Mapping to Manage

The design of a process to fully exploit the benefits of process mapping within APMT’s trajectory towards container terminal automation.
*All container terminal pictures used are retrieved from APM Terminals Management B.V.*
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Master thesis report

Scanned for confidentiality by: Dr.ir. C. Versteegt
The Hague 5 March 2009
Version: Final Version

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APM TERMINALS

TU Delft
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Preface

This research is the final project for the Master program of Systems Engineering Policy Analysis and Management within the specialization track on Modelling, Simulation and Gaming. The research is performed in cooperation with A.P. Moller-Maersk Terminals (APMT), which created a challenging triangle of goals and interests between this company, academic perspectives and personal objectives. I took this challenge with great pleasure in the last six months especially due to the great support of several people whom I would like to thank. At first Cornelis, Michele, Job, Scott and Alexander for their great input and continuous flow of extra challenges in the role of my supervisory committee. Secondly, all colleagues in The Hague for creating a very friendly and stimulating environment, especially: Ben-Jaap, Angelo, Uwe, Silvia and Ross. Furthermore all respondents and experts providing me with very useful input: Edwin, Doug, Jeremy, Finn, Laurens and Rik. The team in Virginia for the steepest learning curve on container terminal operations ever: Richard, Karen, Mark, Matt, Mike, Gary, Kyle, Joey and John. My colleague students for their critical notes and input: Hao, Julia, Virginia, Thijs, Rob, Sander and Max. And last but not least, Albertien, for her support outside the project boundaries.

Besides the research itself it was a great learning experience to be part of the design workshop for the innovative FastNet concept, to participate in the peer review workshop for Maasvlakte II and to give my best shot in the Maersk hockey team. I would hereby like to thank APM Terminals for giving me these opportunities. Finally, I would like to wish the Operations & Implementation support team, especially Nienke, good luck and a fruitful further implementation of the research results for APMT.
Guide to the reader

To get all nuances of the research performed it is advised to read the full report. All main thoughts, conclusions and recommendations are however highlighted as statements:

**Statement**
All statements together are the common thread throughout the argumentation structure of this report.

As a further guide to the reader these statements are brought together in Appendix I which will help in placing the drawn conclusions in perspective. However the report can also be read in several other ways when:

- Interested in the main conclusions it is advised to read the executive summary. When this caught your interest do not only look at the Chapter 9: Conclusions and Recommendations but also at Chapter 10 the discussion and reflection.
- Interested in the methodology read paragraph 1.2.3 and Chapter 2 for the contribution of this research read paragraphs 10.1 and 10.2.
- Interested in the processes at automated container terminals get in contact with the automation team of the innovation department of APMT to be able to look into the confidential models created during this research.

This research furthermore resulted in the paper “Mapping to Manage or Managing to map?” which is attached to this report but must be seen as a separate piece of work.
Executive summary

Automation of processes at container terminals is a possibility to meet the expanding volume of container traffic. The first step in the path towards automation is the understanding of these processes. Process mapping is one of the most widely used methodologies to create this understanding. A process map is a visual representation of a process. APM Terminals (APMT) used this method within their non-automated terminals resulting in the preference to also apply process mapping in the design trajectory towards automated container terminals. There is however no unity in the application of process mapping within APMT and there is no clarity on how and why to use process maps. Furthermore, the innovative aspects of the design trajectory and the distributed characteristics of APMT raise the question if process mapping will add value, because it is unclear how this static method can cope with such a dynamic multi-user environment.

These observations can result in the situation where the creation of the process maps will be more important than the intended purpose of automation. The maps will become ends instead of means. To prevent that the use of process maps within APMT will be a one shot effort this research answers the following research question: How can process mapping be implemented in APMT’s container terminal automation process to fully exploit its benefits?

In order to answer this research question a design methodology is set up to overcome two main challenges. First, the process maps themselves: how they could be improved to become tailor made for APMT. And second, the trajectory: how these tailor made maps should be incorporated in APMT’s process. A solution space for these two challenges was formulated by a structured analysis of the methodology process mapping, the organization APMT and the technological implications of the system. This solution space was embodied by an extensive list of goals and requirements, representing the full possible potential of process mapping for APMT. Within this space a library of standard basis process maps is created. All basis maps that the library provides can be tweaked to a specific project situation. Whereby the library will not only save time for a specific project team but will also make sure all issues are looked at. The usage of the project specific maps will support in standardization, storing information, indentifying opportunities, creating ownership, improving communication, establishing performance measures, reducing risks and increase the efficiency of creating other process documentation.

After an extensive validation the usability of the library seemed insufficient, because the library does not present what is desired by the several users. This is firstly caused by the quantity of the processes: the amount of information present in the library has an inhibiting effect. Secondly, by the skills required for the software the library is created in. And thirdly, the terminology used in the process maps. The result of a second design iteration are two separate versions of the library for two specific user groups: the editors who will actually be tweaking the process maps to create their own project specific process map package and the viewers who are only interested in the information the maps withhold. But with a user friendly library of process maps the full potential will never be reached therefore the maps should be used! It is therefore essential to make clear how and when to use the library versions. A usage-process and implementation plan that fit into the current design cycle, the Process Excellence Life (PEX) cycle and Project Implementation (PEI) framework of APMT, overcomes this problem. They inform the users
within APMT when to use the library, bringing in line the perceptions of the users with the possibilities the library provides. But again: with a description on when and why to use the library it has not been ensured that it is actually used in practice. An organizational structure is therefore implemented to ensure coordination of the usage and support at the different stages.

From these designs several conclusions can be drawn that answer the main research question. APMT can implement process mapping into their process towards container terminal automation by including the usage of the viewers and editors versions of the basis process map library for an automated container terminal in their PEX cycle and PEI framework. Assigning a process owner per project and a global process owner will hereby ensure: the execution of the implementation plan, support for the users and the gathering of feedback to keep the basic maps in the library up to date. From this conclusion several tools are generalized that can help to reach the full potential of process mapping within a dynamic system.

- Create basic standard process maps that turn users from process map authors into editors, this will increase their productivity. Furthermore it sets a basis for process standardization and makes it easier to adjust the static process maps to changes in a dynamic environment.
- Instead of loose maps create a hierarchical structured connection between process maps which will bring the components of the system together at a higher level. Because changes, due to dynamics, are often at lower levels the higher hierarchical levels will not be influenced by the dynamics. Furthermore a hierarchical structure creates the possibility to add all sort of new information to the process maps and shows the implications of changes at one end of the process supporting the consequences of dynamics.
- Change the process map software to meet the user demands or change the user by training, the ability to change process maps increases the resistance to dynamics.
- Make process maps the input to other, tools so they can support dealing with a dynamic environment instead of having to cope with it themselves.
- Coping with dynamics starts with being aware of dynamics. Create a playing field to gather feedback about process changes and their implications to make it easier to keep the process maps in line with the dynamic environment.
- Without a goal or pressure to cope with dynamics this will not happen. Introduce an organizational structure that fits within the current organization and an implementation process to introduce this structure, otherwise process mapping will become a one shot effort.

By using these tools process mapping can be a value-adding tool in the design, implementation, operation, maintenance and eventually change or re-engineering of complex business processes because it can cope with the dynamic environment of the system these processes are situated in.
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AGV</td>
<td>Automated Guided Vehicle</td>
</tr>
<tr>
<td>APMT</td>
<td>APM Terminals</td>
</tr>
<tr>
<td>ccph</td>
<td>Crane Cycles Per Hour (QC productivity)</td>
</tr>
<tr>
<td>DCS</td>
<td>Design and Costing Support</td>
</tr>
<tr>
<td>FEU</td>
<td>Forty feet Equivalent Unit</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>Rehandling in order to prepare the yard for the upcoming operation</td>
</tr>
<tr>
<td>HSSE</td>
<td>Heath Safety Security Environment</td>
</tr>
<tr>
<td>HT</td>
<td>Horizontal Transport</td>
</tr>
<tr>
<td>IMO container</td>
<td>Container with hazardous or dangerous content</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ISPS</td>
<td>International Ship and Port Facility Security Code</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>MECE</td>
<td>Mutually Exclusive Collectively Exhaustive</td>
</tr>
<tr>
<td>MT</td>
<td>Empty Containers</td>
</tr>
<tr>
<td>MTTs</td>
<td>Tractor-multi trailer trains</td>
</tr>
<tr>
<td>MVII</td>
<td>Maasvlakte II</td>
</tr>
<tr>
<td>OIS</td>
<td>Operations and Implementation Support</td>
</tr>
<tr>
<td>PEI</td>
<td>Project Implementation Framework</td>
</tr>
<tr>
<td>PELC</td>
<td>Project Excellence Life Cycle</td>
</tr>
<tr>
<td>PEX</td>
<td>Project Excellence</td>
</tr>
<tr>
<td>PIM</td>
<td>Project Implementation Manager</td>
</tr>
<tr>
<td>POD</td>
<td>Port of Discharge</td>
</tr>
<tr>
<td>QC</td>
<td>Quay Crane</td>
</tr>
<tr>
<td>RBA</td>
<td>Rail Buffer Area</td>
</tr>
<tr>
<td>RMG</td>
<td>Rail Mounted Gantry (Stacking Crane)</td>
</tr>
<tr>
<td>RTG</td>
<td>Rubber Tire Gantry (Crane)</td>
</tr>
<tr>
<td>SC</td>
<td>Shuttle carrier (SC-manned)</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>ST</td>
<td>Shuttle Truck</td>
</tr>
<tr>
<td>TEU</td>
<td>Twenty feet Equivalent Unit</td>
</tr>
<tr>
<td>TOS</td>
<td>Terminal Operating System</td>
</tr>
<tr>
<td>TP</td>
<td>Transfer Point</td>
</tr>
<tr>
<td>TT</td>
<td>Terminal Tractor</td>
</tr>
<tr>
<td>UTR-BC</td>
<td>Utility Truck (coupled tractors) Bomb Cart</td>
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1. Introduction

What is this research about?
The design of a process to fully exploit the benefits of process mapping within APMT’s trajectory towards container terminals automation.
The research will result in:
- A library of process maps for a standard automated container terminal.
- A usage-process for this library.
- Recommendations for further research and APMT on the use of process mapping.
And furthermore the research will provide:
- A contribution to the use of the static method process mapping within the design of a complex system situated in a dynamic multi-user environment.

Why is this research relevant?
Automation could make sure that APM Terminals can realize its ambition to meet the expanding demand of container traffic volumes. Process mapping will be used in the route towards automated terminals but it is unclear how this static method can be usefully incorporated in this dynamic process to be able to use it to its full potential and reuse it in the future.

How is this research set up?
This research is split up in three phases. Phase I the Analysis, which will have to come up with a list of goals and requirements for the design. Phase II the Modelling, Design & Validation, which will take up these requirements and converges to a design, which will subsequently be validated in practice. Phase III the Evaluation, will evaluate the final design resulting in the contribution to APMT. The final chapters of this report provide the conclusions, recommendations, discussion and reflection. This first chapter will work out these points in further detail.

1.1 Problem sketch
APM Terminals is one of the world’s largest operators of container terminals. With over 50 container terminals spanning 31 countries and five continents it had a 12.1% share of the worlds container port throughput (Drewry Shipping Consultants Ltd, 2008). But world trade continues to expand and annual global container traffic volumes have been projected to double from the current 500 million Twenty feet Equivalent Units (TEU) to one billion by 2020 (Int. Pub. I, 2008). With its current projects, APMT has the ambition to meet this expanding demand by developing and managing 200 million TEUs in 2020. Research however acknowledges the fact that today’s conventional terminal technology will not keep APMT competitive in the future (Int. Pub. II, 2002). Innovation is a core policy of APMT that could overcome this threat. Innovation research shows that automation of the current business process can support the stated ambition because cost savings for automated concepts of approximately 30% compared with conventional concepts can be achieved (Int. Pub. II, 2002). Besides, experiences and calculations made show, that the total handling cost per box in a fully automated terminal can be 20% to 25% less than with manual operation (Hamburg Port Consulting GmbH, 2007).
Introduction of automation is a huge project associated with huge risks. Competitor ECT almost needed to close down their automated terminal in Rotterdam in February 2007 due to bad performance (de
Kruif, 2007). This can be expected when working with new logistic concepts, complex ICT systems and unproven technology. Therefore introduction of automation has to take place step-wise (Cederqvist, 2004). The internal research acknowledges this by stating that the risk of automation can be considerably reduced by gradually introducing automation within terminal operations.

