. If the system is implemented using the current way of working, the main advantage of generating alternative plans to create insight into the effects of decisions remains unutilized. Consequently it is very important to embed the system in the organization; otherwise the project can fail.



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CHAPTER 1 INTRODUCTION

Heerema Marine Contractors started in 1948 in the construction and installation of offshore drilling platforms in the oil industry (HMC Technology department, 2007). Since the last 10 years, the installation of deepwater infrastructures is part of Heerema's expertise. Deepwater infrastructures include pipelines for the transport of, for example oil, mooring lines, and structures to create complex pipeline networks (including end-structures or inline-structures). Heerema excels in complex deepwater pipe-lay projects. The main characteristic of these pipe-lay projects is the repetition in the project preparations, as the specifications and context of several projects slightly differ. This increases Heerema's ability to learn from their experience, which can improve their expertise.

1.1 Future challenge – Moving outside the Gulf of Mexico

Currently Heerema performs these pipe-lay projects in the Gulf of Mexico. But in the near future they are involved in projects in West-African and possibly Arctic regions. The lack of experience and the more harsh and difficult weather conditions in those regions increases the complexity and uncertainty of those projects. This is the main challenge Heerema faces for the future.

1.2 Current challenge – Lack of transparency in the effect of decisions

In daily practice Heerema faces the challenge which can be summarized as a lack of transparency in the decisions involved in the logistic planning process. The logistic plan contains all the details of the transport of pipe sections and structures from the yard to the pipe-lay vessel. The lack of transparency arises from the inefficient and unpredictable nature of the logistic planning effort. Decisions are based on incomplete information (especially in the early stage of the planning effort) and intuition. Revised information has as effect the recurrence of calculations, which makes the logistic planning a frustrating task. In particular when different options and alternatives should be compared, the effects of decisions remain unknown. Consequently the opaque and ill-structured reasoning for certain decisions makes the decision process results below its potential to learn and share the knowledge.

1.3 Research aim

Dealing with complex and ill-structured logistic planning processes, the aim of this study is to give more insight in the effect of decisions involved in the process. The research question is therefore: *How can overview of- and insight into the effects of decisions during the pipe/structure-logistic planning effort for pipe-lay projects, be supported?*

The aim is to support the decision makers in improving their decision making by giving better insight in the effects of decisions on their final logistic plan. Therefore the solution can lie in decision support systems, which aim to improve decision making processes (Arnott and Pervan, 2005). Also simulation methods form a fruitful approach to deal with complex and ill-structured problems (Sol, 1982). By approaching the problem with this perspective, the suitable research approach consequently lies in the design science paradigm. In design science the purpose is to describe and improve the reality through constructive intervention (Vaishnavi and Keuchler, 2007). Within this paradigm the research approach is focused on research relevance (towards the environment) and research rigor (based on the theoretical foundations and methods) (Hevner, et al. 2004). For the research the trade-off between relevance and rigor will

form a challenging tension. It must be stated that by choosing the design science paradigm as the approach, the solution space is decreased to the solutions within this narrowed perspective.

Next to the design of the support system, the redesign of the decision process is of relevance in this study, because a side effect of Information Technology (IT) is the ability to reshape the way business is done (Davenport and Short, 1990). This fits the aim of research relevance, because the new support system must add value to the decision environment.

1.4 Report structure

In this study, the method of design research is adopted because this method is applicable to the development of artifacts, which is a support system in this study (Takeda, 1990, see figure 1.1). This method forms the structure for the analysis and report of this study. The needed theoretical background is not gathered in one chapter but clarified there where it is applied to show the rigor-relevance trade-off for each design step. The steps of design research are problem awareness, design suggestion, development of artifact and evaluation. The development is an iterative process where expert and user involvement is stimulated; ensuring problems or dissatisfactions are identified and solved early in the process.

To answer the research question, chapter 2 explains in more detail Heerema's organization around pipe-lay projects. This is to give more insight in the challenge at hand. In chapter 3 the research questions and overall research approach and methods are defined. The analysis of the current situation results in a process and risk overview, using explorative interviews, case-studies and observations of the current tools and processes. This overview is described in chapter 4. Next the decisions from the overview are categorized, to explain where improvements are possible (chapter 5). With the insights of chapter 4, 5 and from those

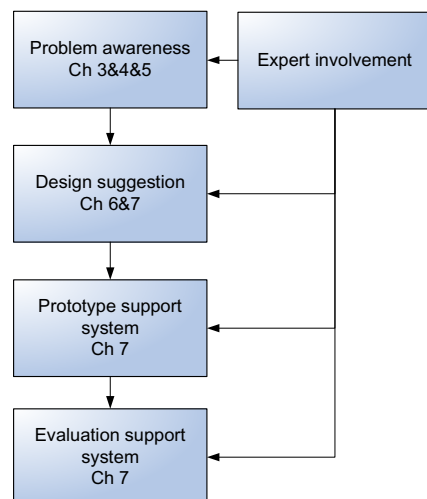


Figure 1.1 Research method (Takeda, 1990)

interviews the requirements for the support system are defined (chapter 6). These requirements are used to design the support in chapter 7 according to the design science method of Hevner et al (2004). With this suggested support system, the functionalities can be evaluated with the experts in an iterative manner, leading to successive revisions and a more detailed prototype. This final prototype of the support system is evaluated with the employees (experts and uninitiated employees) (chapter 7). Finally chapter 8 gives a specification of the prototype concept and the key factors for successful implementation. In chapter 9 gives a first sketch on how to ensure the system will be implemented, focusing on change management. The study concludes with the conclusions, recommendations and a reflection on the study (chapter 10 and 11).

CHAPTER 2 CONTEXT OF PIPE-LAY PROJECTS

The aim of this chapter is to provide insight into the expertise of Heerema Marine Contractors (HMC). For this thesis project the focus is on pipe-lay projects and the difficulties of the logistic planning process. Unless mentioned otherwise, the information in this chapter is based on informal interviews with Heerema's employees.

2.1 Heerema Marine Contractors Expertise

Heerema started in 1948 as a company specialized in the construction and installation of drilling platforms for the oil industry (HMC Technology department, 2007). Until the seventies Heerema focused on increasing lift capacity and stability, because this decreases the costs of platform installation. Now heavier units could be installed, reducing expensive offshore construction hours (HMC Technology department, 2007). Still in the winter months construction work was impossible due to the sensitivity of the vessels to wave motions. In the late seventies, Heerema designed their “semi-submersible” crane vessels (e.g. Balder), which are less sensitive to wave motion and have a increased lift capacity 10 times that of the older vessels (HMC Technology department, 2007). Late nineties, the Heavy lift vessel Balder was transformed into a deepwater construction vessel.

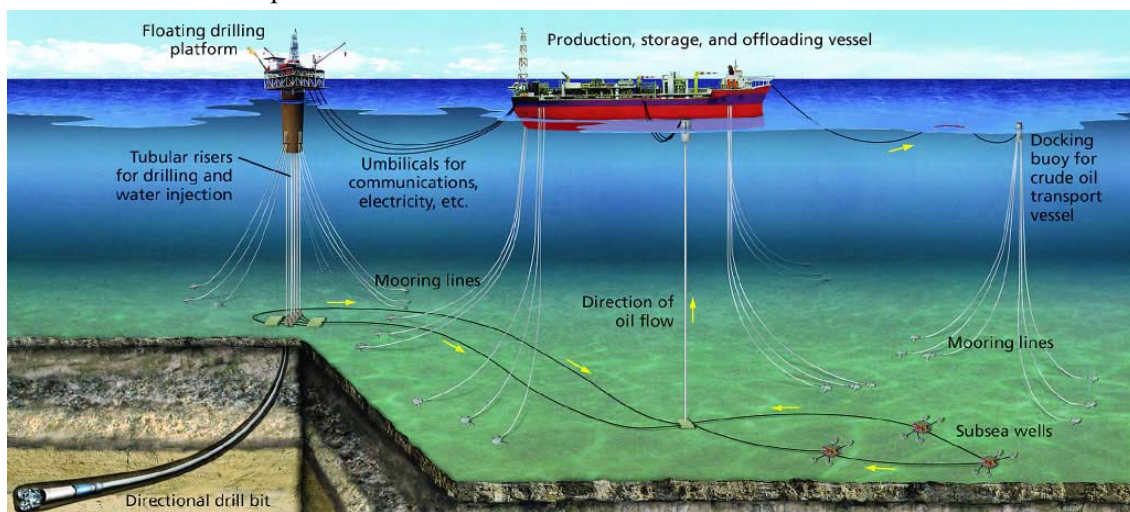


Figure 2.1.1 Overview of drilling platform and construction (source: EHP Online, 2008)

After all these developments, Heerema's current expertise includes (see figure 2.1.1):

- Installation of fixed and floating platforms
- Installation of deepwater infrastructures (pipelines, structures, flow lines, and more)
- Decommissioning and removal of platforms

Heerema has been involved in pipe-lay projects for less than 10 years. Their niche expertise lies in complex ultra deep projects. This is due to their ability to add various types of structures to the network (see appendix A for examples) (HMC Technology department, 2007). The challenge for the future is to broaden their project area from the Gulf of Mexico towards African and Arctic regions. This brings extra complexity and uncertainty for the project execution, for example due to different weather conditions. As the focus of this study is on pipe-lay projects, the installation steps of such projects are described next.

2.2 Pipe-lay projects

Before pipe-lay projects can be executed a logistic plan is defined. First the cycle from fabrication of pipe to a pipeline on the seabed is explained. Then the logistic plan development phase is discussed.

2.2.1 Pipe-lay project logistics

The project preparation results in a logistic planning. It forms the basis for the execution of the pipe-lay project. Appendix B gives an extensive step by step model of the project execution focused on the logistics. There are three main activities (see figure 2.2.1): fabrication, transport and pipe-lay. These three activities are briefly discussed. In appendix A more detailed information is available.

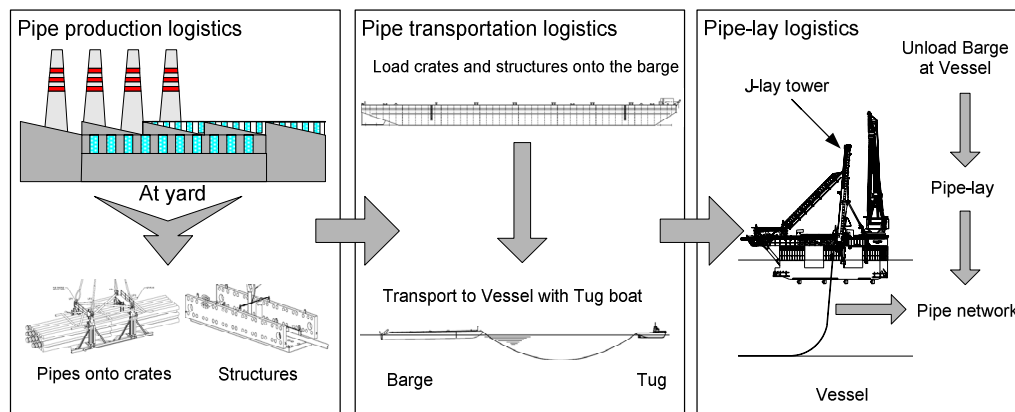


Figure 2.2.1 Logistic overview of pipe-lay projects

Pipe production logistics

At the yard the pipes/structures are finalized so they are ready for transshipped to the pipe-lay vessel (e.g. Balder or New Vessel). Currently the client is responsible for the fabrication of pipe components and offloading onto the barge at the yard. This offloading goes according to Heerema's transportation plan. The responsibility transfers to Heerema when Heerema approves the loaded barge, designed by Heerema. These projects are Transport & Installation projects, meaning Heerema is responsible for the transport and installation. However, Heerema adopted recently an EPIC contract (Engineering, Procurement, Installation and Commissioning); this extends Heerema's responsibility to engineering, fabrication, and procurement.

Pipe transportation logistics

For the transshipment of pipe/structures from the yard to the Balder, Heerema defines a logistic plan. This plan contains the exact information on what should be loaded where on the barge including the departure time. When the loaded barge is approved by Heerema, the departure time based on the weather forecast is estimated. Therefore weather forecast (3-4 days) must be within the allowable criteria. When the weather forecast is unacceptable, the consequent delay might lead to an underutilization of the vessel, e.g. out of pipe. Therefore the number of transport barges is critical for the project's efficiency: too much capacity might lead to cost overruns, under capacity might lead to downtime of the vessel (e.g. out of pipe), which also increases project costs (HMC, 2008).

At the vessel the barge must be unloaded. Therefore the barge is moored to the starboard or stern side of the vessel. Each time one crate is loaded onto the vessel and an empty crate is loaded onto the barge. Unfortunately, the unloading of the barge is sensitive to the weather. Only when the weather and wave motions fall within the criteria, mooring is possible. However in Africa it is expected that the swell will constrain the mooring, because the vessel or the barge will resonate due to the swell, decreasing the workability of the unloading operation.

Pipe-lay logistics

When the pipes are on the Balder, these are welded to each other within the two welding stations on deck. The welds are checked on their quality and coated. When the hex-joints are finished they are attached to the pipeline in the J-lay tower. In the J-lay tower a welding, testing and coating station is present. This station can work under any angle of the J-lay tower. To add structures (see appendix A for more details) to the pipeline, the cranes onboard of the vessel might be needed. They can hang a pipeline attached to a structure into the J-lay tower (HMC J-lay information DVD). A project can involve pipelines with different specifications (diameter, coating, and other specifications) or other place in the field. Each transition consumes time, which is incorporated in the logistic design (HMC J-lay information DVD).

2.2.2 Logistic planning preparation

Pipe-lay projects start with a tender phase which might result in a project for Heerema. For such a project a logistic plan will be formed in the project phase. Finally this logistic plan will be executed. Figure 2.2.2 gives a brief overview of these phases. Per phase the input (from the left), output (to the right), support (from below) and the required data (from above) are depicted.

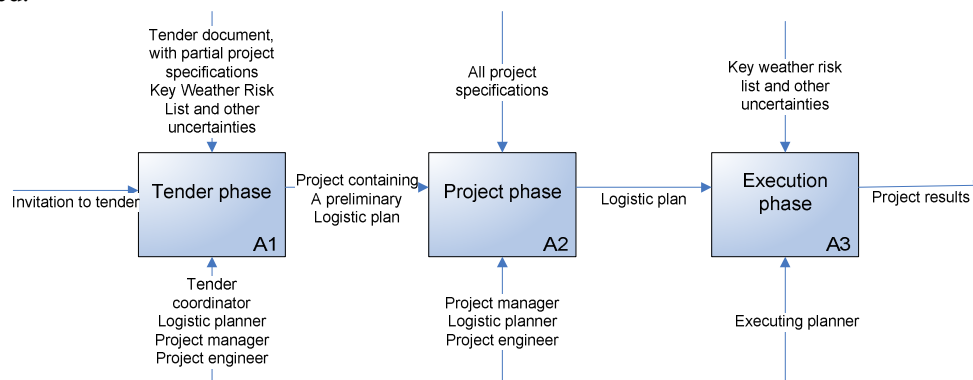


Figure 2.2.2 Phases of pipe-lay projects

Tender phase

The start of the project is the client's invitation to tender. All interested contractors can register for the tender procedure by sending a proposal with their expected project performance within a limited time (on costs, time-overview, equipment, etc). The Tender Coordinator is responsible to decide to register for the project (HMC Heerema Procedures, 2006). To prepare this proposal document the Tender Coordinator consults with departments within Heerema. These departments receive the partial information from the Tender Coordinator (HMC Heerema procedures, 2006). Only partial information is known, as for example the structure's design is not finalized because the design depends on how the vessel installs the structure (Interview with Logistic Engineer). With the available information and experience-based assumptions a draft logistic planning is defined. The Tender Coordinator collects the information and registers for the tender (HMC Heerema procedures, 2006).

This initial logistic plan constrains choice options later on in the project phase; therefore the Project Manager is involved during the tender phase (Interview with Project Manager). For example; an at first sight expensive logistic plan is unlikely to be explored, but might reduce the risks involved in the project, which lowers investment in contingency plans and lowers chances of cost overruns/delays. The result is a drop of potential successful alternatives.

Project phase

When the tender phase results in a project for Heerema the project phase starts. The project design is further detailed, using the complete specifications. The aim of the project manager is to execute the project within the contract agreements. To make profit, the estimated costs must be lower than the contracted costs in the Tender phase. The Project Manager consults the departments to design a logistic plan for the project and test its workability. Workability is important, for example the position of structures on the barge is constrained by the capability of the Balder to safely pick the structure from the barge.

Execution phase

In the execution phase the planning and prepared work defined in the project phase is executed. To adhere to the cost, time, safety and quality requirements, monitoring of all the processes is important. When the executed project deviates from the initial plan, adaptations must be made to the plan. Some flexibility in the initial plan can ensure that the requirements are still achievable within the uncertainties. The detailed activities of the execution are described in Appendix B.

2.3 Design revisions to the logistic plan

The most important “rule of thumb” is: “The speed of the Balder is the bottleneck of the project”. This influences the design of the pipe transportation logistics. Consequently the project must be executed profitably, without high risks of cost overruns/project delays.

To design the logistic plan Heerema faces complex projects, as consist of varied interrelated subtasks (Baccarini, 1996):

- Several departments are involved: interpretations on complexity (due to own tasks)
- Many subtasks: the logistic planning phase consist of interrelated subtasks
- Using ‘rules of thumb’: provide good but not optimal solutions (Feng et al, 2000)
- Inefficiently: there is a lot of repetition of calculations among projects
- Partial information: later on, owning new information leads to revisions of the plan
- Recurring calculations: every plan raises questions leading to revisions.
- Uncertainties: risk events during the execution might lead to revisions in the plan
- Time pressure: during the tender phase the design must be made within a limited time.

From this can be concluded that the logistic planning phase is an iterative, unpredictable, time-consuming and frustrating task. Consequently comparison of alternative plans is difficult to fulfill, leaving the trade-off between predictability and profit unexplored.

2.4 Conclusions

The development of the logistic planning for pipe and structures is important as the main rule is: “The Balder may never run out of pipe”. Therefore the engineering tasks and planning tasks are executed precisely; however this is a complex task, contributing to a lack of insight in the effect of choices. In the next chapter the research questions to address these challenges are defined.

CHAPTER 3 RESEARCH QUESTION AND METHOD

The previous chapter introduced the challenge to support insight into the effect of decisions made to develop a logistic planning. In this chapter the research questions for this challenge are defined. Next, the suitable methods to answer these questions are clarified, based on the aim of designing a support system.

3.1 Brief problem description

For the future Heerema desires to undertake projects in for them unfamiliar regions (arctic and African regions), where the weather conditions are harsh and Heerema has so far no experience. The challenge Heerema currently faces can be summarized as lack of transparency in the decisions involved in logistic planning. The inefficiency and unpredictable nature of the logistic planning effort for pipe-laying makes it a time-consuming and frustrating task. Many calculations recur, but cannot be reused in the current work process. Further, some decisions in the logistic planning are made based on incomplete information or based on experience and intuition. Especially when alternatives should be compared, effects remain unknown, and the time constraints and lack of overview result in the need to take or mitigate risks.

3.2 Research questions

To generate more insight into the decision making, the effects of choices on the criteria (net profit, quality, safety and predictability) of a logistic planning need to become more transparent. Therefore the research question is:

How can overview of- and insight into the effects of decisions, with respect to the pipe/structure-logistic planning process for pipe-lay projects, be achieved?

To answer the main research question, these sub questions need to be answered;

On the current logistic planning process:

- What decisions are made during the logistic planning process, and what are the implications of these decisions on other choices in the logistic plan?
- What is currently done to achieve insight in the effects of decisions in the logistic planning process?
- Who is responsible for the decisions made in the logistic planning process?
- What is the influence of the decision approach in the acquisition of an overview?

On improving the logistic planning effort:

- What information is required to provide insight in the effect of decisions?
- How can this information be retrieved or created?
- How can the decisions process be improved and visualized?

On developing a support system (suits the design science approach):

- What are the requirements for a prototype support system to support insight and overview of the logistic planning process?
- Is this prototype supporting the decision making, is it expected to give enough insight and overview in the decisions to be made?

The research questions strongly relate with the research paradigm; design science. The paradigm narrows down the solution space by the perspective of solving the problem by intervening in the current situation. Next the solution space and research approach are described.

3.3 Solution space

The aim of the research is to improve the insight into- or overview of the effect of decisions on the logistic planning process results. A solution lies in the world of decision support systems and decision enabling systems, because the aim is to support the employees in improving their decision making (Arnott and Pervan, 2005). This is an extensive solution space. Therefore a brief overview of the different types of decision support systems is given.

In the early 1960s many business operational aspects were computerized. These computerized information systems had to perform a certain task (e.g. inventory control). Early 1970s the term Decision Support System (DSS) appears: “Using a computer to support the decision-making of a manager” (Arnott and Pervan, 2005). This leads to the personal decision support systems: small stand-alone systems, developed for one decision task performed by one decision maker (Arnott and Pervan, 2005).

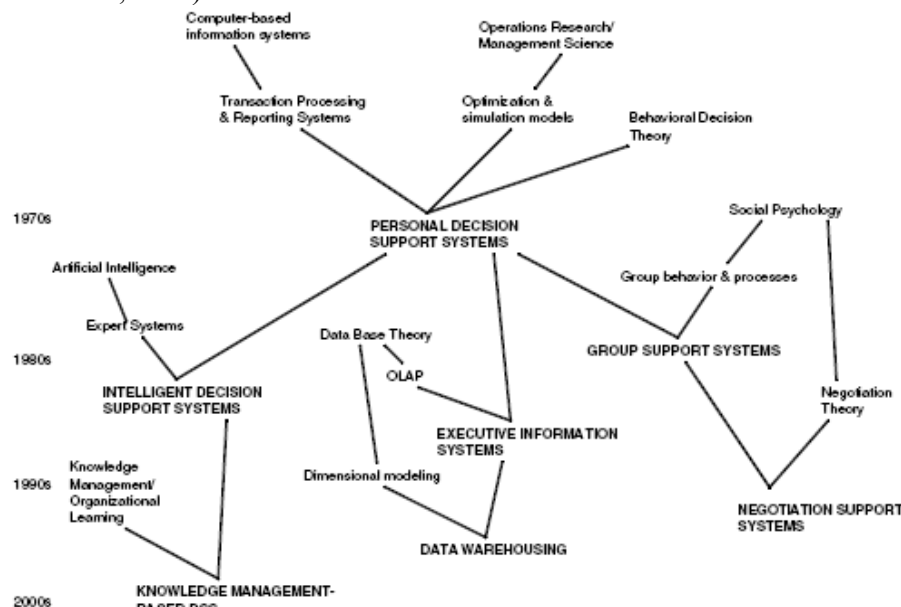


Figure 3.3.1 Evolution of the DSS field (Arnott and Pervan, 2005)

Further evolvement of the decision support systems leads to the fields of intelligent decision support systems and knowledge management based DSS, executive information systems and data warehousing and group support systems and negotiation support systems (see figure 3.3.1). From the critical analysis of DSS by Arnott and Pervan (2005) for each DSS type a brief explanation is given to distinguish their aim:

- Intelligent decision support systems include the aim of artificial intelligent expert systems to (partly) replace the human in the decision task.
- Knowledge management-based DSS supports decision processes to increase innovation including competitive advantage (knowledge creation).
- Executive information systems are systems that report data about the organizational processes to the management.
- Data warehouse analysis generates continuously high-quality data about the operations of an organization and transforms it into useful information to support decision makers.
- Group support systems are designed to facilitate groups where the decision responsibility is shared by more decision makers.
- Negotiation support systems facilitate negotiation between the involved negotiators.

Where the above-mentioned decision support systems stop, decision enabling systems go further. Keen and Sol (2007) envision the support studio. Studios are facilitative environments designed to enable decision makers to make decisions that have impact (Keen and Sol, 2007). This studio accommodates the involved people, decision process and technology. The technology and process are founded in a suite, consisting of information and communication services, simulation instruments, analytical methods and visualization methods (Keen and Sol, 2007). The suite forms the “toolbox” for the decision making (Chin, 2007). This vision aims for flexible, usable and sustainable DSS (Chin, 2007).

An expected side effect of developing a support system is redesign of the organizational processes. Designing a support system is a way of implementing IT. IT is more than automating, as it has the ability to reshape the way business is done (Davenport and Short, 1990). Therefore it is important to keep the process of logistic planning in mind during the design of the support system, and determine the impact of the support system on the logistic planning process. The support system needs to be embedded in the business process.

3.4 Research approach

As the aim of the research is to design an architecture that supports obtaining insight in the effect of decisions in the logistic planning process on the criteria, the *design research paradigm* is applicable for this purpose (March and Smith, 1995; Vaishnavi and Kuechler, 2007; Hevner et al. 2004). Because design research analyses the performance of designed systems to understand, explain and improve performance (Vaishnavi and Kuechler, 2007).

Research paradigm

A research paradigm is a philosophical perspective on what is assumed to constitute ‘valid’ research. This is necessary to select appropriate research approaches (Myers, 1997).

Design science

Design research is the selected paradigm, because it suits the purpose of developing a support system. Design science is seen as a multi-paradigm (Cross, 1993; Hevner et al, 2004; Vaishnavi and Kuechler, 2007). The researcher is a pragmatist with a flavor of instrumentalism, since he researches if the system functions as predicted. This resembles natural science more closely than the involved paradigms (Vaishnavi and Kuechler, 2007). But the paradigm shifts during the research (multi-paradigm). Observations are positioned within the interpretive paradigm. Reflection on the functioning is done with a positive paradigm. Design science tries to explore and create reality through constructive intervention (Vaishnavi and Kuechler, 2007).

The involved paradigms

Positivist - The positivist perspective assumes reality as objectively given and independent of the observer and the applied instruments (Myers, 1997). It is often applied to test theories in order to discover general patterns in the natural and social world (Darke et al, 1998)

Interpretive - The interpretive research perspective assumes reality as subjective (Myers, 1997; Darke et al, 1998). The reality is constructed and interpreted by humans according to their beliefs and value systems (Darke et al, 1998). It is often applied to gain deep understanding of what is investigated, without being concerned with the repeatability of the explanation (Darke et al, 1998).

Design research is the selected paradigm. However my own opinion this paradigm feels unnatural as it changes the world view iteratively. When information need to be abstracted from the world, it uses interpretive methods, on the other hand to test the functioning it

prescribes to use positive research methods. In my research the interpretation on the usability of the support system of different involved actors stays important for the acceptance of the support system and possible process changes. Therefore also for the reflection on the functioning interpretative methods are considered parallel to positivistic methods.

Research approach

Connected to the design science paradigm a suitable research approach is chosen. This approach must add the science to the design. Science is concerned with how things are; design on the contrary is concerned with how things should be to attain goals (Simon, 1969). As science is seen as producing qualified knowledge, consequently design science need to extensively ground choices on proven foundations and methods to be a science discipline (Simon, 1969; Hevner et al, 2004). Therefore the application of methods must be done rigorously instead of by trial and error (Hevner et al, 2004; see figure 3.4.1). The foundations and methods must be selected within the design science methods. On the other hand the environment influences research study. The environment includes the decision makers (people), their process (organizations) and the technologies they use (Keen and Sol, 2007; Hevner et al, 2004). These three are sometimes in conflict, for example a decision maker does not agree with the process, or the technology does not serve its purpose. Consequently the aim of support system is to improve the existing decision making environment (less frustrating, see chapter 2), therefore the study must be relevant to the environment (Davenport and Short, 1990). The implication for the researcher of this research approach is a field of tension between what the rigorously chosen method is, and what method is relevant for the environment (Hevner et al, 2004). On occurrence, this tension should be discussed.

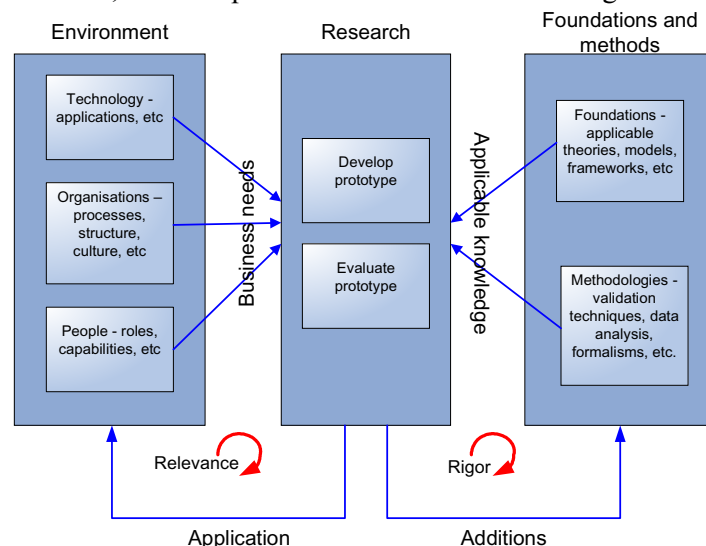


Figure 3.4.1 Research framework (based on Hevner et al, 2004)

Main research method

In figure 3.4.2 the research methodology of Takeda (1990) is shown. This method gives the process steps to design an artifact; this fits the project aim of designing a support system which gives insight in the logistic planning process. First, a profound analysis of the current situation will be accomplished using explorative interviews, observations of current tools and processes and case analysis of several previous logistic planning projects (awareness of problem). With this insight the requirements for support must be derived. Based on these requirements a literature review is performed to identify supporting methods and techniques that can be used to develop a decision support system. This will lead to a visualization of the support system (suggestion). Next the prototype the decision support system is developed in an iterative manner (development). Finally the system is tested and its added value is evaluated by the involved experts and users (evaluation).

Spiral model

For the development the spiral model enhances the iterative design. Each cycle starts with identifying objectives, alternative choices and constraints. The prototype is evaluated at the end of the cycle. The risks of the prototype might be detected; consequently the next step is to develop a strategy to solve the source of the risk (Boehm, 1988). The advantages of the spiral model are the focus on detecting early errors and it involves the performance criteria during the development and mainly by identifying the alternatives early it focus on reuse of existing software (Boehm, 1988).

Expert & user involvement

Experts are involved during the development of the system, as the knowledge is in the back of their minds. This also avoids resistance against change. Three theories for resistance are (based on Markus, 1983):

- Internal: people resist all change
- External: people resist technically deficient systems
- Interaction: people resist systems that alter the balance of power in the organization

Next, early user involvement and top management support in the design process can decrease the level of resistance and will detect early possibilities for resistance (Markus, 1983). The (potential) users are involved during the evaluation, experts in all phases.

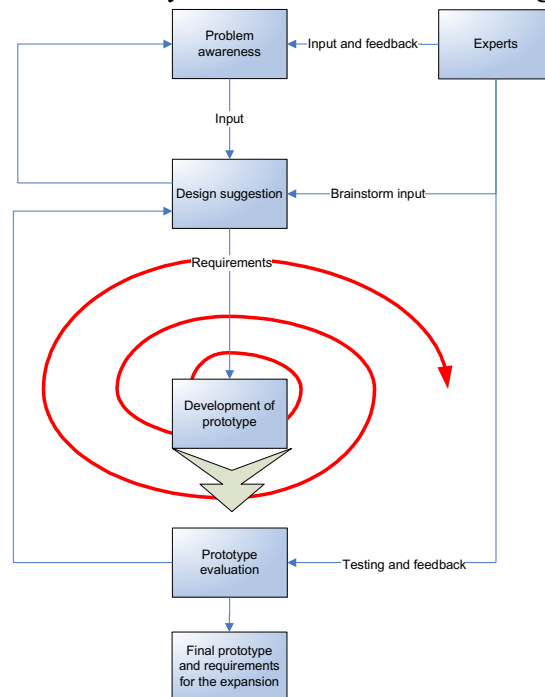


Figure 3.4.2 Methodology of design research (based on Takeda, 1990)

3.5 Prototype evaluation method

To evaluate the quality of the designed architecture, the prototype is tested on effectively supporting the decision process and effectively giving insight in the effects of decisions on the criteria (expected net-profit and predictability of a project). Keen and Sol (2007) have the opinion that effective decision support rests on usefulness, usability and usage:

- *Usefulness* of a support system shows the added value (increased performance) of the used methods and tools to the decision process.
- *Usability* optimizes the relation between the people, process and technology, the system is found usable if using the support system would be free of effort (Davis, 1989). Usability therefore as well relates to flexibility, adaptability and suitability to the decision context.
- *Usage* defines how the support system can be embedded in the business structure.

This will form the theoretical basis for the evaluation of the support system. The prototype must therefore show the functionalities on which these three parts can be measured.

3.6 Conclusions

In this chapter the research questions, approach and methods are defined. These form the start of this study. In the next two chapters the current decision process of the logistic planning effort is analyzed to get insight in the characteristics of the process and the need to change this.



Designing a Decision Enhancement Studio to support the complex logistic planning process of pipe supply

CHAPTER 4 CURRENT LOGISTIC PLANNING PROCESS

For the problem awareness the current situation is mapped. This gives insight into the environment wherein the support system must be implemented, and answers:

- *What decisions are made during the logistic planning process, and what are the implications of these decisions on other decisions in the logistic plan?*
- *What is currently done to achieve insight in the effects of decisions in the logistic planning process?*
- *Who is responsible for the decisions made in the logistic planning process?*

To explore the environment first the scope of the research is defined. Next the roles of the people, processes and technology in the current situation are structured. Then the involved uncertainties are discussed. As research rigor and relevance are important, first the reasoning on the used methods is performed.

4.1 Methods for the problem awareness

The problem awareness forms the first step of the main research method and the interpretative paradigm is applicable (see chapter 3). Both the structuring methods as data collection methods are of importance and their validity is briefly discussed.

4.1.1 Method to define the scope of the analysis

To define the scope the systems diagram analysis is chosen, since it helps visualizing the boundaries of the system (van der Lei and Slinger, forthcoming). This enables to sharply define (based on assumptions) how different components are integrated in this study.

4.1.2 Methods to depict the current logistic planning effort

Next Structured Analysis and Design Technique (SADT) is selected as it structures the process, the role of people and technology but also the procedures are embedded in this structuring technique. This fits the relevance according to the research framework of Hevner et al. (2004), in which the environment is described by people, processes and technologies. This technique is also known for its simplicity and uncomplicated workability. And it is recognized as powerful in representing complex systems (Flood, 2007). Appendix C compares this technique with other techniques to show that SADT is rigorously selected. Next to the SADT model, a risk analysis is performed, as risks and uncertainties play a major role in the logistic planning (informal interview).

4.1.3 Methods for data collection

In chapter 3 it emerged that the interpretative paradigm is relevant for the problem awareness. To validate the data collection the principles of Klein and Myers (1999) guide the evaluation (see appendix C). For the data collection to make the SADT overview, a case study research is fulfilled (see figure 4.1.1). In a case study research more sources form the input, this leads to understanding on agreements and conflicts between the preconceptions and the measured system (Klein and Myers, 1999). Consequently a case study consisting of interviews and a desk-research is applicable.

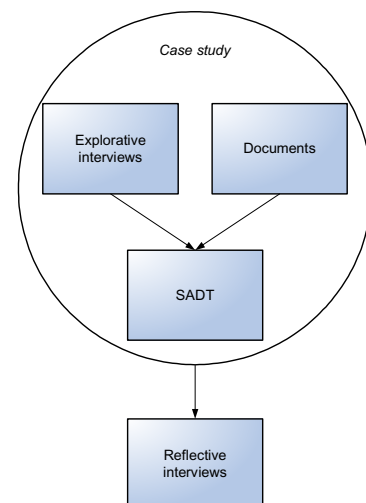


Figure 4.1.1 Data collection method

For the case study there are three principles to enhance validity (Yin, 2003). First the data should be attained from multiple sources; our data will be attained from six interviews with experts, which will be compared with the documents used during the logistic planning process. Secondly the case study results should be organized in a data base and a case study report. Thirdly the chain of evidence should be maintained, acquired by rigorous selection of methods and clear application of those methods. The execution of the methods is clearly described in Appendix C. This makes the case study repeatable and rigor and therefore reliable and valid (Yin, 2003).

Data collection for the case study

The case study consists of an explorative semi-structured interview and desk research. The interview is less structured because the data collection is used in the exploring phase of the research (Kothari, 2005). A desk research on itself is not sufficient, as a process on paper will differ from the process employees apply (Davenport and Short, 1990). But as within Heerema many engineers are hired lately and the documents are consulted by them and will have their influence on the way of working (interview with project manager). To explore the decision process six experts were interviewed according to the informal problem structuring method from Pidd (2007). This method contains the what, when, who, how, why questions, applied to the study context. The advantages and disadvantages of interviewing are defined in appendix C. The risk analysis is based on interviews with the risk department and documents of risk identification of a pipe-lay project.