Container traffic volumes have been projected to double to one billion TEUs by 2020. APMT has the ambition to meet this expanding demand by managing 200 million TEUs in 2020. It is assumed that with automation this stated ambition can be reached.

Taking the need for automation of the current business process within APMT as a fact, while considering that gradual introduction of automation is preferred, the automated yard project is set up. This project has the goal to develop a standard off-the-shelf design for an automated yard. Figure 1 shows the terminal yard and its interfaces with the water- and landside operations. Furthermore the figure directly clarifies what a container terminal is.

Figure 1: Conceptual representation of a container terminal (adapted from Farré, 2008; Oya, 2008).
With this focus on the yard the first demarcation is made sketching the first broad step of the step-wise automation. The switch from human based terminals to automated terminals is a change of APMT’s business process. The first step to automate processes is to understand the processes. Process understanding is created within APMT by describing the processes in process maps. A process map is a visual representation of a process (see paragraph 2.1). Process mapping is one of the most widely used methodologies for supporting such changes (Fenton, 2007). APMT used this concept within their non-automated terminals and because of this familiarity with this methodology APMT has the preference to use it within the change to automation. As described, the first step towards automation is the automated yard project wherein this use of process maps is given an important role. Appendix A further clarifies the positioning of automation within the organization and the overall goals the project contributes to. From this positioning becomes clear that APMT is a distributed and complex organization. Besides, the road towards automation will be a dynamic one. Not only innovation itself is dynamic but due to the distributed character of APMT decisions on automation processes will differ all over the world due to different circumstances. It is therefore questionable how process mapping, being a very static method, can be made useful in this dynamic environment. It should not just be applied, it should be considered in advanced what can be achieved. What kind of drawbacks can be expected and which benefits should be the goal.

At this moment process mapping is positioned within the automated yard project. Figure 2 presents this positioning, which is an adapted version from the original project plan (Int. Pub. III, 2008).

**Figure 2: The automated yard project deliverables.**

Because this is the only position at this moment this is the place where the goals for APMT can be achieved. Based on operational specifications of terminals, process maps should provide the basis to set up a decision support tool for the design of an automated terminal. Furthermore it will support decision making during the design phase about technical specifications, IT specifications and the actual terminal layout. This will result in the required equipment envelope and a practical procurement package for the actual roll out of an automated terminal. The overall goal of the automated yard project is to capture all relevant knowledge in a virtual terminal for communication and management of the knowledge. The function of the virtual terminal will be like the current *terminal in a box* (see terminal in a box within the...

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1 For a brief overview of other methodologies see chapter 2 and Appendix C.
stakeholder analysis of Appendix D). The positioning of the process maps within the automated yard project also makes the importance of this means clear: process mapping will be used as a basis. This positioning seems adequate but it is actually the first part of the problem. With only this position process mapping is incorporated within the automated yard project but it is not incorporated in the automation process itself. This indicates that the maps will only be input to the other deliverables within the project and that there will be no chances to gain other benefits with this method, to accomplish this it should be embedded in the entire automation process. With these findings the problem statement can be formulated:

<table>
<thead>
<tr>
<th>Problem statement</th>
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<tr>
<td>Process mapping will be used in APMT’s automation process but it is unclear how this static method can be usefully incorporated in this dynamic process to be able to use it to its full potential and reuse it in the future.</td>
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</table>

1.2 Research project
This research is done as the final project for the Master program of Systems Engineering Policy Analysis and Management within the specialization track on Modelling, Simulation and Gaming. The research is performed in cooperation with APMT, creating a triangle of goals and interests between organizational, academic and personal objectives. In the exploratory meetings with APMT (Interview I, 2008), APMT stated that it expects two deliverables from this research project, one tangible and one intangible.

1) Firstly it is expected that this research project results in several process maps of an automated container terminal.

2) Secondly APMT wishes to create internal stakeholder engagement for the use of process maps. These deliverables and the observed problem, result in the research objective which will be presented in the following paragraph. But before going into this one additional note should be made. It might have become clear that the project will be practical in nature but formulated and defined as a scientific project. Meaning that there are possibilities to apply, question or add things to current theory. Therefore the research is based on several theoretical pillars related to design theory, process mapping, theory on complex logistic systems, stakeholder theory and theory on validation. These different theories will be addressed in the corresponding sections and will be reflected at the end of this report.

1.2.1 Research objective
The problem statement is supported by the findings of the first exploratory meetings with APMT. From the first two deliverables can be concluded that the adaption of the original project plan in Figure 2 is correct. From the second deliverable and the discussions with APMT the finding can be supported that currently the usage of process maps is bearing down upon a one shot effort: usage within the automated yard project. While it should actually be the other way around: process maps should be used to create stakeholder engagement. To prevent that the use of process maps within APMT will be a one shot effort the goal of this research can be formulated:

<table>
<thead>
<tr>
<th>Research objective</th>
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<tr>
<td>To design a process to fully exploit the benefits of process mapping within APMT’s trajectory towards container terminal automation.</td>
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</table>
1.2.2 Research questions

To reach the stated research objective the following research question is stated:

0. How can process mapping be implemented in APMT’s container terminal automation process to fully exploit its benefits?

This research question falls apart in five elements: (1) process mapping, (2) APMT, (3) container terminals, (4) automation and (5) processes.

From the first four elements requirements (restrictions) and opportunities should be identified that should be implemented in the process (fifth element) in order to do it full justice. The methodology and the structure of this research in the following paragraphs describe the route that will be followed to answer this main research question.

In order to answer the main research question sub-question one and two are set up. With the knowledge gathered after answering these questions the research will try to discuss the third generalizing research question.

1. How can the existing process maps be improved to become tailor made for APMT’s terminal automation process?
   Method: Literature research of scientific publications, conference proceedings, company documents/industry documents and interviews with concerned stakeholders. Field research: process mapping of several terminal processes. (Theoretical, current state descriptive, modelling and empirical)
   Result: A library of basis process maps for a standard automated container terminal.

2. In which way should process maps be incorporated in APMT’s terminal automation process to fully exploit their benefits?
   Method: Process design. (End product related, generalization)
   Result: To overcome the identified first main drawback of process mapping (that it becomes a one shot effort) a generic recommendation on a way of working with process maps will be made and a recommendation on where and how process maps should be used within the APMT’s automation process.

3. How can process mapping deal with the tension between it’s static characteristics and a dynamic distributed multi-actor environment?
   Method: Desk research. (End product related, generalization)
   Result: To overcome the identified second main drawback of process mapping (that it does not suffice in a dynamic environment) a recommendation on how to deal with this tension is the result. This recommendation will consist of a generalized discussion on the use of process mapping within a dynamic environment.

The first deliverable for APMT is embedded in the end result of research question one. The creation of process maps (deliverable 1) for an automated terminal will be necessary to answer research question one. The creation of engagement within APMT for the use process maps (deliverable 2) will not be
realized directly. Instead a process will be designed how to reach this engagement and actually use the process maps (research question 2). These research questions will be transformed into actions and results by using the methodology described in paragraph 1.2.3.

**1.2.3 Methodology**

In order to let process mapping become the methodology within terminal automation this paragraph describes the methodology that will be used in this research. This methodology should be the guideline in the research activities. Looking at the research objective and research questions the main challenge will be a design challenge. The design approach used in this research is based on a design methodology used in the design of systems with many requirements and stakeholders (Herder and Stikkelman, 2004) and on the design cycle (Takeda, Veerkamp et al., 1990). Figure 3 presents the applied design approach, adapted from the original metamodel and the design cycle. In phase I the metamodel is leading, in phase II the design cycle (see Appendix B).

![Design Cycle Diagram](image)

**Figure 3: Model of the design process (Adapted from Takeda, Veerkamp et al., 1990; Herder and Stikkelman, 2004)**

Takeda’s design cycle (1990) consist of five sub processes represented in Figure 3 by first the system analysis: the awareness of the problem. The system analysis consists of three different analyses: an analysis of the methodology of process mapping, the technology and the company. Literature research of scientific publications, conference proceedings, company/industry documents, interviews and a stakeholder analysis will be used in these analyses. These analyses will be performed in parallel to enhance coupling between the three analyses. With further insight in (1) the benefits, drawbacks and use of process mapping, (2) the uncertainties and interfaces within the technology and (3) the complex multi-actor setting and the dynamics of the automation process within the company a list of requirements and goals can be set up that spans the design space. This design space is the second sub-process in the design cycle, it is the identification of the key concepts (root causes) that need to be addressed to solve the problem.

Within this design space a process map design and a way of working with these maps will be set up. This third sub process of the design cycle is the development. Subsequently empirical tests will be performed by creating several maps in practice. This fourth sub process, the evaluation, will provide knowledge for
the fifth process the conclusions. But the word cycle already implicates that designing is an iterative process. Multiple cycles are mostly used for risk control (Maier and Rechtin, 2002). In this research two iterations will be made. The first iteration is the actual creation of several maps. This will result in a detailed design including the findings from the field. This detailed design will be judged by experts in the second iteration on the several requirements and goals identified in the first phase. The result of this second iteration will be a final design. So concluding can be said that by using the adopted version of the metamodel of Herder and Stikkelman (2004) the last three steps of the design cycle will be performed twice to come to a valid design. After walking through this design strategy the overall conclusions recommendations and a general research evaluation will be described in the final chapter of this report.

### 1.3 Structure of the report

The completion of all the steps in the methodology will result in two reports: one confidential report available to APMT and the examination committee and one public report. Figure 4 sketches the outline of these reports.

![Figure 4: Thesis report outline](image)

As described in the previous paragraph research phase I (documented in the first three chapters), the system analysis, will be done in parallel. The documentation in this report is however split up over three chapters. The methodology of process mapping is described first to make the method clear, also the current situation of use within the company is described in this chapter. The succeeding chapters will describe the effects of the technology and the company on the use of the methodology.

Research phase II consist of the two iterations of the design cycle. The first iteration of the design cycle is documented in chapter 5 and 6. Whereby chapter 5 presents the design and chapter 6 discusses the methodology of the validation test and the conclusions of the validation. With these conclusions an adjusted design is presented in chapter 7 focusing mainly on the flaws of the initial design. This chapter
will answer the first research question. Phase III consists of the evaluation of the second design cycle in chapter 8 resulting in a description of the contribution to APMT. Research question two will be answered in paragraph 8.1. The answer to the main research question is finally presented in chapter 9: conclusions and recommendations. This report is finished with a chapter discussing the third research question and a reflection on the used methodologies within this research. Please see the preface if you would rather read this report selectively.
In terms of the design methodology research phase I will try to come up to a design space by performing three structured analyses of the system. The analysis of the methodology of process mapping, the technology and the company, which were in practice performed in parallel, are in this report section documented in a specific order. At first the total possible potential of the methodology process mapping is sorted out. This full potential is subsequently limited by the technological context and the company it will be used in in this research. According to this line of thought the analysis of the methodology is documented in the first chapter of this report section followed by the analysis of the technology and the company, whereby the latter two are interchangeable.
2. Analysis of the methodology

The previous chapter stated the problem that APMT will be using process mapping but that it is unclear how. Therefore it is imperative to go deeper into the method process mapping and identify its opportunities and requirements. The goal of this chapter is to identify the design choices that APMT can influence to seize these opportunities and comply with these requirements so it can become clear how APMT can use process mapping.

First it will be described what process mapping and the purpose of process mapping is. Subsequently the design choices in constructing process maps will be discussed. This theoretical research is finalized by an analysis of the constraints that should be taken into account. The next topic, in paragraph 2.2, is about how the incorporation of process mapping within the current process design can be reached. In the succeeding paragraph (2.3) the current usage of process mapping at APMT will be analyzed. The findings will be wrapped up resulting in the goals that can be reached using process mapping and the requirements that must be met in the design to make it succeed when using this methodology.