4.1.4 Method to evaluate the SADT model

The prototype will be evaluation in two ways. The first way is straightforward; the quality of the model is tested by evaluating if the experts agree with the overview. The second way derives from the reaction of the experts on the model; are their opinions conflict, why is it conflicting and to what extent to they find the overview usable. This second way is aims is to get one overview of their complex decision making process, which is difficult because all actors have their own perspective on the process.

Reflective interview

The SADT model is evaluated applying a reflective interview with four experts. The aim was to test if the interpretation from the analyst was correct (suited the guidelines by Klein and Myers), to test the usability of the overview and to explore alternative approaches to improve the current decision making process. Two methods are selected, the Delphi method and the TAM method.

Delphi method

The objective of the Delphi method is to obtain the most reliable consensus of a group of experts to deal with a complex problem (Okoli and Pawlowski, 2004; Linstone and Turoff, 2002). On issues where judgmental input is essential, the Delphi method is often used. It has the advantage of avoiding direct confrontation of the experts, and avoids discussion (Rowe, et al. 1991). To study the complex decision process it is required to involve different experts. The Delphi method is suitable because it focuses on arriving at consensus among experts, so one model/overview (Linstone and Turoff, 2002).

Usability test

To test the usability of the SADT overview, different research methods are suitable. The TAM method is chosen as it is both powerful as empirical verified and provides good results to predict the behavior towards using an information system (Pijpers et al, 2002).

TAM

TAM stands for the Technology Acceptance Model and was introduced by Davis et al (1989). According to Gefen and Keil (1998): “Subsequent studies have shown TAM to be a relatively robust model”.

“Perceived usefulness” is defined as “the degree to which a person believes that using a system would enhance his job performance” and “perceived ease of use” refers to “the degree to which a person believes that using a system would be free of effort” (Davis, 1989). These perceptions are directly influenced by external factors. The actual system use is influenced by the intended use (see figure 4.1.2). This intended use is based on the attitude towards using. This attitude is influenced by two important beliefs, the perceived ease of use and the perceived usefulness. The difference between a belief, an attitude and the use can be explained by an example: someone believes that without studying it is not possible to pass the exam, the attitude might be to enjoy passing an exam; the intended use is then to study for exam.

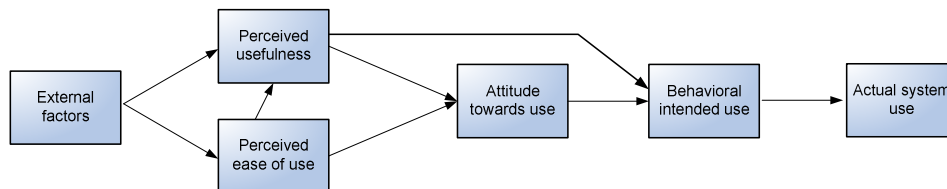


Figure 4.1.2 Technology acceptance model (based on Davis et al, 1989; Pijpers et al. 2002)

In appendix C the TAM questionnaire (based on Davis, 1989: Appendix A) is defined to test the usability of the SADT model. Therefore the perceived usefulness, the perceived ease of use, attitude towards use and the anticipated use are measured.

As the methodologies used to explore and analyze the current decision making process are known, the scope of the study is defined.

4.2 The defined scope

The scope of the project is determined by boundaries and assumptions. The boundaries reduce the scope by defining what subsystems are left out of consideration for this study. The assumptions reduce the scope by simplifying a subsystem. The scope limits exploring an infinite number of details, aiming to not detract relevance. The relevance can be described as the fit of the application to the needs of Heerema (Hevner et al, 2004). To determine the scope a systems diagram of pipe-lay projects is compared with the research aim; to give more insight into the effect of decisions in the logistic planning process (see figure 4.2.1).

4.2.1 Boundary

In the overview the pipe material and coating material can influence the project execution. But for Transport and Installation projects, the client defines the exact specifications of the pipeline network including pipe material and coating. In the future the number of EPIC contracts will increase; this expands the number of variables which increases the number of choices to make (e.g. where the pipe materials can be fabricated and what types of coatings are functional). For these extra decisions, the effects on the criteria are yet unknown, as Heerema currently performs its first EPIC project. This will lead to a lack of information to verify and validate the support system. Therefore this research will only focus on T&I projects.

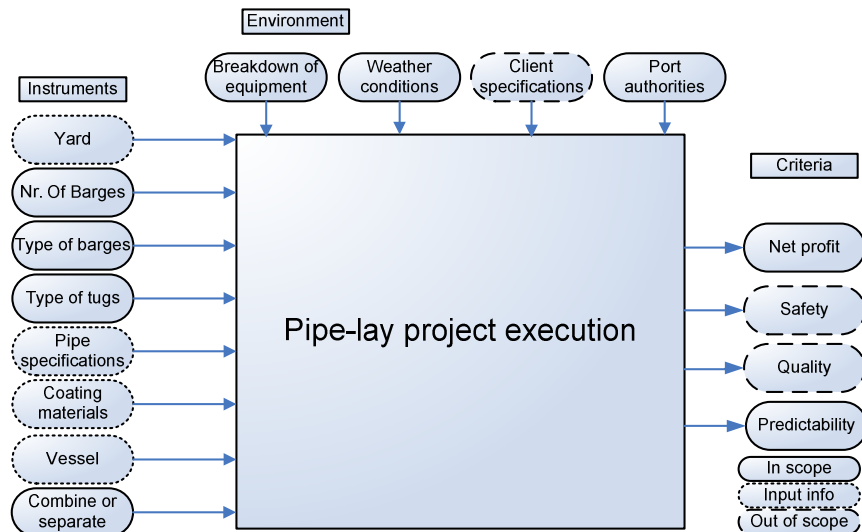


Figure 4.2.1 Systems diagram of pipe-lay projects

The systems diagram consists of a system with inputs, environmental factors, and outcomes (Keeny and Raiffa, 1976). The instruments can be steered by Heerema, on the environmental factors and input information Heerema has no influence, but these affect the system. The outcomes are measured on the criteria Heerema preserves.

4.2.2 Systems diagram and its underlying assumptions

The result of pipe-lay projects is measured by the criteria (see figure 4.2.1). The criteria are:

- Net profit* During the tender phase, the costs and benefits are estimated. The final execution will turn out the attainability of the project estimations.
- Safety* From the interviews appeared that to execute a project the risks of incidents should be as low as reasonably practicable (informal interview). Safety is left out of the scope, since projects must be executed incident and injury free; this is seen as embedded in the project design (informal interview).
- Quality* There is a difference in the quality of the final product and quality of the project (informal interview). Quality of the product is secured by testing the materials and the welds. The quality of the project is specified by the Project Manager. The quality measurement is out of consideration, as this is assumed to be embedded in the project design or statistics - % welds lacks quality (risk).
- Predictability* The predictability of a project is defined by the risks the project takes which delay the project; their chance of occurrence and consequences (informal interview). When more in-formation is available, the project can be better prepared which leads to a more robust project execution.

To influence the results, Heerema's project teams have certain instruments to apply:

- Yard* At the yard the pipes and/or structures are gathered. Here the pipe sections are coated and welded to double joints before they are loaded into crates. Only the reliability of the delivery of pipe/structures is relevant, since decision makers select a yard and not design its capabilities.
- Nr. of barges* The number of barges significantly influences the criteria, as more available barges minimize the risks of having a transport delay by the weather. However more barges will increase the project costs.
- Type of barges* The type of barges influences the workability of loading and offloading at the vessel (interview logistic engineer).

<i>Type of tugs</i>	The type of tug boats is constrained by the barge and its load, as the tug boat must be capable to work with those barges. But when the distance from yard to pipe-lay vessel increases a stronger tug boat decreases the transportation time within limits (interview operations manager).
<i>Pipe specs</i>	The pipe specifications influence the possibilities of the project, because these form the input for the calculations (interview logistics engineer). In EPIC contracts Heerema has freedoms in the defining the pipe specifications, which might influence the results. But as EPIC contracts are out of the scope, the pipe specifications form input.
<i>Coating</i>	The coating has a similar influence on the possibilities of the project as the pipe specifications (interview logistics engineer). However for the same reason the coating specifications only form input data.
<i>Vessel</i>	The vessel capability is input information. Currently Heerema owns one pipe-lay vessel (interview project engineer). The choice of the vessel can have a considerable influence on the criteria, but the capabilities of the new vessel are unknown. Consequently only specifications of the Balder will form the input for the calculations, but in an adaptable way.
<i>Combine</i>	The transport of pipe-crates and structures can be combined or separated on a barge (see appendix D for the current 'rules of thumb' used to make this choice).
Heerema has to deal with external factors influencing the results of the project, which are:	
<i>Breakdown</i>	The equipment (vessel/barge/tug) occasionally breaks down. External because the breakdown of the balder is not redesigned, and of subcontracted equipment can not be steered. Currently T&I planners involve the breakdown to determine the margins for executing the project (interview planner T&I).
<i>Weather</i>	The weather influences the workability of the vessel and barges (interview Operations manager). The swell and weather conditions must match certain criteria to avoid accidents to occur. From the T&I planning department the weather conditions are simply used to determine the maximum project duration for the portfolio planning: "we cause no delays for the reason that we forecasted three days of bad weather which eventually did not occur".
<i>Client specs</i>	The client is involved in the whole decision process via the Project Manager. But the influence of the client is limited to just its input specifications, because the aim of the project is to give insight in the effect of choices. Since the Project Manager communicates with the client, the choices of the Project Manager are assumed to be adapted to- or constrained by the clients' desires.
<i>Port</i>	The Port Authorities influence the execution by limiting the freedom to departure any time optimal for Heerema (informal interview). This can delay the project if these restrictions are unknown. According to the logistic engineer there are two types of restrictions. The first type consists of the fixed restrictions, for example a yard open to sail in or out during day light. The second type consist of events, for example when a navy vessel enters the port, the Port Authorities hamper other ships from moving in or out of the port.

The research scope is on T&I projects (figure 4.2.1). The criteria are net profit and predictability. Heerema can influence the criteria by number of barges, type of barges, type of tugs and combine/separate transport. The uncertainties (e.g. weather conditions, etc) influence the criteria. Next the current decision making process within the scope is described to give insight in this process.

4.3 Logistic planning process

Decision making is based on three aspects: the people making decisions, the process that influences the effectiveness of the decision making and the technology providing support to the people and the process (Keen and Sol, 2006). In the SADT model (see figure 4.3.1) all these aspects are described. Figure 4.3.1 is an overall model; the decompositions can be found in appendix D. This process appears in both the tender phase and the project phase (figure 2.2.2). The role of the employees, the used technologies and the process are described by each of the three steps: project duration calculation, define logistic plan and evaluate results. This is the final model, improved based on the feedback of 4 experts.

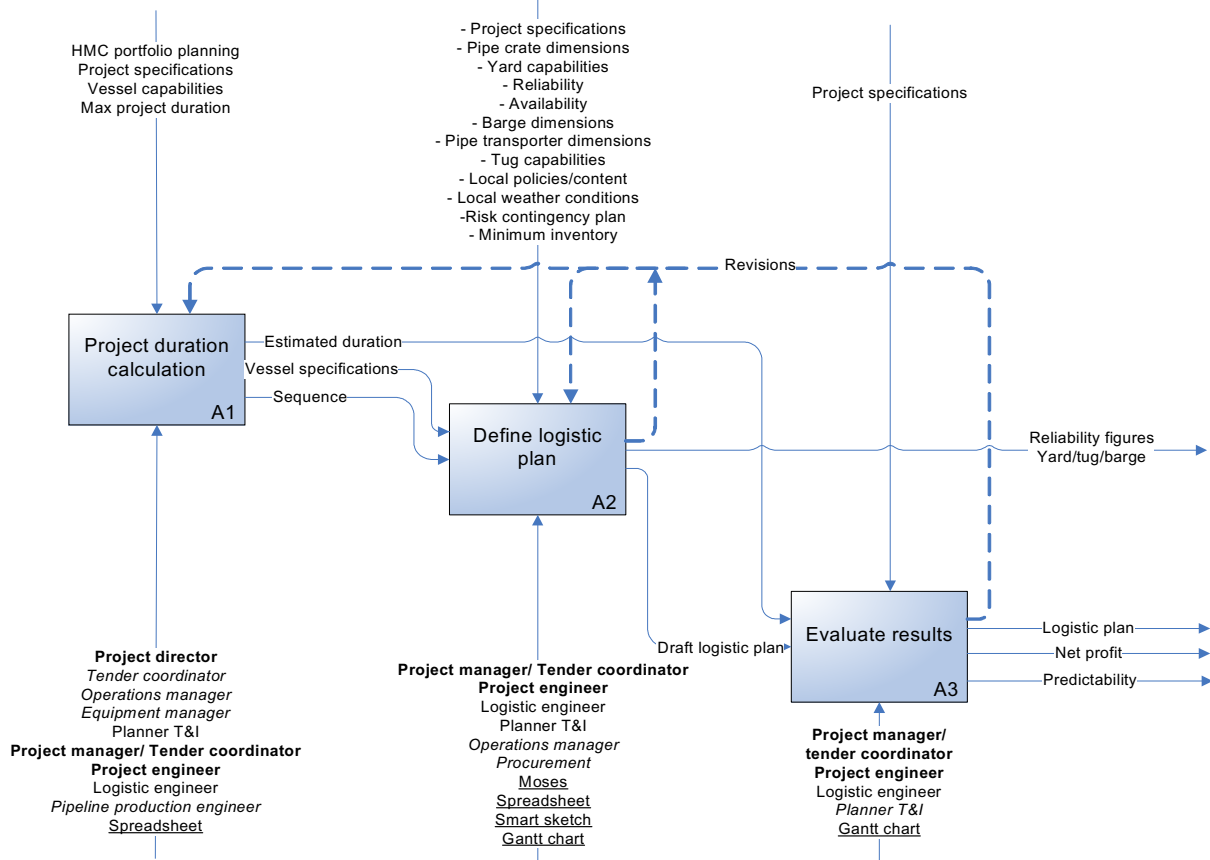


Figure 4.3.1 Highest decomposition of the SADT model

1) Legend: The decision maker is stated in **bold**. The actor that prepares the information for the decision maker is stated in non bold. The actors that generate the input information for the decision are stated in *italic*. The used technologies are underlined.

2) Brief explanation of the involved actors, the extensive analysis can be found in appendix E as it contains confidential information:

The project director is involved in the portfolio planning.

The tender coordinator is responsible for making a tender proposal; this can lead to obtain the project.

The project manager is responsible for the project execution and focuses on durational and financial decisions.

The project engineer is responsible for the technical decisions of the project execution.

The logistic engineer works for SIP where he is responsible to perform engineering tasks.

The planner T&I works for the planning department and performs duration and bar chart calculations.

The operations manager from the operations department charter barges and is responsible for the vessels.

The equipment manager is responsible to define the critical maintenance of Heerema's submersibles.

The pipeline production engineer provides information on pipeline production, for example welding times, etc.

Procurement is involved in the financial aspects and (sub)-contracting strategies.

4.3.1 Project duration calculation

The project starts with the choice of the vessel (see appendix D). This is done on a higher organizational level. The project director is responsible and needs information from the planning department on portfolio planning (2nd interview project manager). The operations and equipment department provides the project director with information on the workability of the vessel on the project and the maintenance plan of the pipe-lay vessel (see appendix C and D). The tender coordinator is involved in the project from the start and will ask the project director to select a vessel and select a timeslot for the project.

When the vessel is known the sequence of the project execution can be confirmed. The logistic engineer designs a sequence based on the project specifications and allowable duration of the project. The planner T&I estimates the duration of the project with the sequence from the logistic engineer using a standardized spreadsheet (2nd interview planner T&I). The duration is initially based on the maximum pipe-lay speed without any risks (e.g. weather events), because the logistic plan should be able to deliver the pipes on time. When the project manager/tender coordinator is unsatisfied with the estimated project duration, the sequence is revised.

4.3.2 Define logistic plan

When the sequence and vessel are known the load sheet can be defined. The load sheet consists of the lay-out of the barges and linked to that the number of transports needed for the project (interview logistic engineer). The logistic plan is a combination of the load sheet and the needed number of barges to execute the load sheet (interview logistic engineer). In the logistic plan, the lay out of the barges and their departure times at the yard to be on time at the pipe-lay vessel are defined. Next to the project manager/tender coordinator the project engineer plays a major role in approving decisions made.

To determine the load sheet, first the yard(s) for delivering the pipe sections and structures are chosen. Most of the times this is embedded in the project specifications but if there are alternatives left the project manager and project engineer will make a choice based on the operations manager's recommendations on workability and the procurement management recommendations on costs. The choice of the yard relates closely with the choice of the barge as the workability of the yard must fit the dimensions of the barge. The project manager and tender coordinator decide what type of barge is going to be used based on charter information from operations management.

When the yard(s) and barges are known, the logistic engineer can start making a barge lay-out. Therefore he determines the number of pipe crates needed with a standardized spreadsheet. Next he decides to combine or separate the transport of structures and pipe sections and engineers the load sheet based on smart sketch to guarantee the sea worthiness of the loaded barges (interview logistic engineer). The project engineer approves the technical details of the load sheet, whereas the project manager/tender coordinator verifies if the load sheet fits the sequence and duration of the project.

The load sheet (number of barges) is transferred to the planner T&I who plans the number of barges necessary for the project execution using bar-chart software. Therefore certain 'rules of thumb' are provided by the project manager on the risk contingency and minimum inventory level at the pipe-lay vessel (interview Planner T&I). When the number of barges is unacceptable to the project manager, revisions regarding the logistic plan are made. They could for example suggest trying another type of barge, changing the project sequence, etc.

4.3.3 Evaluate results

The number of barges combined with the barge lay-out form the draft logistic plan. The project manager compares these results combined with the expected risk events and estimated duration

on his criteria: net profit and predictability. If the results of comparing with the requirements and are unacceptable, the project manager/ tender coordinator hunts for revisions. If the logistic plan is acceptable the execution report/ proposal will be finalized (2nd round interview project manager).

4.4 Risk analysis

Going to new regions, the effect of risks must be assessed. For the risk analysis Heerema Risk department performs a risk identification session with the project team. In this session risks are identified, assessed, mitigated and responded to. According to the risk department, risks occurred after projects are registered in the risk register. Currently a Monte-Carlo analysis is performed on the critical path to measure the effect of risks.

Risk categories

Risk: the possibility that events, the resulting impacts, the actions and the interaction among these three may turn out differently than assumed (Miller and Lessard, 2000). A risk is known and can be described in statistical functions; an uncertainty is not fully understood (Luce and Raiffa, 1957; Jones, 1999; Miller and Lessard, 2000). There are several types of risk that form a threat for the project. Unbundling risks helps to identify risk events which are the basis for constructing a strategic plan to act when a risk occurs (Miller and Lessard, 2000). Examples (see figure 4.4.1):



- Operation risk: break down
- Technical risk: many unaccepted welds
- Completion risk: the project is completed but the pipe is floated
- Financial risk: delays can lead to fines
- Market risks: demand for gas and oil decreases (maybe in future)
- Social acceptability risk: the potential for environmental damage might lead to protests
- Regulatory and political risks: misfit with the regulations might lead to fines of the government.

Figure 4.4.1 Project risk categories

On these risk events Heerema must build strategic reactions. Examples of devices are (based on Miller and Lessard, 2000):

- Information search: research, experts judgment, scenario analysis, risk seminars, etc.
- Network building: Early involvement of contractors, coalitions with affected parties, etc.
- Structures of incentives: contracts, incentives and penalties, etc.
- Project design configuration: select location, flexible contracts, etc.
- Influence: search for windows of opportunity, improve requirements, change laws, educate regulator, etc.

These devices both contain contingency plans and impact studies. The logistic plan forms a part of the project, therefore in this study only the operation risks, technical risks, financial risks, completion risks and regulatory risks play a role. The other risks are on a higher (less operation) level, for example portfolio planning, and will consequently generate input for the project (e.g. contract agreements).

4.5 Characteristics of the logistic planning process

From the SADT overview (appendix D), section 2.3 and the risk analysis the characteristics of the logistic planning process are defined, which later form the basis for chance to change and selection of requirements. The characteristics are defined in the decision process and of the information visualization. The decision process includes the flow of the decisions, the involved actors and the constraints. The information visualization focuses on what information decisions are based.

Information visualization:

- *Subjectivity*: Not all the decisions are based on natural science (lay-out barges) or optimality (# of barges), but on intuition. For example dealing with risk using ‘rules of thumb’ (interview Project manager) is not grounded on quantitative measures.
- *Lack of information*: during the tender phase only partial information is available (see chapter 2.3). This also leads to revisions of the project details and consequently to recurrence of calculations.
- *Uncertainties*: Each project has its uncertainties on the weather conditions, port authorities, etc.

Decision process:

- *Multi-actor system*: In figure 4.3.1 it gets clear that many actors are involved in the decision making process.
- *Iterative*: The constraints, as the workability dimensions of the yard constrain the choice of barge. This changes the linearity of the process towards an iterative process; calculations recur causing frustration.
- *Flexibility*: with small differences between projects and in the future new project regions the logistic planning process must be adaptable to different situations.
- *‘Satisficing’*: due to the long process, determining more alternatives leads to frustration of the involved actors. This makes the final logistic planning still rational, but according to the ‘satisficing’ procedure of Simon (Rubinstein, 1998). Complete rationality is to compare all the alternatives. However when time is lacking, the strategy searches an alternative in a satisfying path within the project criteria.
- *Varied perspectives*: the involved actors are in conflict on some of the processes in the logistic planning process. (see paragraph 4.5)

4.6 Conflict handling

By using methods from the interpretative philosophy the critical reflection on conflicts on the structure of the SADT overview depicted by the reflective interview are handled with attention. Each type of conflict is explicated with an example and the way of dealing with this conflict is clarified. The four second round interviews formed the input information for addressing the conflicts.

The conflicts:

1. Difference between the Documents of Heerema and the interviews. In the documents the organization and task description of functions in Heerema’s organization are defined. For example according to the documents operation management has a ballast engineer who determines how the ballast should be positioned on the barges to guarantee the seaworthiness of the barge. But in the case of pipe-lay project the logistic engineer is

responsible for the ballast positioning, which is not described in the documents as ballast is seldom used in these projects.

Processes have two characteristics (Davenport and Short, 1990). A formal and informal network that influences the process. Consequently the processes described by the employees are decisive as that describes how they work.

2. Conflicts in the formal and informal way of working. For example the sequence is determined by the Logistic engineer but the duration calculated by the Planner T&I. But the logistic engineer will try to approach the sequence with the shortest duration.

The formal loop is visualized in the process because this is where officially the decisions are based on. But one should keep in mind that the employees might think ahead and constrain their options based on their assumptions about constraints or optimality.

3. Missing arrows was the biggest group of “conflicts”. It is not a real conflict, because it was a remarked missing arrow. An example is the storage on board of the pipe-lay vessel determining the load sheet of the barge.

These “conflicts” were handed back to the interviewees to verify if they agree with the extra arrows. This has led to consensus (Delphi method).

4. Some interviewees remarked a change of decision flow, where others agreed with the flow as being representative. For example the Vessel should be the first decision of a project.

These kind of problems were also handed back to the interviewees to verify their opinion on a possible change.

5. The doubt of any impact on the results of a certain decision, made the interviewees insist to remove a certain decision activity. For example the choice on the type of tugs. The tugs are not influencing the speed; because the distances are short and the weight of the load is low therefore the impact of the capacity of the tug is negligible.

However if the impact is not measured, or the distances increase in the future, this might have impact. Consequently these kinds of conflicts are addressed by the researcher. The researcher decided to integrate them in the process, until the actual impact is proven.

Now the perceptual conflicts on the current situation are addressed and handled with, the usability of the model is discussed.

4.7 Usability of the SADT model

The second round of interviews was concluded with a TAM questionnaire from Davis. The results are not evaluated with the formal methods (for example regression analysis) as there were only 4 expert respondents. The outcomes are depicted on mean and standard deviation. A negative answer scores 1 point and a positive answer scores 7 points (see table 4.7.1).

Extremely unlikely	Quite	Slightly	Neither	Slightly	Quite	Extremely likely
1	2	3	4	5	6	7

Table 4.7.1 Overview of the scores

The average outcomes are not extremely positive (see table 4.7.2). This has two reasons. First, the effect of one respondent who found the SADT model not usable in his position (increasing the standard deviations). This employee fulfils a specific task; the overall model is not how he depicts the process. Secondly because the model is seen as inflexible, since it only gives an overview of the processes. In general SADT model is not believed to be harmful, bad, foolish or negative by the employees. The respondents understood the model within 10 minutes (average), which was measured at the point they start telling the process behind the model on their own (caused by ease of use).

On average the model is not expected to be used on a regular basis, because it is inflexible; the exemptions are not modeled. But the model can give fast insight on how the decisions are structured in general. “This might help new employees in the process to understand where they are involved” a Project Manager highlighted.

	Mean	Std.Dev.
Using the SADT model in my job would be:		
Good	4.5	1
Beneficial	4.5	0.6
Wise	4.5	1
Positive	4.75	1
Confidence:	4.75	1
Perceived ease of use		
Learning to use the model would be easy for me	5.5	1.3
I would find the SADT model easy to use	5	1.2
I would find the SADT model flexible to interact	4.5	1
I would find the model understandable and clear	4.75	1
confidence:	4.75	1
Perceived usefulness		
Using the SADT model would give me more insight in my job	4	2.2
Using the SADT model would increase my job performance	4.25	1.3
Using the SADT model would make it easier to do my job	3.5	1.3
Using the SADT model would enhance the effectiveness on the job	4	1.6
I would find the SADT model useful in my job	4.5	1
confidence:	5.5	1
Anticipated use		
Use on regular basis		
Likely	3.5	1.9
Probable	4	1.6
confidence:	5.25	1

Table 4.7.2 Results of the TAM questionnaire

To conclude: the SADT model is understandable and therefore easy to use, but it is not expected to improve the performance. Even though the model explains the constraints, responsibilities and influences of decisions on other decisions, it seems not supportive for the decision process. This is interesting to compare with the reactions on the support system.

4.8 Conclusions

What decisions are made during the logistic planning process, and what are the implications of these decisions on other decisions?

In the SADT model the decisions made are structured. The implication of a decision on another decision is depicted by the decision process. The process is a result of what information is needed for a decision. This sometimes resulted in feedback loops when decisions constrain one another.

What is currently done to achieve insight in the effect of decisions in the logistic planning process?

When more time is available, more alternatives are designed to determine the effect on the net-profit and predictability of the logistic plan (interview project manager). This and the revisions in a certain design lead to insight into the effects of decisions.

Who are responsible for the decisions made in the logistic planning process?

There are different types of involvement in the planning process. The tender manager/project manager is responsible for the commercial decisions. The project engineer is responsible for the technical design. The planners, operation managers and logistic engineers fulfill calculations that influence the project results. Other actors and stakeholders (e.g. client, PPD, risk department, procurement, etc) supply necessary information to the logistic planning process.

The current situation is visualized with the SADT structuring technique. The involved people, processes and technologies in the logistic planning process are clarified by this analysis. This SADT model is easy to use, but not assumed very useful by the actors involved in the process. In the next chapter some change is suggested to the current approach of decision making per decision.

CHAPTER 5 ANALYSIS OF DECISION APPROACH

In chapter 4 insight in the decision process as a whole is generated. This has led to an overview of the decision flow. In this flow the three environment components (technology, people and process) are structured. This chapter searches the answer to: *What is the influence of the decision approach in the acquisition of an overview?*

5.1 Decision theory

From the prior chapters it became apparent that certain decisions are made based on intuition, experience and assumptions. To analyze the effect of each decision with more depth, the approach per decision is defined. However to explain the aspects of decision making, some background information on decision theory is given.

Decision theory

Decision theory reflects on how decisions are made (Hansson, 1994). Decisions, seen within decision theory, are concerned with **selecting** the best alternative for the **goal** of the decision (Hansson, 1994; Anderson, 2002). This is named rationality; realizing an objective by using the available means in the best way possible (Isla, 2000).

Rational decision making is based on complete information. Unfortunately decision making in general is not based on complete information. To be fully rational the world is assumed to be objectively observable (positivist paradigm). Where the choice is based on predetermined options which are evaluated by calculating the utility (Isla, 2000). But within organizations, where experience play a role in evaluating the possible options (Isla, 2000), the observed world is incomplete and can be subjectively interpreted. The level of comprehension is an indicator for the type of decision making. When being fully rational, the level of comprehension is high, when making decisions based on intuition, the level of comprehension is low (Jones, 1999). Figure 5.1.1 shows four different theories on decision making, decision making based on intuition, on routine, on 'satisficing' and on rationality.

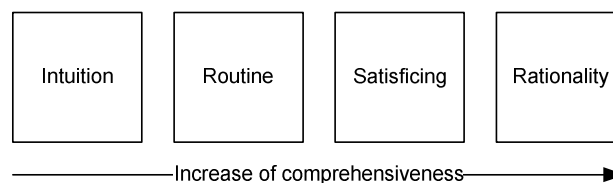


Figure 5.1.1 Decision theories ordered by the level of comprehensiveness

Rationality

Rationality includes three assumptions (Lovett, 2006):

- First, the actors must be capable of acting purposefully. This does not require assuming that human are the only individuals capable of doing this, it does not require believing that humans always act purposefully and it does not require thinking purposeful acting is unconstrained.
- Secondly, rational choice theory assumes that actors optimize mathematical utility functions.
- Thirdly, actors are assumed to behave rational, and focused on optimization.

When there is uncertainty in the decision making outcomes, the rational choice theory uses an expected utility function in which risks and uncertainties are incorporated (Jones, 1999). Instead of maximizing the utility, decision makers must maximize the expected utility (Jones, 1999). To make a trade-off between different alternatives and optimize the utility, an actor must reveal its preferences. This is more difficult in complex problems, where the number of elements and interdependencies between those elements increase (Jones, 1999).

The main disadvantages of rationality are:

- Rational decision making relies on the consistency and continuity assumptions. For the consistency assumption, it is required that when A is preferred over B, and B preferred over C, A must be preferred over C. But in reality actors not always behave like this (Lovett, 2006). For the continuity assumption it is required that when someone prefers A to B to C. And the choice option is having B for sure or a lottery between A and C, with a chance (p) of winning A and (1-p) of winning C. There is a (p) where someone will be indifferent between B and the lottery. But in reality actors are discontinuous in their preferences, for example when two preferences are 'incommensurable' for example liberty and efficiency (Jones, 1999; Lovett, 2006).
- The nature of the decision maker can lead to a decrease of comprehensiveness (Jones, 1999; Lovett, 2006). Examples from Jones (1999): Actors not always consider all aspects, when they believe an aspect is not relevant. Actors also cannot always calculate all alternatives completely. When one alternative is described by benefits instead of costs, a decision maker will tend to choose the positive alternative, this is a framing problem. Actors tend to get emotionally connected to the means, which leads to a conservative perception on using more effective means.

'Satisficing' decision making

An attack on the rational decision making theory comes from Simon (Jones, 1999). The characteristics of 'satisficing' actors are limitation imposed by the bounded cognitive ability and the complexity of the environment, tendency to have multiple goals, tendency to work sequential as there is a bottleneck of short-term memory, and the tendency to work 'satisficing' rather than optimizing. Consequently when searching for a solution, when entered a 'satisficing' path, an actor will not conduct more searches. This is also known as procedural rationality, where a local optimum is searched. According to Simon (1957) the rationality is bounded both internal as external; internal because of power and human bias, external because of the inability to view at the complete environment, due to the complexity of this environment. The disadvantage is that there is a limited view on the reality, as it is observed incomplete; this leads to a potential mismatch between the solution and its environment (Jones, 1999).

Routine decision making

Organizations tend to adopt task performance rules, which lead to routine approaches for even the most important decisions (March and Simon, 1958). The adoption of routines is stimulated by the fact that the decision makers have a limited ability to adjust the organization to its environment (Jones, 1999). However learning within the organization is this way slow and based on conflicts, conflicting as the actors identify with the rules and therefore ignore certain problems of the rules (Jones, 1999).

Intuitive decision making

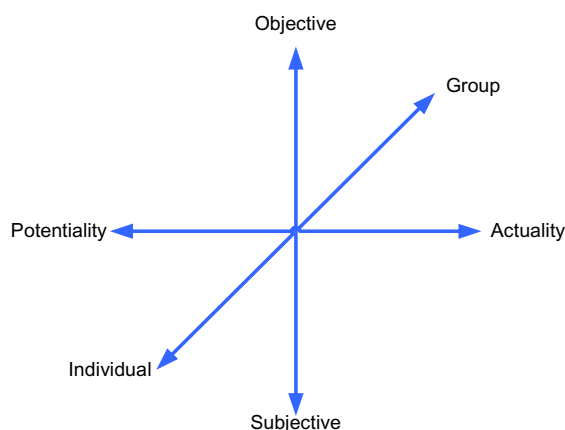
When the information is unavailable and the decision makers disagree with the decision procedures decision makers use their sense of feeling on recognizing patterns and relationships (Sauter, 1999). While intuition can promote fast decision making and innovation, there is a negative side; when a manager is too intuitive, he will ignore routines, details or repetition, which will lead to ignoring relevant facts and consequently to bad decisions (Sauter, 1999).

These different decision theories all have their advantages and disadvantages. When being more rational, the learning potential increases, but all information must be available and consequently the decision environment can not be very complex. On the other side intuition leads to innovative and fast decision, but have a higher chance of being the wrong decision as the chance of ignoring relevant facts is high (Sauter, 1999). To analyze the decisions made in the logistic planning process, first the research method is discussed.

5.2 Research methods

The four paradigms for the analysis of social theory form the starting point of the categorical analysis (Burrell and Morgan, 1979). These paradigms are based on two dimensions: the objective-subjective dimension and the radical change-regulation dimension. The paradigms are seen as alternative models for analysis of social processes (Burrell and Morgan, 1979). The decision making for the logistic planning process is a social process, since there is a lot of interaction and interdependency between the involved actors (see SADT chapter 4). The interaction is showed by the information need, evaluation and task fulfillment of the actors. The interdependency of the decisions is shown by the feedback loops in the decision making; the iterative characteristic of process (see chapter 4). With these characteristics the categories suit to categorize the decisions of the logistic planning process. This method suits the decision

theory as it gives insight in the objectivity or subjectivity of decision (rational or intuitive).



To illustrate the decision approaches per decision, the decision paradigms of Burrell and Morgan are used. But they are adapted to our aim. The aim is to specify the difference between the current decision making approach and the desired decision making approach. First the three dimensions are explained and why these are interesting to compare the approaches on (figure 5.2.1).

Figure 5.2.1 Dimensions for decision categories

Objective vs. subjective

Objective decision making views the social world in a natural world paradigm, applying models and methods from natural sciences (Burrell and Morgan, 1979). Subjective decisions are based on intuition of individuals (Mattia and Weistroffer, 2008). This is interesting as it is possible that some subjective decisions (currently based on 'rules of thumb') are applicable for objective reasoning. Objectivity is often bounded by uncertainties. Especially when more criteria, preferences and alternatives are possible, this makes the decision process complex (Rubenstein, 1998). Risk aversion or model simplification bounds the rationality of the decision (Rubenstein, 1998), this appears when the environment is complex (see decision theory). A methods is not or completely objective or completely subjective: the decision can be based on a bounded rational or by routine calculations (see decision theory).

The decisions in the logistic planning process are characterized by constraints of earlier made or future decisions in the process. For example the workability of the yard can misfit the workability requirements of a type of barge. This type of barge is therefore not usable for the transport of pipe and/or structures. Consequently this constrains the solution space of the decision on the type of barge. Both objective and subjective choices can be constraining. This is indicated by using the word constrained or unconstrained in front of objectivity or subjectivity.

Actuality vs. potentiality

Actuality versus potentiality better suits our purpose than the original dimension. It is a sub-component of radical change and regulation (Burrell and Morgan, 1979). The worldview based

on actuality focuses on fact based current reality (Burrell and Morgan, 1979). A decision maker with a focus on potentiality is more oriented to change towards possible realities. This focus on potentiality can lead to daring of the current process and lead to innovative design of the process or of the logistic plan. To dare is a principle of Heerema and is therefore an interesting dimension to categorize the decisions (Reed, 2008). But this will lead to more uncertainty when trying for example pipe transporters, as the workability with the Balder of these transporters is unknown. It can be estimated, but is not based on proof (informal interview).

Individual vs. group

Decisions can be made on an individual basis or in a group context. This might also lead to interesting challenges for the support system and is therefore one of the dimensions.

5.3 Decision approaches

In table 5.3.1 the different categories are explained. This gives a rough insight in how a decision can be approached.

Objectivity- subjectivity	Actuality - potentiality	Individual - group	Category sketch
<i>Objectivity</i>	<i>Actuality</i>	<i>Individual</i>	Follows a traditional problem oriented approach for problem solving giving a rational explanation (Mattia and Weistroffer, 2008). These problems are solved individually.
		<i>Group</i>	Follows a traditional problem oriented approach for problem solving giving a rational explanation (Mattia and Weistroffer, 2008). These problems are solved by a group, this leads to a consensus approach (Burrell and Morgan, 1979).
	<i>Potentiality</i>	<i>Individual</i>	Is focused to solve the decisions rationally by changing the current decision process (Burrell and Morgan, 1979). The individual seeks to explore new alternatives and new processes, more uncertainty is involved.
		<i>Group</i>	Is focused to solve the decisions rationally by changing the current decision process (Burrell and Morgan, 1979). The group using debate , explores new alternatives and new processes.
<i>Subjectivity</i>	<i>Actuality</i>	<i>Individual</i>	Make decision based on subjective intuition or experience (Mattia and Weistroffer, 2008).
		<i>Group</i>	Make consensus decision based on subjective intuition or experience (Mattia and Weistroffer, 2008).
	<i>Potentiality</i>	<i>Individual</i>	Challenge the decision process based on intuition and explore alternatives (Burrell and Morgan, 1979).
		<i>Group</i>	Challenge the decision process based on intuition or experience and explore alternatives within the group and discuss the options (Burrell and Morgan, 1979).

Table 5.3.1 Explanation of the 8 categories

Now the different categories are explained, the decisions can be structured according to these categories (table 5.3.2). An overview is given in figure 5.3.1.

Decision	Objective- subjective	Actual- potential	Individual -group	Explanation
Choice of vessel	-co	+/-	g	This decision is constrained by the required vessel capability and the room in the portfolio planning of the vessel (expert feedback). The choice of the vessel is a capability check with the project specifications and is constrained by the available room in the portfolio planning, therefore it is not an optimal decision, but it must be at least a 'satisficing' decision. The project director discusses this with the portfolio team (group decision), very actual decision making, but creativity might lead to solve the portfolio puzzle (expert feedback).
Determine sequence	-co	p	i	The logistic engineer determines the most optimal sequence possible within the maximum allowable time duration. The sequence leads to a time duration which gives new input for the sequence selection, therefore the decision is constraint. The logistic engineer has freedoms in selecting a sequence, but the shortest possible is chosen within the desires of Heerema and the client (almost objective and individual). The objectivity is based on intuition, and not on real calculations (the feedback loop gives real calculations). (expert feedback).
Estimate duration	uo	a	i	With information from PPD and OPS the planner T&I estimates the duration of laying pipes with the tower (interview planner T&I). With this duration the project duration of the sequence is estimated. This is objectively done, because it is based on standardized spreadsheet calculations. The planner T&I depicts individually what the actual consequence of the sequence is on the duration in a Gantt chart.
Calculate # of barges	u+/- -	p	i	The planner T&I calculates the number of barges based on the number of transports based on a Gantt chart. With 'rules of thumb' about the inventory and needed slack in to fulfill the project with less risks of delay (and cost overruns) (interview project manager). Therefore this is subjective. The planner T&I tries creatively to reduce the number of needed barges (2 nd round interview planner).
Choice on yard	co	a	i	If the yard is not defined by the client, Heerema can pick a capable yard (interview operations management). This is constraint by the desired workability for the barges. There are a lot of criteria to base the choice on; this makes the decision making objective and actual (no potentiality for innovative decisions). Early in the project this is decided on by the project manager and checked by procurement (financial) and operations (workability). (expert feedback)
Transport choice	cs	p	i	The operations manager chooses what transport equipment can be used for the project. As they do not know the effect on needed number of equipment and effect on project results, it is a subjective choice based on the workability of the transport requirements equipment and the current availability. There is freedom to choose between different types of transport in the early stadium. (interview operations department)
Check availability	uo	a	i	The actual availability of the needed number of barges is checked by the operations manager. This leads to feedback to the transport choice. If the chosen barges are not available, different transport equipment must be chosen.

Calculate # of crates	uo	-a	i	The logistic engineer calculates the number of barges with a standardized spreadsheet. He must follow certain protocols on loading criteria of a crate. But within those criteria all solutions are possible. Together with combine/separate and load-sheet activity's results, the loading of the crates can be adapted to decrease the number of transports needed. Therefore this is considered to be more actual; however there are potential expert opinions on alternative options. (interview logistic engineer)
Combine or separate	us	p	i	This choice is based on subjective feeling that combining transport of pipe sections and structures is more interesting for the project. Therefore logistic engineers use their own 'rules of thumb' (interview logistic engineer). The effect of this choice is hard to measure, as the recurrence of calculations is time consuming (informal interviews).
Determine load sheet	co	-a	i	Based on all the earlier made choices the actual lay-out of the transport equipment is designed by the logistic engineer. There are fewer freedoms left, and the engineer works with smart sketch to ensure the sea worthiness of the loaded barge.
Finalize logistic plan	uo	a	i	The logistic engineer gathers the barge lay-outs and the Gantt chart to finalize the project execution manual. This is a simple task to create overview on the project execution.
Calculate results	+/-	a	i	The project manager gathers all the information and calculates the project costs and risks. This is now based on P50 scenarios as this is the basis of the logistic plan (Interview Planner T&I). This gives a lack of information and need the perception of the Project manager to see the real risks and therefore project duration (and costs).
Compare results	+/-	a	i	To compare the results based on the expected project outcomes (proposal and contract with client) and the expected results. The risks taken by the project manager are based on their own level of risk aversion (informal interviews).

Table 5.3.2 Categorization of the decisions. Explanation: Unconstrained objectivity (UO) Constrained objectivity (CO) Unconstrained subjectivity (US) Constrained subjectivity (CS) Actuality (A) Potentiality (P) Individual (I) Group (G) in between the dimensions (+/-) more objective than subjective (-O)

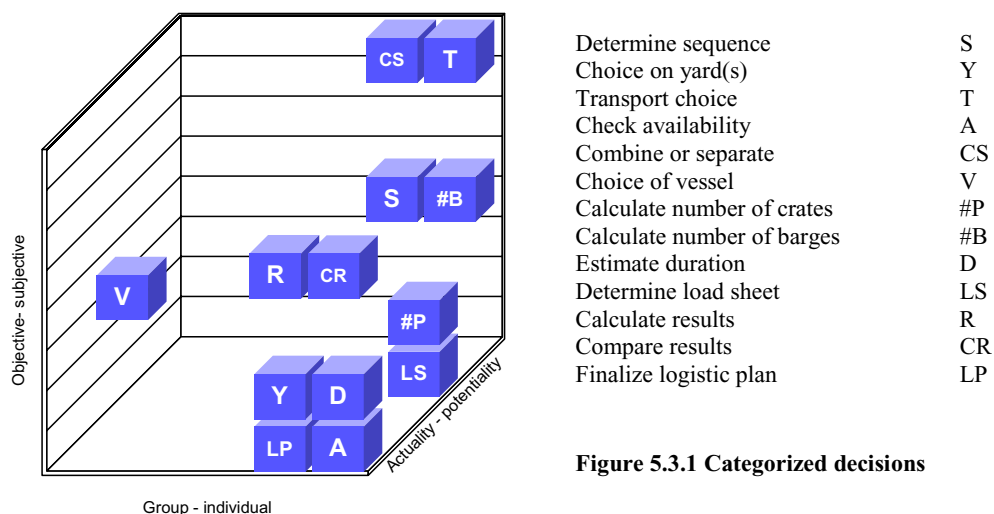


Figure 5.3.1 Categorized decisions

Decisions that are already based on objective information can be unrevised, since it gives insight in the reasoning behind the decision, improving the learning effect. But six decisions are based on intuition, which are:

1. Choice of combine or separate the transport
2. Choice of transport equipment
3. Choice of vessel
4. Sequence
5. Calculate number of barges
6. Calculate and compare results

The subjectivity is caused by the early decisions during the tender phase as they are based on intuition. However these decisions (1, 2 and 3) can influence the results. On the other hand it is a frustrating and time-consuming task to explore more alternatives, which leaves these decisions made by intuition. But when these decisions would be made with a bounded rational, a simplified system to calculate the effect of the choice on the criteria, better decisions can be made in the tender phase. There is consensus on the attainability of this (informal interviews).

The sequence, handling results and number of barges are partly based on 'rules of thumb'. This makes the process supported by routines and calculated by a bounded rational. But the real influence is not clarified, because these routines might not be effective enough; therefore evidence on the effect will help to improve the routine procedures. However it is important to stay daring these procedures, as decision makers tend to stick to their routine rather than looking to the evidence (decision theory).

5.4 Proposed changes to the categorization

From the interviews some changes to the categories can be made, the researcher also recognizes some potential possibilities to change the current process. This will lead to requirements for the support system and might lead to process changes.

Changes from interviews

- When more actors are needed for the decision making more communication together would stimulate less recurrence of calculations (2nd round Interview Logistic engineer; 2nd round interview operations manager).
- Slack is now intuitive, more insight in the risks of the project execution might standardize the result comparison (2nd round interview Project manager).

Suggested changes by researcher

- The decision for a sequence can be determined more objectively if the effects of different alternatives are made visible.
- This also counts for the load sheet, combine and separate, and type of barges. If the influence on the final results can be visualized easier. Better choices can be made.

5.5 Characteristics of the logistic planning – suggested improvements

From these desired and suggested changes to the way decisions are taken, some improvements of the characteristics of the logistic planning system are defined:

Information visualization:

- *From subjectivity to objectivity*: The support system should stimulate objective decision making. This will improve the discussion on what can be learned from experience. It will finally turn intuition into facts.
- *Transparency in the effect of decisions*: a characteristic of the logistic planning must be the clear visualization of the information needed to make decisions that have impact. To visualize the knowledge of the experts, the information must be made objective instead of subjective. The objective decisions from figure 5.3.1 should lower to more objectivity.

Decision process:

- *Embedding in the business process*: a characteristic of the logistic planning must be that the new steps fit the process. As Keen and Sol (2007) stated that the process must be acceptable by the users to ensure the system works as it is aimed to work. Also within the time limitations to design a plan during the tender phase.
- *Enhance transparency*: the decision processes must enhance the transparency of the logistic planning, show why decisions were constrained (communication).
- *Compare alternatives*: the process must be improved so alternatives are compared in the future to improve the decision making.

5.6 Conclusions

What is the influence of the decision approach in the acquisition of an overview? Due to for example subjective decision making, the effects are not transparent. It can be concluded that the decision process affects the transparency of the logistic planning process. Therefore it is desired to create more objectivity and transparency in the process to acquire more overview.

The current way of working, does affect acquiring overview, as these characteristics limit the insight one can have into the effect of decisions on the criteria. Therefore the needed systems' characteristics based on the improved current characteristics, form the desired characteristics:

Information visualization:

- Objective decision making (desire – currently many decisions are based on intuition)
- Lack of information (desire – complete or accurate 'default' information)
- Deal with uncertainties (weather, breakdown, harbor authorities)
- Transparent

Decision process:

- Multi-actor
- Varied perspectives (desire- depict perspectives)
- Iterative design
- Flexible to each context
- Alternative comparison (desire – currently due to time constraints this is impossible)
- Transparent process (desire – clear project status)
- Embedded in business processes (desire – the support system must enhance the relation between people, technology and process)

With these characteristics the requirements for the support system can be defined, this is done in chapter 6.

CHAPTER 6 REQUIREMENTS FOR THE SUPPORT SYSTEM

In this chapter the requirements for the support system are depicted. An important comment is: “If you don’t nail the requirements, you fail the project. If you nail the requirements, you’ll deliver” (McConnel, 1998). Consequently to select the requirements is an important task. This chapter first deliberates on the method used to select the requirements, then Heerema’s needs/desires and the requirements are described.

6.1 Method

To enhance the design of the support system, there is a need to use effective requirements practices. With effective requirements practices it is attainable to achieve (Young, 2001):

- Insight in Heerema’s real needs;
- Strong commitment of all involved actors on the objectives;
- With quality selected requirements for the support system that accommodates Heerema’s current and future needs.

The prototype is iteratively developed; consequently the requirements are improved during the iterative design of the prototype. For the development of the requirements a process is applicable, as it enhances structuring of the requirements. Structuring gives more overview when different rounds of improvements are expected (Young, 2001). A process is a set of activities that results in the achievement of an outcome. A process integrates people, tools and methods (Young, 2001; Keen and Sol, 2007). The process helps to select the requirements in an effective and transparent matter (Young, 2001). The advantages of using a process for the requirements selection are according to Young (2001); first reusability, saving effort time and money of recreating a new process. Secondly the opportunity for continuous improvement of the requirements selection process is enhanced by having a defined and documented process, as it is easier to capture suggestions.

Requirements selection process

A process approach can lead to an increased productivity on requirements selection, as it contains the important steps to follow (see below). This will decrease the needed amount of time and the defects of the designed system.

The requirements process addresses (Young, 2001):

- 1) Identification of requirements
- 2) Understanding the Heerema’s needs
- 3) Clarifying and restating the requirements
- 4) Set criteria to analyze the requirements
- 5) Prioritize requirements
- 6) Derive sub-requirements from the main requirements
- 7) Categorize requirements
- 8) Test and verify the requirements
- 9) Validate the requirements

This process is a condensed but complete version of the steps Young (2001) advises to integrate in the requirements selection process. The result of this chapter is an extensive list of requirements for the support system. To evaluate the effectiveness of the support system, next the requirements the prototype must meet are selected.

6.2 Application of the requirements selection process

The detailed list of requirements is defined on the theoretical basis for setting requirements for a support system, the (current and desired) characteristics of the support system and the criteria to analyze the requirements. Focusing on these three lists the steps of the requirements selection process is executed.

Evaluation “three Us”

To capture a detailed set of requirements: usefulness, usability and usage form the general set of requirements (the “three Us”). Because Keen and Sol (2007) have the opinion that effective decision support rests on usefulness, usability and usage:

- *Usefulness* of a support system shows the added value (increased performance) of the used methods and tools to the decision process.
- *Usability* optimizes the relation between the people, process and technology. The system is found usable if using the support system would be free of effort (Davis, 1989). Usability therefore as well relates to flexibility, adaptability and suitability to the decision context (Keen and Sol, 2007).
- *Usage* defines how the support system can be embedded in the business structure.

Characteristics of the logistic planning

The requirements must fit the desired characteristics of the logistic planning process. The characteristics are defined in chapter 4 and 5. These characteristics are:

Information visualization:

- Objective decision making (desire – currently many decisions are based on intuition)
- Lack of information (desire – complete or accurate ‘default’ information)
- Deal with uncertainties (weather, breakdown, harbor authorities)
- Transparent

Decision process:

- Multi-actor
- Varied perspectives (desire- depict perspectives)
- Iterative design
- Flexible to each context
- Alternative comparison (desire – currently due to time constraints this is impossible)
- Transparent process (desire – clear project status)
- Embedded in business processes (desire – the support system must enhance the relation between people, technology and process)

Criteria

With these criteria the requirements are verified to ensure: they describe Heerema’s needs, the requirements will be clear to all actors, can all be met, as they are not in conflict and they are also verifiable to test the implementation.

Criteria for effective requirements validation:

- Necessary: helps to select the requirements that have impact on the needs.
- Verifiable: helps to define requirements in such a way that conformance to the requirements can be checked.
- Unambiguous: decreased interpretation problems.
- Consistent: ensures that the requirements can all be met, no conflicts arise.

6.3 Weights of requirements

The weights for the requirements are based on the analysis of chapter 4 and 5. The characteristics and desires for the support system are of high importance and will therefore score ++. When a requirement can be easily substituted by other means, it is less important to be met (for example requirement 9). Also requirements that do not influence the research aim will score lower. The scores range: [--, -, 0, +, ++]. -- low importance, ++ high importance.

6.4 Requirements for the support system

Combining the “three Us” and the characteristics the requirements for the support system are selected and categorized.

Usefulness

For the usefulness the information visualization characteristics for the support system are of importance. As with information of quality, the performance of the decision making increases. These three requirements are identified:

Requirement 1 [++]: The system should provide information visualization to support the design and *objective* choice between alternative logistic plans. Therefore the system must:

- Show the relative results of the alternatives to each other, based on net profit and predictability;
- Visualize the trade-off ;
- Support the involvement of extra information to make a choice when needed (for example on utility rates or critical path).

Requirement 2 [++]: The system must deal with *dynamic information*, varying from a lack of information to changing information. Therefore the system must:

- Contain a database with ‘default’ information;
- Be flexible to the change of information in an alternative, later during the process.

Requirement 3 [++]: The effect of *uncertainties* on projects must be visual. Therefore the system must:

- Be capable of simulating uncertainties (weather influence, breakdown, etc);
- Run multiple runs to generate different scenarios.

Usability

For the usability, the desired decision process characteristics are important as they give understanding of the desired process; which is not as frustrating as the current process, but free of effort.

Requirement 4 [++]: The support system should be *flexible* within projects varying in complexity. Therefore the system must:

- Be adaptable to new project contexts;
- Be flexible to perform all types of logistics plans: multiple and more vessels/barges/yards/etc;
- Be flexible enough to change earlier made decisions.

Requirement 5 [+]: The support system must enhance *multi-actor* decision making process. Therefore the system must:

- Be easy to use by different actors;
- Enhance discussion to eliminate different perspectives;
- Give insight in the responsibilities per actor;
- Support parallel project design (actors can work on the same design simultaneously).

Requirement 6 [++]: The support system must stimulate the comparison of *alternatives*. Therefore the system must:

- Enhance the development of alternatives (saving time compared to current situation);
- Keep track of all the actions and decisions made, including their reasoning/results.

Requirement 7 [++]: The decision process must be *transparent and intuitive*. Therefore the system must:

- Eliminate black boxes (transparent);
- Give insight in the steps to take to make a decision (intuitively);
- Present all needed input and output information.

Usage

The usage requirements are based on how the support system can be embedded in the organization. These requirements are derived from the requirements on the usability and usefulness, to enhance integration with the business structure.

Requirement 8 [-]: The different tools in the system must be based on existing, applicable (to perform a certain task) and if possible standardized software.

Requirement 9 [-]: The different tools in the system should be able to run in a MS Windows environment.

Requirement 10 [++]: The different tools in the system shall be connectable to each other.

Requirement 11 [0]: The system must form the input for the project proposal and project logistic plan information that goes to the Heerema/client. Therefore the system must:

- Make a difference between confidential and commercial information;
- Have an interface that can be adjusted when talking with a client, to enhance communication with the client;
- Have an interface for the client, which contains nice pictures, animations and crucial aspects.

Requirement 12 [+]: The system must support the design phase and therefore creativity. Therefore the system must:

- Be as flexible to add new creative ideas

Requirement 13 [++]: For the validation and verification of the results, these results must be reproducible.

Requirement 14 [++]: The system must be easy to use to stimulate usage (Davis, 1989).

6.5 Evaluation by prototyping

The usefulness, usability and usage of the support system are evaluated by prototyping. To validate if the requirements are met in the design of the support system, the prototype must show the functionalities of the integrated methods and tools to support the decision making. This can be done on a few levels:

1. Technology level – verify if the functionalities of the software meet the required functionalities (Nikoukaran et al, 1998).
2. Feedback level – based on the feedback of experts during the design phase, the support system can be improved based on their opinion and suggestions. Therefore a semi-structured interview can be held, as the feedback must be comparable, but it must leave room for suggestion (appendix C).
3. Usability level – verify the usability of the system by executing a usability test with users (Davis, 1989b). This will give insight in their attitude towards using the system.
4. Results validation level – to validate the outcomes of the support system to ensure the system produces valid information (Sargeng, 2007).
5. Intended use level – to test if the users use the system as was intended. This can be done by a walk-through, to systematically evaluate interfaces (Lewis et al, 1990).
6. Case study level – show that the support system improves the decision making. This can be done by performing a case study to compare the results of an old project with the new results attained with the support system, or by observations comparison with results (Yin, 2003).

As the prototyping forms a part of the design phase, first the requirements are tested on level 1 and 2. As there will be no finished support system, the other levels are not possible to perform in this study of the design for the support system. Requirement 7 is not evaluated, as the aim of the support system is to propose how the effects of decisions can be visualized. Requirement 7 focuses on the process; this needs a final prototype instead of the prototype showing the functionalities.

Some requirements are merely focused on the technology functionalities needed. These are only evaluated on level 1:

- Requirement 5 – Multi actor usage
- Requirement 8 – Proven technology
- Requirement 9 – Run in a MS Windows environment
- Requirement 10 – Adaptable to show what is relevant for the client
- Requirement 13 – Reproducibility of results

These requirements are important to meet, but are less relevant for the main research question on how the process can be supported to get insight in the effect of decisions made. Therefore the trade-off to make decisions, the effect of uncertainties, the generation of alternatives and the flexibility of the system (also capability to stimulate creativity) are evaluated by feedback to measure the effectiveness of the support system on providing insight in the effects of decisions on the criteria during the logistic planning process of pipe-lay projects.

6.6 Conclusions

Now the requirements are selected, a prototype can be designed. In the next chapter a suggested design for the support system is proposed.



Designing a Decision Enhancement Studio to support the complex logistic planning process of pipe supply

CHAPTER 7 ITERATIVE DESIGN PROCESS

To improve the decision making process a design for the prototype is suggested. This is a result of an iterative process. At the end of this chapter the following questions are answered:

- *What information is required to provide insight in the effect of decisions?*
- *How can this information be retrieved or created?*
- *How can the decision process be improved and visualized?*
- *What are the requirements for a prototype support system to support insight and overview of the logistic planning process?*
- *Is this prototype supporting the decision making, does it give enough insight into- and overview of the decisions to be made?*

First the suitable research methods are discussed; next the suggested design for the support system is described.

7.1 Methods involved in designing the support system

The aim of this chapter is to suggest the design for the support system. The spiral model is used for the development approach, as it helps to find problems in the early design stages (Boehm, 1998). Therefore the design of the suggested support system is done iteratively. To support these iterative circles, the support system is prototyped. Prototypes are recognized as a core means of exploring and expressing designs (Houde and Hill, 1997). The final support system will be a complex model; therefore it is not feasible to make a complete prototype (Houde and Hill, 1997). Consequently a more focused prototype is build to evaluate the functionalities by involvement of the users in the early development stage. Prototyping rounds consist of gathering requirements, creating a prototype, evaluate the prototype and act to improve the prototype or deliver a working system (Arthur, 1992).

In chapter 6 is stated that the evaluation of the prototype is done on two levels: the technology level and the feedback level. These evaluations lead to changes in the requirements. Two prototypes are developed. The first is a paper prototype; this is to evaluate the chosen technologies. The second is a digital prototype using the selected technologies, giving a clear vision of the support systems look-and-feel and its possibilities

7.1.1 Technology level - method

Based on the requirements and software selection methods (Nikoukaran, et al. 1998; Tewolderberhan, et al. 2002), the support system is composed. This method supports both research rigor and relevance. As the requirements form the relevance and the software selection methods promote to choose the suiting software rigorously according to those requirements. The result is the suggestion for the support system.

7.1.2 Feedback level - method

The prototypes are evaluated to meet and improve the requirements. Therefore prototypes are evaluated by semi-structured interviews. Semi-structured, for two reasons. First to increase openness for exploring ideas proposed by the interviewee. Secondly, to avoid dominance of actors during a group interview (Kothari, 2005; see appendix C). Consequently the interpretative paradigm is important. As the evaluation is done in an iterative manner (spiral model), the principle of interaction and the principle of multiple interpretations of Klein and Myers (1999) form a basis of interview analysis, which increases the quality of the research.

The aim of the paper prototype is to verify if the provided technologies and information visualization are applicable for the logistic planning process and will form an effective support system. This is therefore done with only two experts. Only two, because the prototype is still abstract which make it difficult to imagine functionality. Therefore the paper prototype is less suitable to test with a broader group of respondents. However the requirements for the support system are verified by interviewing two committed and open-minded experts, who are capable of understanding the paper prototype. The selected experts are: one with knowledge on the technologies; the other is familiar with the information needed to make decisions.

The aim of the digital prototype is to evaluate the effectiveness of the prototype with a broad group of experts and employees. This has two reasons. First not only experts can evaluate the effectiveness, as in the future the system must also be understandable and usable for new employees. Secondly, to stimulate acceptance throughout Heerema. Therefore twelve respondents (logistic engineers, project engineers, project managers, tender coordinators, business control employees, planning, knowledge engineers and engineers without experience) were asked to give their opinion as input for the evaluation.

7.2 Suggested support system

To start designing the support system, the boundaries of the support system must be defined. Then the technologies for the support system must be chosen addressing the requirement. First the underlying platform, then the decision support tools. Finally there is some discussion on embedding the tool in the business processes. The basics of the suggested support system can be seen in figure 7.2.1.

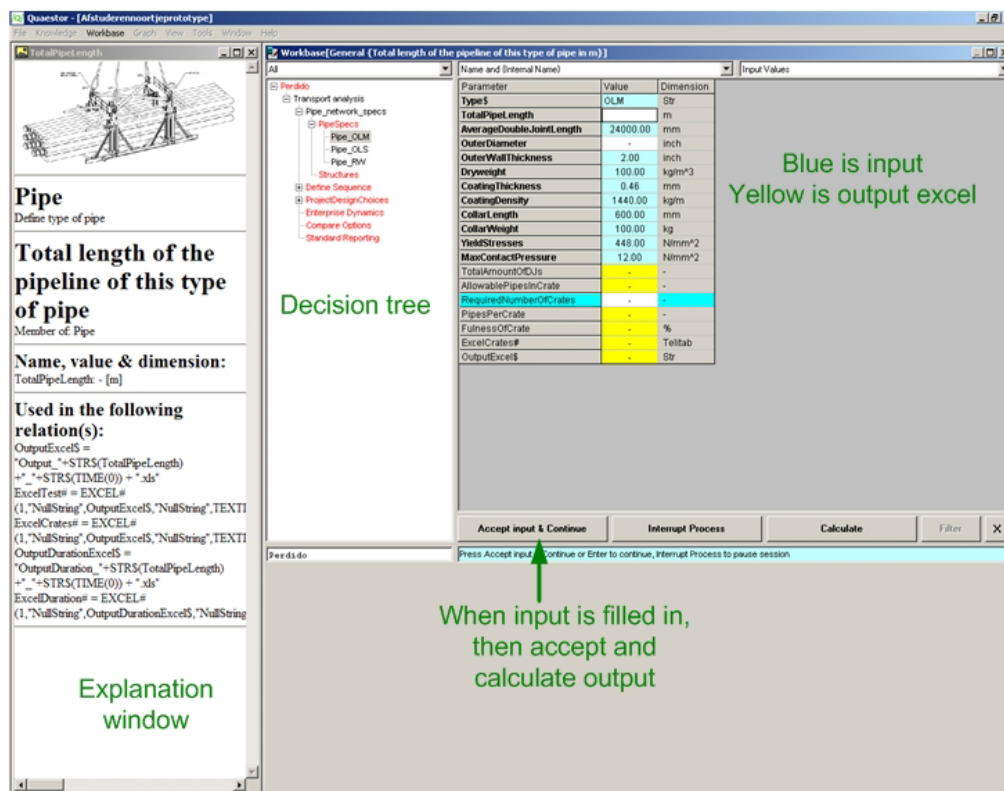


Figure 7.2.1 Overview on the suggested support system

7.2.1 Boundaries for the support system

To set the boundaries for the support system, it is important to define what activities of the current decision process must be supported by the system. As the aim of the support system is to visualize the effect of decisions, all decisions from chapter 4 are present in the support system, except for the activity to check the availability of barges, because this constrains the development of alternatives. The effect of the choice for other barges based on a lack of availability is interesting to measure. Therefore the check of availability of barges activity is left out of scope. On the other hand, technical constraints are a part of the support system, because this leads to a workable and realistic solution space.

7.2.2 Software platform

To visualize the knowledge and information, a type of support system must be chosen. The requirements of chapter 6 fit several types of support systems. For example to improve communication a group decision support system would be interesting and to decrease subjectivity an individual decision support system can be applicable. Therefore a suite of support systems is suitable, integrated in a Decision Enhancement Studio (DES). This studio will form a toolbox with decision support tools (Keen and Sol, 2007). The most important focus points of DES are visualization, information levels and adding to the process (to trigger the shift towards using the support system's tools) (Keen and Sol, 2007). For the studio a suitable interface must be chosen to visualize all information and available tools.

The prototype is made in Quaestor. Quaestor is a knowledge-based system that enables to streamline analysis, design and engineering processes (Qnowledge, 2008). It is a numerical model assembler that works in cooperation with the designer, instead of autonomously (van Hees, 1997). This is based on using computers to support the design phase, but the role of the designer is to make the decisions. Quaestor has proven its use for several projects, for example ship design, propeller design, etc (Qnowledge, 2008) Heerema uses Quaestor to support the development of placing pile sections on a barge. Quaestor forms the basis of the software, because it fits the requirements and it is already used by Heerema (advantage of trained people).

Quaestor fits the requirements because (Qnowledge, 2008):

- Quaestor is able to use various models and programs; this supports the need for integrating other software to visualize the information (requirement 1).
- Quaestor is able to generate different design options next to each other, which enables to visualize the trade-off to make (requirement 1, 6, 10 and 13).
- It allows concurrent use of the various models and programs connected to Quaestor (requirement 4 and 10). All these connected programs enhance the transparency (requirement 7).
- Quaestor structures the decision flow for the design and therefore the discussion on the results is easier to start between the actors (requirement 5). Quaestor currently does not support parallel project design, but is developing this (informal interview).
- In Quaestor a decision tree is generated that shows the decision steps. This tree can make the process intuitively (requirement 7).
- Quaestor can show constraints by comparing information based on the constraining rules (requirement 15) (Informal Interview).
- Calculations made by Quaestor can be changed by the designer; Quaestor even stimulates to add documents to prove the changed result (requirement 6 and 12).

- Quaestor can run in a MS Windows environment (requirement 9).
- Within Quaestor it is possible to show or hide information (informal interview) (requirement 10).
- Quaestor can be connected to Word documents to standardize and automate the result presentation of a logistic plan.

7.2.3 Decision support tools

Most important to boost the effectiveness of the support system is the visualization of the information to enhance objective decisions. As the visualized information is a result from the technologies used, it is important in selecting decision support tools. In the box the power of visualization is explained.

The power of information visualization

To improve the transparency of the decision making, the visualization of information must be effective (Keen and Sol, 2007). According to Keller and Tergan (2005) visualization has been proven to be an effective strategy for supporting users in coping with complexity in knowledge- and information-rich scenarios. Tufte (1990) mentioned that visualization is an artifact; with visualization the complexity of the real world can be partly depicted.

The concepts of visualization are data, information and knowledge (Keller and Tergan, 2005):

1. Data represent the raw non-interpreted facts.
2. Information consists of interpreted data. Information provides answers to the who, what, where, when and why questions. Information can be based on facts (objective information) and on opinions (subjective information).
3. Knowledge is cognitively processed information. Knowledge is inside the brain, information is outside the brain. With knowledge the how questions can be answered.

The derivation of information from the data is difficult. The aim of information visualization is to facilitate this difficulty using visualization tools (Spence, 2001). Conversely knowledge visualization focuses on the transfer of knowledge between different stakeholders, especially the perceptual insights (Burkhard, 2004). Architects combine different visualization techniques to illustrate different levels of detail. Combining information visualizations is a promising approach to increase knowledge transfer quality (Burkhard, 2004; Keen and Sol, 2007). Visualizations motivate actors as it can present their perspective and it increases remembrance/ learning effects as visualizations bring more structure to the knowledge which better coordinates the communication of knowledge (Eppler, 2004). It is given that the human brain is better in visual recall than verbal recall, and visualizations help them to recognize patterns more easily then when the same is presented verbally (Burkhard, 2004).

Different types of visualization are (based on Burkhard, 2004):

- Sketch: helps to support reasoning and arguing during meetings
- Diagram: depicts the relations, and structures the information
- Image: gives an impression which can inspire
- Object: brings different ideas together to a complete object
- Interaction: leaves the user in control by let him manipulate the parameters

The decisions could best be based on the distributions of costs and duration and the correlation between the cost and duration of different alternatives. The criteria to ground a decision on are the predictability and the net-profit. These criteria are based on the trade-off between construction time and costs. The time and cost relation leads to several iterations to select the proper equipment, etc to find an acceptable project duration within the contractual limits (Feng et al, 2000; see chapter 4 and 5). As in construction projects, pipe-lay projects likewise, the

time and costs are depending on uncertainties (Feng et al, 2000). To evaluate different alternatives, the uncertainties should be considered (Feng et al, 2000). To better evaluate options, the distributions give better information than the mean of the costs and duration of an option, as it can show overlap between the different options and the predictability of an option. But because both costs and duration are determined by the choices of equipment, etc, they are assumed to be correlated (Feng et al, 2000). Therefore comparing the cost with the duration in a diagram depicts the correlation of the time and cost (Burkhard, 2004).

For each calculation activity, one or more decision tools are chosen to enhance transfer of knowledge and help to reach insight in the distributions and correlation between the duration and costs of different alternatives:

Estimate duration: by implementing the existing valid spreadsheets, to enhance transparency for- and trust of users.

Define load sheet: The load sheet defines how many transports are necessary based on sequence of the pipe-lay project and the workability with the vessel (see appendix D). This can be done in two ways:

- Simple calculation: the load sheet is a result of the number of crates to be transported and the decision to combine or separate the transport of structures and pipes. With the simple calculation, the number of transports equals the number crates to be transported divided by the number of crates that fit on a barge. Here the constraints of workability with the vessel and sea-worthiness of the loading are not integrated. But it gives an indication of the number of transports.
- Complex calculation: the logistic engineer will perform a study to optimize and validate the load sheet by using programs such as Smart Sketch (this is the proven and existing software, requirement 8).

Calculate the number of barges: This is based on the specifications of the pipe to be installed. Therefore currently a proven and standardized excel spreadsheet is used (chapter 4). To enhance the transparency this excel sheet must be connected to the platform.

Calculate results: The results are currently compared based on a bar chart. The sequential basic project steps form input for the risk analysis. Based on these two sources of information the project manager decides if the proposed logistic design is within the risk level and profitable (chapter 4 and 5). Also the scenarios of weather, barge price fluctuations, etc, are not involved in early project decisions (chapter 4 and 5). For more tools is chosen, because it can switch in the level of detail needed for a decision maker (suited requirement 4).

- The current method must be maintained in the system. As these do give insight in the simplified project duration (no external influences) and accompanying costs (requirement 1). A bar chart has the advantage to clearly show the elements to fulfill a project and the duration in an understandable overview (Flood, 2007).
- An extra tool is necessary to add weather conditions and other external uncertainties. The aim of the tool is to show the effects of the designed logistic planning on costs and predictability (criteria). Critical path methods (e.g. Pert Master) or discrete simulation packages (e.g. Arena, Enterprise dynamics) both can play a role in project planning (flood, 2007). But as there are resources, such as barges, crates, pipe, etc, and the state of these resources are dynamic in time, a discrete simulation model is advised

(Verbraeck, Interview 2008). Discrete event simulations are made to show the time-state relation in the model, where in critical path methods the implementation of resources is very pretended. For the discrete event simulation package Enterprise Dynamics is chosen. This is done by Heerema employees in 2006, their requirements fit with the requirements of this study and their performed method is consistent with the method suggested by Tewoldeberhan et al (2002). Therefore it is both a rigor choice (suitable method), as a relevant choice (Heerema is familiar with the method, so less training hours are needed). With this tool they can interactively define the weaknesses and strengths of their logistic planning (Burkhard, 2004). It is advisable to test the different building blocks within a simulation program on how they are used, as experts might hesitate the use and novices might interpret the functionality of the building blocks wrongly and have trouble implementing them (Valentin et al, 2003)

All the chosen tools can run in a MS Windows environment, this suits requirement 9.

7.2.4 Embedding in business process

Because the current decision process affects the transparency of the logistic planning process (see chapter 5) which leads to frustration of the actors, consequently this process needs redesign. As the paradigm of this study, design science, focuses on change by intervention, re-engineering principles are applicable. As re-engineering focuses on radical change instead of incremental change, this is more suitable for creating a system to intervene.