2.1 Process mapping

To construe what process mapping is, first it should be considered what a process is. Hammer and Champy define a process as “a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer” (1993). From this definition several characteristics of a process can be identified. At first a process has boundaries: the inputs and output. Secondly a process has a customer wherefore the process adds value, the third characteristic. Looking at Davenport’s definition another characteristic can be added. “A process is a specific ordering of activities across time and space (…)” (1993). Finally Oulds adds two more features: “it is carried out collaboratively by a group “i.e. we are concerned with more than the work of an individual” and “it often crosses functional boundaries” (1995).

A process map is a visual graphical representation of a process (Rummler and Brache, 1990; Terhürne and ter Welle, 2007). But one can imagine that a concept with so many characteristics is difficult to grasp in a single visual representation. This results in various techniques to makes this representation (Mayer, Benjamin et al., 2000) (see Appendix C), for example workflow modelling (van der Aalst, ter Hofstede et al., 2002), flowcharting (Damelio, 1996) and IDEF (Institute of Electrical and Electronics Engineers, 1998). These techniques vary depending on the purpose of use, and it should therefore be determined which processes process mapping, the method of this research, can fulfil.

2.1.1 Purpose of process mapping

Process mapping can serve several purposes. The first choice is to determine this purpose. The analyses of process mapping literature resulted in the following list of possible purposes of process mapping APMT can pursue:

Process support by description

First of all process mapping, encourages a process orientation and overview over the entire process (Buchanan, 1998). Creating insight is most of the time the main purpose. Not only the insight the map itself creates but also the actual procedure of creating it can help people to define roles and create insight in who does what (Greasley, 2006). This gained insight is used to better support the processes
within the organization. It is therefore necessary that the map provides enough detail or precision to support the purpose of use. Therefore the first indicator to judge the usability of the map is **density**.

**Process improvement**

Process maps can be used to identify opportunities and reduce risks and uncertainties (Terhörne and ter Welle, 2007). They can for example help to evaluate or establish alternative ways to organize processes and to identify risks inside the process (Damelio, 1996; Fenton, 2007).

**Process re-engineering support**

Process mapping is one of the most widely used methodologies within business process re-engineering (Fenton, 2007). When a core business process is fundamentally changed or a new way of working is set up, process maps can support all phases of this change process. Within terminal automation the process maps can for example be used to support the design, implementation, operation and maintenance phases. One can imagine that such a process is dynamic over a long period of time so an indicator for the process maps is **maintainability**.

**Process standardization**

Process maps can be used to identify standard processes, support the standardization of non standard processes and support the implementation of standardization. For example to become ISO9000 (International Organization for Standardization, 2008) certified (Terhörne and ter Welle, 2007). To be compliant the maps should be accurate, so **validity** of the maps is an indicator. Validity is in this context defined as the extent in which the process map complies with reality.

**Process information management**

Process maps store knowledge and show where knowledge originates within the organization (Fenton, 2007). Rather than only storing the knowledge it is important to take advantage of what is known to maximize the output. A proper visualization is important to store knowledge but also the way the maps are saved and managed influences the success of all purposes. Furthermore, it is important that the steps followed could be retraced to audit the output of the map (Ragsdale, 2008). So the **re-usability** of the maps is an indicator. The definition of re-usability in this context is the ease of retrieval and auditability of information.

**Legislative compliance**

Process maps can be used to comply with legislative requirements (Ferla, 2004). Strong process description can be of help when insurance or safety issues occur, for example in International Ship and Port Facility Security Code, ISPS, compliance (International maritime organization, 2003). In this case validity is again a very important criterion.

**Create ownership / stakeholder engagement**

As described, the process maps can be used to create ownership of the change process among all people involved (Fenton, 2007). They could make automation real for the stakeholders by involving them in the process of creation and use of the process map. Even if there are no process improvements realized the stakeholders will perceive that the process is more efficient (Terhörne and ter Welle, 2007).

**Means of communication**

Process maps can be used as means of communication (Terhörne and ter Welle, 2007). Process maps make work visible and increased visibility improves communication and understanding. Process maps make change concrete and negotiable for groups; they are more easily processed than other forms of communication (Fenton, 2007). Besides, process maps can be used to get up people to speed to what is
happening in the rest of the organization and vice versa (Damelio, 1996; Fenton, 2007). To be able to reach this purpose an indicator for the process map is **clarity**. This indicator is in this context defined as the unambiguity of the presented information, for example if all different maps have a uniform representation.

**Establish performance measures**

They can be used to evaluate, establish, or strengthen performance measures (Damelio, 1996).

When process maps are used within the entire process to reach these purposes, process mapping is the link pin in the process between the preparatory phases and the subsequent phases during which the new process designs are developed (Biazzo, 2002) and implemented.

To be able to serve these purposes five performance indicators for the process map itself were identified: density, clarity, validity, re-usability and maintainability. These indicators contribute to the overall performance indicator, the **usability** of the process map for stated purpose of use.

### Conclusion

Process maps at their full potential ensure standardization, store information, indentify opportunities, create ownership, improve communication, establish performance measures, reduce risks and increase the efficiency of creating other process documentation. But they need to comply with the indicators of density, maintainability, validity, re-usability and clarity to be usable to reach its full potential.

This paragraph described why process maps can be made. But, before moving up in detail level again to how the process maps can be used to support these whys, a step deeper should be made. Because the six performance indicators itself are not enough, it should be identified how these performance indicators can be influenced. What actually can be done to create density, clarity, validity, re-usability and maintainability? The following paragraphs take a closer look at the four design choices that can be altered to optimize the set of performance indicators for the actual map itself.

#### 2.1.2 Design choice I & II: Process classification and map detail level

This usability for the purpose of a process map is logically determined by what it presents. But, what it needs to present depends on the purpose of use. This is directly the big trade-off in the discussion about the detail level of a process map. Process maps should not be very complicated because this will make them more difficult to comprehend. On the other hand the documentation must be of sufficient detail to allow for substantial improvements (Ungan, 2006). In for example the designing phase of a new automated operation the availability of more process details reduces the likelihood of obtaining defective work from that process. So, in this case, the more levels of mapping the more useful the information but the higher the cost of mapping (Soliman, 1998). On the contrary when leaving detail out the focus can really be on the key drivers to see what is happening (Rasiel, 1999). This results besides the trade-off between the detail level and the usability in a second trade-off between the detail level and the costs of mapping.

With a clear view in the trade-offs of determining the detail level, the possibilities for creating detail level will be explored. Usually the first level of process mapping is the overall core process. This core
process is funded by support process and overlooked by the management processes (Ould, 1995). Within these three broad types (see Figure 5) several specific classifications can be made to create more structure.

![Diagram of business processes]

**Figure 5:** The three types of business processes (Ould, 1995).

Core processes can for example be import, export and transhipment of containers supported by marine operations and yard operations and managed by process management operations. A design choice is to determine classifications within these processes. This can result in a clearer overview of the processes and help in reaching the required level of detail.

To create more detail these classifications should be unraveled. Malone, Crowston et. al. identify a *process compass* to split up each of these classifications in different dimensions (1999).

![Diagram of process compass]

**Figure 6:** Process compass to split up processes (Adapted from Malone, Crowston et al., 1999).

A process can go *down* to the different parts of an activity (its subactivities), or *up* to activities of which it is part, right to the different types of the activity (its specializations), and left to the different activities of which this one is a type (its generalizations). For example a generic activity *transport container horizontally on the yard* can be broken up into parts (or subactivities) like *pick up container*, *determine route* and *travel*. The generic activity can also be differentiated into types (or specializations) like *transport horizontally by AGV* and *transport horizontally by straddle carrier*. Learning from the analysis of other representation techniques (see Appendix C) a hierarchical structure could for instance be considered.

By using classifications of processes and splitting them up along different dimensions the required detail level can be reached. But what is the required detail level? The answer to this design question depends
on the purpose, the goals of using process mapping within APMT. This question will be answered in chapter 5 where all goals and requirements identified are taken together to come up to a process map design. The question can be answered on basis of the proposed detail level / purpose relationship in Table 1.

Table 1: The relationship between purpose and level of detail (Adapted from Ungan, 2006).

<table>
<thead>
<tr>
<th>Level of detail</th>
<th>Process improvement</th>
<th>Process description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parts with problems</td>
<td>Overview</td>
</tr>
<tr>
<td>Detailed</td>
<td>Not detailed</td>
<td>Detailed</td>
</tr>
<tr>
<td></td>
<td>Parts working well</td>
<td>Very detailed</td>
</tr>
<tr>
<td></td>
<td>Process reengineering</td>
<td>Not detailed</td>
</tr>
<tr>
<td></td>
<td>Process standardization</td>
<td>Detailed</td>
</tr>
</tbody>
</table>

But from this table it is still questionable what is detailed and what is very detailed. In fact this is very case specific and should thus depend on APMT. But one should be aware not to describe very logical obvious steps. Best practice is to distinguish processes from procedures that are by definition a detailed subset of a process (Fresco and Pederiva, 2003). Therefore, a design choice is to determine the level of detail of the process maps, which is a trade-off with usability and costs.

But, including or excluding processes to achieve classifications and a certain level of detail is not always easy, because there are several types of dependencies between processes (Malone, Crowston et al., 1999; Biazzo, 2000):

![Figure 7: Basic types of dependencies among activities (Zlotkin, 1995).](image_url)

1. **Flow dependencies**: One activity produces a resource that is used by another activity. This producer-consumer link implicates that the right thing must be in the right place (accessibility) at the right time (prerequisite). So there will be notifications in the process, compatibility checks, buffers or when simultaneity is present, synchronization.

2. **Sharing dependencies**: Multiple activities use the same resource. In this dependency no-coordination is necessary if the resource can always be shared. In case of non-sharable re-usable resources the claim activities lay on this resource can cause conflicts. These conflicts must be made visible and the resource use should be programmed. But if it is non-reusable an activity should be selected to be performed.

3. **Fit dependencies**: Multiple activities collectively produces a single resource. In this case activities should be coordinated to be able to include parallel processes.
Besides effects on the possibilities for classification the dependencies also set requirements on the process map itself. The process maps should be able to represent the different dependencies.

### 2.1.3 Design choice III: Visualization

If it is identified what the process map should represent the next design choice is how this should be represented. As described there are several methods for this representation (see Appendix C). The field of visualization itself is even broader and it is therefore essential to keep the boundaries of this research into account. Taking a quick look ahead it must be stated that it is not useful to analyze all these different visualization techniques in depth because APMT is already using a form of representation. This type of representation, the first boundary to visualization, is prescribed for this research with the additional note that one iteration step of improvement might be necessary. Figure 8 shows the cross-functional process mapping technique used at APMT.

![Cross-functional process mapping technique](image)

**Figure 8: Cross-functional map view (Damelio, 1996).**

This type of technique shows functions, steps, sequence of steps, inputs and outputs for a particular work process (Damelio, 1996). Within this prescribed context several options can still be filled in to make the choice on the way of visualization a real design choice. Especially because different visual representations can be valuable in highlighting different characteristics of that activity, and in triggering discussion, about change, improvement, and development (Buchanan, 1998). Aesthetics can really make a difference, because some like to read, some like to do and other like to see.

A different set-up within the context of a cross-functional process map can have different implications on the identified performance indicators and thus a different effect on the purpose.

Figure 9 presents several options for the actual design of the process map retrieved from the various representation techniques (see Appendix C). This will not result in an entirely new technique on representing process maps, but these are the options that can be used within the currently used representation.
In the actual design of the process map these options should be analyzed on their added value. This added value should be looked at by taking the total of all options used instead of one single option at the time. Because the use of more representation techniques can result in a better density and validity but also quickly leads to a lower clarity of the map. This should be taken into account seriously because it was concluded that a uniform representation throughout all separate process maps is very important. Furthermore, it should be noted that visualization is directly related to the software used for the development of the process maps, especially for implementing digital functions. This is the second boundary for the freedom in visualization. In this research the software package iGrafx (iGrafx, 2008) has to be used. This came forward from an extensive discussion with the stakeholders in December, who jointly decided that changing the package is unnecessary. Mainly because iGrafx is already widely used within APMT and the time investment in changing the current library to a new format will not be worth it. Furthermore there are still possibilities within iGrafx unutilized. For these reasons the stakeholders were highly reluctant to change, so from this point forward the usage of the package iGrafx is a fact and the option of switching the software package will not be discussed any further. The possibilities of Figure 9 already take into account this limitation.

With these two boundaries in mind only several general notes can be taken up from the research field of visualization. It is important to come, within the project boundaries, to a visualisation with only a few and simple symbols, which together form one model with one meaning (Oude Luttighuis, Lankhorst et
al., 2001). This visualization should be flexible in such a way that for example a manager can quickly get an overview of the overall process (Bobrik, Reichert et al., 2005). It can be concluded that a design choice is how the processes can be visually represented within the boundaries of the current use at APMT and the software package. In contrast with the broad field of visualization, documenting many possibilities, this research can only use several limited visual techniques, like colours and arrows, within APMT’s current visual representation.

2.1.4 Design choice IV: Map creation procedure

If the detail level is determined and the way of visualization is set up, the process maps should actually be made. Classifications should be discussed, information collected and maps should be sketched. This should not just be performed; it should be reasoned how this process should look like because results can already be achieved in this phase. There is no uniform agreed formula, prescription or methodology for mapping (Buchanan, 1998) but creation of a process map is usually performed in the following steps (Soliman, 1998; Biazzo, 2000):

1) Identification of products and services and their related processes. Related within the definition of the boundaries and of the customers of these processes, of the main inputs and outputs and of the stakeholders involved.
2) Data gathering and preparation.
3) Creation of the map on the basis of the information acquired and step by step iterative revision of the map.

The way these steps are executed differs depending on the purpose of the map. Damelio sketches three basic methods (1996). If the process is known, the described steps can be filled in by an individual. This method, called self generation, is fast, but its usefulness is limited by the knowledge of the individual. Besides this, no additional stakeholders can be engaged in the process. To enhance this, series of one-on-one interviews can be performed, and after creation of the maps the interviewees can be asked to review the resulting maps for completeness and accuracy. To even create more direct interaction group interviews can be organized (Fülscher and Powell, 1999). This participation “broadens cross-functional awareness and understanding and it potentially fosters mutual respect for different contributions” (Buchanan, 1998). This will create a sense of ownership over the process by the stakeholders involved. But the steps will almost always be based on the gathering of data from internal documents, written process specifications, photo/video documentation and process walks (Buchanan, 1998).

After configuring the steps and the choice how to execute these steps the third choice in the procedure of map creation is the approach to the map. As a matter of course this is a top-down approach: first the core-process is described which is later on broken up until the preferred level of detail is reached. But it should be mentioned that a bottom-up approach can also create the above described sense of ownership. With minimal mapping skills and without an overall knowledge of the entire business, people can document the business activities they are involved in. By linking and grouping these activities at higher levels complete process maps can be generated (Fresco and Pederiva, 2003).

Taken together the procedure of map creation is a design choice by itself depending on the purpose (see paragraph 2.1.1), but one thing is sure: it is an iterative process (Ungan, 2006).
2.1.5 Constraints of process mapping

The first and one of the biggest dangers is that process maps are not used as means for the described purposes (see paragraph 2.1.1). They are in practice often used as ends (Damelio, 1996), not means. Process mapping can become more important than the intended purpose (Peppard and Rowland, 1995). It should be prevented that the process maps are only useful within a short time following their set up, because practice shows that they are often a one shot effort (Fresco and Pederiva, 2003).

The second drawback is that a process map only provides a static view, a picture at a certain period. So it cannot predict behaviours over time in response to fluctuating demand and resource availability (Greasley, 2006). It is thus questionable if a process map is useful in a dynamic environment. Besides, any static process representation can give the impression that the process is more stable than it actually is (Malone, Crowston et al., 1999).

Besides the threatening scenarios of becoming a one shot effort that cannot cope with a dynamic environment, several other drawbacks should be taken into account when using this methodology:

- Process maps are found to attribute a residual, or minor, role to social aspects. The description of the social system is not a constituent element of the process map. Process maps are said to be neglecting the issues relating personality predisposition, power relationships, status structures, attitudes, commitment, etc. (Biazzo, 2002).

- The costs and time of process mapping should be taken into account (Soliman, 1998).

- It should be considered that process mapping is often a one size fits all approach. So the different needs of different parts of the organization should be incorporated into the process documents (Ungan, 2006). So the process characteristics constrain the mapping possibilities.

- Information availability is often too limited to be able to create a valid process map, especially when future or innovative processes are mapped.

Concluding can be said that the design choices, discussed in the previous paragraphs, are directly imposed by time, cost and information availability generating several drawbacks. The most threatening drawback is that the process maps will become a one shot effort that cannot cope with a dynamic environment.
2.1.6 Wrap up
Paragraph 2.1.1 described why process maps should be used. The goal is to also use process mapping within AMPT for these purposes resulting in the goals summarized inside the pie of Figure 10. But for realizing these goals several requirements should be met, numbered in the boxes of Figure 10. Furthermore indicators for determining the usability of the process maps are indentified (bold).

Figure 10: Goals and requirements coming forward from the analyses of the methodology.
This figure describes the theoretical potential of process mapping. The further analyses of paragraph 2.1 focused on how to reach these goals by analysing what should be represented how. From this analysis can be concluded that by controlling the visualization, classification, detail level and the map creation procedure the clarity, density, validity, re-usability and maintainability of the process map can be influenced to reach the full potential. It is however very important to state that this is the theoretical potential because all these factors are determined by the technology and organization in which the process maps are used. Figure 11 summarizes this by showing the connection between the design choices (the hows and whats) for creating process maps to the indicators for usability. The chapters 3 and 4 will subsequently limit or change this picture by looking at the influence of the technology and organization on using process mapping. The wrap up after research phase I will eventually bring theory and the practice of the technology and organization together coming up to a final list of goals and requirements for the design in research phase II.
Figure 11: Choices, constraints and performance indicators for creating process maps²

Taking this figure into account the optimal map for one of the stated goals of Figure 10 could be created. But with an optimal map the goal is absolutely not reached yet! The creation of the map itself is only supportive. The performance indicators show the quality of the map but not the usability for the goal. This completely depends on how the process map is used within its dynamic environment, how it is incorporated in other processes than the creation of the map itself taking into account the technology and organization.

Conclusion

The indicators for process maps can be influenced by altering the design choices on classifications, the detail level, the type of visualization used and the procedure to create the process maps. The design choices are directly imposed by constraints and generate several drawbacks that should be taken into account. The most threatening drawback is that the process maps will become a one shot effort that cannot cope with a dynamic environment. So by only creating the maps the full potential of process mapping will never reached therefore the map should be used.

To use maps it should be stated where in the entire process they can be of help. This can be done by designing a process itself. The succeeding paragraph will take a close look at this.

2.2 Process design

From the previous paragraphs became clear that the process in which the process maps will be used is decisive for its success. This paragraph briefly describes how the incorporation of process mapping within the current process design can be reached.

The process towards the implementation of an automated terminal within APMT, is guided along several decision making rounds. To be able to fully exploit the benefits of process mapping the maps should be used in these decision making rounds. The following steps can be identified to reach this goal:

² This figure tries in no possible way to represent a ‘systems diagram’ as described by Bots (2002).
1. The process towards terminal automation within APMT should be analyzed.
2. The points in this process in which the process maps could be used should be identified.
3. It should be described how the process maps should be used at these different points.
4. Process mapping should be included in the trajectory towards terminal automation.

This research will only search for an answer on how to use process mapping within the process towards terminal automation. The first step after the completion of this research will be to set the agenda to create a discussion to include process mapping.

5. Engagement should be created to convince the process participants of the benefits of process mapping.

During this research several interviews with possible users of process mapping already showed that there might be some resistance against the use of process mapping. This research will provide the arguments to engage the participants (see paragraph 2.1.1)

6. Support in the use of process mapping during the process should be provided.

The technique of creating the process maps is not easy and clear therefore support provided while actually using the maps.

With a clear view on the purposes of process mapping, the performance indicators for process maps, the instruments to influence these indicators, and the way process maps should be incorporated in the current process, the literature study on process mapping is finished. Before moving on to the design and use of the process maps the current situation will be taken into account. This will be done by analyzing the current positioning of process mapping within APMT in the remaining paragraphs of this chapter and analyzing the technology context in which the maps will be used in Chapter 3 and analyzing the organization in which the maps will be used in Chapter 4.

2.3 Process mapping within APMT

Because process mapping is already used at APMT’s human based terminals it is essential to take a look at this current situation. Constraints for future use of process maps should be identified and learning from best practices should bring forward other purposes or benefits than identified through the literature study in the previous paragraphs. Furthermore it gives a first look in the field, which creates more insight in the conclusions drawn from literature. This should result in several goals and requirements. To come to these goals and requirements, in this paragraph the use process mapping at this moment is described. This will be done in the same order as the analysis of the methodology process mapping is described in paragraph 2.1. The current purpose of mapping within APMT will be described, taking into account the gathered information of paragraph 2.1.1, followed by the current decisions to the identified design choices in paragraphs 2.1.2 to 2.1.4.

2.3.1 Purpose of process mapping at APMT

As a result of several interviews, the consulting of internal documents and visits of the terminals in Zeebrugge and Rotterdam during the stakeholder analysis (see paragraph 4.1) (Gottwald port technology, 2003; Interview II, 2008; Interview III, 2008; Interview IV, 2008; Interview V, 2008; Interview VI, 2008) the following overview of the current use of process maps at APMT can be given.
The succeeding examples further clarify these X's that identify the current purposes:

**Standards & guidelines team**
- Within Operations Implementation team there is a responsibility for standards and guidelines resulting in several standardized basic process maps. Terminals could use these basic maps as a guideline to set up more specific maps for their own terminal characteristics.

**Team at the existing terminal Zeebrugge**
- Process maps are used to support the set up of standard operating procedures (SOP’s) and job descriptions in the start up phase of the terminal.
- Process maps are used in internal communication. For example the training of new people and to show people what functions others have and what else is performed in the organization.
- Process maps were used in external communication. For example in meetings with the TOS vendor, the process maps were the input for the software design.
- Process maps were used once during process improvement and will be used in the future by the business process manager responsible for process excellence.

**Operational implementation support team**
- Process maps are used to support the set up of SOP’s and job descriptions.
- Process maps support the training process.

**Other teams**
- During the design phase process maps support other decisions on for example the terminal layout and the input of the business model.
- Some terminals do not use process maps (Rotterdam) or just make process maps to be compliant with the ISO9000 norm of standardization, especially in North America. In this case the terminal management holds the opinion that making process maps only takes time and does not deliver other benefits than compliance.

Besides being, as described, input for the automated yard project current process maps are already used within APMT for several other purposes. The design should in the future again be used for these purposes.

---

**Table 2: Purpose of use of process mapping currently within APMT (X serves this purpose at this location)**

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Standards &amp; guidelines team</th>
<th>Process excellence team</th>
<th>Operations implementation support team</th>
<th>Team at existing terminal Zeebrugge</th>
<th>Team at existing terminal Rotterdam</th>
<th>Team at existing terminal Virginia</th>
<th>Other teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process support by description</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process improvement</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process re-engineering support</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Process standardization</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Process information management</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Legislative compliance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholder engagement / ownership creation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Means of communication</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mapping to Manage.
purposes because the past proved they added value. Furthermore, the fact that process maps are already used within APMT implies that the identified design choices, wrapped up in paragraph 2.1.6, were already answered in the past. From the considerations in these answers learning should occur for the design phase of this research. The answers to the design questions are discussed in the following paragraphs. The goals and requirements for the design coming forward from this usage by the current stakeholders will further be described during the analysis of the organization (chapter 4).

2.3.2 Design decisions I & II: Process classification and map detail level
Looking at the actual maps used at this moment several decisions that have been made can create insight in the set up design choices. In the current maps, classification of processes is applied on a high level. Not only classifications between core and supporting processes are made but also classifications between core processes itself (see Figure 6), because there are several ways the core process can be performed. For example: the entire terminal operation by RTG and the entire operation by SC are mapped (APMT Standards and guidelines, 2007).