Business process redesign

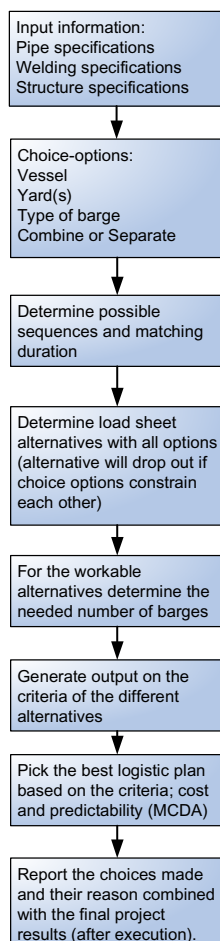
According to Davenport & Short (1990), business process redesign is the analysis and design of processes within or between organizations. They define business process as “a set of logically related tasks performed to achieve a defined business outcome”. Davenport and Stoddard (1994) identified that Information Technology is often suggested to fulfill the leadership role in process redesign; however non-IT project leaders have better control over the processes that are being designed. The IT role is generally seen as a partner within the project team (Davenport and Stoddard, 1994). IT capabilities are suggested to support business processes, therefore business processes should be in terms of the capabilities IT can provide (Malhorta, 1998).

There are two main approaches in business process redesign, namely quality management and re-engineering (Malhotra, 1998). Quality management orients on continuous improvements of the outputs over an open-ended period of time (Malhorta, 1998). Re-engineering is focused on initiatives that achieve improvement by radical redesign in a bounded time frame (Malhotra, 1998). However it is a myth that redesign of processes is completely based on one approach, companies often integrate the different approaches to support change (Davenport and Stoddard, 1994). In this study the design science paradigm is followed. This paradigm is focused on intervention of the planning process with a design. Therefore the process redesign can be mainly supported by re-engineering principles.

Hammer (1990) considers Information Technology an important enabler for business process redesign. Hammer (1990) suggested seven principles of re-engineering towards a logical process:

- Organize around outcomes, not tasks
- Have those who use the output of the process perform the process
- Subsume information processing work into real work that produces the information
- Treat geographically dispersed resources as though they were centralized
- Link parallel activities instead of integrating their results
- Put the decision point where the work is performed and build control in the process
- Capture information once and at the source

Based on the principles and requirement the process is redesigned. The requirements addressing the process: comparison of alternatives (requirement 6) and transparent and intuitive process (requirement 7).



Therefore the designed process is focused on the generation of alternatives and focusing on displaying the results to compare the selected/designed alternatives (see figure 7.2.2). The process makes it possible to design different alternatives next to each other. This has advantages: it enables reuse information of other alternatives, comparison of the alternatives is transparent, it can show the effect of a single different decision (for example the used type of barge), the basic project information is the starting point from which several alternatives can be generated, etc.

Also parallel activities, such as deciding the yard and the barges (now leading to iterations), are connected in the early stage, to show the constraints of the combination. This makes it possible to remove non workable alternatives early in the design phase.

If the suggested support system and its process form an intuitive design process is not possible to measure on the technology level or feedback level of a prototype. This is therefore not integrated in the prototype (what information should be positions where, etc). The acceptance of the process is important to measure in next implementation rounds to eliminate the occurrence of resistance (Markus, 1983).

The responsibilities of who is involved in which step is based on the current situation. The Logistic engineer designs the load sheet, implements the specifications and determines the possible sequences. The planner calculates the duration, and helps visualizing the alternatives by making Gantt charts if asked for.

Figure 7.2.2 Redesigned process

This process will, when information is visual, give the user insight in the steps to take to define alternatives. Also the simplification of the process, to more goal orientation, gives the decision process more overview. But this is only a suggestion for logical steps; it is not tested in this study.

The current decision process within Heerema is very iterative and focused on developing and improving one alternative. When a logistic engineer and planner submitted a logistic planning to the project manager, he decides if the current design is acceptable, or must be revised. But also other constraints lead to revisions, for example the unavailability of the needed barges, might lead to a different type of barge or a plan with only three instead of the four needed barges. To use a different type of barge, the whole design must be recalculated and the plan must be again visualized by the planner (to depict the slack in the system). The new goal-oriented process focuses on parallel developing of alternative logistic plans. This will have an impact on the way of working.

Organizational change

There are different coordination mechanisms for work processes (see figure 7.2.3). The complexity of the project and of the environment steer the organization to adjust its coordination mechanism. First the five mechanisms are described, and then the reasoning to shift towards another mechanism is discussed.

These are the five coordination mechanisms for work processes according to Mintzberg (1992):

- Mutual adjustment: the work process is coordinated via informal communication. The control on the work lies in the hands of the operators. This way of working is applied in small and simple organizations and in complex organizations which have many specialists.
- Direct control: when the organization grows, most organizations implement direct control. In this mechanism one person has the responsibility for the work of others. This person gives the others instructions and protects the quality of the work.
- Standardization of work process: the work processes can also be coordinated by standardization. When the work processes are standardized, the substance of the work is specified, for example installation instructions.
- Standardization of output: Standardization of output is possible when the output is specified.
- Standardization of skills: when it is not possible to standardize the output or work process, then the skills/ training of the employees can be standardized. For example two surgeons barely need to communicate with each other

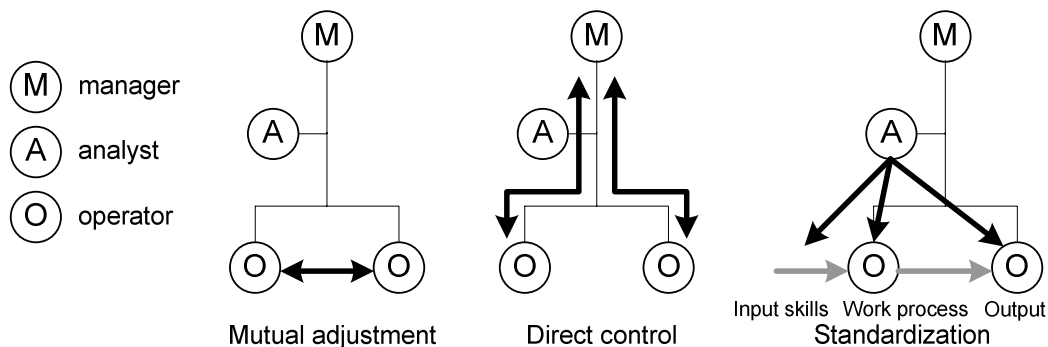


Figure 7.2.3 Coordination mechanisms (Mintzberg, 1992)

Influence of the complexity of work (Mintzberg, 1992)

According to the increasing complexity of the work, the coordination mechanism shifts from mutual adjustment, towards direct control and subsequently towards standardization (preferably from work processes to output to input skills). Finally when the complexity even more increases, the coordination mechanism shifts back to mutual adjustment.

Influence of environment (Mintzberg, 1992)

When the stability of an organization's environment increases, there is a tendency to standardization, but when the complexity of the organization's environment increases, there is a tendency towards decentralization (where there is no direct control, the most decentralized mechanism is mutual adjustment).

The current coordination mechanism is approximately direct control, as the tender coordinator and project manager are responsible for the complete work of the departments (see information on organizational change). This mechanism leads to decision making lacking of transparency and objectivity (de Bruijn et al, 2002) as the decision is taken by the project manager. Different project managers have their own risk adversity (interview project manager), and therefore there is no consensus about the relative weight of the criteria to make a decision (de Bruijn et al, 2002). The logistic planning process is therefore an unstructured challenge and due to the revisions a dynamic challenge (different departments involved, constraints, etc), this makes the work complex and therefore less suitable to be managed by direct control. A shift towards

standardization is therefore desired. The work process must be supported, not completely standardized by routine procedures. As the risk of routine will be a lack of creativity and alertness of the engineers and planners, but the support must give more transparency and decrease the frustration caused by the recurrence of tasks (see chapter 5).

As the logistic planning turns out to be complex, the process to come to a solution can have its impact on several aspects: it can support the decision making, enrich the problem definitions and solutions as there are more viewpoints from departments involved, incorporate the dynamic nature of the planning, increase the transparency and decrease the resistance against the tool (de Bruijn, 2002). The new process makes the decision process more transparent as the information and calculations are visualized and stored in the support system and more robust for iterations because the system easily recalculates results (fit the dynamics of the project). However the impact on the resistance against the tool is hard to measure. The tool must be embedded in the organization, and therefore fit the desires of the users. The users now have control on their tasks and are steered by direct control of the project manager. The feeling of this control must be captured by the system. Therefore the system can only steer the decision makers, not take over the decision making. The main risk will be that the users will use the new system according to their old way of working, by just generating one alternative.

For the process it is also important to add responsibilities for the actors on how they must use the system. From the actor involvement analysis (see Appendix E; table E.6 and E.7) can be concluded that especially the tender manager, project manager, project engineer and planner must be involved in the logistic planning process, as they can influence the project results. The information stream from the client, equipment manager, PPD and risk department is important for the project, so this must be a part of the process. The other departments are not closely involved in the project of logistic planning for structures and pipes as they are less interested in the outcomes and have no influence on the results. Consequently the first idea is to let the tender manager/project manager, project engineer and team and planner gather information and use the support system.

Multi-criteria decision analysis

Multiple criteria decision analysis should be used in all other cases than when one aspect matters in one moment in time to one decision maker. For all other cases a multiple criteria decision analysis can be useful. According to Munda (1995) it is especially interesting when:

- *The alternative decision depends on subjective preferences*

This is considered to be a characteristic in the logistics planning process. With the support system the aim is to stimulate objective decisions. But the final preference for a more robust or for more profit will still be subjective.

- *Qualitative mixed with quantitative evaluation plays a role*

Net profit is a quantitative result, but the robustness is more qualitative. Therefore the selection of an alternative will be influenced by both qualitative and quantitative evaluations.

- *Not all the consequences can be transformed into monetary values*

This links to the prior reason for using multiple criteria decision analysis. The robustness of a system can be better evaluated on the visualization, than the mean of an alternative. Therefore this is less easy to quantify.

- *Close fit to the real world is important*

The project manager is responsible for the authorization of the chosen logistic plan. Therefore he is involved in the comparison of alternative plans. His preferences play a role in deciding what logistic plan fits the project agreements and flexibilities in those agreements. Therefore the project manager must be the decision maker; this fits the current and desired situation.

- *There is a relation with other dimensions or systems*

The logistic plan has relations with the pipe-lay vessel's lay speed and the production speed of the yard. The optimum would be that this fits seamlessly. The insight in these interactions between these systems can be caught in criteria, which helps selecting the best alternative.

- *A process with discussion leads to understanding.*

The involved departments have their own perspective on the project results. Therefore a discussion can bring up the understanding of the meaning of the results for the different departments. This applies to the discussion Heerema's project managers will have when comparing alternatives. Both net-profit and project predictability are important. But also the total days of waiting on pipe on board of the pipe-lay vessel might be needed to discuss what alternatives fit the project specifications best.

A disadvantage is that different criteria and relations can be constructed for the same problem leading to different solutions. Also the rankings are arbitrary as they are based on subjectivity (McCaffrey, 2005). Consequently there is no sound proof for the multiple-criteria decision analysis (Steiguer, 2003). And adding indifferent criteria, on which all alternatives score the same, can potentially flaw the results (McCaffrey, 2005). In spite of these disadvantages multiple-criteria decision analysis can help to visualize how a decision maker selected an alternative. As this is based on subjectivity, it helps to structure and depict the effect of the criteria on the alternative selection. The aim of the multi-criteria decision analysis tool is to get insight in the reasoning on why certain alternatives are selected or not, to make the decision more transparent (requirement 7). In appendix F a specific multi-criteria decision tool is selected for this specific aim.

7.3 Evaluation by a paper prototype

The first evaluation of the suggested design is done by the paper prototype. First the background for the implementation of the paper prototype is explained. Then the feedback, leading to revisions in the requirements, is discussed.

7.3.1 Functionality of the paper prototype

To evaluate a prototype the role of the support system forms the key component, namely its functionalities. But the user evaluation also depends on the implementation and the look-and-feel. For the first prototype is chosen to make a storyboard of the functionalities of the system. Storyboards enrich the discussion on the role of the support system (Houde and Hill, 1997). It is designed to generate discussion via a tangible concept of the support system (Madsen and Aiken, 1993). The role is the focus point and the assessment of the requirements must be presented well in the prototype, but the visual representation of the paper prototype also tells something about the visualization of information by the technologies of the support system.

Although a paper storyboard lies far from the final support system, it is a prototype as it gives insight in the ideas for the support system (Houde and Hill, 1997). It also permits users to participate in the requirements validation process, which suits the aim of involving experts in the design (Madsen and Aiken, 1993). Appendix G can be consulted to check the paper prototype and the questions of the semi-structured interview.

7.3.2 Feedback level – changes to the requirements

The feedback of the two experts led to one extra requirement for the usefulness of the support system:

Requirement 15 [++]: The system should show the *prior conditions* for creating an alternative. Therefore the system must:

- Show technical constraints;
- Share experiences among actors.

The iterative process characteristic was already integrated in the requirement of flexibility (requirement 2 and 4, chapter 6). But as both experts stated this as very important, a new requirement on prior conditions is added to the list of requirements. This has no big consequences for the suggested design, as it already formed a part of the suggested support system. However, there is now more emphasis on the prior conditions in the requirements.

7.4 Evaluation by a digital prototype

The aim of the digital prototype is to evaluate the effectiveness (“three Us”) of the prototype with a broad group of experts and employees. Therefore twelve respondents were asked to give their opinion as input for the evaluation.

7.4.1 Functionality of the digital prototype

The following functionalities are evaluated with the prototype (see chapter 6 for the reasoning on why these are evaluated on the feedback level):

<i>Usefulness</i>	Visualize the information to make the trade-off between alternatives on net-profit and predictability (requirement 1)
	Does the system give insight in the effect of uncertainties (requirement 3)
<i>Usability</i>	Is the system flexible, can it support iterations in the process (requirement 4)
	Support the generation of realistic alternatives (requirement 6, 14)
<i>Usage</i>	Does the system enhance creativity (requirement 12)
	Would you recommend others to use the system? (Usage of support system)
	Would you like to use the system? (Usage of support system)

The prototype can help to evaluate these functionalities of the system, as the result visualization of distributions and correlations is showed in the prototype. Also the effect of weather, breakdown and port authorities is shown in the simulation model. In Quaestor the different alternatives can be generated after defining the project scope (pipe specifications, etc). And it can show that constraints can be added to the calculations, as well as scope changes, which triggers the recalculation of all the done steps (Quaestors- functionality). Appendix H contains a picture-overview of the digital prototype.

7.4.2 Feedback level – changes to the requirements

The feedback was very positive, the average grade over all questions was a 7.8. Only three were evaluated with a grade lower than a 7.5 (see appendix H). As there are limitations on the interpretation of these results in grades (see appendix H), only the feedback for each functionality (usefulness, usability, usage) is summarized in points to maintain and points to improve (see table 7.4.1), with the emphasis on improving the 3 lower scoring functionalities.

Functionality	Maintain	Improve
Usefulness	Practical input aspects Ease to change the input and see effect Different case construction Simplicity in output Openness in structure Objective information Quickly see implications of a decision Risk analysis, as it can give extra info Monitor information of simulation	Does depend on accurate input and generate accurate output Protocol for simulation Must be sufficient for 90% of projects Keep input to all information accessible On/off function for uncertainties to improve the insight Model must remain practical – not extremely complex
Usability	Automatic coupling with spreadsheets Easiness to try alternatives Easiness to recalculate with changed input Output lead to optimization of an alternative	Ensure the 'default' info is up to date Keep room for technical solutions Provide support for many departments Valid for most projects (>90%)
Usage	Flexibility in input screens Improved control of risks Time saving promise to set up a complex plan	Find all pitfalls by verification/validation Develop user interfaces/ process to use User-friendliness promised by prototype

Table 7.4.1 summarized respond of the evaluation

Since none of the questions was answered with a consensus of no, the suggestions for improvement are used to improve the list of requirements.

Requirement 16 [++]: The system must generate *accurate* output based on accurate input. Therefore the system must:

- Be well verified and validated before use;
- Submit a simulation protocol to generate valid results;
- Have a check to verify if the results fit the input.

Requirement 17 [++]: the system must be *sufficient* to use for at least 90% of the projects. Therefore the system must:

- Leave room for technical solutions in different projects;
- Ensure that the 'default' information is kept up to date.

Requirement 18 [++]: the system must remain *practical*. Therefore the system must:

- Easy steer through the different methods to select;
- Have easy buttons to choose to use uncertainties or not for the calculations;
- Have a good level of detail, valid but as simple as possible.

Compared to SADT model:

The SADT model was not expected to be used even though it was seen as easy to use. Fortunately the support system is expected to be used (see appendix H), however the ease of use is not proved yet. In my opinion this is due to the advantages of the improved process, which promise to be less frustrating, whereas the SADT model showed the source of the current frustrations.

7.5 Conclusions

With this chapter on designing a DES, the following questions are answered:

What information is required to provide insight in the effect of decisions?

It is important to visualize the criteria: net-profit and predictability. This can be done by showing the distributions of the costs and duration of the project. This will give insight in the overlap between alternatives and the predictability of the outcomes (Feng et al, 2000).

How can this information be retrieved or created?

By using current tools to leave the calculation methods transparent, and by adding a simulation model that can give insight in the effect of uncertainties on the duration and costs (leading to the distributions of the cost and duration of a project).

How can the decisions process be improved and visualized?

The process is improved by simplifying the decision process to a goal-oriented process. The Quaestor decision tree depicts to actors the steps to generate and compare alternatives.

What are the requirements for a prototype support system to support insight into- and overview of the logistic planning process? (A complete list of the requirements is given in chapter 9)

The list of requirements consist of the requirements in chapter 6 and these requirements based on the feedback during the evaluation of the prototypes:

Requirement 15 [++]: The system should show the *prior conditions* for creating an alternative. Therefore the system must:

- Show technical constraints;
- Share experiences among actors.

Requirement 16 [++]: The system must generate *accurate* output based on accurate input. Therefore the system must:

- Be well verified and validated before use;
- Submit a simulation protocol to generate valid results;
- Have a check to verify if the results fit the input.

Requirement 17 [++]: the system must be *sufficient* to use for at least 90% of the projects. Therefore the system must:

- Leave room for technical solutions in different projects;
- Ensure that the 'default' information is kept up to date.

Requirement 18 [++]: the system must remain *practical*. Therefore the system must:

- Easy steer through the different methods to select;
- Have easy buttons to choose to use uncertainties or not for the calculations;
- Have a good level of detail, valid but as simple as possible.

Is this prototype supporting the decision making: is it expected to give enough insight in- and overview of the decisions to be made?

As the aim of the evaluation was to test if the respondents find the system capable of providing insight in the decisions made, the feedback certifies that the concept is promising. To really answer this question, the system must be tested on old projects and compare the results with the historical decisions. This was not possible to measure by these prototypes (chapter 6 and 7).

CHAPTER 8 DESIGN SPECIFICATION

This chapter discusses the Decision Enhancement Studio and how it fits the characteristics of the logistic planning process. Also the conditions for success and generalization of the applicability of the concept in other domains are discussed.

8.1 Decision Enhancement Studio (DES)

During the research steps the sub research questions were answered. With these answers the main research question was answered by a concept support system. The sub questions stimulated to collect the characteristics of the current system, triggered to answer how the information should be gathered and visualized to create insight in the effect of decisions and finally stimulated to set up the requirements for the system and evaluate the functionalities. The final concept is presented here based on the characteristics of the current process of decision making, including the desired characteristics. Figure 8.1.1 depicts the concept of the support system.

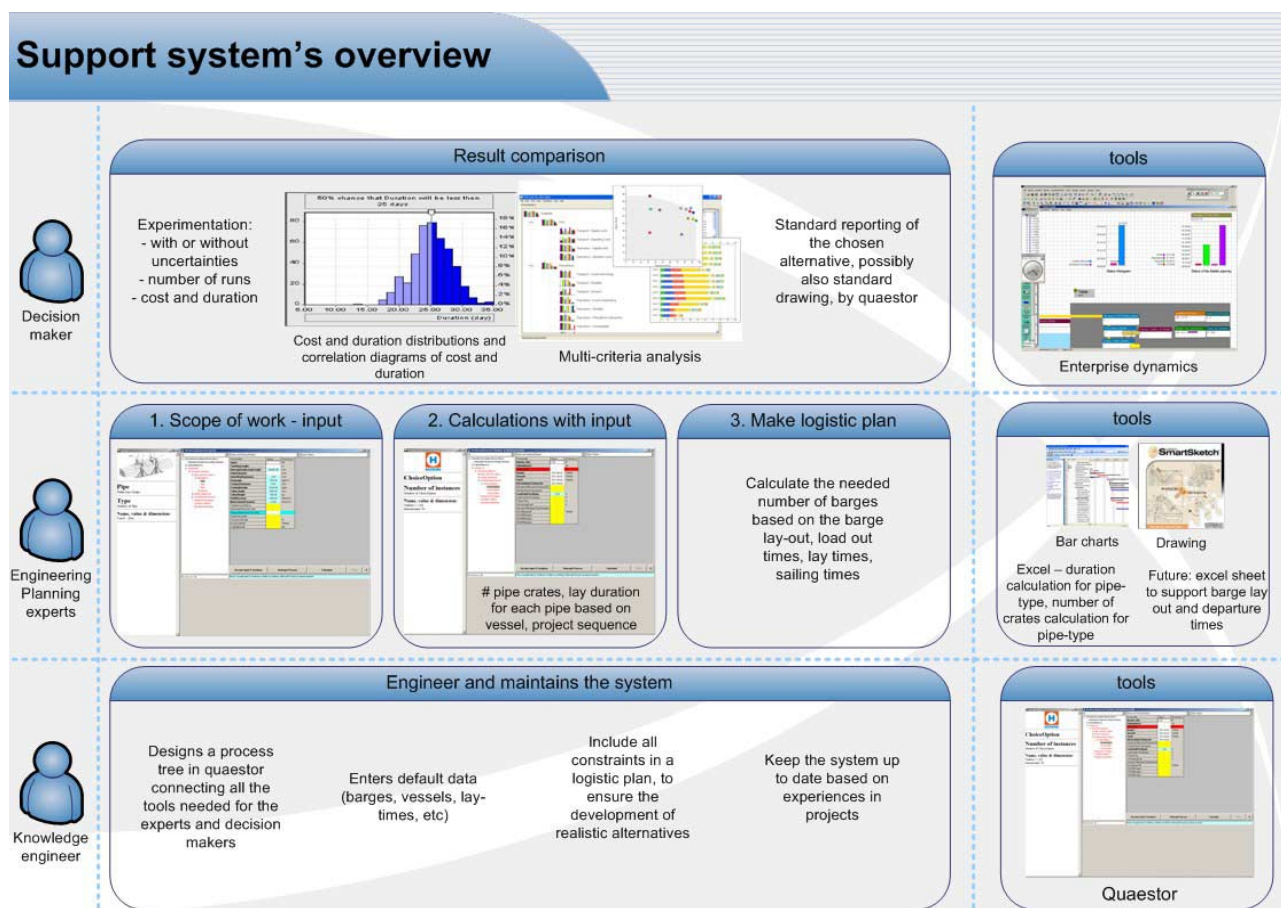


Figure 8.1.1 Concept of the support system

As getting insight in the effect of decision on the criteria is important, these effects must be clarified to base the effect on *objective* information. Consequently the visualization of the information is of great importance (Keller and Tergan, 2005). To compare alternative logistic plans Heerema's criteria are relevant; net-profit and predictability. As the time and costs are

depending on *uncertainties*, it is important to show the distributions of the costs and duration of a project, as this will give insight in the predictability of a project outcome (Feng et al, 2000). Currently the mean is often used to make decisions, but this gives no insight in the overlap between alternatives (Feng et al, 2000). Next to the distribution of the project costs and duration, the correlation between them, because both cost and duration are depending on equipment options, etc (Feng et al, 2000). This can show how the costs depend on the time in one alternative. As the process must be *transparent*, all the information, and how it is transformed to knowledge during the decision making process, must be open.

The technologies used form a toolbox of current used spreadsheets, and a new added discrete event simulation model. For complex activities the simulation model can depict the dependency between the activities and the dependency on uncertainties (Kamat and Martinez, 2000). By adding a broad toolbox, the system is *flexible* for projects with a varying complexity.

To connect the different calculation programs and databases together, Quaestor was selected. This is a knowledge-based system that enables to streamline analysis, design and engineering processes (van Hees, 1997). Quaestor fits the requirements, since it is able to connect different calculation programs and keeps track of decisions made in the designed process. Quaestor is also able to recalculate the outcomes when the input changes (*iterations*). This improves the ability to work with dynamic information, but also stimulates to improve an alternative or testing the effect of a certain change (for example more crew at the construction site). Also databases with 'default' information can be connected in Quaestor. This helps in two ways: primary by having all necessary information in one location, secondary by having 'default' information and calculation rules available when the information of the project is incomplete (e.g. in the tender phase there can be a *lack of information*).

The current process is very complex, because the *involved departments* autonomously share information with each other. These departments practice their own part within the design phase of the logistic plan. Also among the project managers for instance there are differences in opinions on what 'rules of thumb' to use. Also the risk avoidance amongst project managers is *diverging*. Consequently these both do not give the overview on the effect of certain decisions in the logistic planning process. To focus the process on determining the effect of a decision, the process must be more *goal-oriented* (Hammer, 1990). The new process is according to the principles of Hammer (1990); organized around the outcomes by capturing information in one source and stimulate to design *more than one alternative*.

8.2 Prior conditions for the success of the DES

To make the DES successful some prior conditions must be guaranteed in the support system. Therefore the most required prior conditions to make the support system successful are explained around the three environmental triggers: technology, process and people.

Technology

- Accuracy: In the evaluation interviews it became clear that the system must work accurate to be successful, the information to compare the alternatives must be valid, and otherwise wrong decisions are taken.
- Flexible: The system must be useful in at least 90 percent of the projects; otherwise there is no urgency to make a system. The system must also be easy to adapt to future situations and data.

- Transparent: In the evaluation the need for transparency and openness of the system was highlighted. Therefore all the data and calculation methods must be transparent.

Process

- Culture change: to make the system successful, different alternatives should be compared. The risk is that the system will be used, supporting the current working style of the employees (developing and revising one alternative). This must be avoided, as the added value lies in comparing alternatives and creating insight in the effects of decisions on the criteria (net-profit and predictability).
- Improve process: To make the implementation usable for the employees, the process must be improved compared to the current frustrating way of working. Therefore the system must take away the frustrations of manually recalculating parts after the input was partly revised.
- Practical process: Despite the complexity of the logistic planning process, the system is highly advised to remain practical in use (see evaluation chapter 9). The information must be conveniently arranged and maintain insight in the decision making.
- Support: The process must support the decision making, not make it a routine as creativity or manual input for a difficult project (fall out of the 90% scope) must be possible. In routine there lies the danger of not being alert to problems (section 5.1).

People

- Transparent: the system must be transparent and by that trusted by the users; otherwise they will not use the system. Potential users highlighted this during the evaluation of the system.
- User-friendly: The system must be user-friendly, as it must be easy to use; otherwise the intention to use will decrease (Davis, 1989).
- Responsibilities: During the evaluation of the prototype the actors stated that the role of the actors involved must be clarified and accepted by all the involved actors to make the support system successful.

8.3 Generic applicability of the concept

At this moment there is a promising Decision Enhancement studio designed. But this is based on one case, the logistic planning process within Heerema Marine Contractors. Within Heerema, there might be other fields where such a system can be useful. Therefore the following question is answered:

To what extent is this concept for the suggested support system applicable to projects other than the pipe-lay logistic planning projects? To answer this question dependence of the design on the characteristics of the system is explored in which the boundaries of the used tools are defined. Figure 8.3.1 shows the dependencies between the characteristics and the chosen tools based on the conclusions. For all ten dependencies the boundaries are explored.

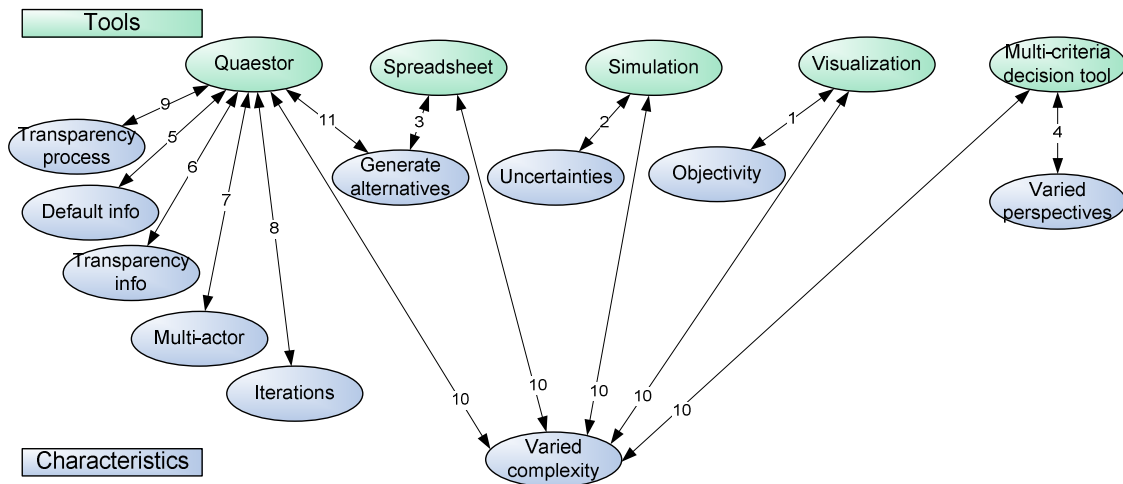


Figure 8.3.1 Dependencies between the characteristics and the tools

Objective decision making depends on the *visualization of information*. This information visualization (distribution of duration, etc) was chosen as it gives insight into the effect of uncertainties on the criteria (Feng et al, 2000). Therefore this method is applicable when the results of a project are not deterministic, but dependent on *uncertainties*. (Dependency 1)

Dealing the dynamics of *uncertainties* and generation of *alternatives* is improved by using *discrete event simulation* software. The aim of simulations is to perform experiments, which can not be performed in the real world; this is the case (Kamat and Martinez, 2000). As well other methods that incorporate uncertainties, Gantt charts, PERT analysis, can be used in the support system. However it depends on the complexity of the resources and activities in the project execution, what the most applicable method is (Verbraeck, interview 2008). (Dependency 2)

The *alternatives* are now calculated by using different *spreadsheets*. In these excel sheets, the calculation rules are standardized. This is results from the fact that the differences in pipe-lay project specifications are not very wide, which do make these spreadsheets useful (informal interview). (Dependency 3)

As several project managers exhibit different level of risk aversion (Meredith and Mantel, 2006), they use different ‘rules of thumb’ and find different criteria important (informal interview). The discussion for these *varied perspectives* can be communicated by a *multi-criteria decision tool*. When there would be only a single decision maker, this multi-criteria analysis can help him to select the alternative that fits his objectives. So this tool is applicable for projects containing either more criteria or more involved actors. (Dependency 4)

Quaestor as a tool can connect databases and ‘default’ calculation rules to generate a possible solution when the information is still *incomplete* (Dependency 5), but when the information is complete it is easy to change the suggested outcomes by real input for the project. Quaestor also shows the input to the other tools and the selected output. This makes the process very *transparent* (Dependency 6); on the other hand it is possible to hide information which can make the calculations a black box. This counts also for the process steps, Quaestor shows a

decision tree giving insight in the process, but certain steps can be hidden (Dependency 9). To give insight in the process a more complex tree of decision activities is needed, this is more difficult for Quaestor. The company of Quaestor is developing a system to enhance parallel design by different actors. This can lead to *multi-actor* usage of the system for one project (Dependency 7), but Quaestor can also be used by one engineer completing the whole project steps. When information changes during the project, the input must be changed. Quaestor calculates every alternative based on input. When this input changes (iterations), this will be recalculated to the alternative (Dependency 8).

All the tools must be able to deal with varying complexity, but are very limited to deal with other project domains. As the *simulation* model only produces pipe that can be transported by a barge to the pipe-lay vessel. The complexity can vary, because in *Quaestor* several methods to *spreadsheet* calculation of the alternatives are present, but the domain can not vary. All the tools are applicable for 90% of the pipe-lay project logistics. For the *multi-criteria decision support* also other information than the defined criteria can be depicted in Quaestor if a decision maker would like that. (Dependency 10)

As from the former points Quaestor is widely applicable for different decision activities, but only when different tools are connected to Quaestor. In this case the project alternatives to calculate are very detailed (exactly what is transported, when and how). But if the alternatives, which must be checked, are not so detailed, then these spreadsheet calculations to form an alternative are not needed. When this occurs Quaestor becomes unusable, as in this case just an input sheet for the simulation study can be designed and connected directly to the simulation system. (Dependency 11)

Summarized, the boundaries on applicability are:

1. The project results must depend on uncertainties
2. Alternatives can not be tested in the real world
3. Calculations to set up alternative can be standardized (fit >90% of projects)
4. Project must contain either more involved actors or more objectives
5. Both work with complete and incomplete information
6. The information can be both transparent as hidden
7. Single- and multi-actor proof
8. Quaestor can handle iterations in input
9. The process can be clarified by a tree of activities.
10. Only able to handle complexity within the domain (the 90% of the projects)
11. The generation of alternatives must be complex (needing more calculations methods and have many constraints)

8.4 Conclusions

The evaluation of chapter 7 states that the support system's concept is a promising support system for the logistic planning of pipe/structure supply for pipe-lay projects. This chapter gave an overview of the system and stated the conditions that must be fulfilled to make this promising concept successful in practice. The next chapter contains a scoping document (preliminary business case), which discusses the implementation risks and opportunities, the costs and benefits and a plan to take the concept to the business case level. The business case level contains a detailed and completely defined support system accompanied by the implementation planning.



Designing a Decision Enhancement Studio to support the complex logistic planning process of pipe supply

CHAPTER 9 EMBEDDING IN BUSINESS

To realize the designed support system is embedded in the organization, first the requirements are defined, as they form the input for the type of support that is needed. Then the culture differences between the current and the proposed way of working are discussed. To deal with the management of this change must be supported, otherwise embedding the system might fail.

9.1 Requirements

Requirement 1 [++]: The system should provide information visualization to support the design and *objective* choice between alternative logistic plans. Therefore the system must:

- Show the relative results of the alternatives to each other, based on net profit and predictability;
- Visualize the trade-off ;
- Support the involvement of extra information to make a choice when needed (for example on utility rates or critical path).

Requirement 2 [++]: The system must deal with *dynamic information*, varying from a lack of information to changing information. Therefore the system must:

- Contain a database with 'default' information;
- Be flexible to the change of information in an alternative, later during the process.

Requirement 3 [++]: The effect of *uncertainties* on projects must be visual. Therefore the system must:

- Be capable of simulating uncertainties (weather influence, breakdown, etc);
- Run multiple runs to generate different scenarios.

Requirement 4 [++]: The support system should be *flexible* within projects varying in complexity. Therefore the system must:

- Be adaptable to new project contexts;
- Be flexible to perform all types of logistics plans: multiple and more vessels/barges/yards/etc;
- Be flexible enough to change earlier made decisions.

Requirement 5 [++]: The support system must enhance *multi-actor* decision making process. Therefore the system must:

- Be easy to use by different actors;
- Enhance discussion to eliminate different perspectives;
- Give insight in the responsibilities per actor;
- Support parallel project design (actors can work on the same design simultaneously).

Requirement 6 [++]: The support system must stimulate the comparison of *alternatives*. Therefore the system must:

- Enhance the development of alternatives (saving time compared to current situation);
- Keep track of all the actions and decisions made, including their reasoning/results.

Requirement 7 [++]: The decision process must be *transparent and intuitive*. Therefore the system must:

- Eliminate black boxes (transparent);
- Give insight in the steps to take to make a decision (intuitively);
- Present all needed input and output information.

Requirement 8 [-]: The different tools in the system must be based on existing, applicable (to perform a certain task) and if possible standardized software.

Requirement 9 [-]: The different tools in the system should be able to run in a MS Windows environment.

Requirement 10 [++]: The different tools in the system shall be connectable to each other.

Requirement 11 [0]: The system must form the input for the project proposal and project logistic plan information that goes to the Heerema/client. Therefore the system must:

- Make a difference between confidential and commercial information;
- Have an interface that can be adjusted when talking with a client, to enhance communication with the client;
- Have an interface for the client, which contains nice pictures, animations and crucial aspects.

Requirement 12 [+]: The system must support the design phase and therefore creativity. Therefore the system must:

- Be as flexible to add new creative ideas

Requirement 13 [++]: For the validation and verification of the results, these results must be reproducible.

Requirement 14 [++]: The system must be easy to use to stimulate usage (Davis, 1989).