In the preceding research³ (Farré, 2008; Oya, 2008) on process maps within the automated yard project classifications for the semi-automated terminal in Virginia have been set up in cooperation with several parties. The result were broad classes of terminal operations, maritime operations, yard operations and gate & rail operations which are generally accepted. It is advised by the authors of the preceding research to stick to this classification in this research. But this classification is only suggested in a separate document and not implemented in the used software or maps. This resulted in separately created process maps without any linkage between them. From this can be concluded that the classification at lower levels is debateable and that the implementation of the classification should be revised.

Detail level is currently used as a tool. For example the described standard basic maps with a low detail level of the standards and guidelines team are set up and used to set up terminal specific maps with a high level of detail. Hereby detail level is used intentional. But logically there is no uniform detail level in the process maps present at APMT, because all maps are used for different purposes. The detail level of a process map will therefore always be subject of discussion not only at the beginning of the process map creation but also during the creation of the map. So this design choice is a choice that will be answered at a broad scale in the beginning and over and over again during the creation of the actual map. For every process in a map the question can be asked if it adds to the purpose, if it is for example standardized enough or if it is specific enough for the purpose.

In the business process manual (Int. Pub. IV, 2008) for example, more attention is paid to the planning and supporting IT systems maps compared with the maps in the preceding research. Besides that some maps are split up in more detail or made broader in the business process manual because this is of importance in the support of implementation. For example starting the process with the arrival of the personnel at the terminal instead of assuming that that all personnel is already present. This example within the analysis of the map detail level of the current maps APMT reveals that practice is in line with literature. The design choice on detail level can only go up or down but also left and right (see Figure 6).

³ For the purpose of readability whenever the ‘preceding research’ is mentioned reference is made to Farré and Oya (2008; Oya, 2008).
Within the preceding research several documents, interviews and a workshop have led to a list of several processes of interest in the semi-automated terminal of Virginia. The created list reflects the desired detail level at that point in time. This list will be seen as a best practice while considering the detail level in the design in this research, but depending on additional purposes this will be subject of debate, maybe resulting in iterations up, down, left or right.

It can be concluded that the two design choices on classification and detail level are already filled in in a proper way at the broad lines but that revision is needed at the lower levels and the implementation of the choices.

2.3.3 Design decisions III: Visualization

When looking at the representation of the processes in the current situation it can be concluded that there is no uniform means of representation. Also there has never been a study within APMT which assessed the value of the visualization of process maps. In practice the type of visualization is driven by the software and maps already available. The software package iGrafx (iGrafx, 2008) is used within APMT (as discussed in paragraph 2.1.3) for making process maps, so all maps look uniform within the boundaries of this software package. It should be added that the real boundaries of this software package are never reached because only the really basic functions are used. Taking for example the aspect of time: it is possible to include this in the software used, but the time concept is never used APMT’s process maps. However time can be used for process improvements. The preceding research used a uniform layout within the created process maps. These maps will be used as a basis to prevent execution of repeated work. But, because choices within this research on the visualization are reasoned and just like in the current usage based on iGrafx, improvements can be achieved by making an extra iteration in the visualization. Especially because visualization is an important factor in selling the use of process maps within the organization. It is however important to notice that the essential aspect is to create uniform visualized maps. Because uniform maps as a basis can dissolve these differences gradually: if these maps will serve as the basis for the future maps within the organization the differences in visualization will grow out of the organization gradually.

2.3.4 Design decision IV: Map creation procedure

At this moment the stakeholder that needs the maps creates them on the basis of its own process knowledge and available documentation. After this the maps are often validated by someone else. In spite of the extensive description of approaches in literature (paragraph 2.1.4) there is no standard procedure. It should however be taken into account in the design that several techniques are already used to identify which processes are present that should be mapped. In the preceding research for example workshops and a group brainstorm session were held resulting in extensive lists of processes. These techniques were evaluated positively (Interview VII, 2008) for the generation of processes lists and this could be incorporated in the future procedure. So it can be concluded that the benefits that could be achieved in the map creation procedure, like creating process ownership, are not yet fully exploited in the current situation, and this should thus be improved in the future.
2.4 Round up

When all sub paragraphs are taken together the following general conclusion of the analysis of the methodology can be drawn:

When process maps are used several purposes can be supported. Performance indicators for assessing the process maps are density, clarity, validity, re-usability and maintainability. The design choices to influence these indicators are to determine classifications, the detail level, the type of visualization used and the procedure to create the process maps. The design choices that influence the performance indicators are directly imposed by constraints and generate several general drawbacks that should be taken into account. The most threatening drawback is that the process maps will become a one shot effort that cannot cope with a dynamic environment.

Altering the design choices in creating a map can influence the performance indicators for a usable map, but by creating the map alone the purposes will never be fully satisfied therefore **the map should be used**. The usage of process mapping already has a starting point within APMT which imposes requirements and opportunities on the future use. The eventual design should take into account this starting point. When assessing this starting point on the performance indicators it can be concluded that the design choices on classification and detail level need revision at the lower detail levels and that a close look should be given to the implementation of classifications. The design choices on visualization should result in uniform maps following the preceding research and the map creation procedure is not yet fully exploited in the current situation, and should thus be improved in the future.

The detailed goals and requirements forthcoming from this conclusion will be taken together in the wrap up of the first research phase.

---

**Conclusion**

The design space from the perspective of the methodology is set up resulting in the full potential of process mapping. It became clear that if APMT will continue using process mapping in the automation process they should try to exploit this potential while preventing the drawbacks to occur. This can be reached by integrating the use of process mapping in the automation process taking into account the current usage.
3. Analysis of the technology

Process mapping is an approach broadly used, but an identified drawback is that it is often a one size fits all approach. For the future use of process mapping within APMT this should be acknowledged by taking a close look at the technology characteristics of the container terminal system, the implications for the automation process and the use of process mapping within APMT. This chapter presents the performed analysis starting from the highest level, the transport system, in order to prevent that factors of influence will be neglected. By going to lower levels the APMT specific technical characteristics of interest will be identified. This will result in several implications that limit the potential of the usage of process mapping which should be taken into account during the design phase of this research.

3.1 The transport system

Before focussing on an APMT terminal this paragraph first zooms out to see in what kind of environment the system is situated. This analysis will show the complexity of the environment which is a dynamic system with many interactions. A proven method for describing complex logistic systems, the TRAIL layer scheme (van Binsbergen and Visser, 1999), is adapted for this specific situation to make the implications for APMT’s automation process and the use of process mapping clear.

![Figure 12: TRAIL layer scheme for the transport system (Adapted from van Binsbergen and Visser, 1999).](image)

The first layer in the scheme refers to the world trade which generates a demand for cargo transportation in a quick, cheap and safe way. As described in the introduction this demand for cargo
transportation is growing\textsuperscript{4} which imposes a major challenge in the trade offs for terminal operation & management companies between time, costs and safety. This is a driver for automation within APMT. The challenge is made more complex by the spatial component of the demand. APMT is spread out over five continents all with their own implications on costs and safety and thus the automation process. The other three layers in the figure bring in the technical aspects to the challenge. The second layer shows that the cargo can be transported in all sorts of transport units, e.g. containers. A variety of types of containers, 20ft, 40ft, reefers, etc. impose requirements on the rest of the system. A container terminal operator like APMT should take this layer as a given fact in the automation of their business process. Their automated system should just be able handle these transport units.

The third and the fourth layer are the layers that are within the influence of a terminal operator (see Figure 1). The means of transport within a terminal (e.g. the quay cranes (QCs), stacking cranes (SCs) and horizontal transport means) can be automated to satisfy the needs of the higher layers. The factors of time, cost and safety can directly be influenced by the choices made by the terminal operator in this layer. But changes in this layer impose requirements for the infrastructure layer. A detailed overview of operations at a container is provided by Steenken (2004), Vis (2003) and Watanabe (2004), which were used in the design phase of this research.

These described layers are situated in an environment. Formal institutions from the society lay down laws and regulations on the system. These laws and regulations also differ all over the world. Quality norms and safety standards are examples of this, which further thwart the challenge. These regulations impose constraints on the automation of the processes, but as described can give process mapping an extra purpose (see paragraph 2.1.1 on the legislative purpose of process mapping). On the other hand the automation process is also bounded by scarcity of resources like capital, time, labour and knowledge. Most of them are imposed internally within APMT, but scarcity of time can also be imposed by the customers demand on the market. Constrains on knowledge and information can be brought forward from suppliers of for example supportive systems.

Finally two other components add to the complexity. Firstly the automation technologies itself. The current possibilities with for example automated guided vehicles (AGVs) and automated stacking cranes (ASCs) will all be taken into account in the automated yard project. This will result in different processes compared to the current situation with more and complex ICT systems. These techniques are innovative and thus subject to change. So the system can from this point of view also be called dynamic. This dynamic complexity should all be reflected in the process maps to be able to use them in the communication with for example the terminal operation system (TOS) vendors.

Secondly the management situation under which the process maps will be used for automation will differ. Some terminals are only owned and not operated and others are only operated and not owned. Different stakeholders will thus impose demands on the management process, resulting in different routes in process- and project management. For example in the construction of a terminal different parties will be involved all over the world. Besides that the process maps will be used at several different management levels, from direct steering by the shift manager up to the described communication in design.

\textsuperscript{4} During this research the situation in the transport market was influenced by the economic crisis. This is evaluated in paragraph 8.1.
Only with interactions between these layers and between the layers and the environment the entire system is able to function. These interfaces make the system even more complex. And these interfaces again differ around the world. For the automation of terminal operation the traffic control layer between the means of transport and the infrastructure is central. The interfaces also implicate that all components are interwoven en thus hard to break up in smaller pieces. Within a terminal a lot of these so called *handshake* processes are present. The quay crane has to for example drop the container directly on the vehicle in case of horizontal transport with an AGV. This *handshake* makes it difficult to split up the process in a separate process maps for the quay crane and for the AGV. This will complicate the possibilities for standardization and the creation of separate process maps.

From the description of the TRAIL layer scheme for the system in which APMT is situated can be concluded that the scheme simplifies a system that is in practice very complex. Every component in the scheme interacts with every component. An example will make this clearer. The outcome of the choice on which automated means of transport to use on the terminal will differ all over the world. The different means of transport in the third layer do not only depend on the technology performances and the internal connection with the other layers but also on the described society situation, the resources and the management present. This distributed character will result in lots of technology differences. So it can be concluded that standardization of this system seems impossible, this will thus more likely result in several standardized automated concepts. For example standardization within a same terminal category based on the means of transport. So the process maps should leave room for these different choices.

> The automation of terminal operation is situated in a highly complex technical system with no uniform automated terminal lay-out. The presence of *handshakes* in the processes makes it difficult to standardize and split up the processes into separate process maps. Taken this together with the observation that parts in this system are dynamic the entire setting of the design challenge can be called socio- and technical complex. The process map design should support these dynamics.

### 3.2 Automation

To create even more insight in the technological environment this research is situated in and to analyze if this has any further implication for the use of process mapping this paragraph addresses the topic of automation. As stated in the introduction automation is seen as a possibility to meet the growing demand in the container industry. It could increase the capacity, productivity, safety, efficiency and predictability of operations at a container terminal. Whereby it can lower the energy consumption, labour costs and operational costs. But what are the implications for the use of process mapping? Does the fact that the processes that should be mapped are automated make the mapping more difficult and are there any burdens or chances in the usage in an automated environment?

For identification of the possible problems and chances for process mapping in this automated environment the theory on management of complex product systems (CoPS) is used (Hobday, 1998; Hobday and Rush, 1999). Hobday identifies nine types of common hotspots of problems within CoPS of which several also apply on automated container terminals. The first issue that becomes clear when
researching automation within logistic systems and container terminals is that there are a lot of
different possibilities for automation which certainly has implications for the use of process mapping.
Because there is not one best option for automation a wide scope of possibilities for automation should
be represented by the process maps. Room should for example be made for systems with rail mounted
gantry (RMG) stacking cranes and automated guided vehicles (AGV) or for a system with automated
shuttle carriers. For the sake of this research it adds no value to identify and describe all these
possibilities, only the observation that there are a lot of possibilities is essential. However, for an
overview of these possibilities in the field of automation at container terminals and within APMT specific
reference is made to Oya (2008). The amount of possibilities creates a tremendous challenge for the
classification of the maps. A hierarchy as described in the previous paragraph could hereby bring relief.
A second issue with implications for process mapping is that automation often makes use of complex ICT
systems. In case of a container terminal the terminal operating system (TOS) should for example steer all
processes at the terminal. It is essential that the process maps include these ICT systems, because a
possible usage of the maps could be communication with the TOS vendors.
The third and final issue that should be taken into account is the high degree of change due to
innovation in the field of automation. An automated process today will, almost for certain, look different
in a few years. This implicates that it should be easy to change the process maps and that they should be
kept up to date with the current state of technology.

The process map classification should be able to cope with various diversified possibilities of
automation. Furthermore the innovative character of automation creates the need that it
must be easy to change the process maps because new insights in automation will bring
forward new processes.

Just like Figure 10 represented the goals and requirements for the analysis of the methodology Figure 13
summarizes the goals and requirements for the design coming forward from the technology. Whereby
the goals can be reached and requirements (indented in Figure 13) must be met by the design.

10. The maps should be usable within different societal systems
11. The maps should be usable within different management structures
12. The maps should include differences of suppliers
13. The maps should include several automation possibilities
   13.1 The maps should include different means of transport
14. The maps should handle with the interwoven characteristics of the processes
   14.1 The maps should be able to handle dependencies between processes (handshakes)
   14.2 The maps should be able to handle and indicate parallel processes
   14.3 The maps should make constraints for processes clear
15. The maps should include an indication of process time
16. The maps should be able to handle dynamics in the processes

Figure 13: Goals and requirements coming forward from the analysis of the technology.
4. Analysis of the organization

One of the drawbacks of using process maps is, as described, the danger that it becomes a one shot effort. This resulted in the identification of all possible purposes of process mapping. The conclusion from this research was that the success of process mapping is determined by the usage of them in practice by the organization they are created for. A second identified drawback is that process maps often become one size fits all, with this was meant that they often do not take into account the specific characteristics of the organization they will be used in. From these two findings can be concluded that it is important for the success of this research to take a closer look at the organization.

This is supported by the fact that this research is performed within a company, APMT, which implicates that the design of a process to use process maps already has a starting point. The setting of the problem within APMT should be taken into account bringing forward goals and requirements for the end result.

First the internal and external multi-stakeholder setting of the system will be unravelled with a stakeholder analysis; this is done to identify which stakeholders can provide input and which will be the end users. Second, the trajectory in which the use of process maps should be incorporated is described. This current process together with the basis from literature on how to implement processes analyzed in paragraph 2.2 will form the input for the new process design in research phase II.

4.1 Stakeholder analysis

The purpose of the stakeholder analysis for this research is twofold. The first goal is to identify which stakeholders can provide further input in the research. Secondly the end-users should be identified, bringing forward requirements and goals. Three different theoretical perspectives can be used to describe stakeholders and/or their interactions, focusing either on networks, perceptions or the resources of stakeholders (Hermans, 2005). For the first goal, providing input to this research, the resources of the different stakeholders are of interest. For the second goal it is important to have a clear insight in the perception of the stakeholders on the use of process mapping, so what are their goals and interest in this research? The stakeholder analysis is performed according to Enserink, Koppenjan et al. (2004) using Hermans (2005) as a guideline. Figure 14 presents the conclusions important for this research from the results of the stakeholder analysis presented in Appendix D.

![Figure 14: Results stakeholder analysis.](image-url)
A brief description per stakeholder will clarify their input or requirements to the end result.

**Automated yard project**

As briefly described in the introduction process mapping will be used as a basis for the other deliverables within the automated yard project. The automated yard project is the main end-user. This brings forward the following requirements for the design, process maps should: support the decisions on the dimensioning of automated terminal, help in specifying what preferred suppliers should deliver in standard agreements on automated equipment, describe which process should be incorporated in design templates of an automated terminal, help in determining technical and IT specifications, support communication with vendors and serve as information in the virtual terminal (see Figure 2).

**Operations & Implementation Support (OIS)**

The operations implementation support team uses process mapping at this moment in their business process manual for the support during implementation. For an automated terminal process mapping will serve as input for the future automated business process manual. Furthermore it is required that the process maps can be used as a basis for training and the setup of standard operating procedures and job descriptions.

Within the operations & implementation department there will be one other end-user. The standards and guidelines team. As described they already made several basic process maps for standardizing existing terminals. To be usable within this team in the future, a requirement for the process maps is that they should be as standardized as possible. Meaning that only generic terms can be used and that it should be avoided to include case specific processes. Besides, the low usage of the standard process maps of this team implicates that it should be clearly identified for them how the standard process maps can be used. Ones standardized the process maps can be communicated through the terminal in a box concept. This is a electronic resource of standard tools and templates that can be used during implementation to avoid reinventing the wheel for each individual project.

**Design and Costing Support (DCS)**

Process maps will serve as input in the design of the actual terminal lay out. The process maps represent what should be handled within the design layout.

**Process Excellence (PEX)**

One last internal stakeholder came out of the stakeholder analysis as important. The process excellence team, they can use the maps to identify possibilities for process improvement and in their process excellence program. A goal for the design is the identification and the description of where and how the maps can be used within this program.

Other internal stakeholders

Looking briefly at the other outcomes of the stakeholder analysis it can be concluded that several other internal stakeholders are identified which can gain benefits from the use of process mapping. Process mapping can help HR in determining the type and amount of staffing and it can give the HSSE (Health Safety Security Environment) insight in the possible risks in processes at an automated terminal. It can help existing terminals in the future with automation issues and finally process mapping can help the legal department in setting up standard document for the compliance with regulations or standards, like ISPS. The goal for the design is to describe how and when the process maps should be used to reach these benefits.
From these results the end-users for this research became clear. Their detailed goals and requirements will be taken together in the wrap up of the first research phase. The second goal of the stakeholder analysis was to identify the stakeholders that can provide input to this research. Because this input is directly used (for example in paragraph 2.3) and of no further real interest for the research outcomes reference is made to Appendix D.

It is however of interest to elaborate further on the dependencies, current perceptions and interwoven characteristics of the stakeholders. Because the current perceptions on the use of process maps are not all uniformly positive. Not that they are negative and barriers should be expected, but the fact that process maps are only used on a very small scale within the identified departments and that only a few existing terminals really use or have used them implies that the use of process maps is not completely obvious for the stakeholders. Or that the current way of working with process maps does not add any value for the stakeholders. This results in an important addition to the conclusion of the analysis of the methodology.

Exploiting all benefits of process mapping by embedding the use of process mapping in the automation process can only succeed if the involved stakeholders in this process are in advanced committed to this process. The automated yard project and the operations and implementation support team are the first stakeholders to involve being the end-users of this research deliverables. Their requirements and goals for the use of process mapping should be taken into account.

4.2 APMT's trajectory towards container terminal automation
The usage of process mapping should be embedded in a process, but this process cannot just be designed from scratch. The phases for terminal design and the execution of this design, the project implementation, are already delineated within APMT. This paragraph briefly describes these phases that directly constrain the design space because the process maps can only be used within these phases, which are not very flexible for expansion.

The first phase is the current state in time: the automated yard project. The project boundaries have already been sketched in the introduction (see Figure 1), process mapping will serve as input for all other deliverables within the automated yard project. This implicates that the usability of the maps is influenced by the purposes and requirements imposed on the use of process mapping within these deliverables. These requirements became clear in the previous paragraph because the ones responsible for the other deliverables within the automated yard project are stakeholders in this research. In this part it is important to see if the set up of the automated yard project influences the usage-process.

From a first look at the timeline of the automated yard project can be concluded that interaction of this research with the other deliverables is under pressure and can only be limited because draft versions of some of them will have to be finished before the final deadline of this research. So results in this first phase should already be achieved within the research and it should not just be described how to achieve them. Especially because this first phase is not recurring like the following two, process descriptions are less necessary.
The first phase of the process is the interactions of process mapping with the other automated yard project deliverables. Because this phase is already up and running with several deadlines before the finalization of this research project it will not be included in the usage-process design but the interactions will be supported during the research.

If all deliverables of the automated yard project are finished the actual terminal design will follow the Project Excellence Design Life Cycle (PELC) (see Figure 15).

![Diagram of Project Excellence Design Life Cycle](image)

**Figure 15: Project excellence design life cycle (Int. Pub. V, 2008).**

A brief description of this cycle results in several implications of this cycle to the design space.  
**Prove:** In the probe phase a market analysis is set up and the opportunities for the project are identified.  
Within this preliminary phase the role of a detailed tool like process mapping is limited because the decisions made in this phase are at a higher level.  
**Develop:** In the develop phase a business case should be created and all key stakeholders should be warmed up. This business case will be based on the processes in the terminal and a draft design of the terminal layout will be set up also based on the expected processes in the project. The design phase is therefore of high importance in the final use of process mapping.  
**Secure:** In the secure phase the preparations and negotiations for the signins are made. The business case might be fine tuned at this stage but the major support of process maps is finished.  
**Implement:** The implement phase consists of several sub phases (see Figure 16), from the stakeholder analysis already became clear that there will be a role for process mapping in this phase.

![Diagram of Project Implementation Life Cycle](image)

**Figure 16: Project implementation life cycle (Int. Pub. VI, 2008).**

The initiation phase of the implementation consists of the hand over from the design to the Project Implementation Manager (PIM) with no major tangible deliverables. In the second phase the project management plan is set up. This plan forms the baseline for the project on how the project will be planned, executed, monitored & controlled and closed. No content related subjects are discussed at this moment but several plans are set up that can be supported with insight gained from high level process maps. In the design a close look should be given to, if and how process mapping can for example help in setting up the work brake down structure, the HR plan and the procurement plan. In the third phase the
actual work will take place, this is the moment to gain the most benefits from the process maps. Deliverables in the beginning of this phase are for example process designs, future process models, and detailed IT design. These can all be very well supported by process maps. Further on, vendors will be selected and equipment will actually be developed and manufactured. In these stages a lot of communication takes place which can be enhanced by the use of process maps. It must be clear that the execution phase is the moment within the implementation phase to take full advantage of the process maps. In the close out phase a series of actions will be executed to officially handover the project to the terminal manager. The role of process mapping in this stage will be minor.

Operate & evaluate: The primary activities in the operate & evaluate phase are reviewing the project and evaluate opportunities for the future. For validation and process improvement purposes, process mapping can be used in this phase so this phase should be taken into account in the design.

This paragraph sketched the process in which the use of process maps should be incorporated. This process is the boundary to the process design in the second research phase.

The main focus of the design for the use of process maps within the automation trajectory should be on the design and implement phases. Within the implementation the execution phase is the moment to take full advantage of the process maps.

Just like Figure 10 and Figure 13 summarized the goals and requirements for the methodology and technology Figure 17 presents the goals and requirements forthcoming form the analysis in this chapter, the organization.

17. The maps should take the current usage of maps and the current design cycles into account
   17.1 The usage of the maps should be incorporated in the project excellence life cycle
   17.2 Incorporation in the project implementation life cycle is necessary
18. The maps should help in the training process
19. The maps should help in the set up of standard operating procedures
20. The maps should help in determining the type of staffing and setting up job descriptions
21. The maps should support the automated yard project
   21.1 The maps should provide insight in the design parameters for an automated terminal
   21.2 The maps should provide insight in technical and IT specifications
   21.3 The maps should support the design of the layout of an automated terminal
22. The maps should serve as information in the virtual terminal
23. The maps should help existing terminals in automation

Figure 17: Goals and requirements coming forward from the analysis of the organization.
Intermezzo: wrap up requirements research phase I

It is clear that process mapping will be a component in the automation process of APMT. But at this moment only a part of the potential of process mapping is exploited. APMT should try to exploit all the benefits of this method and prevent the conceivable drawbacks to occur. This can be reached by first creating commitment of the involved stakeholders and subsequently embed the use of process mapping in the automation process. This will be the design challenge for the second part of this research. The exploratory analysis of the methodology, the technology and the organization led to goals and requirements for this design. Figure 18 brings together Figure 10, Figure 13 and Figure 17, which presented these goals and requirements, for reasons of clarity and make retracing within the first research phase unnecessary.