Requirement 15 [++]: The system should show the *prior conditions* for creating an alternative. Therefore the system must:

- Show technical constraints;
- Share experiences among actors.

Requirement 16 [++]: The system must generate *accurate* output based on accurate input. Therefore the system must:

- Be well verified and validated before use;
- Submit a simulation protocol to generate valid results;
- Have a check to verify if the results fit the input.

Requirement 17 [++]: the system must be *sufficient* to use for at least 90% of the projects. Therefore the system must:

- Leave room for technical solutions in different projects;
- Ensure that the 'default' information is kept up to date.

Requirement 18 [++]: the system must remain *practical*. Therefore the system must:

- Easy steer through the different methods to select;
- Have easy buttons to choose to use uncertainties or not for the calculations;
- Have a good level of detail, valid but as simple as possible.

9.2 Embedding of the process

In chapter 7, a gap between the current behavior and the suggested behavior was recognized, as the way of working (process) must change to achieve insight into the effect of decisions. Therefore some literature on change management is engaged, to compose a business case team and an approach to convince the involved parties on the urgency to change their behavior.

Change management

There are several reasons why change processes fail (according to Kotter (1990)):

- Too complex
- Failing to build a substantial coalition
- No clear vision
- Failing to clearly communicate the vision
- Forget to remove obstacles to prevent implementation
- Not planning for short term results and not realizing them
- Declaring victory too soon
- Fail to anchor in corporate culture

These reasons that are an obstacle for successive process change are strongly related to Kotter's eight steps of change (figure 9.4.1):

1. Create a sense of commitment based on a shared need and urgency to change. This step leads to a positive feeling towards the change process.
2. Create a team which will highlight the current issues and feel responsible to find a solution.
3. This team must define a vision and strategy to address the current issues
4. The vision must be communicated towards the actors and stakeholders, which must get committed to the vision. This goes along with the implementation of the support system.
5. Then the actors can change their behavior by using the new support system. However all the obstacles must be taken away to ensure they can change their behavior.
6. To create a strong commitment the short term wins must be highlighted and celebrated.
7. On the long term the successes must continuously be communicated to the actors.
8. The final goal is to make the system sustainable; this is reached when the actors will communicate the system towards new employees for example.

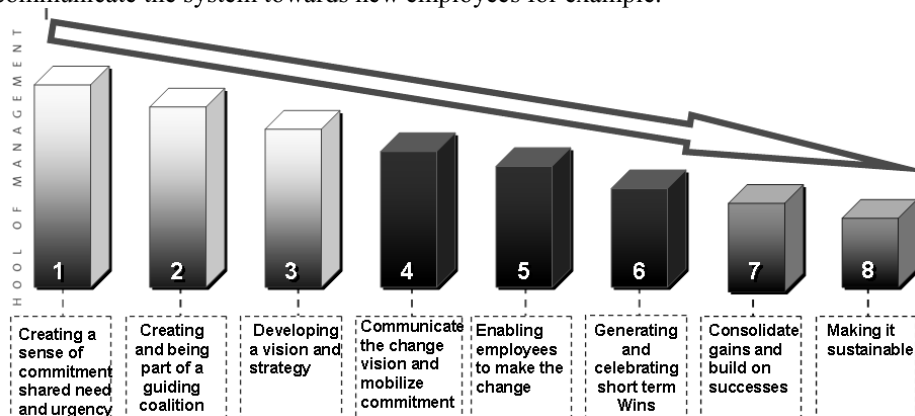


Figure 9.4.1 Kotter's eight steps of change (Kotter, 1990).

Behavior can be changed by (based on informal meeting with lead process engineer):

- Penalties or incentives – this has a short term impact, and when removed: the old behavior will be the way of working again.
- Affiliation – this is also not long term, when people move to other job-functions, the

organizational affiliation will be less useful.

- Internalization – based on committing all involved actors within the logistic planning process, this is a long term solution.
- By IT implementation – an implementation can avoid or require a certain way of behaving, as it limits the behavioral freedoms. This also has a long term impact.

According to Kotter and Cohen. (2002) there are two ways to convince and commit actors: first by the traditional approach. This approach consists of analysis, think and change. The new insights will commit the actors to change. The advantage is that this approach fits engineers due to their analytical and logical way of thinking. The second method is the different approach. This approach focuses on making the actors experience the need for change. The advantage is that it hits actors on a deeper, emotional level. This can be done by organizing a workshop with the new support system and let the actors experience the functionalities of the support system.

From this analysis two things are of importance to ensure successful implementation:

1. Make a **vision team**, composed of actors from the different involved departments (see appendix E). Due to the thesis characteristics of the research, step 1 and 2 were done by only an analyst. The disadvantage is the lack of communication towards the organization of the need to change. The perspectives of the different actors were gathered by the analyst and used to make a support system. But to get the business team one step further, it is important to involve a team that will enhance the commitment of the different departments.
2. **Communication plan** of the vision (support system development with behavior change) must be designed the business case. This can be done in the traditional or different approach, but a combination is possible as well. For example organize a work shop with two teams; one works according to their current way of working, the other team uses the support system. Their final logistic plans battle in a simulation to show the potential results on the criteria (net-profit and predictability). This captures both the analytical steps to proof the need for change, but also touches the experience with the new support system and process.

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

This chapter gives an overview of the conclusions of this study. Complementary recommendations on further development of the support system are defined.

10.1 Conclusions

For the conclusions first the challenges Heerema faces are summarized, then the research question is presented, followed by the research approach and answer to the research question.

10.1.1 Challenges for Heerema

Currently Heerema performs pipe-lay projects in the Gulf of Mexico. But in the near future they will be involved in projects in West-African and possibly Arctic regions. The lack of experience there and more harsh weather conditions in those regions increases the complexity and uncertainty of those projects. However, for this moment Heerema faces another challenge. This can be summarized as a lack of transparency in the decisions involved in the logistic planning process in daily practice. The lack of transparency arises from the inefficient and unpredictable nature of the logistic planning effort. Decisions are based on incomplete information (especially in the early stage of the planning effort) and intuition. Revised information has as effect the recurrence of calculations, which makes the logistic planning a frustrating task. In particular when different options and alternatives should be compared, the effects of decisions remain unknown. Consequently the opaque and ill-structured reasoning for certain decisions makes that the decision process performs below its potential to learn and to share knowledge.

10.1.2 Research question

To generate more insight into the decision making, the effects of choices on the criteria (net profit, quality, safety and predictability) of a logistic planning need to become more transparent. Therefore the research question is:

How can overview of- and insight into the effects of decisions, with respect to the pipe/structure-logistic planning process for pipe-lay projects, be achieved?

10.1.3 Research approach

The aim of the study is to improve the insight in- and overview of the effect of decisions on the logistic planning process results. The design science paradigm is selected, because it fits the purpose of developing a support system (Vaishnavi and Kuechler, 2007; Hevner et al, 2004). Connected to the paradigm, the research approach of Hevner et al (2004) is selected. This approach connects the design (how should thing be to attain goals) to science (how things are). The implication of this approach is that for the development of the support system, the used methods must be both rigorously selected and relevant for the environment (people, processes and technologies).

During the research steps (see picture 10.1.1) the method selection is based on the tension between research relevance and research rigor. First the current situation (defining the problem awareness) was structured according to the SADT structuring technique, based on a case study of six interviews and current used documents and technologies. As different actors have different opinions, the result was tested by four experts using the Delphi method. This method enhances consensus, by reflecting on the conflicts between the involved experts. The problem

awareness step raises the characteristics of the current and desired situation for the decision process.

The second step was to design a support system, therefore first the characteristics obtained in the first step, were translated into requirements based on the evaluation criteria aiming effective decision support (usefulness, usability and usage). With these requirements a support system is designed using software selection methods, information visualization criteria and process redesign principles. After the suggested design was depicted, the prototyping step could start.

Two prototypes were designed to enhance the iterative design (Bhoem, 1988); the first prototype was evaluated with two experts on the functionalities, the information visualization and the suggested process. This was done by a semi-structured interview, and added one extra requirement. The second prototype was to evaluate the functionalities of the concept with twelve actors, experiences and inexperienced. This prototype was therefore digitally and improved by the feedback of the first prototype. The digital prototype gives a more realistic view on the functionalities of the prototype, leaving less room for different interpretations. This prototype was evaluated by a semi-structured interview, to stimulate respondents to give suggestions. This also led to changes to the list of requirements. The feedback was positive, and therefore the concept of the support system is promising.

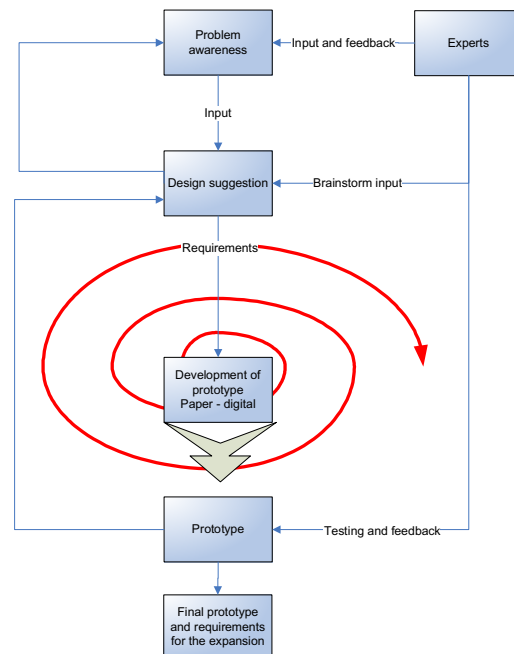


Figure 10.1.1 Methodology of design research (based on Takeda, 1990)

10.1.4 Research conclusions

To answer the research question, first the sub research questions are briefly answered to give insight in the composition of the answer to the research question.

What decisions are made during the logistic planning process, and what are the implications of these decisions on other decisions?

In the SADT model the decisions made are structured, varying from equipment selection (barge, vessel, etc) to dealing with uncertainties (weather, etc) (chapter 3). The implication of a decision on another decision is depicted by the decision process. The process is a result of what information is needed for a decision. On some cases resulted in feedback loops when decisions constrain one another. The main constraints are:

- The workability of the yard on the type of barge
- The allowable project duration on the sequence of laying the pipe
- The available barges on the required barges

What is currently done to achieve insight in the effect of decisions in the logistic planning process?

When in the current situation more time is available, more alternative plans are designed to determine the effect on the net-profit and predictability of the project (interview project manager). This and the revisions in a certain design lead to insight into the effects of decisions.

Who are responsible for the decisions made in the logistic planning process?

There are different types of involvement in the planning process. The tender manager/project manager is responsible for the commercial decisions. The project engineer is responsible for the technical design. The planners, operation managers and logistic engineers fulfill calculations that influence the project results. Other actors and stakeholders (e.g. client, PPD, risk department, procurement, etc) supply necessary information to the logistic planning process.

What is the influence of the decision approach in the acquisition of an overview?

Example: Due to subjective decision making, the effects are not transparent. It can be concluded that the decision process affects the transparency of the logistic planning process. Therefore it is desired to create more objectivity and transparency in the process.

What information is required to provide insight in the effect of decisions?

It is important to visualize the project criteria: net-profit and predictability. This can be done by depicting the distributions of the costs and duration of the project. This will give insight in the overlap between alternatives and the predictability of the outcomes (Feng et al, 2000).

How can this information be retrieved or created?

By using current tools to leave the calculation methods transparent, and by adding a simulation model that can give insight in the effect of uncertainties on the duration and costs (leading to the distributions of the cost and duration of a project).

How can the decisions process be improved and visualized?

The process is improved by simplifying the decision process to a goal-oriented process. The goal is to create insight into the effect of decisions. Therefore different alternatives must be designed and compared to depict the relative effect of a decision. The support system's decision tree depicts to actors the steps to generate and compare alternatives.

What are the requirements for a prototype support system to support insight into- and overview of the logistic planning process?

Chapter 9 gives an extensive overview of the requirements. But briefly the system must: Visualize the necessary information; Deal with dynamic information; Show the effect of uncertainties; Be flexible to varying; Stimulate the comparison of alternative plans; Contain a transparent and intuitive process; Connect different calculation methods; Be open for creative design; Show the prior conditions for projects; Generate accurate output; Be sufficient to 90% of the projects; Remain practical; Be easy to use.

Is this prototype supporting the decision making: is it expected to give enough insight in- and overview of the decisions to be made?

As the aim of the evaluation was to test if the respondents find the system capable of providing insight in the decisions made, the feedback certifies that the concept is promising. To really answer this question, the system must be tested on old projects and compare the results with the historical decisions. This was not possible to measure by these prototypes (chapter 6 and 7).

Final conclusion

The logistic planning process can be supported by the *promising* Decision Enhancement Studio (DES), which is focused on the technologies, process and people that are involved in the decision making. This studio has the ability to give users insight into the effects of decisions. The DES connects different tools, which can be used in the decision making process. The

current decision making is characterized by a lack of transparency (subjectivity, revisions, intuition, ‘rules of thumb’, revisions, etc) and a possible increase of uncertainty (future regions, weather conditions, etc). Therefore the DES must be useful in 90% of the logistic planning project for pipe-lay projects and the system must give room for the creativity of the decision maker. However the decisions must still be made by the decision makers, but the DES must steer the process to ensure the decision maker is able to compare alternatives and get insight in the difficulties of the project. Furthermore the DES must be flexibility. The different tools, visualization of information, the ‘default’ information databases and share the reasoning behind decisions, give the actors the tools and information they need to increase the efficiency and quality of decision making in the logistic planning process.

10.2 Recommendations

The recommendations are subdivided in recommendation on further development and recommendations on further research.

10.2.1 Further development recommendations

The development is divided in recommendations for further design of the toolbox, recommendations for qualitative evaluation and implementation of the DES.

Further design

Extend the current spread sheets and simulation model to fit 90% of the projects: Therefore add the calculations for types of pipe (different coating, pipe-in-pipe, different transport means, etc). Add the calculation on how many spare pipes to bring to the pipe-lay vessel. Add calculating the weight of crates as this is important for loading the barges optimal. And extent welding times, etc. with distributions to weld instead of the mean.

Collect ‘default’ information and calculation methods: This is twofold; first the standard information on barge specifications, vessel specifications and constraints, etc. must be available. Secondly when the current information is incomplete, the system must give suggestions. For example when the structure dimensions are not known, the system might calculate these according to the type of seabed and the diameter of the pipe. For this type of incomplete information, calculation rules that will approach the final dimensions are usable during phases of incomplete information.

Generate a valid and accurate calculation method for the number of barges: The number of needed barges is depending on the distance between the yard and the field, the sequence to lay the network, the type of barge and its load capacity, the lay speed of the vessel and the contingency plans for uncertainties as weather, port authorities, etc. To generate a calculation method that contains all these specifications of the project can help to fast calculate the number of barges. This process is time-consuming, as engineering and planning both calculate/engineer their part manually. However this automated calculation is only interesting if it supports 90% of the projects varying in complexity.

Generate a financial calculation method: The project costs are not all linear; some depend on contract agreements with the client. For example if a certain delay occurs due to the responsibility of the client. The contract holds agreements on the fine the client pays to Heerema. To compare the projects on net-profit, it is important to generate a valid (for >90% of the projects) financial calculation sheet.

Risk identification for logistics of pipe-lay projects: The risks that are relevant in most pipe-lay projects must be identified and assessed to incorporate them in the simulation model (for >90% of the projects).

Weather generator: The weather conditions vary according to location, season, and year. Weather is very unpredictable. Therefore it is interesting to have a weather generator model for projects, to visualize the effects of weather scenarios on the results.

Standard output files: For different output the output files must be standardized, in such a way Quaestor can add the needed information to those files.

Process design: The designed process is more goal-oriented; unfortunately the design is still incomplete after this study. As the responsibilities of actors are not redesigned yet, the process must be designed fitting the organizational processes. This can be done as an example by making one engineer responsible for using the system, or by making all departments responsible for filling in their information and calculations in the system.

Qualitative evaluation

When the new calculation methods are finalized, the effectiveness of the DES can be evaluated:

- Use old projects as input information and define several alternatives. With the visualized information on the net-profit and predictability a multi criteria procedure can be set up by letting many project managers and project engineers, select an alternative. The alternative that is chosen by them can battle with the original designed logistic plan and the effect can be depicted. This can also help to evaluate multi criteria selection methods.
- Measure the current time needed to calculate an alternative and measure this when the same project is performed by using all information, simulation and spreadsheets. This might show the timesaving of having all information together, implemented in Quaestor will lead to even faster design.
- Verify and validate the system on several use-cases covering at least 90% of the projects.

Implementation

For the implementation the communication of the urgency is important to make the support system get embedded in the organization and with that used by the decision makers. From the change management theory, I conclude that the first step Heerema should take is make a team that further designs and develops the DES to make this system fit within the organization.

10.2.2 Further research recommendations

This research approach and method are applied to **one** case-study resulting in the 'promising' design to support the logistic planning process, which gives a poor body of evidence. When further development proofs this support system is effective for the decision making, the question will rise if this concept support system would be applicable for other domains. In our generalization the boundaries of applicability to certain system characteristics were explored. But it is recommended to compare this suggested support system with the same type of support systems designed in other domains. This way a study can be fulfilled of the characteristics of the domains, the included tools and the effectiveness, which might lead to a design framework for developing a Decision Enhancement Studio concept applicable to many domains. This could be a PhD project.

CHAPTER 11 REFLECTIONS

This chapter is reflecting on the research study as is accomplished for my master thesis project.

11.1 Reflection on approach

From my own perspective the design science paradigm and chosen methods are suitable for equal type of problems. For ill-structured problems (involving different actors, where different options per activity must be tackled, etc), this is a suitable approach: since the focus is on designing an artifact, that is both relevant and based on proven technologies and where the balance between people, technology and process is important (Hevner et al, 2004). However it is probably not the approach to come up with the proof on the effect of decisions. Only a simulation study of designed options in old projects could proof effects (Angelides, 1998), to identify for example the wrong ‘rules of thumb’ is used. This would be a more positivist approach, as it is based on proving that one logistic plan functions better (on net profit and predictability) than another plan. So the design science paradigm “colors” the solution. But I have the opinion that within this project it is important to also embed the new technology within the business process, otherwise the new discrete event simulation package only is seen as added value, but does not stimulate the comparison of alternatives. By using the design science paradigm, the focus was on the process as well, leading to a different solution. I conclude this broader focus as the main advantage of the design science paradigm.

11.2 Reflection on perspective

The structuring of the current logistic process deals with interpretation problems. Interpretation plays a key role in the quality of the analysis (Klein and Myers, 1999). During the analysis the principles to increase the quality of interpretative research of Klein and Myers (1999) were adapted. An example is the use of the Delphi method to read consensus of experts on the SADT model (see chapter 4). However, not only feedback and input of experts/users is difficult to interpret, also the structuring method influence how the interpretation of the current situation (Mylopoulos, 1999). Selecting another structuring technique, the process might look different (see appendix C). The freedoms for different interpretations form the weakness of qualitative research (Klein and Myers, 1999). As for the interviews, the validity of interpretation was improved by taking care of the principles; unfortunately the structuring technique still can form a too “colored” view on the current situation. Representing the current situation differently, by for example lay the focus on information streams (flow chart) could lead to a different solution. This would not focus on the influences of the involved actors on the process. However the flow of information is more specified having the potential to lead to a slightly problem statement and different solution.

11.3 Reflection on generalization

The execution of approaches and methods from this study are only applied to one case; therefore body of evidence is poor. The domain is of logistic planning of pipe-supply is also a very specific domain with its own characteristics and risks. This is a complex problem where more actors are involved, risks and uncertainties influence the results and the generation of alternatives is complex (difficult calculations). As the final concept of the support system is seen as promising, it might be a useful concept to implement in other domains, but to really generalize the conclusions on successfulness, more evidence within this case and on more cases is necessary.



Designing a Decision Enhancement Studio to support the complex logistic planning process of pipe supply

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APPENDICES



Designing a Decision Enhancement Studio to support the complex logistic planning process of pipe supply

APPENDIX A DETAILED BACKGROUND INFORMATION

For the pipe-lay project a lot of technical equipment is needed, for example the Balder. Also for the pipes different options are possible for the materials and the coatings, etc. This appendix provides an overview of all this equipment and resources for pipe-lay projects.

Balder

The Balder has a dual crane lift which makes it possible to install large fixed structures. The Balder also has a J-lay pipe-laying tower (see figure A.1). The aim of Heerema is to make the Balder work as fast as possible; therefore the utility of the tower is critical. The speed of the tower determines the fastest process of pipe-lay, because it is the final process. All other processes must adapt to the speed of pipe-lay process to make sure it does not decrease the utility of the tower. The Balder can only handle double-joint pipes. The Balder has a fabrication process onboard, where it connects 3 double-joints of pipeline (hex-joints) to lower with the tower to the seabed.

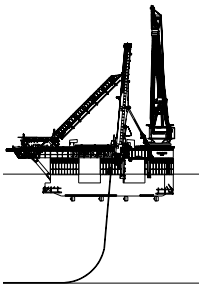


Figure A.1 Balder with J-lay method

In figure A.2 the lay out of the Balder can be seen. The double joints will be placed on deck in the storage area (blue). In the pipe handling area the double joints are first welded and coated to quad-joints and in the next step to hex joints. The hex joints will be hung in the tower with the pipe elevator system.

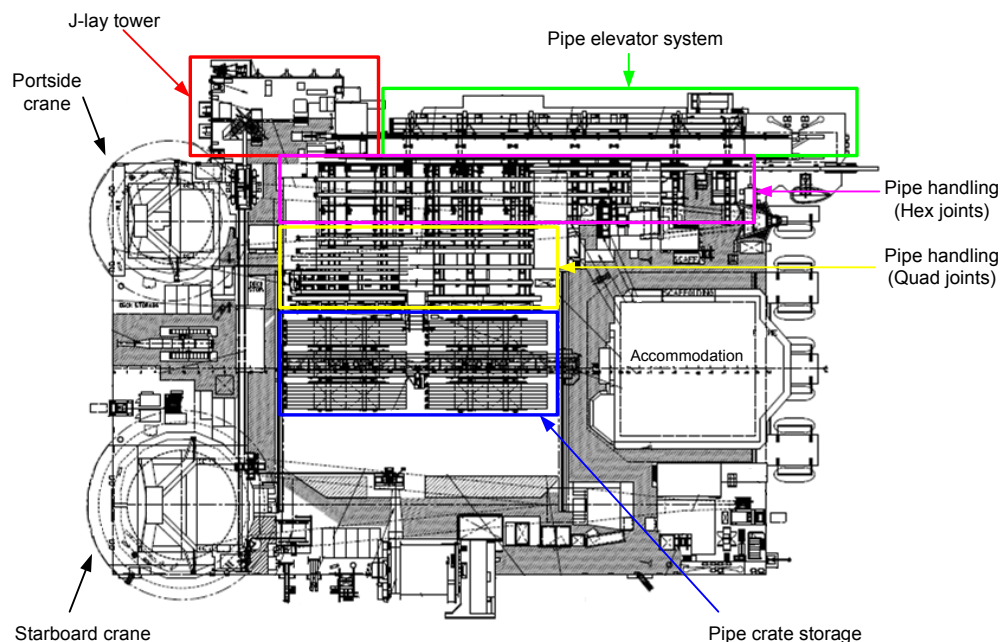


Figure A.2 Balder lay out

Pipe-lay methods

To give some background on the advantages of the J-lay method, this and other methods are described. Ploeg (2001) made a comparison of the different pipe-lay methods based on several criteria. In table A.1 the overview can be seen. First the criteria and their importance for projects will be described. Then the processes of the different pipe-lay methods are described. This will lead to a discussion on the advantages and disadvantages of each method.

	S-lay	J-lay	Reeling
Water depth limit	0	++	++
Pipe size limit	++	+	-
Lay speed	+	0	+
Installation of structures (e.g. ITA)	-	0	--
SCR installation	-	+	0
PIP installation	+	+	+
Free span/curves	-	+	+
Workability	0	+	+
<i>Symbols: -- very bad, - bad, 0 neutral, + good, ++ very good</i>			

Table A.1 Comparison pipe-lay methods (Ploeg, 2001)

Criteria

Water depth limit is important for the choice of the vessel. For a project the client's specifications also determine the water depth of the pipeline network. Pipe size limits the choice for a vessel, because the vessel must be capable of laying the specified pipeline. The lay speed influences how fast the network is finished. When the network needs structures (e.g. ITA, PLET) the vessel must be capable of adding those structures to the pipeline network. This also counts for special pipelines with SCR installation or PIP installation. The free span/curves that the vessel employs on the pipeline, limits the choice for pipeline materials. And also the workability of the vessel is important because clients expect high capacity pipe-lay vessels.

S-lay

For the pipe sections are welded on the deck of the S-lay vessel. These welding stations are in one line on the deck followed by the NDT station and a stinger. The stinger structure deploys the pipeline horizontally with rollers to control the curvature of the pipe (see figure A.3). The tensioners make sure the pipeline does not fall of the stinger due to pulling forces of the vessel (Igland, 2000).

This method leads to two bends on the pipeline, one with the ship and one with the seabed. This leads to more pulling forces on the pipe. Especially these spans are large, which leads to high stresses and strains on the pipe. Therefore there is a depth limit, which is determined by the pipe diameter, material and installation criteria.

On the other hand the S-lay method is fast and has not that many pipe size limits. Heerema has no such a vessel.



Figure A.3 Stinger structure

J-lay

With the J-lay method the pipe sections are welded on deck of the vessel and the hex-joint pipe sections are almost vertically welded in the J-lay tower. J-lay pipe-laying causes less bends on the pipes than the S-lay pipe-laying method does, because with the J-lay method, the pipe only have to make one bend with the seabed. This pipe-laying method also has the advantage of

causing less pulling forces on the pipe. It also has the advantage of being capable of adding structures to the pipeline. And this method suits deepwater pipeline construction. Disadvantage is the vertical position of the tower, which makes the process less continuous and less fast when using the arm to get a pipe in the tower and the pipeline also need collars to make the hanging possible.

Reeling and towing

The last options are Reeling and Towing are methods. When using reeling large parts of pipelines must onshore be bended and winded onto a reel. Onboard the reel is attached and unwinds the pipeline, straight it again and laid down it on the seabed. Important is the limitation on the strain on the pipeline, this is material dependent (Walker, 2004). With this higher bend ratio, this could be used in shallower waters. And because of the larger strains, only small diameters are possible in laying pipeline structures. With smaller diameters smaller vessels than the Balder could be used (Walker, 2004). The speed can be compared with S-lay, but it is harder to add structures to the network.

Towing by preparing the pipeline on the beach is cost-saving, because the vessels that tow the pipeline are not specialized pipe-lay vessels, which are less costly to operate (German, 2004). Also towing takes less time, which saves costs. However the risk of total loss of a pipeline cannot be eliminated in contrast to the conventional methods of pipe-lay projects (J-lay, S-lay and Reeling) (German, 2004).

Conclusions on pipe-lay methods

The J-lay method does not put many constraints on the depth, pipe diameter and needed structures for the pipeline network. The majority of deepwater networks can be constructed by this method. Ploeg (2001) expected that the depths were going to increase in the future and the workability must increase by the demands of clients. The S-lay and Reeling method will be the dominant method for lines that suite those methods, because of the lay speed, which results in low costs. The choice for towing is determined by the costs and the chance of total loss, when it is profitable this method will be used. Heerema aimed to be able to lay pipes deeper than competitors (Reed, 1998); therefore together with the expected future trends the J-lay method was built onto the Balder.

Pipes

The pipe components are produced as single joints (SJ), this production is done at a steel mill. The steel mill is often not located at the yard. Therefore, extra transport is needed (on water or land) from the steel mill to the yard. At the yard the SJs are coated and welded to double joints (DJ), which are around 24 meters long. The coating is needed to prevent the pipe from corroding. On one in three DJs a collar (C) is welded, named a Collar Joint (CJ) (see figure A.3.1). Collars are needed to hang the hex joint (HJ) in the J-lay tower (see figure A.4), where the collar will hang in a mechanical clamp. This is the standard procedure for the DJ production at the yard, but deviations are possible. Onboard of the Balder the pipes are welded to Hex joints, also special add-ons are attached to the pipes on the Balder.

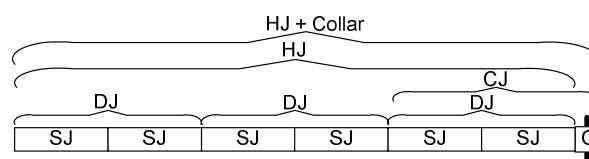


Figure A.4 Pipe components

There are some different options for the pipes. The pipeline is built up in flow lines with if necessary a steel catenary riser (SCR) or structure. The flow line lies on the seabed; the riser connects the flowline with the platform. The riser needs a flex joint when fixing the pipe to a floating platform. This flexible joint between the riser and the platform absorbs the large angular movements of the platform (Quintin et al, 2007). Also pipe-in-pipe (PIP) projects are possible to lay with the Balder. The difficulty there is the movement of the inner pipe during construction, the inner pipe can move as only the outer pipe is fixed to the structures. For the welding onboard of the Balder the inner pipe can be temporarily fixed with the Obelix or Idefix tool. The Obelix can fix higher forces than the Idefix, but takes more time to install (informal interview).

Connected to the pipe network are PLETs (Pipeline End Termination) which can be the beginning/end of a network pipe and ITAs (Inline Tee Assembly) which allows an extra pipe to enter the network with a T-splitting (See figure A.5 & A.6). These are necessary to form a network on the seabed. The design of these special structures is determined by the pipe diameter. The bigger the diameter the heavier and bigger the structure, which leads to a bigger support mud mat structure to prevent from sink in the mud of the seabed.

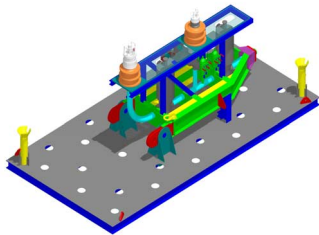


Figure A.5 Design of a PLET

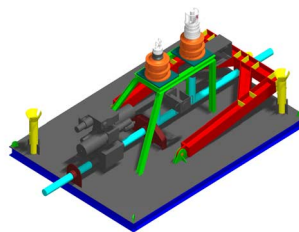


Figure A.6 Design of a ITA

Barges

A barge is a floating box with almost only deck space and must be towed by a tug-boat. Barges are needed for the pipe logistics from the yard to the vessel. Different barges can be used, bigger or smaller barges, with or without crates, etc. This will influence the costs of the project, but might have an interesting relation with the efficiency of the transport towards the Balder.

Heerema Marine Contractors owns 7 barges. But as they sail under the Panamanian flag, they are not allowed to transport pipe to the yard in the Gulf of Mexico. The Jones act (a US law) forces that all transports between US ports or US facilities on the coast have to be performed with US owned and operated vessels, only pipes can be brought out of the yard by differently owned vessel. In Europe these protection laws are fading out due to acts of the European Union. But the Jones Act contains an exemption for the offshore transport of multi-joints. So Heerema could use their barges in the Gulf of Mexico.

Tug-boats

The choice to hire certain tug-boats is determined by a mix of costs, availability, quality (based on experience) and the capacity, named bollard pull (determines if the tug is capable for the job). The capacity now focuses on the fact that the tug-boat must be able to handle the loaded barge. Currently the speed of transportation is not very important, as the distances are small. But in the future this might get one of the parameters to ground the choice on, due to an increasing fuel price or due to highly specialized yards that are further away from the project (Interview operations department).

APPENDIX B SYSTEMS OVERVIEW

Structured analysis and design technique (SADT) is an activity oriented modeling approach (Santarek and Buseif, 1998). It gives insight in the performed activities and their flow. Each activity has an input, which will be transformed by the activity. The activity process leads to a result visualized as the activity output. An activity can be a decision, a material conversion or an information conversion (Santarek and Buseif, 1998). The procedures and system conditions are described by the control arrow, while the resources are described by the mechanism arrow. Figure B.1 describes a SADT building block. Each activity is decomposed in subsystems, until the detail suffice the aim of the modeler (Marca and McGowan, 1985). This technique is known for its simplicity and uncomplicated applicability, nevertheless supports no time evolution (Santarek and Buseif, 1998).

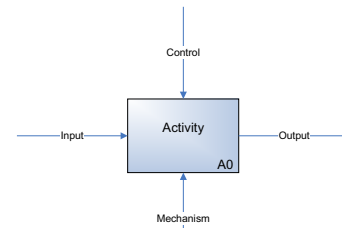


Figure B.1 SADT building block

This technique is applied to give overview on the steps taken to execute a pipe-lay project. It starts at the yard: that the pipe sections are fabricated at the yard, is assumed in this model. For some projects pipe sections are fabricated at another location and transported to the yard where they are coated and welded to double joints.

Pipe-lay project execution

The execution is decomposed in the pipe production, pipe transportation and pipe-lay logistics (see figure B.2). These three overall steps result in a pipeline on the seabed starting from the raw pipe material, coating materials, welding materials and collars. First level A1 on the production of multi-joints with collars is described in more detail. Then we elaborate on the pipe transportation and pipe-lay logistics.

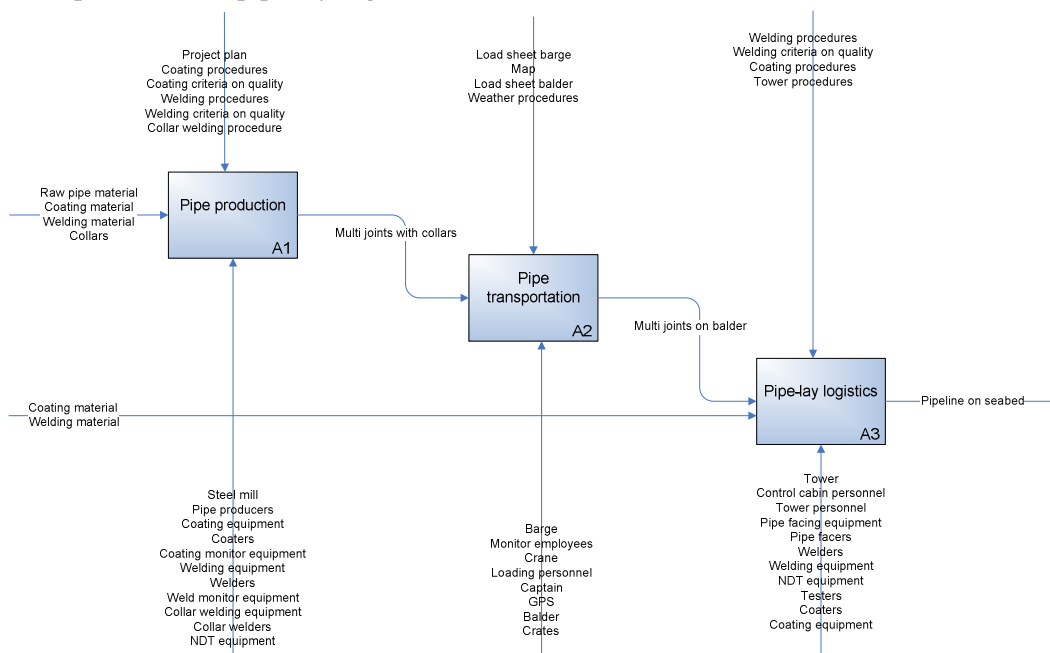


Figure B.2 Decomposition of level A0

Level A1 Pipe production

From the raw pipe material single joint pipe sections are fabricated in a Steel Mill (see figure B.3). Then the single joints are coated at the yard following the coating procedures and quality requirements. Two single joints are welded together, which forms with an added collar the transportable multi joint. Only one collar is welded per hex joint (which is formed out of 6 single joints).