1. Provide support by description of the processes
   1.1 The maps should create overview and insight in the processes
   1.2 The maps should help in defining roles
   1.3 The maps should provide the desired density
2. Support the process of process improvement (*: process excellence)
   2.1 The maps should help in identify process risks (*: HSSE)
   2.2 The maps should help in reducing uncertainties
3. Support the process of process re-engineering
   3.1 The maps should be easily changeable: maintainability
4. Support the process towards process standardization (*: standards & guidelines)
   4.1 The terminology in the maps should be standardized
   4.2 Specific, non standard processes should be avoided
   4.3 The maps should be valid with reality
5. Help in storing and managing information about processes
   5.1 The maps should be easily re-usable and maintainable
6. Help in legislative compliance of processes
7. The use of the maps should create stakeholder engagement / process ownership
8. The maps should be used to enhance communication (*: with ICT vendors, HT suppliers)
   8.1 The maps should be clear without unambiguities (clarity)
9. The maps should be used to identify and establish performance measures in the process

10. The maps should be usable within different societal systems
11. The maps should be usable within different management structures
12. The maps should include differences of suppliers
13. The maps should include several automation possibilities
    13.1 The maps should include different means of transport
14. The maps should handle the interwoven characteristics of the processes
    14.1 The maps should be able to handle dependencies between processes
    14.2 The maps should be able to handle and indicate parallel processes
    14.3 The maps should make constraints for processes clear
15. The maps should include an indication of process time
16. The maps should be able to handle dynamics in the processes

*: also came forward from the analysis of the organization.
17. The maps should take the current usage of maps and the current design cycles into account
   17.1 The usage of the maps should be incorporated in the ‘project excellence life cycle’
   17.2 Incorporation in the ‘project implementation life cycle’ is necessary
18. The maps should help in the training process
19. The maps should help in the set up of standard operating procedures
20. The maps should help in determining the type of staffing and setting up job descriptions
21. The maps should support the ‘automated yard project’
   21.1 The maps should provide insight in the design parameters for an automated terminal
   21.2 The maps should provide insight in technical and IT specifications
   21.3 The maps should support the design of the layout of an automated terminal
22. The maps should serve as information in the ‘virtual terminal’
23. The maps should help existing terminals in automation

Figure 18: Goals and requirements forthcoming from research phase I: analysis.

In this figure goals can be reached and requirements (indented in the figure) must be met to reach the corresponding goal. It should be noticed that because the second and third block are additions to the goals and requirements in the first block the stated lists in the second and third block are not the complete results of the separate analyses of the technology and organization.

It might be clear that it will be nearly impossible to reach all goals in this extensive list. But the goal of this first research phase was to diverge. With this first phase analysis all aspects are identified and it is time to converge. But it is important to recall from the introduction were to converge to and update this focus with the gained insight from the analysis phase. The problem statement of paragraph 1.1 can, with this insight, be made more concrete by naming the root causes of the problem. These root causes can be identified from the gaps found in the application of the researched theory to practice within APMT. Firstly, paragraph 2.3 showed that there is a difference in appliance of process mapping throughout APMT not only in the purpose but also in the representation. This in contrast with theory which showed that process mapping should focus at multiple purposes whereby it is very important to keep a uniform representation between separate maps. Secondly, the fact that process maps in practice look different and are used different, points out that it is unclear for the users how to use process maps within their projects.

**Conclusion**

The confrontation of theory and practice made clear that there are two root causes of the current problem: (1) there is no unity in the application of process mapping within APMT and (2) there is no clarity on how to use process maps. From the analysis of the methodology, technology and organization a list of requirements and goals is conducted which stretches up the design space for the two deliverables within this research that will tackle the two root causes: (1) a hierarchical library of basis process maps and (2) a usage-process.
To further clarify this conclusion Figure 19 presents a conceptual representation of this design space.

**Figure 19: Design space.**

In this design space the two deliverables are clear. First, a hierarchical library of process maps that can be used as a basis to overcome the first root cause. And second, the design of a usage-process to prevent the second root cause to occur. The design space is constraint at two places by the requirements. First the creation of the process maps is constraint by the technology characteristics, like *handshake* processes, information availability and time and cost available for the creation. Secondly the design of the usage-process is constraint by the fact that it should fit in the current process, the PEX and PELC cycles. But the most important thing to state is that the goals going into the design process and these requirements are set by the stakeholders, the eventual users. The actual choices on all design aspects will be made in research phase II: Modelling, Design & Validation.
Modelling, Design & Validation

The first research phase resulted in a design space stretched up by an extensive list of requirements. Following the research methodology, the second research phase will take up these requirements and converge to a design. The purpose of this design is to reach the most of the potential of process mapping as possible. So the design will try to fulfil all the identified possible goals of process mapping. This design will be validated in practice to come up to a final detailed design. This validated detailed design will be the basis for the conclusions and recommendations of this research.
5. From requirements to design

The design of the process maps that will have to bring the use of process mapping within APMT to its full potential will follow the identified design choices in paragraph 2.1. This design will have to take the current situation of process mapping within APMT, described in paragraph 2.3, into account. Paragraph 5.2 subsequently discusses the design of the usage-process of the process maps. These two resulting designs will be validated in practise which is reported in chapter 6.

5.1 Process map design

5.1.1 Design choice I & II: Process classification and map detail level

The conclusion in the first research phase on design choice I was that the current classification is accepted at the broad lines but should be refined at lower levels. Besides it was concluded that the implementation of this classification was insufficient to make the classification clear. So the goal of the design is to create a library of process maps that overcomes this flaw. In the first step towards this design the list of processes from the former research is extended to try to cover all possible processes in an automated terminal. But this already created a challenge. Looking for example at servicing a vessel ± 9 types of containers can be distinguished which can be picked up or delivered by ± 4 types of horizontal transport vehicles. Each of these vehicles can have different implications for the process because they can be produced by several vendors. Furthermore, the safety regulations imposed on this process will differ from Europe to America to Africa. And this is only a process for discharging a vessel, of course all operations at the yard, gate and rail should be included in the library. Besides this the spatial deviation of processes like IT processes and maintenance & repair processes should be given a place in the library. A rough estimation even without the vendor and region specific elements already resulted in more than 1000 possible combinations.

To accommodate these combinations the library is set up as a hierarchy (see IDEF modelling Appendix C) to distinguish classes and to reach deeper levels of detail. By using a hierarchical structure the stated goal of standardization can be reached by pushing non standard processes deeper in the hierarchy. Meaning that at the higher levels the processes can be described in a standard way and at lower levels differences can be included. Besides standardization a hierarchy is a way to cope with dynamics. Because changes are often at lower levels with much detail the higher hierarchical levels will not be influenced by the dynamics. Looking again at the example process of discharging a vessel will clarify this. At the top level the process map is describing the interaction with the quay crane and horizontal transport. At a lower level this horizontal transport is split up in specific maps for SCs and AGVs. If the SC or AGVs are replaced by a new innovative type of transport the higher hierarchical process map does not have to be changed.

Beside the huge amount of possible combinations the puzzle of classifying the processes and creating detail level in a hierarchical library is made more complex due to the technology. As described in paragraph 3.1 handshake processes make it very difficult to split up the process at an automated container terminal, which in theory is one big coupled process. This was experienced when the first set up of the library within this research was created and an attempt was made to create an actual process map within this library. It was impossible to exactly fit the map in the split the library suggested. So this first library setup was given up. A second consequence was that the created maps in the former
research could not be copied directly into the new library. From this first iteration was concluded that a process classification can not be made without in-depth knowledge of the process. So the method for setting up a process library has to be based on learning by doing whereby insight is progressed during the set up of the process maps.

Classifying processes and creating detail level in a hierarchical library of process maps goes hand in hand with creating these process maps instead of a top down or bottom up approach.

After this conclusion a long iterative process of making process maps and adjusting the library according to the MECE principle resulted in the hierarchical library of which an example is presented in Appendix E\(^5\). The full version can be retrieved from APMT because of confidentiality reasons. The MECE principle is useful in mapping processes in such a way that they are Mutually Exclusive and Collectively Exhaustive (Rasiel, 1999). This must result in an overall process that is divided in sub-processes that comprehensively represent the overall process without overlap and gaps. Figure 20 shows terminal operations as this overall process separated in marine, yard, gate, rail and other operations (in line with Figure 1). The processes falling under other operations are gathered by using the exceptions perspective of workflow modelling (see Appendix C). Detailed description of each of these sections can be found in Appendix E. With this separation the advised classification from the preceding research is persevered (see paragraph 2.3.2).

<table>
<thead>
<tr>
<th>0. Terminal operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Marine operations</td>
</tr>
<tr>
<td>2. Yard operations</td>
</tr>
<tr>
<td>3. Gate operations</td>
</tr>
<tr>
<td>4. Rail operations</td>
</tr>
<tr>
<td>5. Other operations</td>
</tr>
</tbody>
</table>

**Figure 20: Classification of the highest level in the process library.**

Within these operations a split is made between the pre-operations and the actual processes during operation. Stepping deeper in these actual processes the processes are separated according to the different purposes of the actions. For example entering or exiting of a road truck at the gate. The next step in the hierarchy provides specific processes which will differ from terminal to terminal. Figure 21 gives an example of the implementation of these different hierarchy levels making several combinations possible.

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\(^5\) Appendix E however presents the library including the adjustments after the validation phase.
Figure 21: Example of the different hierarchy levels at yard operations.

Next the designed library will be taken in practice to see whether the created detail level and model logic is valid.

5.1.2 Design choice III: Visualization

It was concluded in paragraph 2.1.3 that the visualization is bounded by the current representation at APMT and the software package. Furthermore it was advised to generally follow the visualization from the preceding research but that a critical iteration can bring improvements. Figure 9 showed all possible representation techniques. While creating the process maps several adjustments were made for further clarification using these techniques. Figure 22 presents an example map with all visual elements in it.

Figure 22: Example of implemented visualization.

To be MECE and thus completely fit into the designed hierarchy every output of a map should be the input of an other map. The colours in the map clarify this. A further adjustment is the descriptions accompanying processes within blue boxes. These descriptions consist of extra information about the process. The visual techniques preserved are the two types of arrows for parallel activities and different types of shapes for start/end processes, normal processes, sub-processes and decisions. In this design time and digital functions are not used. Furthermore, the recommendation from the analysis of other techniques (see Appendix C) to split value added from non value added activities is not incorporated.
Finally, in the preceding research each map was guided by a template with a description of the process taking place in the map. Since the maps from the library will be used as a basis for the creation of specific maps for specific projects it has no added value to further describe the maps in the library. The specific maps created from the maps in the library will be input for other documentation, e.g. a business process manual or job description, where this description will be provided. This supports the choice that only at higher levels a general process description is added (see Appendix E). All basic map information, like the author and status, is however included at a map level based on the documentation used for IDEF modelling (see Appendix C). This together leads to the following broad conventions:
- Time or sequences is visualized from left to right
- Crossing lines are avoided
- Terminology is used uniformly
- Functions or equipment are separated horizontally by *swimming lanes*
- Notes are added in blue boxes
- Dotted arrows are used to show parallelism
- Green indicates the beginning of a process forthcoming from a previous process indicated in the note
- Red indicates the end of a process whereby the succeeding process is indicated in the note
- Decisions, beginning/end, processes and sub-processes each have their own shape
- When multiple processes precede a process it is indicated if both or just one of the preceding process is required with the texts AND & OR.

Wrapping up can be said that the visualisation is set up using, like literature prescribed (Oude Luttighuis, Lankhorst et al., 2001), a few simple symbols. Furthermore the visualization of sub-processes makes the model flexible in such a way that for a example a manager can quickly get an overview of the overall process.