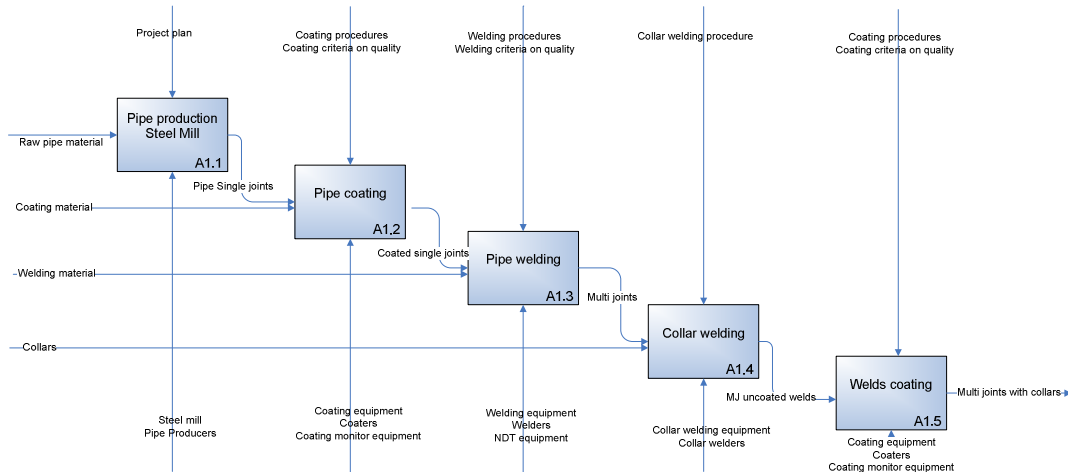


Figure B.3 Decomposition of Pipe production

The coating and the welds are tested on their quality (Figure B.4 and B.5). If the quality is unacceptable the weld or coating needs to be redone or improved. For example if a weld fits no quality standard, this can lead to a cut out. Then the weld is completely removed from the pipe section and need to be redone (including the preparation of the pipe ends). This much detail is not included because the yard's exact details fall out of the scope (chapter 4).

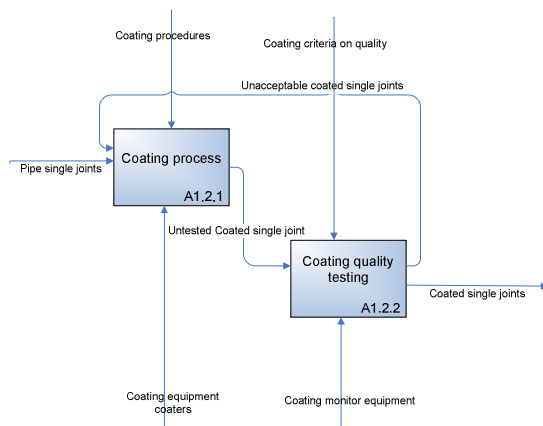


Figure B.4 Coating process

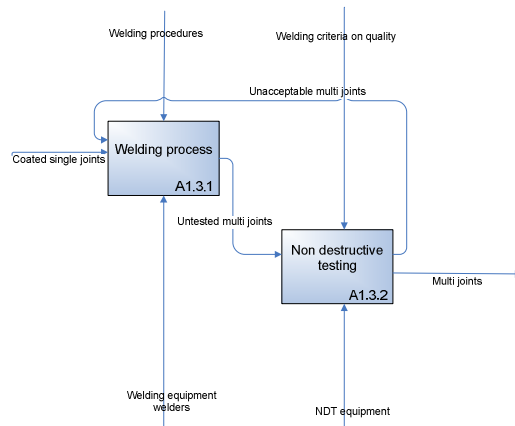


Figure B.5 welding process

Level A2 Pipe transportation

At the yard the multi joints are loaded into crates (see figure B.6). These crates are already onto the barge. The load sheet determines precisely the location of the crates/pipes on the barge. When the barge is loaded the transportation can start. A tug with captain executes the transportation of the barge, only when the weather forecast is acceptable they can leave the yard.

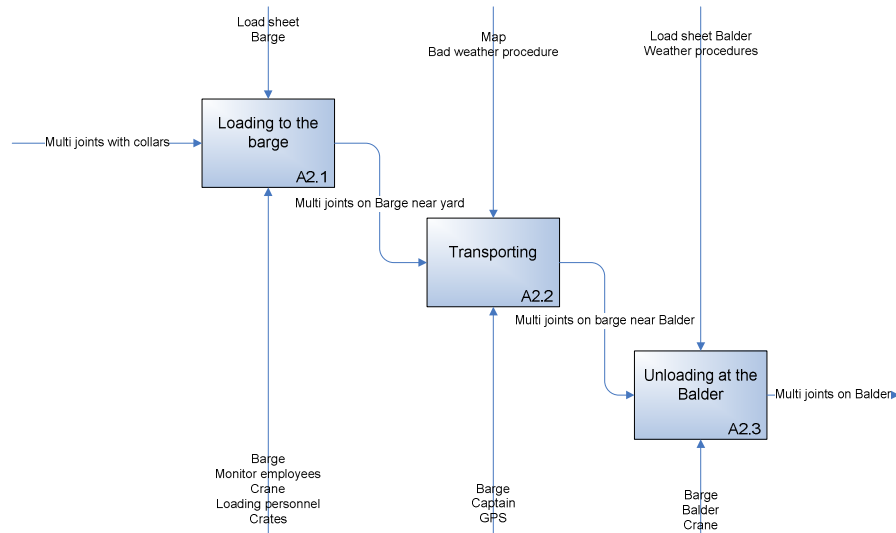


Figure B.6 Decomposition of the pipe transportation process

Level A3 Pipe-lay logistics

The pipe-lay process on the Balder is twofold (see figure B.7). First the multi joints must be welded into hex joints. Then these hex joints are hung into the pipe-lay tower where the hex joint is welded onto the pipeline and lowered onto the seabed.

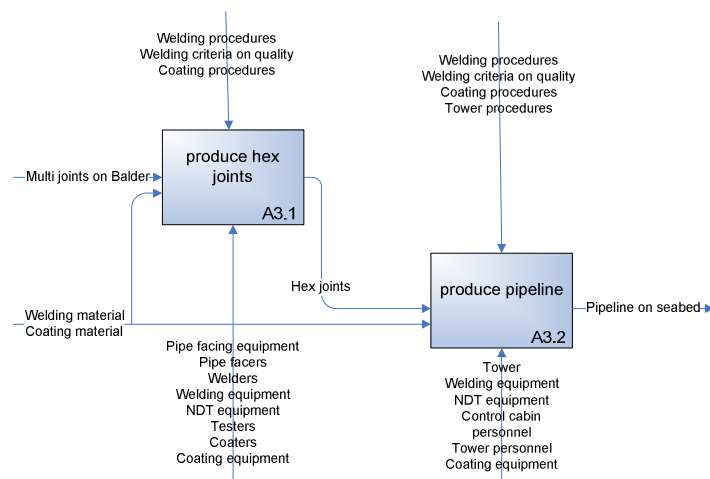


Figure B.7 Pipe-lay logistics

In figure B.8 the welding and coating activities are presented this is comparable with the welding and coating at the yard.

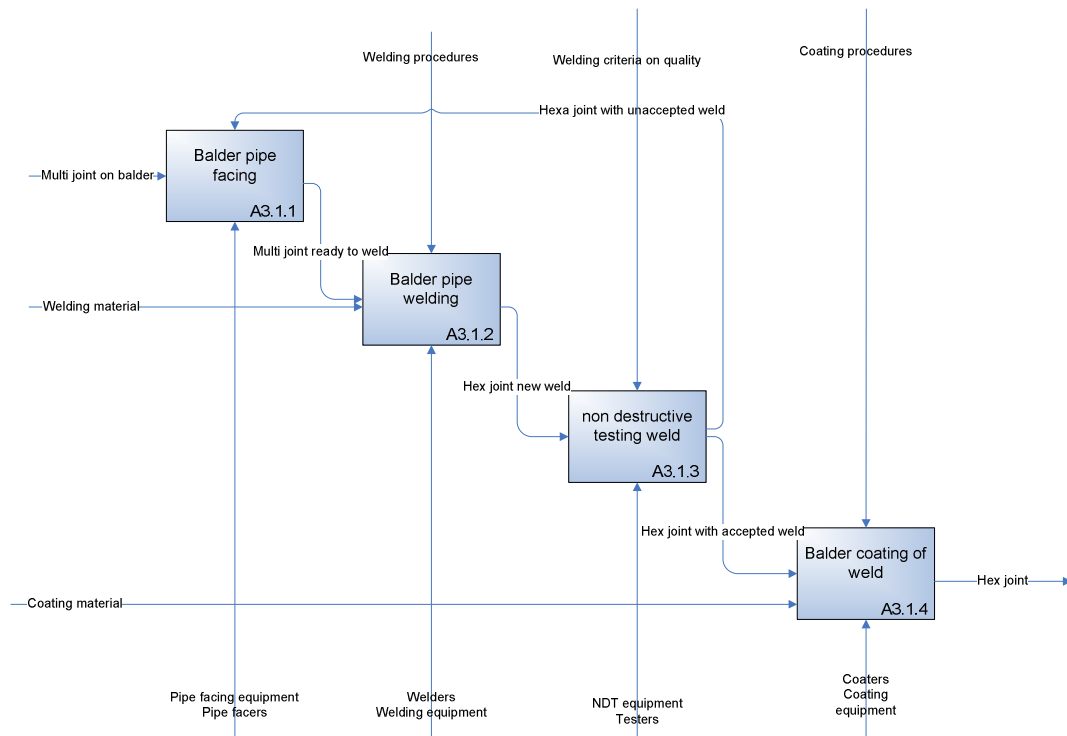


Figure B.8 on deck of the Balder

Figure B.9 elaborates on the welding and coating activities in the j-lay tower.

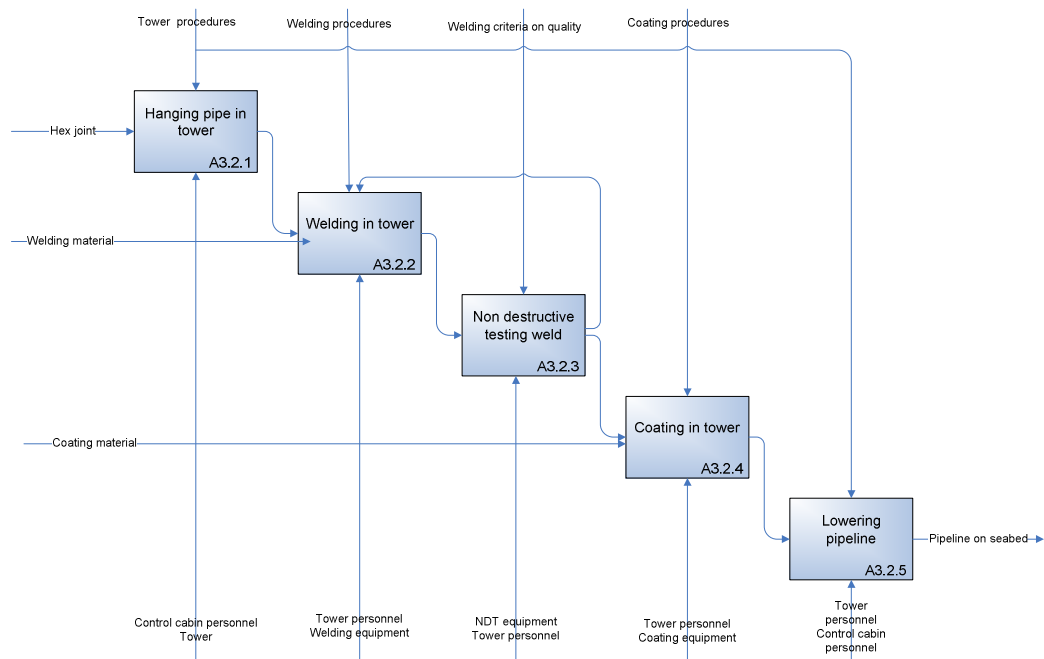


Figure B.9 activities in the J-lay tower

APPENDIX C INTERVIEW ANALYSIS

For the data collection interviews and documents form the main sources (see figure C.1); the explorative interview, documents and reflective interviews. To make sure the information received is of high quality the principles of Klein and Myers (1999) will be used. First the principles are briefly explained (see C.1). Next an explanation between different types of data collection is provided (C.2). Also a discussion on different structure techniques is provided in C.3, this was necessary for decision for SADT as a structuring technique. Then the interviewing procedures for this thesis project are discussed C.4. In this procedure the principles are translated into applicable and practical methods (including the interview questions). For some the analysis of the answers is an important step and is therefore deliberated on.

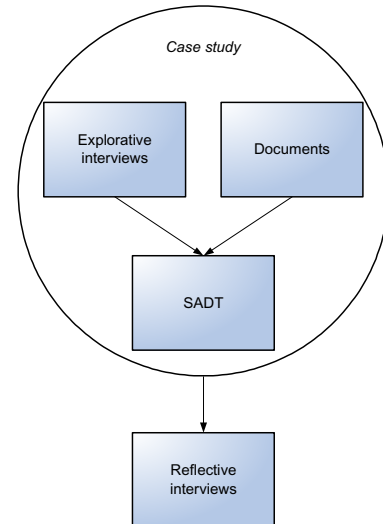


Figure C.1 Data collection overview

C.1 Principles

Interpretation plays a key role in interviewing. Important is the quality of the interpretation (Klein and Myers, 1999). Their principles give some guideline in the evaluation of the research:

- The first is the principle of Hermeneutic circles; this is based upon the understanding of a complex set of ideas about the meaning of the parts and the relations between those parts. The understanding is finally a result of iterating between the meaning of the parts and the meaning of the whole.
- To understand the meaning of something, the understanding of the context is important, this is called the principle of contextualization. In interpretive view the context is constantly changing.
- Also the interaction between the researcher and the subject determines the interpretation; own assumptions should be questioned (principle of interaction).
- From the principle of abstraction can be concluded that theory plays an important role for interpretative research, not only in falsifying but also as sensitizing device
- In the end the principle of dialogical reasoning is important to confront the end results with the prior preconceptions.
- When there are conflicts about the interpretation, the researcher should always confront this conflict and revise his understanding accordingly, which is the principle of multiple interpretation.
- The final principle that can be used to reach quality is the principle of suspicion; this principle challenges the researchers for critical thinking.

C.2 Types of qualitative data collection

This comparison is based on Fontana and Frey (1994):

Structured interview	Semi-structured interview	Group interview
Complete script which leaves no room for improvisation. Also there is little room for variation in the responses, except when using open-ended questions. Advantages: There is little room for variation in the responses, except when using open-ended questions, better to compare Disadvantage: No flexibility	Incomplete script, there is a need for improvisation. Advantages: Goes more about understanding, than explaining. Disadvantage: Every interview is different	Interview with more than one interviewee. Advantage: Capabilities of whole group together. Disadvantage: Group dynamics, e.g. one person can dominate the group

C.3 Structuring techniques

To structure the world different conceptual models are available. Conceptual models comprise of building blocks, structuring mechanism, consistent symbol structure states to interpret the model. Here SADT, flowchart and Entity-relationship models are compared. Causal modeling is not suitable as not all the relations in the logistic planning domain are causal, for example the choice for a type of barge depends on other settings in the domain.

<i>SADT</i>	<i>ER</i>	<i>Flowchart</i>
World consist of activities and data. Each activity consumes and produces data, is controlled by procedures and executed by someone/something (Santarek and Buseif, 1998) Advantages: - All inclusive model (Mylopoulos, 1999). - To communicate ideas (Mylopoulos, 1999) - Ability to show hierarchy (Santarek and Buseif, 1998) Disadvantages: - With many decompositions hard to read - No time constraints	World consists of entities and relationships. It is combined with logical language on the properties of the different classes (Mylopoulos, 1999). Advantages: - Ability to reuse earlier defined classes - Shows the constraints between entities (Mylopoulos, 1999) Disadvantages: - Does not show the process	Flow diagrams model the flow of data and focuses especially on this data flow within an organization (Mylopoulos, 1999). Advantages: - Deep focus on the flow of data. Disadvantages: - Only focus on the data flow does not include procedures.

The SADT and flowchart technique are suitable for the logistic planning process, as it is important to show the process of the logistic planning (research question). For this reason ER is not suitable. The advantage of SADT in relation with the flowchart technique is the ability to show the techniques, actors and procedures in the flow. This will complicate the model, but is applicable to the research approach of design science, as it is relevant showing people, techniques and processes (Hevner et al, 2004).

C.4 Data collection procedures

In this part of the appendix the protocols for the different executed data collections are described.

Explorative interview protocol

The procedure is the Delphi interview method, and is executed face-to-face with 6 experts. In the Delphi method first the respondents answer open questions, which will be extensively compared (Verschuren and Doorewaard, 1999). The differences found by this comparison of answers, will be returned to some of the respondents (via mail). The respondents can react by giving their opinion about the differences between the respondents.

- The involved employees of Heerema will be interviewed, because they have the knowledge about making a logistic plan. First they will all be interviewed with the same questions. These are described in the analysis interview. A summary will be send back to them to avoid misunderstandings (principle of interactions). The conflicts in their explanation of the system will be confronted, to find the exact way they make a logistic plan. (Takes care of the principle of multiple interpretations). Also conflicts with my assumptions or doubts should be cleared up during the first interviews (principle of interaction and principle of suspicion).
- During the first interview an overview of the logistic planning design must be formed. Therefore all the involved employees will be questioned the same questions. After that I will make an overview and discuss it with some of them. Together because this might result in conflict solving. And it also will go from the parts up to the choices that have interdependent relations in the whole logistic planning. (Takes care of the principle of hermeneutic circles). Only some of them, because a small group will be easier to steer and more open to new ideas.
- The context is; the tender and project phase for logistic pipe-lay projects, on how the logistic planning is done (Takes care of the principle of contextualize).
- The questions should be open (yes or no answers are not possible), to avoid only a short yes or no, but to get a real answer.
- As it is explorative, the questions will be according to the informal problem structuring of Pidd (2007).

Analysis interview

To get an overview on every choice in the logistic planning, the following questions are important:

Overall:

- What are all the choices to make?
- What is the starting point of the decision making (if there is one)?

Per choice

- What are the options per choice?
- Who makes these choices?
- What information is necessary to make these choices?
- How are these choices made (what tool, what calculation method, which 'rules of thumb')?
- What is the result of the choice?
- What is the implication of a choice on other choices?

The result of the interview will be answers to these questions, which might be captured in a model (e.g. flowchart model). The interviewee should agree with the model been made, to make sure the interpretation of answers was correct.

Results

Conflicts:

Heerema is growing, last year they hired 150 new employees. This will lead to the involvement of more strangers for the projects between departments, as it will be difficult to get to know all the employees. This might lead to distrust between departments.

During the interviews and stakeholder analysis it was sometimes vague who is responsible for what. The employees tend to broaden their scope of work, which will lead to some overlap between the different departments. However this leads to uncertainties about who is really responsible. And I would advise Heerema to lay more focus on clearly describing responsibilities. And especially with the growth of the company this can help employees to clearly behave responsible but also as expected, which will prevent from the possible distrust.

There is also a difference between the design of logistic plan and the execution. The designers focus mainly on the most efficient design. But during the execution anything can happen, therefore a more flexible design can better handle the events. So for the designers the number of barges should stay low, to save costs. But for the execution an extra barge at hand would be very useful in case of the event they have to offload the inventory on the Balder.

Reflective interview protocol

With the explorative interview and documents we made a draft overview of the logistic planning process using the SADT structuring method. The step from the interviews and documents to a SADT model is partly based on our own interpretation. To test our own interpretation of the logistic planning process, this is validated by testing the model on the experts. For this test 4 experts were interviewed. The explorative interview consists of a structured interview performed according to the Delphi method and a usability test according to the TAM questionnaire by Davis et al (1989). First the questions and answers are listed, then the conflicts in the answers are reflected on and the result of the TAM questionnaire is discussed. To deal with the conflicts extra feedback was gathered from documents and/or experts.

Reflective interview questions

1) Delphi questions

Per activity

Check of the system per activity:

Are you involved in this activity?

If yes, what is your task Decision maker/task fulfiller/influencer?

Does the activity give you a realistic overview, input output control and mechanism?

Improve per activity:

Does the activity give you a realistic overview, input output control and mechanism?

Overall system

Check of the overall system:

Is this decision chain representative for the logistic planning process?

If no, what would be representative?

Improve the overall system:

Is this also the representative decision chain for the future, or is there a need for improvements?

What would you like to improve on the decision chain for the logistic planning process?

2) TAM Questionnaire

My using the SADT model in my job would be:

Good							Bad
	Extremely	quite	slightly	neither	slightly	quite	extremely
Harmful							Beneficial
	Extremely	quite	slightly	neither	slightly	quite	extremely
Wise							Foolish
	Extremely	quite	slightly	neither	slightly	quite	extremely
Negative							Positive
	Extremely	quite	slightly	neither	slightly	quite	extremely

How confident are you in the ratings you have made on the overall model?

Not at all							complete
	Extreme	quite	slightly	neither	slightly	quite	extreme

Perceived ease of use:

Learning to use the SADT model would be easy for me.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

I would find the SADT model easy to use.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

I would find the SADT model flexible to interact with.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

I would find the SADT model understandable and clear.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

How confident are you in the ratings you have made on the perceived ease of use?

Not at all							complete
	Extreme	quite	slightly	neither	slightly	quite	extreme

Perceived usefulness:

Using the SADT model would give me more insight in my job.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

Using the SADT model would increase my job performance.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

Using the SADT model would make it easier to do my job.

Likely							Unlikely
	Extremely	quite	slightly	neither	slightly	quite	extremely

Using the SADT model would enhance the effectiveness on the job.

Likely

--	--	--	--	--	--	--

 Unlikely
Extremely quite slightly neither slightly quite extremely

I would find the SADT model useful in my job.

Likely

--	--	--	--	--	--	--

 Unlikely
Extremely quite slightly neither slightly quite extremely

How confident are you in the ratings you have made on the perceived usefulness?

Not at all

--	--	--	--	--	--	--

 complete
Extreme quite slightly neither slightly quite extreme

Anticipated use:

Assuming that the SADT model would be available on my job I predict that I will use it on a regular basis in the future.

Likely

--	--	--	--	--	--	--

 Unlikely
Extremely quite slightly neither slightly quite extremely

improbable

--	--	--	--	--	--	--

 probable
Extremely quite slightly neither slightly quite extremely

How confident are you in the ratings you have made on the anticipated use?

Not at all

--	--	--	--	--	--	--

 complete
Extreme quite slightly neither slightly quite extreme

Results Delphi interviews

#	Explanation of conflict	Solution and reasoning
1	Role of the project manager changes over time (tender phase, project phase, etc); this is not visible in the model.	<i>Consult experts and documents.</i> Validate the new input with the documents and experts.
2	The duration of a sequence is based on the vessel and project specifications. This is calculated by the T&I planner, but might be estimated by the Logistic Engineer while choosing a less time consuming sequence.	<i>Formal vs. informal process.</i> The logistic engineer defines the sequence based on logical thinking and specifications. There is a formal loop between the visualized bar chart of the duration and needed revisions to the sequence. This formal loop is visualized in the process.
3	This list form <i>added arrows</i> for certain decisions: - Finalize logistic plan: T&I planner not involved, Logistic Engineer makes the final report. - Duration calculation: PPD also gives necessary information data for the calculation. - Load sheet determination: vessel storage also constrains how a barge can be loaded. Also a smart sketch software program is used to support the decisions. The final load sheet is also checked by the Project manager to verify it with the project duration. - Number of barges is also depending on the specifications of the yard and the estimated duration (which is based on the lay speed), and also the project engineer is involved in this process. - Choice of yard(s): will also put constrains on the barge (dimensions inland water way and quay length) and load sheet (due to load out equipment capabilities). This is also	<i>Consult experts</i> to validate the new insights.

controlled by the costs, reachableness, required workability, local policies/content, and local weather conditions. The mechanism can be extended by procurement (costs), operations (workability) and project engineering.

- Depth is not a leading factor in determining the transportation equipment, workability is more important.
- To combine: the transport of structures and crates the risks of sailing to/from a yard is a control.
- Type of barge: is only determined by the operations manager and project manager.
- Availability check of equipment: is also supported by the project manager and procurement department to check the finances.

4	This list suggests <i>decision flow alternatives</i> : - Choice of barge is most important of making a load sheet and should therefore be started with. - Number of crates is important to know for the combine or separate decision in the determination of the load sheet. Therefore it can move forward in the chain.	<i>Consult experts</i> to validate new insights.
5	One respondent disagrees with the risk contingency and inventory level 'rules of thumb' used for a project. This is probably caused by dynamic 'rules of thumb' (differ per project) and the naming of these 'rules of thumb' included in the project planning.	<i>Insight in effect of choices.</i> This is important to capture in the support tool as these decision can affect the output. As it is assumed that when less risk is taken, the cost of the project increase.
#	Agreements	How to adapt the SADT model
1	Duration is estimated by the planner T&I and also checked by the project engineer.	Adapt arrow in the model.
2	The choice of the vessel lies on a higher level.	Consult expert on this higher level to get the information on how they make the decision.
3	The number of tugs might differ from the number of barges	Adapt this in the model, by separate the tugs more from the barges.

#	Observations leading to problems	
1	During the sessions I observed interpretation problems based on the allocated names for activities or arrows. - Load sheet is a combination of barge lay-out and number of transports. - Functions of departments are sometimes too generic or too specific to support understanding of the model.	Adapt this terminology to make the SADT model clearer.
2	Project specification is a too generic term.	Still name it project specifications, but specify what exact information is needed for an activity.

Deal with the conflicts where experts are needed:

- 1) This problem is solved with documents. Assumed is that the tender coordinator the role compared to the role of a project manager but situated in the tender phase. This is based on the documents on the Tender proposal phase.
- 3)4)5) Make a list of suggested changes and send it back to 2 experts to check with the changes. Only to two experts because 2 of the 4 interviewed experts were more interested, and therefore more committed to help.

Deal with the agreements where experts are needed:

- 2) This is consulted with a Core Competence leader, having years of experience in the logistic planning process. He confirmed the Project Director makes this decision.

Ask feedback from experts via mail:

Task: go through this list and make a sentence green if you agree. When you disagree please color the sentence red and give feedback.

This list form *added arrows* for certain decisions:

- Finalize logistic plan:
 - ☐ T&I planner not involved
 - ☐ Logistic Engineer makes the final report.
- Duration calculation:
 - ☐ Planner collects from PPD necessary information data for the calculation.
- Load sheet determination:
 - ☐ Vessel storage also constrains how a barge can be loaded.
 - ☐ Also a smart sketch software program is used to support the decisions.
 - ☐ The final load sheet is also checked by the Project manager to verify it with the project duration.
- Number of barges
 - ☐ ~~Is depending on the specifications of the yard~~
 - ☐ The ~~estimated duration~~ (which is based on the lay speed)
 - ☐ The project engineer is involved in this process.
- Choice of yard(s):
 - ☐ Will also put constrains on the barge (dimensions inland water way and quay length) and load sheet (due to load out equipment capabilities)
 - ☐ This is also controlled by the costs
 - ☐ This is also controlled by the reachableness
 - ☐ This is also controlled by the required workability
 - ☐ This is also controlled by the local policies/content
 - ☐ This is also controlled by the local weather conditions
 - ☐ The mechanism can be extended by procurement (costs)
 - ☐ The mechanism can be extended by operations (workability)
 - ☐ The mechanism can be extended by project engineering.
- Transport equipment:
 - ☐ Depth is not a leading factor in determining the transportation equipment
 - ☐ Workability is more important
- To combine or separate transportation of structures and crates:
 - ☐ The risks of sailing to/from a yard is forms a control.
- Type of barge:
 - ☐ Is only determined by the operations manager and project manager.
- Availability check of equipment:
 - ☐ Is also supported by the project manager and procurement department to check the finances.

This list suggests *decision flow alternatives*:

- Choice of barge is most important of making a load sheet and should therefore be started with.
- Number of crates is important to know for the combine or separate decision in the determination of the load sheet. Therefore it can move forward in the chain.

Feedback

The yard can only influence the number of barges by the distance. There is no quay room for more than one barge. The lay speed on the other hand controls the amount of pipe needed on the Balder at what time, not the total duration. There was agreement on the other suggestions.

Answers TAM questionnaire

The answers were rated 1 (negative) to 7 (positive) points. With the mean and standard deviation insight is given. In chapter 4 the reasons for these results are explained.

Using the SADT model in my job would be:								Good	Bad
								Harmful	Beneficial
								Wise	Foolish
								Negative	Positive
Confidence:								Not at all	complete
Perceived ease of use								Likely	Unlikely
Learning to use the model would be easy for me								Likely	Unlikely
I would find the SADT model easy to use								Likely	Unlikely
I would find the sadt model flexible to interact								Likely	Unlikely
I would find the model understandable and clear								Likely	Unlikely
confidence:								not at all	complete
Perceived usefulness								Likely	Unlikely
Using the SADT model would give me more insight in my job								Likely	Unlikely
Using the SADT model would increase my job performance								Likely	Unlikely
Using the SADT model would make it easier to do my job								Likely	Unlikely
Using the SADT model would enhance the effectiveness on the job								Likely	Unlikely
I would find the SADT model useful in my job								Likely	Unlikely
confidence:								not at all	complete
Anticipated use								Likely	Unlikely
Use on regular basis								Improbable	probable
confidence:								not at all	complete
								Mean	Std.Dev.
quite good	6	Neither	4	Neither	4	Neither	4	4.5	1
slightly beneficial	5	Neither	4	slightly beneficial	5	Neither	4	4.5	0.5773503
quite wise	6	Neither	4	neither	4	Neither	4	4.5	1
quite positive	6	Neither	4	slightly positive	5	Neither	4	4.75	0.9574271
slightly complete	5	quite complete	6	neither	4	Neither	4	4.75	0.9574271
extremely likely	7	slightly likely	5	quite likely	6	Neither	4	5.5	1.2909944
quite likely	6	neither	4	quite likely	6	Neither	4	5	1.1547005
quite likely	6	neither	4	neither	4	Neither	4	4.5	1
quite likely	6	neither	4	slightly likely	5	Neither	4	4.75	0.9574271
neither	4	quite complete	6	slightly complete	5	Neither	4	4.75	0.9574271
extremely likely	7	slightly unlikely	3	quite unlikely	2	Neither	4	4	2.1602469
quite likely	6	slightly unlikely	3	neither	4	Neither	4	4.25	1.2583057
slightly likely	5	slightly unlikely	3	quite unlikely	2	Neither	4	3.5	1.2909944
quite likely	6	neither	4	quite unlikely	2	Neither	4	4	1.6329932
quite likely	6	neither	4	neither	4	Neither	4	4.5	1
quite complete	6	quite complete	6	quite complete	6	Neither	4	5.5	1
quite likely	6	quite unlikely	2	quite unlikely	2	neither	4	3.5	1.9148542
quite probable	6	neither	4	quite improbable	2	neither	4	4	1.6329932
quite complete	6	slightly complete	5	quite complete	6	neither	4	5.25	0.9574271

APPENDIX D COMPLEX DECISION MAKING

The information in this appendix is removed as it contains confidential information.

APPENDIX E STAKEHOLDER AND ACTOR ANALYSIS

The information in this appendix is removed as it contains confidential information.

APPENDIX F MULTI-CRITERIA DECISION METHOD

This appendix determines what multi-criteria analysis tool would fit the decision support system for logistic planning process of pipe and structures transport. There are many tools available, with all their advantages and disadvantages, this appendix gives a suggestion, but when the frame for the tool changes, the choice for a tool can also change. Therefore first the frame is defined.

Frame

The goal of adding a multi-criteria analysis tool is to depict the perspective of the project manager on why he decides for an alternative. And it might support the input for a discussion when there are a variety of perspectives.

Tool selection

There are different types of multiple criteria decision analysis methods (Ragsdale, 1995). These can be classified according to the size of the set of strategies, the type of aggregation and the nature of the input data.

Size of strategies (Ragsdale, 1995)

1. Multi-attribute decision making (MADM) methods are concerned with choice among small finite countable number of strategies.
2. Multi-objective decision making (MODM) methods are concerned with very large uncountable and finite set of strategies.

Type of aggregation (Vickne et al. 1992)

1. complete aggregation methods (MAUT), disregards any incomparability
2. outranking relation methods which accepts incomparability
3. interactive local judgment approaches with trial and error iterations

Nature of input data (counts for MAUT) (Vickne et al. 1992)

1. hierarchy between criteria
2. order between criteria
3. trade-offs between criteria
4. no a-priori or no inter-criteria information

There is no best multiple criteria decision methods, the choice of a method depends on the situation of the decision maker, the internal consistency (compatibility of method on the data) and the external consistency, with the input and output.

The alternatives Heerema generates with the support system are countable, but there can be an extensive number of alternatives due to the large number of variables. But it is still a discrete amount of alternatives, which is not continuous. This leads us to the MADM. The nature of the input data is both qualitative and quantitative (net profit versus predictability). The decision maker decides what the best alternative is based on several criteria (net-profit and predictability). On which the different systems will score. This makes the criteria for the best system a hierarchy of criteria. Therefore the Analytical Hierarchy Process (AHP) method is suitable (Keyser, 1994). There is no order between the criteria and also not real trade-off. Only

the preference is important and the aim is selecting the best alternative based on the underlying criteria.

Analytical Hierarchy Process (AHP)

When a decision is taken, the project manager involves a number of factors to base his decision on. This is now done intuitively by the project manager himself based on the information from the departments. But by using a multiple criteria decision method, this will be more transparent, though still subjective. The AHP method was selected for the comparison of alternatives. This method has the following steps:

- The factors are weighted on importance.
- The alternatives are evaluated by a factor weight.
- This leads to a weighted evaluation of different alternatives.
- Then the alternatives are pair wise compared to reveal the preferences.
- The factor evaluation and consistency ratios are calculated.
- When consistent, all the factor weights are multiplied with the factor evaluation.

The advantage AHP has is the easy way of structuring many criteria (within the hierarchy). But the calculation is exhaustive. Fortunately there are computer programs available to help with the AHP calculations (Yu, 2005), for example a template in Excel. When there is insecurity about the factor weights and comparison, AHP helps to determine if someone is consistent, by calculating a consistency ratio. This helps when it is difficult to make factor weights, as it compares alternatives pair wisely.

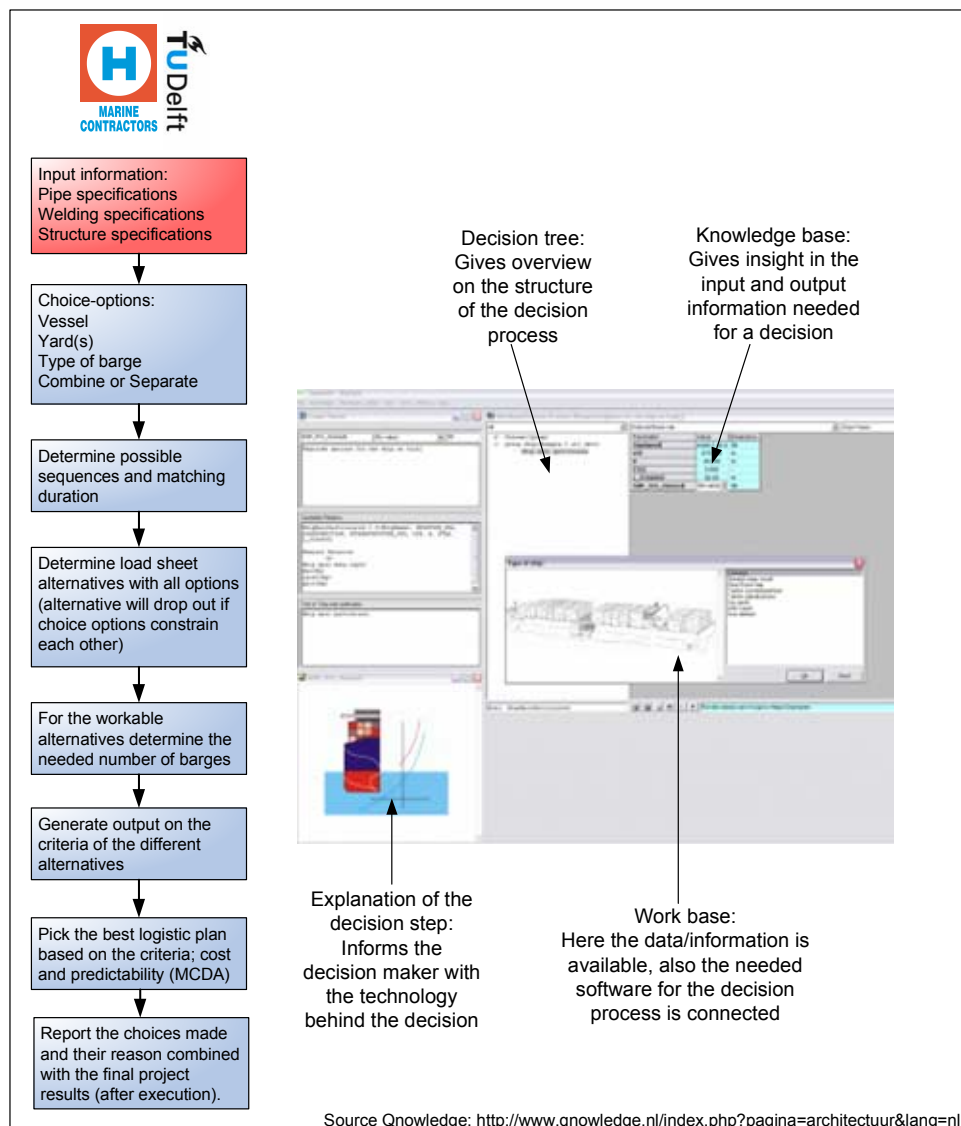
A disadvantage is that different hierarchies can be constructed for the same problem leading to different solutions and the rankings are arbitrary as they are based on subjectivity (McCaffrey, 2005). Also there is no sound proof for this process (Steiguer, 2003). Therefore adding indifferent criteria, on which all alternatives score the same, can potentially flaw the results (McCaffrey, 2005). In spite of these disadvantages it can help to visualize how a decision maker selected an alternative. As this is based on subjectivity, it helps to structure the effect of the criteria on the selection and shows when the decision maker is inconsistent.

When desired, additions can be used for group decision. These additions help to compare the preferences and show the density of the consensus (Moreno-Jimenez et al, 2008). As well for decisions containing uncertainties and risks, the multiple criteria method is useful, because the utility value of an alternative must be maximized. When selection an alternative the predictability of the outcome is an important criterion, therefore one can talk about robust decisions. Robustness refers to the ability of a solution to cope with uncertainties (Wallenius et al, 2008), therefore the predictability of an alternative must be included in the multiple criteria analysis. When a decision maker will prefer the predictability over the net profit, an option with a slightly higher amount of costs, will win from a cheaper alternative when it is more predictable (this is when the duration distribution is less wide and therefore more predictable).

APPENDIX G PAPER PROTOTYPE

In this chapter the paper prototype of the support system is depicted. With this prototype the process redesign and needed functionalities of the support system was tested.

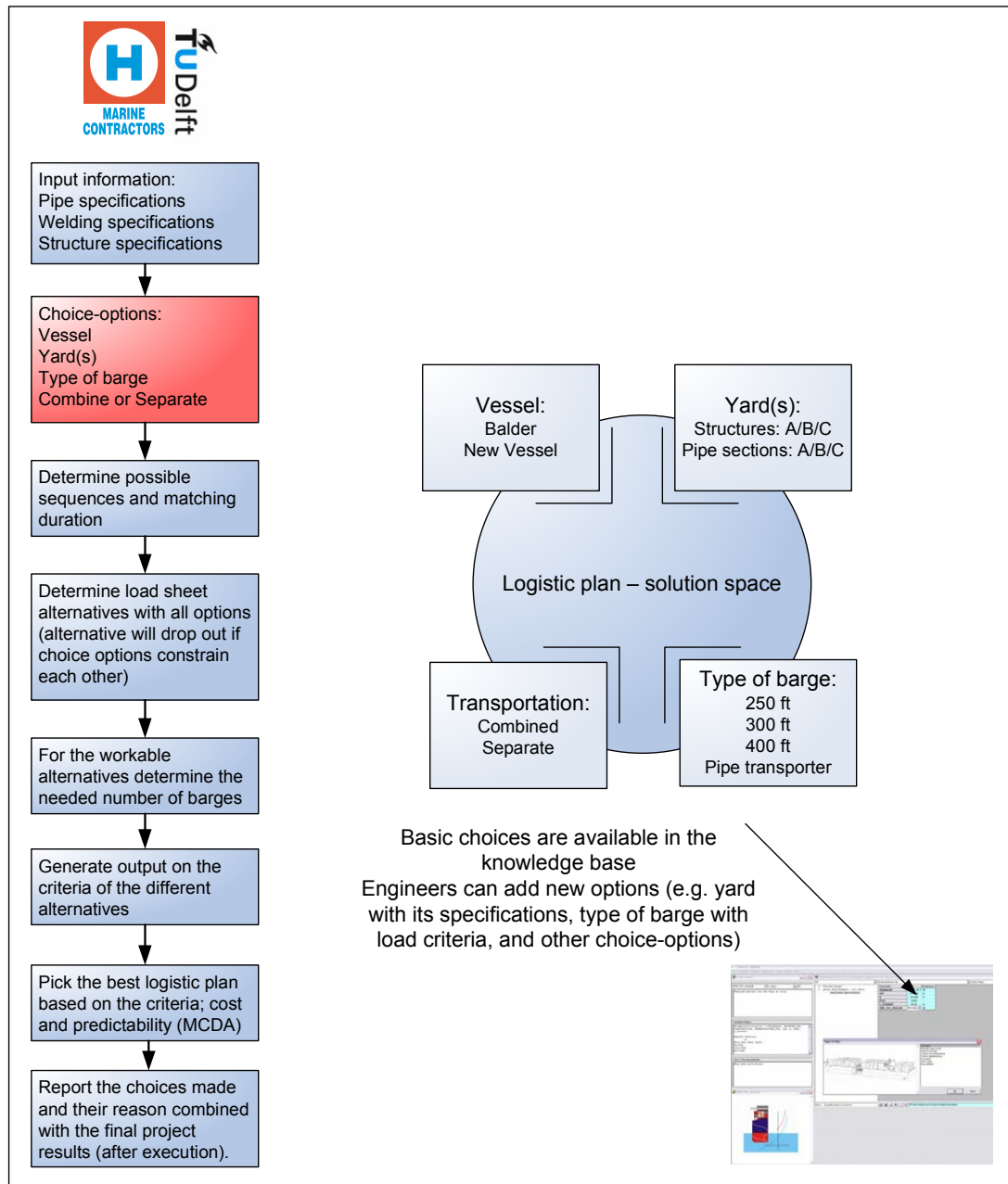
Paper prototype



Storyboard of vision on the prototype

Fill in the project specifications (pipe network specifications, pipe dimensions, pipe coatings, welding times, structure dimensions, etc). The specifications are added to the knowledge base.

Executed by the Logistic Engineer.

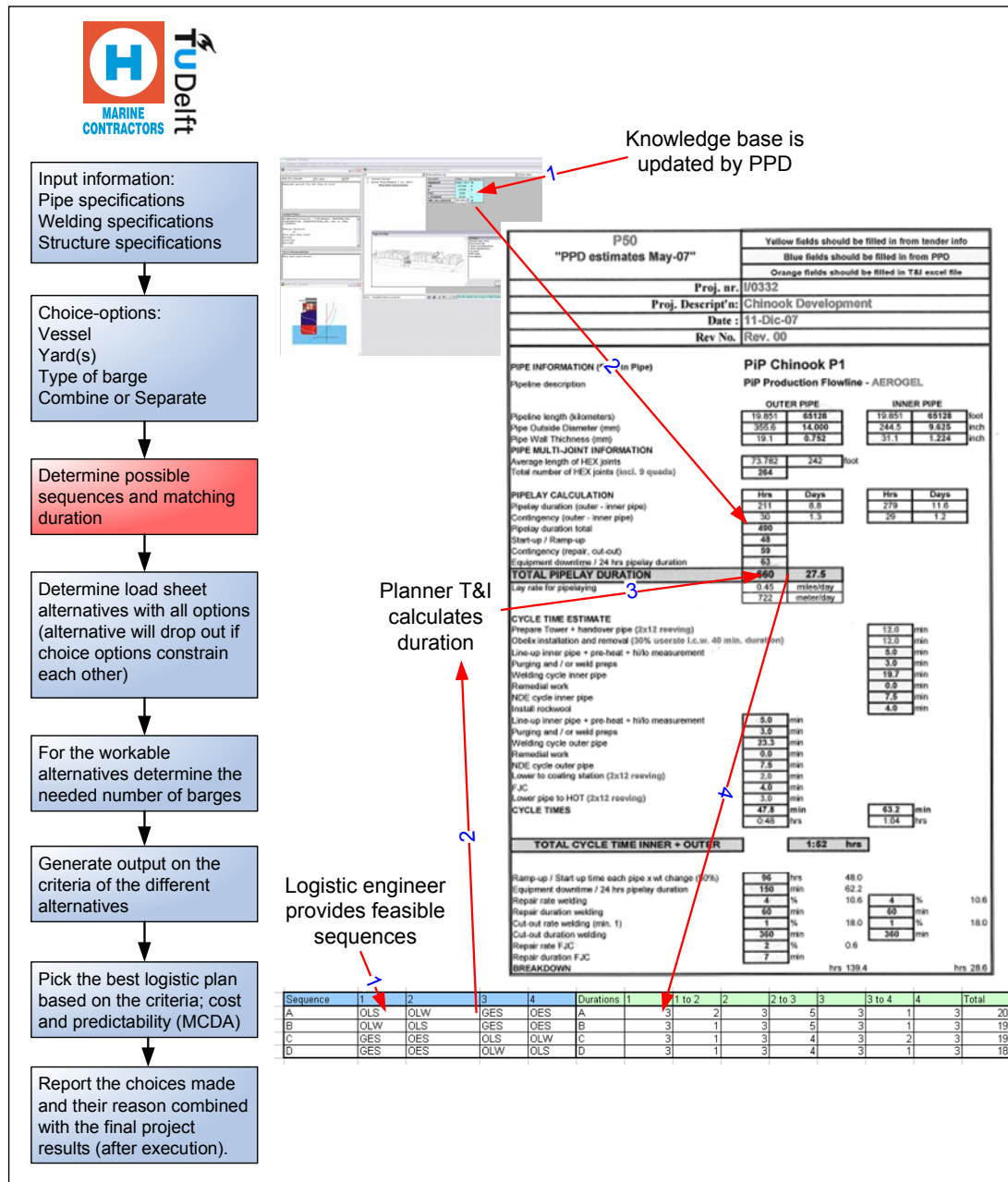


Storyboard of vision on the prototype

The solution space can be narrowed down by selecting the only choice options that are relevant for the project. For example in the project phase, the vessel that executes the project is fixed. Then only the relevant vessel is available to generate alternative logistic plan alternatives.

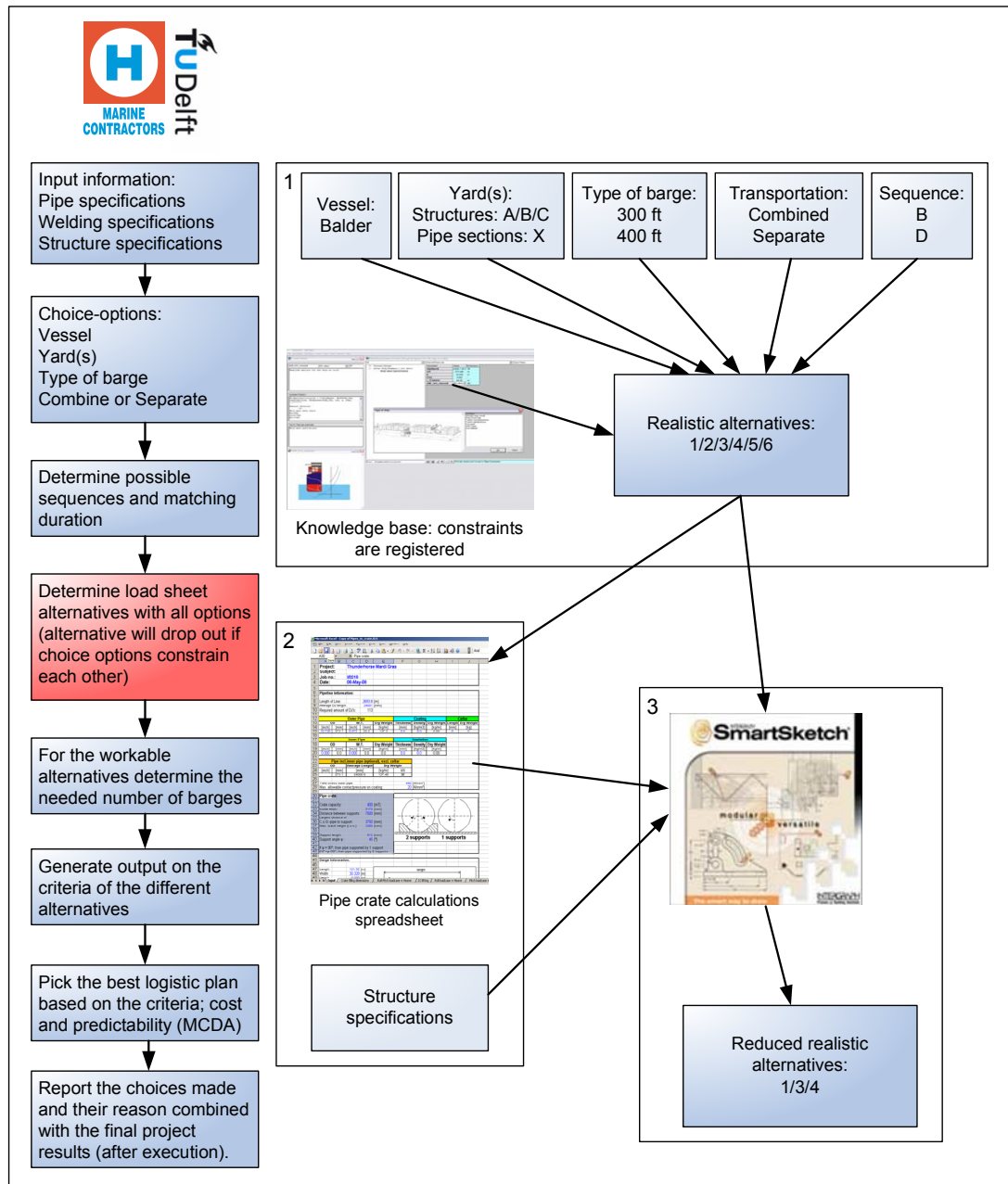
Executed by the Project Manager

2

**Storyboard of vision on the prototype**

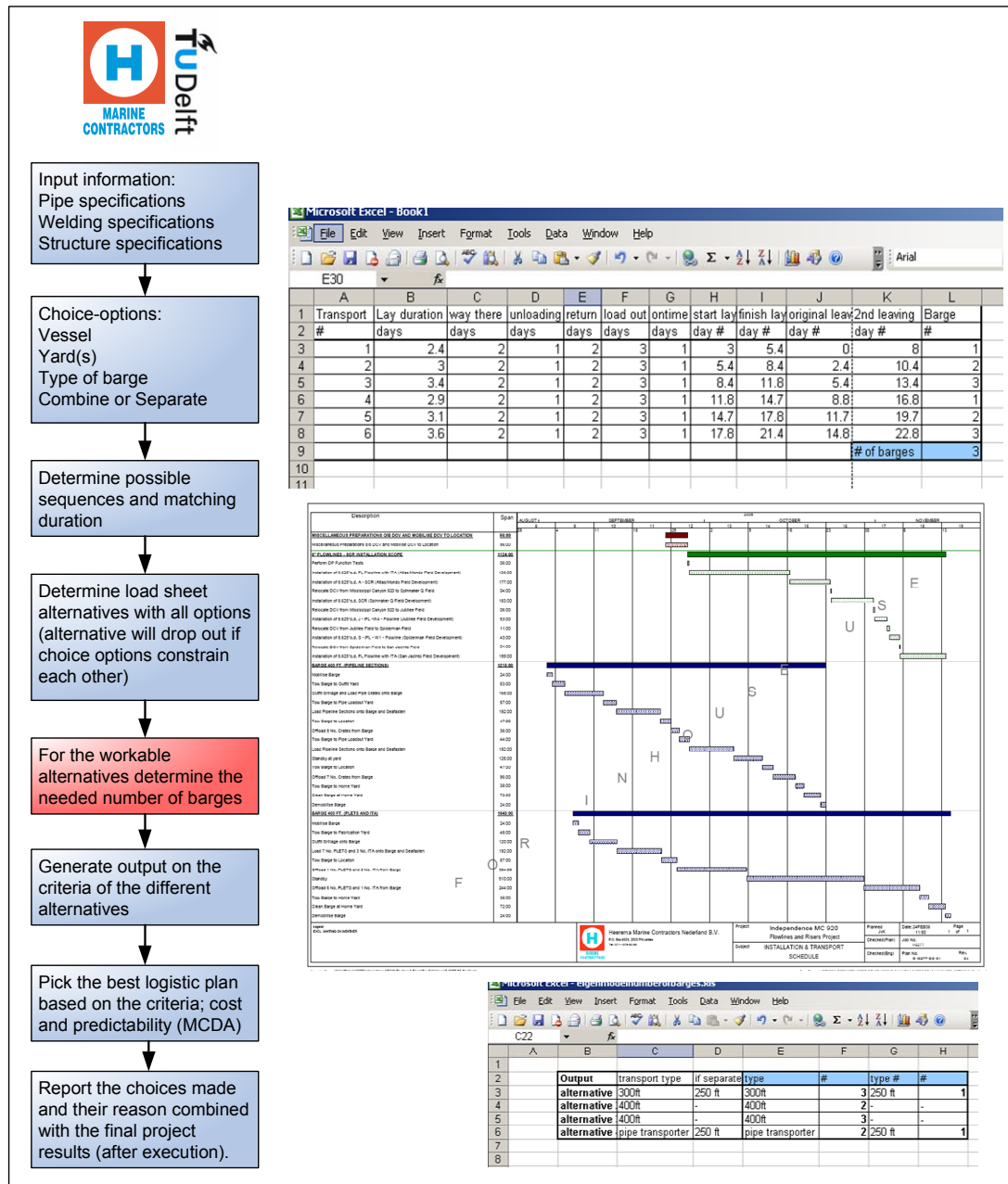
- 1) PPD collects the relevant data for the duration calculations.
- 2) The Logistic engineer makes a list of all the realistic sequences.
- 3) The Planner T&I calculates the sequences, with a standardized excel spreadsheet. This can be automated by Quaestor for simple sequences.

Executed by Planner T&I which receives information from PPD and the logistic engineer.



Storyboard of vision on the prototype

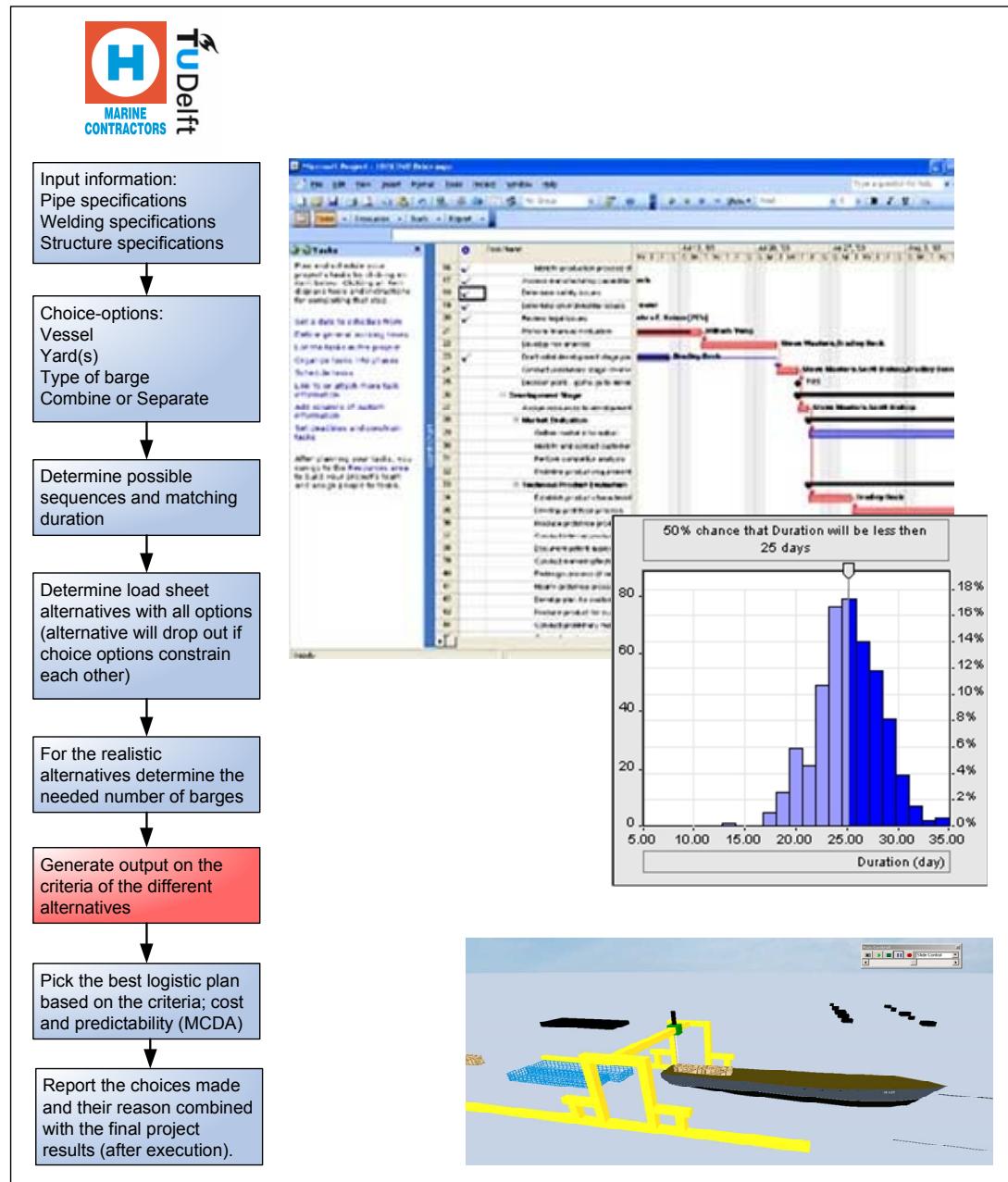
- 1) The Logistic Engineer creates realistic alternatives with quaestor, limited by the constraints registered in Quaestor.
- 2) The Logistic Engineer determines the number of pipe-crates with connected spreadsheet and checks the specifications of the structures according to the latest design of the structures.
- 3) The Logistic Engineer uses smart sketch to design logistic plans (# transports) according to the formed alternatives. Some alternatives will be less optimal and dropped out of the analysis (reasoning should be registered)



Storyboard of vision on the prototype

- 1) Small expert excel spreadsheet: For the calculation of the # barges for a simple logistic planning. Based on the number of transports, the transport time and the lay speed. The aim is fast calculation.
- 2) Bar chart visualization: To design innovative barge logistics for more complex logistic planning. Also verify if the small excel solution is possible.

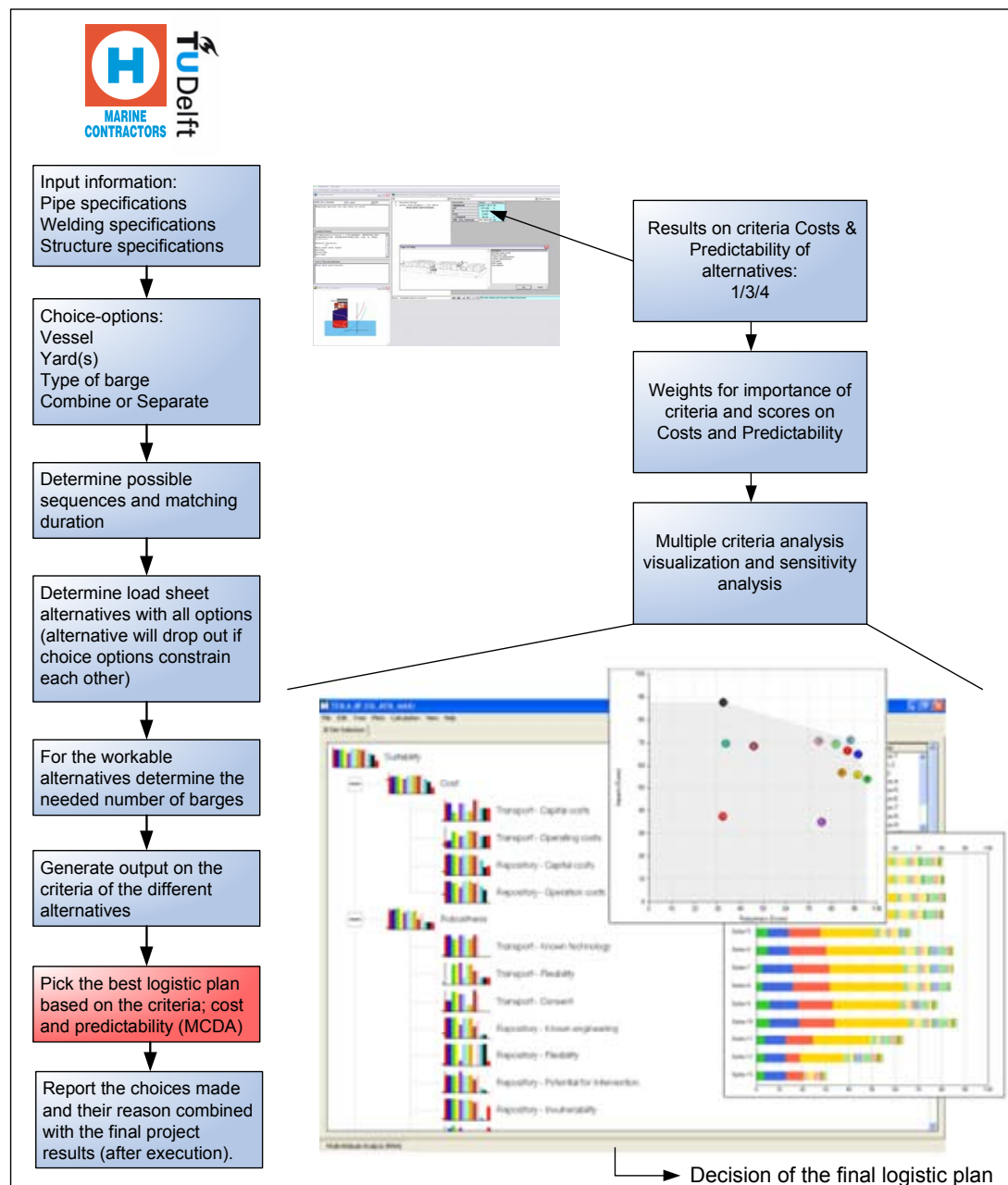
Executed by Planner T&I



Storyboard of vision on the prototype

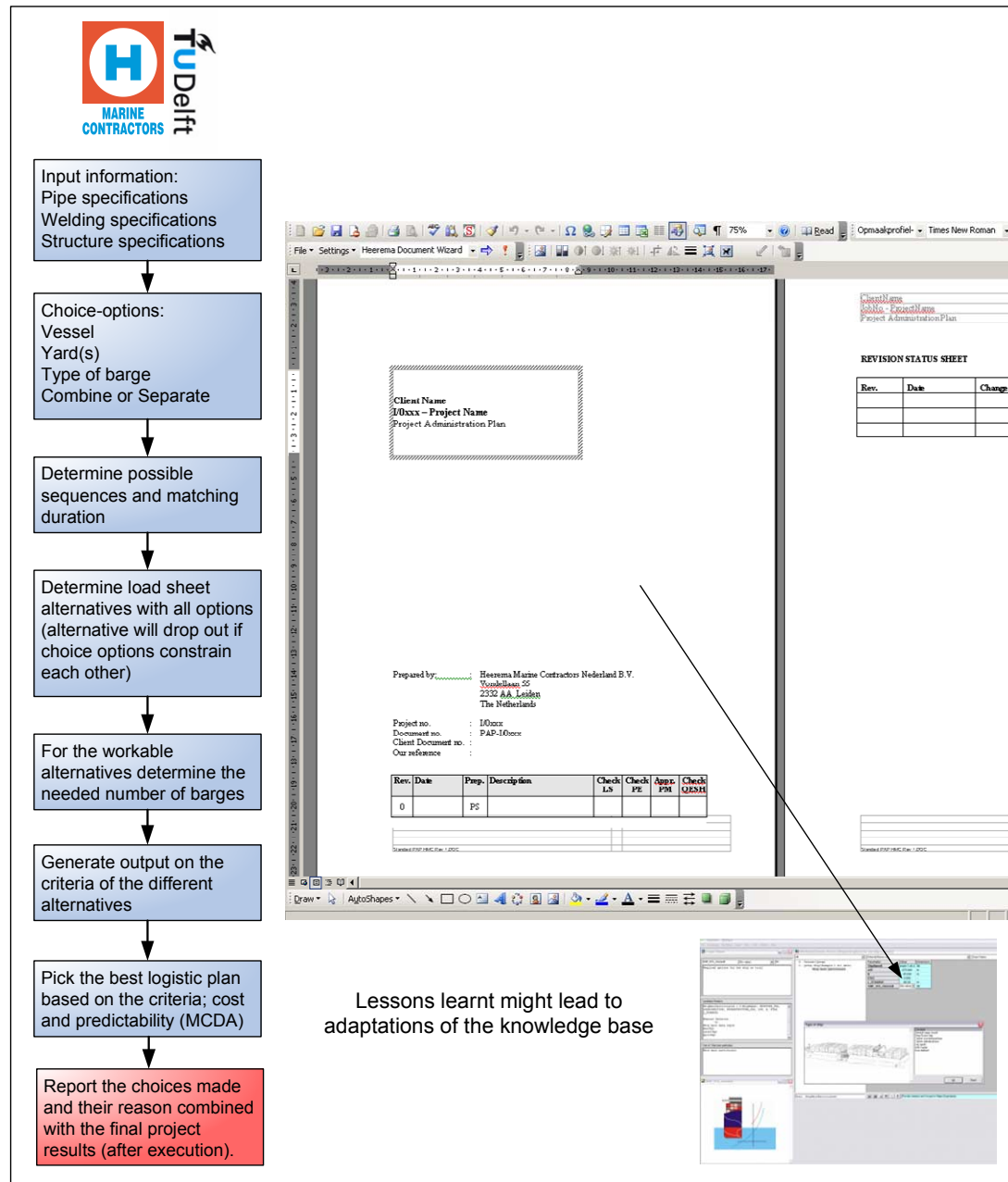
- 1) Critical path methodology (MS Project): to generate output on the expected duration and accompanying costs of the project. Breakdown risks of equipment are incorporated in the calculations.
- 2) Visualization of the project execution (Enterprise Dynamics): to give insight in the effect of weather-, port- and breakdown risks on the project execution. To get a feeling for the robustness of the logistic plan.

Executed by a Planner T&I with the Project Manager



Storyboard of vision on the prototype

- 1) From the previous step the output of the alternatives is translated to the criteria Costs and Predictability.
- 2) The Project Manager weights the criteria on importance to make the trade-off between different alternative logistics plans. This is according to his preferences.
- 3) The Multiple Criteria Analysis will highlight the best alternative according to the preferences.
- 4) With a sensitivity analysis the robustness of the alternative according to the weights is determined. Executed by the Project Manager.



Storyboard of vision on the prototype

The report contains:

- Decisions trade-offs made in the logistic planning phase (and the reasoning)
- Results of the execution phase
- Lessons learned from this project

Standardized report output by Quaestor is possible

Executed by the Project Manager

Paper prototype evaluation questionnaire

Paper prototype, the aim is to focus the most on the functionality of the support system and the visualization of information.

Based on usefulness:

The role of the support system is to enhance insight in the effect of decisions. Do you expect the suggested functionalities to be useful?

What functionalities would you like to add or change?

Based on usability:

Do you think this process will increase the transparency of the logistic planning effort?

Does it improve the insight in the effect of decisions on the final outcomes (costs and predictability)?

Do you have suggestions to improve the decision process?

Based on usage:

Do you expect the support system to be useful for the decision making?

Would you like to implement such a system?

APPENDIX H DIGITAL PROTOTYPE

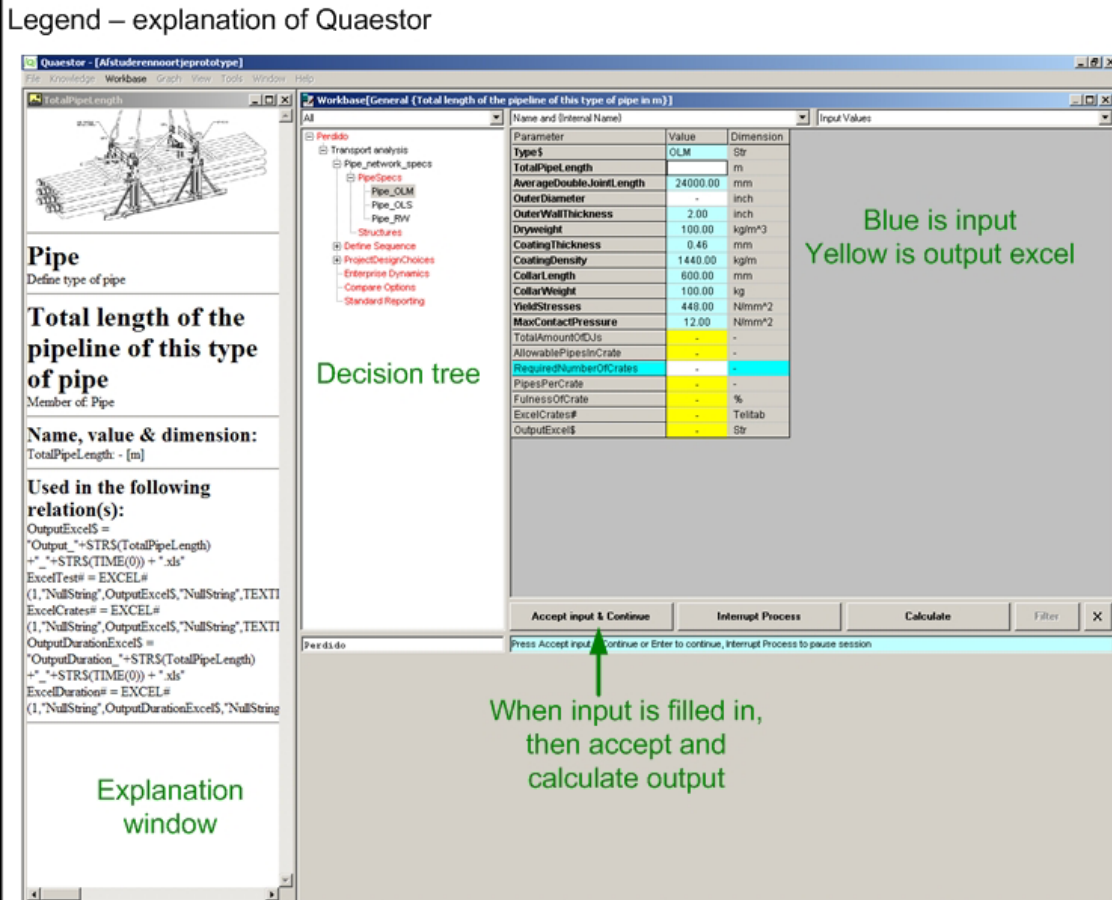
In this appendix the digital prototype is captured in pictures to explain its functionalities. It also contains the structure of the semi-structured interview, the questionnaire (related to the requirements) and the quantitative feedback on the questionnaire.

H.1 Digital prototype

In this first picture the structure of Quaestor is explained. There is a decision tree, which shows the steps to take. Then there is an input/calculation window, the blue parameters must be filled in by the decision maker. The yellow parameters are calculated by Quaestor (using spreadsheets, functions, etc). In the explanation window there are pictures, the parameter's name, and the explanation of each parameter including their dimensions and relation/function.

To make this prototype I had help from Qnowledge engineers, which explained by the Quaestor program and solved the problems I faced during the development. For the simulation model I used the model made by Enterprise Dynamics for the pipe-supply, which I partly changed to make it connectable to the Quaestor and more generic for different options.

Legend – explanation of Quaestor



The screenshot displays the Quaestor software interface with the following components:

- Decision tree:** A tree structure on the left showing the workflow, including 'PipeSpecs', 'Pipe_OLM', 'Pipe_OLS', 'Pipe_RW', 'Define Sequence', 'PointDesignChoices', 'Enterprise Dynamics', 'Compare Options', and 'Standard Reporting'.
- Parameter Table:** A table with columns 'Parameter', 'Value', and 'Dimension'. Parameters are color-coded: blue for input and yellow for output.

Parameter	Value	Dimension
Type5	OLM	Str
TotalPipeLength	-	m
AverageDoubleJointLength	24000.00	mm
OuterDiameter	-	inch
OuterWallThickness	2.00	inch
Dryweight	100.00	kg/m ³
CoatingThickness	0.46	mm
CoatingDensity	1440.00	kg/m
CoatingLength	600.00	mm
CoatingWeight	100.00	kg
YieldStresses	448.00	N/mm ²
MaxContactPressure	12.00	N/mm ²
TotalAmountOfJoints	-	-
AllowablePipesInCrate	-	-
RequiredNumberOfCrate	-	-
PipesPerCrate	-	-
FulnessOfCrate	-	%
ExcelCrate#	-	Tab
OutputExcel\$	-	Str
- Explanation window:** A panel on the left titled 'Pipe' with a sub-header 'Total length of the pipeline of this type of pipe'. It includes a 'Name, value & dimension' section showing 'TotalPipeLength: - [m]' and a 'Used in the following relation(s):' section with Excel formulas.

Used in the following relation(s):

```

OutputExcel$ =
"Output "&STR$(TotalPipeLength)
"&" "&STR$(TIME(0))&" ".xls
ExcelTest# = EXCEL#
(1,"NullString",OutputExcel$, "NullString",TEXT)
ExcelCrate# = EXCEL#
(1,"NullString",OutputExcel$, "NullString",TEXT)
OutputDurationExcel$ =
"OutputDuration "&STR$(TotalPipeLength)
"&" "&STR$(TIME(0))&" ".xls
ExcelDuration# = EXCEL#
(1,"NullString",OutputDurationExcel$, "NullString"
      
```

Annotations on the screenshot:

- Green text: "Blue is input Yellow is output excel"
- Green text: "When input is filled in, then accept and calculate output" with an arrow pointing to the 'Accept input & Continue' button.

Datasets contain default information on the Barges, Vessels and Yards

Database of vessels
Object name:
VESSEL

Parameter	Value	Dimension
BARGES	Object	Obj
VESSEL	Object	Obj
YARD	Object	Obj

Barge information

	#1 = NewVessel	#2 = Balder
BargeSpeed	10.00	12.00
BargeDepth [m]	25.00	24.00
BargeName \$ [Str]	400m	300m
BargeSpeed [km/h]	10.00	12.00
CratePlaces [-]	9.00	6.00

Vessel information

	#1 = Omega	#2 = Bredero	#3 = Bayou
VesselName \$	NewVessel	Balder	
Vesselcratespace [km/h]	6.00	4.00	
VesselName \$ [Str]	NewVessel	Balder	

Yard information

	#1 = Omega	#2 = Bredero	#3 = Bayou
Yarddepth [m]	25.00	30.00	30.00
Yarddistance [m]	100.00	400.00	600.00
YardName \$ [Str]	Omega	Bredero	Bayou

Start a new project by doing a transport analysis

Database of barges
Object name:
BARGES

Parameter	Value	Dimension
BARGES	Object	Obj
VESSEL	Object	Obj
YARD	Object	Obj

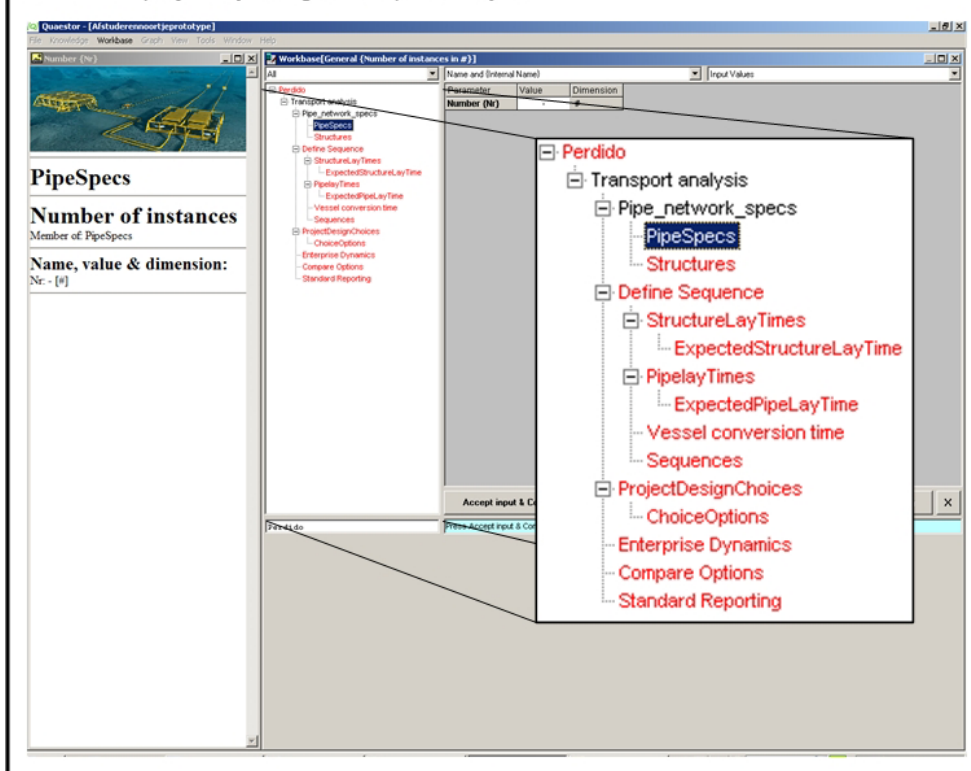
Task

☒ Transport analysis

Compute Top goal:
Transport analysis
Entity object

Create Transport analysis Cancel

Start a new project by doing a transport analysis

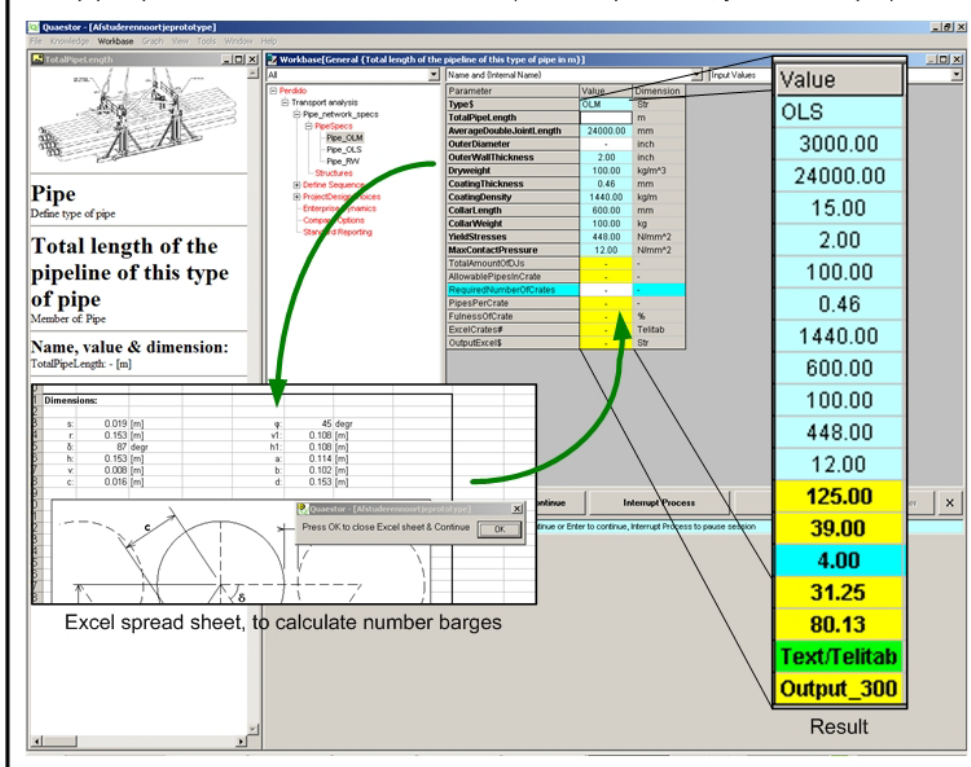


PipeSpecs
Number of instances
Member of PipeSpecs
Name, value & dimension:
Nr. - [n]

Transport analysis

- Pipe_network_specs
 - PipeSpecs
 - Structures
- Define Sequence
 - StructureLayTimes
 - ExpectedStructureLayTime
 - PipelineTimes
 - ExpectedPipeLayTime
 - Vessel conversion time
 - Sequences
- ProjectDesignChoices
 - ChoiceOptions
 - Enterprise Dynamics
 - Compare Options
 - Standard Reporting

Fill in pipe specifications – connected to excel (blue is input excel, yellow is output)



Pipe
Define type of pipe
Total length of the pipeline of this type of pipe
Member of Pipe
Name, value & dimension:
TotalPipeLength - [m]

Dimensions:

Parameter	Value	Dimension
s	0.019 [m]	
r	0.153 [m]	
b	67 deg	
h	0.153 [m]	
v	0.008 [m]	
c	0.016 [m]	
φ	45 deg	
v1	0.108 [m]	
h1	0.108 [m]	
a	0.114 [m]	
b	0.102 [m]	
d	0.153 [m]	

Excel spread sheet, to calculate number barges

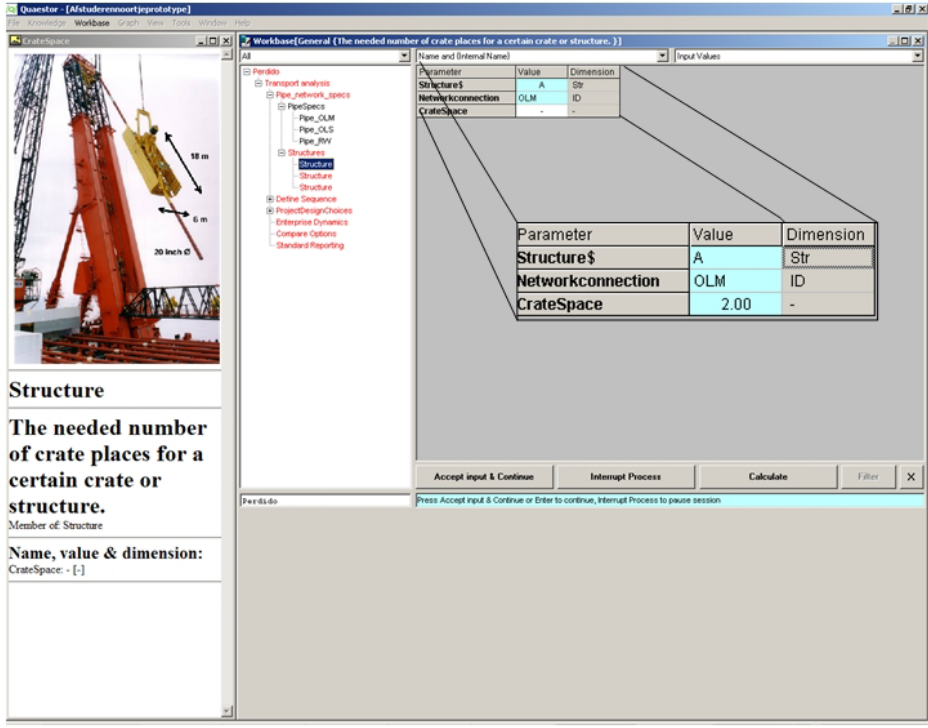
Value

Parameter	Value	Dimension
Types	OLM	Str
TotalPipeLength	24000.00	m
InnerPipeLength	24000.00	m
OuterDiameter	2.00	inch
OuterWallThickness	100.00	kg/m ³
DryWeight	0.46	mm
CoatingThickness	1440.00	kg/m
CoatingDensity	600.00	mm
CollarLength	100.00	kg
CollarWeight	448.00	N/mm ²
YieldStresses	12.00	N/mm ²
MaxContactPressure	-	-
TotalAmountOfCUs	-	-
AllowablePipesInCrate	-	-
RequiredNumberOfCrates	-	-
PipesPerCrate	-	-
FulnessOfCrate	-	%
ExcelCrate#	-	Texttab
OutputExcel#	-	Str

Result

125.00
39.00
4.00
31.25
80.13
Text/Texttab
Output_300

Fill in structure specifications – name, connection and dimension compared to cratespace



Structure

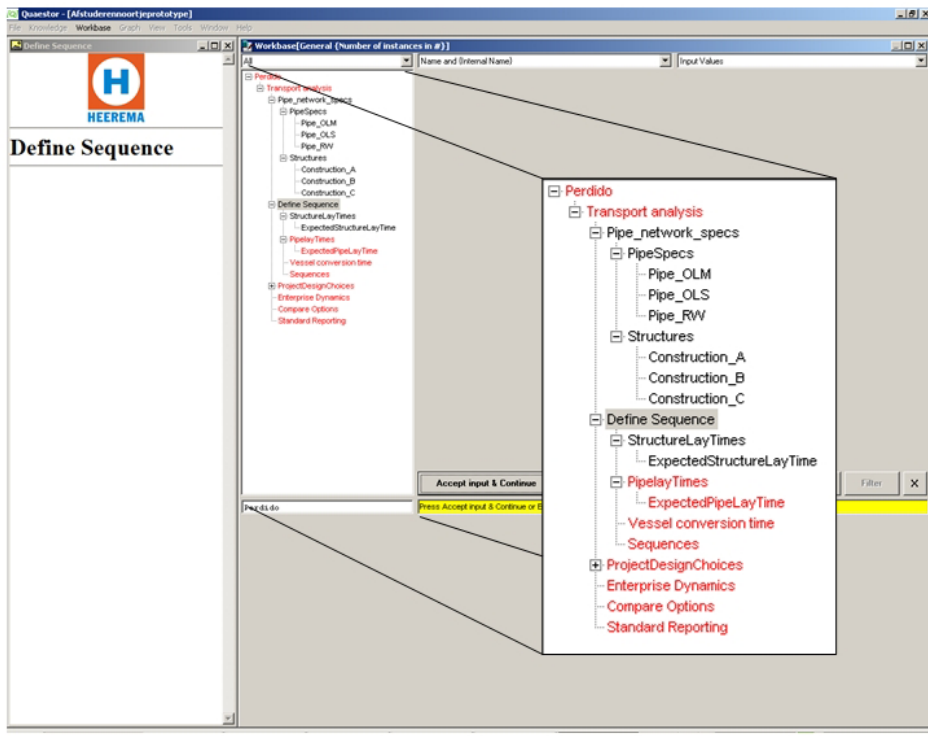
The needed number of crate places for a certain crate or structure.

Member of Structure

Name, value & dimension:
 CrateSpace: [-]

Parameter	Value	Dimension
Structure\$	A	Str
Networkconnection	OLM	ID
CrateSpace	2.00	-

Sequence in the prototype relates to the lay times of pipe-structure and conversion time



Define Sequence

Sequence in the prototype relates to the lay times of pipe-structure and conversion time

Parameter	Value	Dimension
Structure\$	A	Str
Networkconnection	OLM	ID
CrateSpace	2.00	-

Sequence 1 – First fill in the lay time of the structures (hrs)

Quaestor - [Afstuderennoortjeprototype]

File Knowledge Workbase Graph View Tools Window Help

StructureLayTimes

ExpectedStructureLayTime

Laytime for one structure (e.g. hang, weld and lower)

Member of ExpectedStructureLayTime

Name, value & dimension:
StructureLayTimes = 13 [h]

Workbase (General (Laytime for one structure (e.g. hang, weld and lower) in h))

Parameter Value Dimension

Number (Nr) 3.00 #

Accept input & Continue Interrupt Process Calculate Filter X

Press Accept input & Continue or Enter to continue, Interrupt Process to pause session

StructureLayTimes	#1 = 10.00	#2 = 12.00	#3 = 13.00
Counter [-]	1.00	2.00	3.00
Structure\$ [Str]	A	B	C
StructureLayTimes [h]	10.00	12.00	13.00

Sequence 2 – Calculate by excel the lay duration of a hex-joint

Quaestor - [Afstuderennoortjeprototype]

File Knowledge Workbase Graph View Tools Window Help

Weldingcycle0

ExpectedPipeLayTime

Time needed to weld one double joint

Member of ExpectedPipeLayTime

Name, value & dimension:
WeldingcycleDf = [min]

Used in the following relation(s):
ExcelDuration = EXCEL#
(1, 'NullString', OutputDurationExcel, 'NullString')

Workbase (General (Time needed to weld one double joint))

Parameter Value Dimension

Number 1

Accept input & Continue Interrupt Process Calculate Filter X

Press Accept input & Continue or Enter to continue, Interrupt Process to pause session

WeldingcycleDf	#1 = 2.00	#2 = 2.00	#3 = 3.00
Counter [-]	1.00	2.00	3.00
ExcelDuration [Excel#]	1	2	3
OutputDurationExcel [Str]	1	2	3
Type\$ [Str]	1	2	3

Excel sheet showing calculations for lay duration of a hex-joint. The sheet includes sections for PIPE INFORMATION, PIPELay CALCULATION, CYCLE TIME ESTIMATE, and PIPELINE PRODUCTION DEPARTMENT INPUT. A green arrow points from the Excel sheet to the Quaestor interface.

Sequence 3 – Conversion time between two types of pipe

Vessel conversion time

Time to change the settings of the Balder between two different pipes (e.g. different in coating, diameter, etc).
Member of: Vessel conversion time

Name, value & dimension:
ConversionTime: - [h]

EntityName	Pipe_type [ID]	Pipe_type2 [ID]	ConversionTime [h]	Combination_name\$ [Str]
#1 = _Vessel conversion time	OLM	OLS	48	OLM_OLS
#2 = _Vessel conversion time	OLM	RW	30	OLM_RW
#3 = _Vessel conversion time	OLS	RW	20	OLS_RW
#4 = _Vessel conversion time	OLM	OLS	48	OLS_OLM
#5 = _Vessel conversion time	OLM	RW	30	RW_OLM
#6 = _Vessel conversion time	OLS	RW	20	RW_OLS

Sequence 4 – Define one or more possible sequences

Total project time

Select a defined pipe type

Choices:
OLM
OLS
RW
Member of: Total project time

Name, value & dimension:
Pipe_type: - [ID]

Pipe_type	#1 = 1.00	#2 = 2.00	#3 = 3.00
Pipe_type [ID]	OLM	OLS	RW
Type\$ [Str]	OLM	OLS	RW
Combination_name\$ [Str]	NA	OLM_OLS	OLS_RW
ConversionTime [h]	0.00	48.00	20.00
PipeLayTime [h]	287.00	111.00	317.00
Total_time [h]	287.00	159.00	337.00

Define choice options (1) – Constraints this barge cannot reach the yard verified by depth

ChoiceOption

The number of transports for the structures, when the transport of structures and pipe is separated.

Member of ChoiceOption

Name, value & dimension:
NumberOfStructureTransports = 0 [-]

Computed in solution by:
NumberOfStructureTransports = If (SetCombineOrSeparate.EQ.2)*ENTITY# (12).Nr

Parameter

Parameter	Value	Dimension
Number (Nr)	1.00	#
OptionName\$	option1	Str
Barge#	400t	Telitab
Vessel#	NewVessel	Telitab
Yard#	Omega	Telitab
SetCombineOrSeparate	1.00 (One type of barge)	-
NumberOfStructureTransports	0.00	-
NumberPipeTransports	15.00	-
LoadOutAtYardDays	2.00	d
LayDurationPerBarge	54.53	d
TravelTime	10.00	d
UnloadingDays	1.00	d
NumberOfBargesPipeNeeded	1.00	-
ExcelBarges#	Text/Telitab	Telitab
Nr250ftbarges	0.00	-
Nr300ftbarges	0.00	-
Nr400ftbarges	1.00	-

VerifyDepth Barge cannot reach yard

Define choice options (2) – Simple excel calculation for the needed number of barges

ChoiceOption

The number of transports for the structures, when the transport of structures and pipe is separated.

Member of ChoiceOption

Name, value & dimension:
NumberOfStructureTransports = 3 [-]

Computed in solution by:
NumberOfStructureTransports = If (SetCombineOrSeparate.EQ.2)*ENTITY# (12).Nr

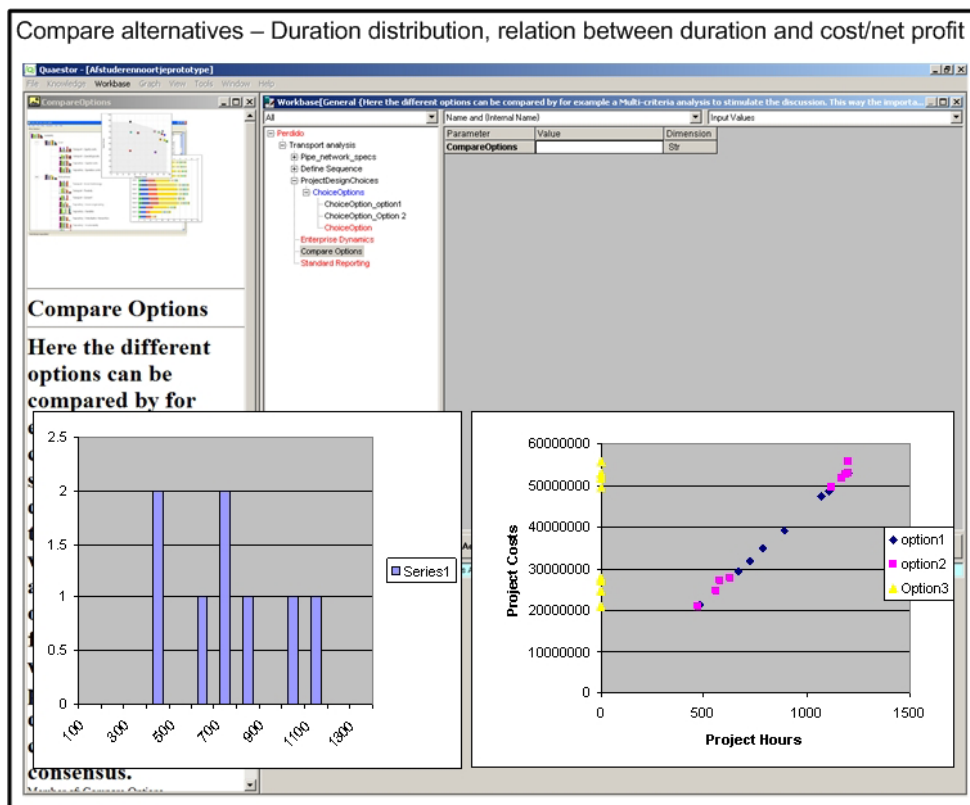
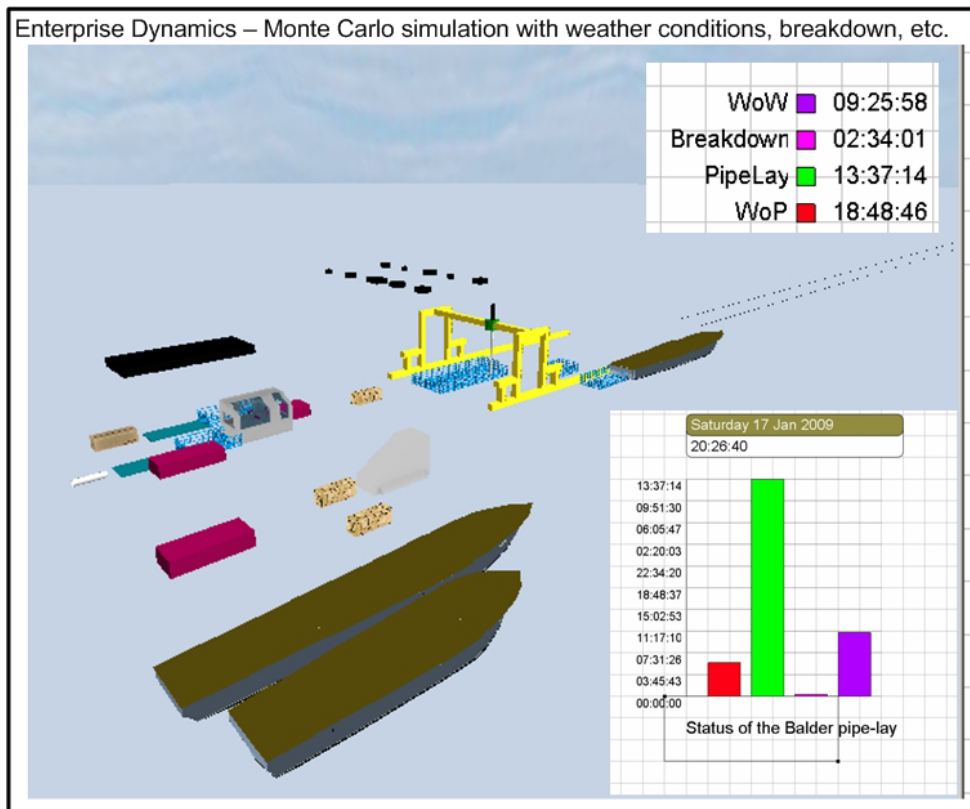
Parameter

Parameter	Value	Dimension
Number (Nr)	1.00	#
OptionName\$	Option 2	Str
Barge#	400t	Telitab
Vessel#	Balder	Telitab
Yard#	Bayou	Telitab
SetCombineOrSeparate	2.00 (Two separate logistic bar)	-
NumberOfStructureTransports	3.00	-
NumberPipeTransports	7.00	-
LoadOutAtYardDays	2.00	d
LayDurationPerBarge	116.86	d
TravelTime	60.00	d
UnloadingDays	262.93	d
NumberOfBargesPipeNeeded	2.00	-
ExcelBarges#	Text/Telitab	Telitab
Nr250ftbarges	1.00	-
Nr300ftbarges	0.00	-
Nr400ftbarges	2.00	-

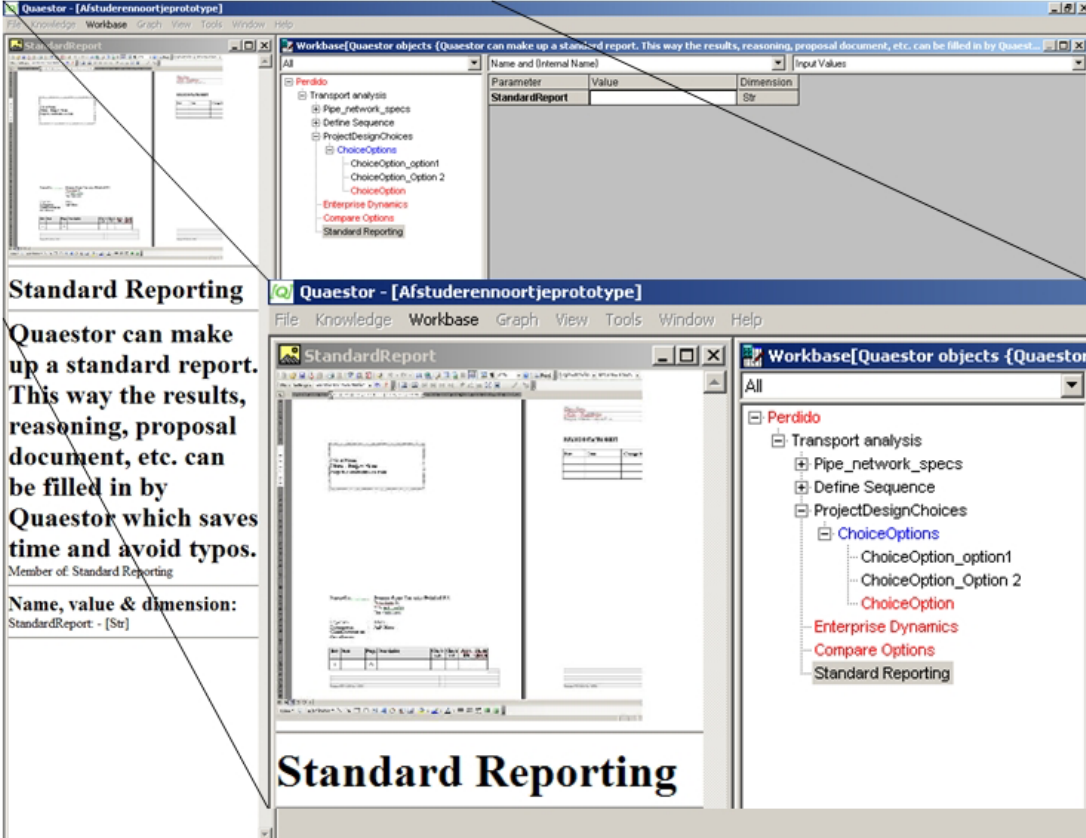
VerifyDepth Barge can reach Yard

Accept input & Continue Interrupt Process Calculate Filter

	A	B	C	D	E	F	G	H	I	J	K	L
1	Transport	Lay duration	way there	unloading	return	load out	ontime	start lay	finish lay	original leav	2nd leaving	Barge
2	#	days	days	days	days	days	days	day #	day #	day #	day #	#
3	1	116.857143	60	262.929	60	2	1	322.93	439.79	261.92857	384.92857	1
4	2	116.857143	60	262.929	60	2	1	439.79	556.64	378.78571	501.78571	2
5	3	116.857143	60	262.929	60	2	1	556.64	673.5	495.64286	618.64286	1
6	4	116.857143	60	262.929	60	2	1	673.5	790.36	612.5	735.5	2
7	5	116.857143	60	262.929	60	2	1	790.36	907.21	729.35714	852.35714	1
8	6	116.857143	60	262.929	60	2	1	907.21	1024.1	846.21429	969.21429	2
9											# of barges	2



Standard reporting – standard word documents and drawings can be generated



Standard Reporting

Quaestor can make up a standard report. This way the results, reasoning, proposal document, etc. can be filled in by Quaestor which saves time and avoid typos.

Member of: Standard Reporting

Name, value & dimension:
StandardReport - [Str]

Parameter	Value	Dimension
StandardReport		Str

Standard Reporting

H.2 Digital prototype interview protocol

1. Introduction of my thesis project

Not every respondent is familiar with my project. Therefore some background information on the context of the research is shared.

Research problem and question

For the future Heerema wants undertake projects in for them unfamiliar regions (arctic and African regions), where the weather conditions are harsh and Heerema has no experience so far. The challenge Heerema currently faces can be summarized as lack of transparency in the decisions involved in logistic planning. The inefficiency and unpredictable nature of the logistic planning effort for pipe-laying makes it a time-consuming and frustrating task. Many calculations recur, but cannot be reused in the current work process. Further, some decisions in the logistic planning are made based on incomplete information or based on experience and intuition. Especially when alternatives should be compared, effects remain unknown, and the time constraints and lack of overview, result in the need to take or mitigate risks.

Research question

How can overview of- and insight into the effects of decisions, with respect to the pipe/structure-logistic planning process for pipe-lay projects, be achieved?

2. Show the prototype

With a small example of a pipe-lay project show the workings of the prototype. Also show the flexibility, etc.

For 3 different pipe types:

Pipe A Length 9000 m Outer diameter 10 inch Wall thickness 0.8 inch Dry weight 100 kg/m Coating thickness 0.46 mm Coating Density 1440 kg/m ³ Collar length 600 mm Collar dry weight 100 kg Yield stresses 448 N/mm ² Max contact pr 12 N/mm ² Cycle time 15 min	Pipe B Length 3000 m Outer diameter 16 inch Wall thickness 0.8 inch Dry weight 100 kg/m Coating thickness 0.46 mm Coating Density 1440 kg/m ³ Collar length 600 mm Collar dry weight 100 kg Yield stresses 448 N/mm ² Max contact pr 12 N/mm ² Cycle time 18 min	Pipe C Length 10000 m Outer diameter 16 inch Wall thickness 0.7 inch Dry weight 100 kg/m Coating thickness 0.46 mm Coating Density 1440 kg/m ³ Collar length 600 mm Collar dry weight 100 kg Yield stresses 448 N/mm ² Max contact pr 12 N/mm ² Cycle time 16 min
--	--	---

3 structures:

- a – lay time 10 hrs
- b – lay time 12 hrs
- c - lay time 13 hrs

Sequence (1): OLS (with A), OLW (with B), RW (with C) named short

- From A – B 6 hrs
- From B – C 7 hrs
- From A – C 10 hrs

Options

400ft - 300ft Balder Omega combine	400 ft Balder Bayou combine	400ft Balder Bayou separate
---	--------------------------------------	--------------------------------------

Checklist:

- Change combine and separate in the different alternatives. And increase the number of barges needed with 1, to show the effect (in the combined alternative). These 3 alternatives can be compared.
- Show they can add own documents.
- Show there are calculated numbers, which are changeable if needed (using comments to explain).
- Show that if you would like to change one number in a pipe, the recurrence of the calculations is automatically done.
- Show that the system can give insight in constraints.
- Show the databases of vessels; explain there can be ‘default’ information in the system.
- Show results to compare alternatives and multi-criteria analysis.
- Show simulation with uncertainties (weather, harbor, etc).

For each question a grade from 1-10 is asked (1 is negative, 10 is a positive response) assuming that the system as depicted will work. Then the reasoning for giving a certain grade, the parts to remain and the parts needing improvement are asked to the interviewee.

The first questions evaluate the usefulness:

<i>Requirement</i>	<i>level</i>	<i>Questions</i>
1- trade-off visualization	1+2	1. To what degree do you think you can compare alternatives based on this information? 2. To what degree does this give you the right information to make a decision for a certain alternative? 4. To what degree do you think this system improves the decision making? 5. To what degree do you think the system can improve the effectiveness of decisions making? 6. To what degree do you think the system can improve the quality of the decisions made?
2- dynamic info	1	The selection of software is the step to address this requirement
3- visualize uncertainties	1-2	3. To what degree do the results give clear insight in the uncertainties of a project?

General on usefulness

7. How would you grade the result visualization on usefulness? 1-10 (1 not useful, 10 useful)

The next questions evaluate the usability of the support system:

<i>Requirement</i>	<i>level</i>	<i>Questions</i>
4- flexible	1+2	8. To what degree do you think this support system support the iteration in the design phase (changing parameters, etc)?
5-multi-actor	1	Is not evaluated as in the prototype the upgrade will not show if the effect of decisions can be visualized.
6- develop alternatives	1+2	9. To what degree does the system change and improve the current process? 10. To what degree do you think the system can enhance the development of alternatives? 11. To what degree do you think the system is able to generate realistic and workable alternatives?
7- transparent intuitive	-	Is not evaluated because needs more finalized prototype, which is not feasible in this study.

The last questions evaluate the usage of the system:

<i>Requirement</i>	<i>level</i>	<i>Questions</i>
8- proven software	1	The selection of software is the step to address this requirement
9- windows	1	The selection of software is the step to address this requirement
10- connect ability	1	The selection of software is the step to address this requirement
11- Client	1	Must be possible with the software, but is not tested (out of scope, chapter 4)
12- enhance creativity	1+2	12. To what degree do you think that the system enhances the creativity in the design phase?
13- reproducibility	1	The selection of software is the step to address this requirement

General questions:

13. To what degree would you recommend others to use the system?

14. To what degree would you like to use this system?

Evaluation results

The experience of the respondents varied from zero to a lot of experience. And the respondents had a varying background:

- Logistic engineers (one with experience, one with no experience)
- Project engineer
- Planner
- Project manager
- Head business control
- Tender coordinators (one with more experience, one with some experience)
- Manager of projects
- Quaestor engineer
- SIP department manager
- Professor Delft on Offshore Technology

Question:													mean	st.dev
1	10	9	8	7	9	8	-	7	7	8	8	7	8.0	1.0
2	9	7	7	5	8	7	-	6	-	8	8	7	7.2	1.1
3	9	8	10	6	8	8	-	6	10	8	8	8	8.1	1.3
4	9	8	10	7	8	7	-	5	10	-	8	8	8.0	1.5
5	8	-	10	7	8	8	-	-	10	7	6	8	8.0	1.3
6	9	7	8	4	7	5	-	-	-	8	5	6	6.6	1.7
7	5	7	-	7	8	7	-	6	-	-	5	7	6.5	1.1
8	10	8	9	7	8	7	-	7	-	9	8	9	8.2	1.0
9	10	7	9	5	8	8	-	-	8	8	9	6	7.8	1.5
10	10	9	8	7	8	8	-	-	10	8	8	9	8.5	1.0
11	9	7	8	7	8	7	-	-	10	9	6	7	7.8	1.2
12	9	8	5	4	7	8	-	-	10	-	8	9	7.6	1.9
13	10	9	8	7	9	8	7	7	10	9	8	8	8.3	1.1
14	10	8	8	7	8	-	7	7	10	9	7	7	8.0	1.2
Experience	3	3	0	4	2	0	2	4	0	0	4	2	2.0	1.7

Table H.1 Response on the interview questions

Experience: 0 means no experience, 1 means experience with only 1 project, 2 means experience with around 2 projects, 3 experience with more then 3 projects and 4 means experience with more than 5 projects.

The final mean is 7.8 which is very high, therefore the concept support system can be seen as promising. But as can be seen in table H.1, not all the respondents answered all the questions. This had two reasons, or they found they were not the ones that should answer those questions as they do not work as a logistic engineer or planner anymore. Or they found they had no knowledge or experience to answer those questions.

Limitations to interpret these answers:

As there is a limited number of responses, and the difference in perspectives on the meaning of a grade makes the outcomes limited usable (Klein and Myers, 1999). Everyone has another meaning on how he/she would grade a positive point, for one giving 7 or 8 is very positive, for another only a full 10 is very positive. However the average results are higher than a 6.7, which means the system is found more useful and usable then not. And the intention to use the system scores on average more than an 8. Because of these results the concept for the support system found promising.