### 5.1.3 Design choice IV: Map creation procedure

Research phase I described that the benefits that could be achieved in the map creation procedure are not yet fully exploited. The extra additions to exploit these benefits are included in the design of the use of the process maps (see paragraph 5.2). Because it was concluded that creating a map goes hand in hand with creating the hierarchy this research had to start right away with creating the maps on basis of self-generation, with several validation steps.

It is important to mention again that the generic process maps in the library will always have to be changed to the specific situation. This change procedure is seen as the map creation procedure and included in the usage-process design

### 5.1.4 Design results

This chapter resulted in a hierarchical process map library filled with process maps presented in Appendix E. This library incorporated several of the set up goals and requirements from research phase I presented in Figure 23.
The hierarchical library provides an overview and the maps provide insight in the processes.

1.1 The maps should create overview and insight in the processes
1.2 The maps should help in defining roles
Including roles at a horizontal level in the map creates insight in who is responsible for which activity.
4.1 The terminology in the maps should be standardized
Only generic terms are used in the maps and library.
4.2 Specific, non standard processes should be avoided
The fact that the library is set up as a hierarchy identified standard processes. The higher in the level the more standard the process is.

13. The maps should include several automation possibilities
No separate processes are created for different technologies but the different technologies are added as notes to generic processes. No research is performed to see if these different technologies are all technologies possible.
13.1 The maps should include different means of transport
By including the different means of transport at a deeper level in the library generic it is prevented that the library becomes to specific.
14. The maps should handle the interwoven characteristics of the processes
14.1 The maps should be able to handle dependencies between processes (handshakes)
By connecting process that should follow each other with arrows and including labels, like ‘AND’, its is made clear that processes depend on other processes or multiple processes
14.2 The maps should be able to handle and indicate parallel processes
Dashed arrows in the process map indicate that processes can be performed in parallel
14.3 The maps should make constraints for processes clear
The described arrows and labels make constraints clear and they are included in notes connected to

Figure 23: Incorporated goals and requirements by the process map and library design.
It is essential to state that these are the achievements in the designer’s point of view. It still remains to be proven if the incorporation of the goals and requirements also means the goals are met. This will come forward in the next chapter. For the further design it is important to compare these achievements with the initial list presented in the wrap up of research phase I. The goal of the further design should be to include all remaining issues from this list not jet addressed.

Conclusion
A hierarchical process library is designed. The detail level is chosen in such a way that the maps in the library can be changed for a specific situation. So the maps provided in the library will never be used directly, but will always be altered to the specific purpose of use. Standardization will be reached because this set of basis maps will provide for unity in the usage of process mapping within APMT, which overcomes the first root cause of the problem. Furthermore the hierarchical setup able to cope with changes due to dynamics in the system.
5.2 Usage-process design

In the first research phase was concluded that the usage of process mapping already has a starting point within APMT. The usage of the designed library should take this starting point into account. Furthermore it was concluded that the trajectory (PEX cycle and PELC framework) in which the library will be used is already known. This paragraph presents the design of the usage process of the library. The goal of this design is to include all other goals, requirements and constraints that were not yet satisfied by the design of the library itself.

From the analysis of the existing process (paragraph 4.2) was concluded that the main focus of the inclusion of process mapping in the current process should be on the develop phase of the PELC cycle and on the implementation phase by looking at the PEI framework. It was concluded that the main focus within this PEI framework should be on the execution phase.

Taking paragraph 4.2 as a basis Figure 24 presents an overview of the proposed usage-process.

![Figure 24: Usage-process overview.](image)

This paragraph will first give a detailed insight in the two phases of focus, the develop phase of the PELC cycle and the execution step in the PEI framework. In the final paragraph all other included purposes of use are described.

5.2.1 Usage in the develop phase of the PELC cycle

This paragraph will describe the design of the inclusion of process mapping in the develop phase of the PELC cycle. In the develop phase a business case is created and all key stakeholders should be warmed up. This paragraph will clarify in more detail each of the purposes proposed in the develop phase in Figure 24.

The process map library will provide insight to the involved team in the processes at an automated terminal. This insight will support the set up of the business case in several ways. The hierarchy can help in configuring several scenarios. With all possibilities included in the library the required sort of equipment with its superstructure and the required sort of manning can be identified. Important to mention is that the library does not provide quantities of equipment or staff but will create insight in the very beginning which types are necessary. With a final version of a business case the library will be the input for the required operation plan (Int. Pub. X, 2007) behind the case. All basis maps that the library provides can be tweaked to the specific situation. Whereby the library will not only save time for the team but will
also make sure all issues are looked at. With a process map package\(^6\) for the specific case several other activities can be supported. The HR plan behind the case can be set up by subtracting the several functions from the maps which will be useful in setting up job descriptions. Furthermore the specific process map package can be used by the HSSE department to identify risks in the processes which can be added to the risk overview template and risk assessment template. From this description becomes clear that there are several obligatory documents that the project team needs to deliver which can be supported very well by the process map library. The narrative document to support operations manager in using the operations project plan (Int. Pub. XI, 2008) even consists of the following required operational implementation deliverables which can directly stem from the library:

- “TOS Critical processes mapped”
- “Execution processes mapped“
- “Planning processes mapped”
- “Marine services and other activities mapped”
- “Contingency processes mapped” (Int. Pub. XI, 2008)

The currently used standards are developed in order to speed up the process of developing new terminals all over the world. Besides, standardization can make the terminals uniform which gives flexibility: people and machinery can for example easily be moved between the terminals. Standardization is most easy reached in the develop phase. Obviously, when terminals are already designed or already exist it is harder to make them uniform to the entire terminal portfolio. Using the process map library as a basis for the design it will contribute to the goal of standardization. The more processes within the library that will be obligatory or fixed the more uniformity will be reached. Setting processes as obligatory can be the result of several iterations of the library. The entire efforts on standardization of terminal processes can results in ISO compliance.

Within the develop phase a lot of communication takes places with several parties. Especially parties with basic insight in the processes at an automated terminal can gain their benefits by learning from the library. But, the focus of usage for communication purposes within the develop phase should be on communication with IT parties. To create the business case most often simulation is used to fund several design choices. At this moment simulation consultants set up their models on basis of their own expertise and several meetings with the project team where after they come up with several scenarios. In this design this sequence will be the other way around. APMT has to define which processes it wants to incorporate in their design and thus in the simulation models. The process map package will be the basis of this communication with the simulation consultant. This will guarantee that the simulation advice fits the demands of the project team. Of course the simulation consultant should have input in the process maps, because their suggested process improvements can

\(^6\) Here and forward with ‘process map package’ the adjusted package of process maps for a specific terminal is meant based on the standard process maps from the library.
be of great value. But these adjustments should be made in the process maps and not in the simulation model itself. This will ensure that the improvements are actually implemented, because the adjusted maps will be (as described) input for other implementation documents.

A second IT party with which communication takes place in the develop phase is the TOS vendor. In the develop phase there is a first step to the decision on which TOS package will be used. Therefore it should be explained what the TOS does in the operation and how it supports other processes. The process map package can be the basis of this communication, because the maps in this package represent the processes that should be supported by the TOS.

It can be concluded that the usage of the process map library should indeed focus on the develop phase within the PELC cycle. Several efficiency benefits can be reached by using the library and quality/completeness are assured.

5.2.2 Usage in the execution phase of the PEI framework

Paragraph 4.2 showed that the implementation phase of the PELC cycle is embodied by the PEI framework. A further conclusion was that the focus of the usage of the library should be within the execution phase of this framework. In this phase all documents will come to a final version. Deliverables for this phase are for example (Int. Pub. XII, 2008): future process models, detailed IT design, job descriptions, an operation manual and several protocols like SOPs. The in the develop phase created process map package on basis of the library will be the primary input to these documents. But, because the documentation created in this phase will be more detailed, the standard library can also again be of help. An example is the use of the library in the set up of the training for the future terminal. Besides training an even more important function of the library is to bring new people in the project up to speed. These training sessions and the usage for bringing people up to speed can create ownership over the processes with the participants.

As stated many times until this point process maps can be used to support communication with vendors of IT systems or power equipment. In the execution phase this communication can come to a clear milestone: the completion of a deal. This is a point in which this research sees a clear role for process mapping coming forward from the theory of incomplete contracting (Grossman and Hart, 1986). This theory postulates that in for example the acquisition of a set of RMGs it is impossible to foresee and contract for every contingency. Either because of the bounded rationality of the parties involved, because the high transaction costs of contracting or, a third reason added by Spier (1992), because of information asymmetry. All “contracts will somehow be incomplete in that it is either impossible, or too expensive, to foresee, define, enumerate, and contract upon all circumstances and contingencies which may occur in the future” (Wareham, Bjørn-Andersen et al., 1997). The gaps in these contracts will in a later stage be filled in by renegotiation or legal intervention. A map of for example the processes a RMG is involved in decrease the information asymmetry between APMT and the RMG vendor. Furthermore adding a map of this process to the procurement contract will give something to refer back to in the renegotiation or legal actions at later stages. In other words process maps can be used during contracting in the execution phase, because maps make it unnecessary to exactly specify contracts.
5.2.3 Usage in other phases

Besides the focus points in the usage-process described in the previous two paragraphs several minor possibilities for usage are possible:

- During operation of the terminal the set up process maps package for a terminal can be used in legislative issues. Accurate maps can help in the argumentation for insurance, safety claims and compliance with the International Ship and Port Facility Security Code, ISPS (International maritime organization, 2003).

- A second possibility is the usage of the process maps to establish performance measures, especially process performance measures. At this moment KPIs (Key Performance Indicators) within APMT are focused on productivity and speed. But KPIs of processes can not only be measured at the input or output but also in the process itself (Terhürne and ter Welle, 2007). Searching the processes for possible performance indicators for the processes can complete the set of quantitative KPIs with several qualitative indicators. These indicators should determine if the process in practice adhere to the designed process. An example can be the precision of the vessel stowage to the initial stowage plan or the amount of reversed containers in the stack. The measurement of these indicators can be set up in the process maps. The second example indicator can be measured at the point where containers are pulled out of the stack, because if the wrong container comes up out of the stack it is probably put in incorrect.

- When a terminal in operation is willing to set up a process improvement effort the process map package set up in earlier stages will be of help. When this effort is for example focussed at the gate processes the initial process design can be compared with the actual processes taking place in practice. A mismatch with practice might imply a possibility for improvement or the other maps at the same level in the library might give suggestions for changes. A second possibility for the usage in improvements efforts is by including the maps in the current PEX program. Within this program workshops are already given which make use of process mapping. If the library is fitted into these workshops the participants would be able to become editors of process maps instead of authors, which can improve the end products of these workshops.

- The word library itself already implies that it holds information, an obvious goal of usage can be that the library is a place to store information about processes in an automated terminal. By incorporating the library in the virtual terminal the information can actually be retrieved. During all phases of the design this information can be consulted. A loop should herein establish that the library stays up to date. The created terminal specific process map packages can be the input for adjustments to keep the general maps up to date.
5.2.4 Design results

With this usage-process several more of the set up goals, requirements and constraints are met:

\[ \pm 2. \text{ Support the process of process improvement (\^{}: process excellence)} \]
\[ \text{It is included in the usage-process how to support the Process Excellence department. It is however not easy to quickly focus on a certain process of interest.} \]
\[ \pm 2.1 \text{ The maps should help in identify process risks (\^{}: HSSE)} \]
\[ \text{It is included in the usage-process how to support the HSSE department. It is however not easy to quickly focus on a certain process of interest.} \]
\[ \checkmark 4. \text{ Support the process towards process standardization (\^{}: standards & guidelines)} \]
\[ \text{It is included in the usage-process in which documents the standards & guidelines teams should use the process maps.} \]
\[ \pm 5. \text{ Help in storing and managing information about processes} \]
\[ \text{It is included in the usage-process how the process maps can help in storing information. It is however not easy to manage this information at this moment.} \]
\[ \checkmark 6. \text{ Help in legislative compliance of processes} \]
\[ \pm 7. \text{ The use of the maps should create stakeholder engagement / process ownership} \]
\[ \text{The process is described in such a way that ownership can occur but engagement of other stakeholders is questionable.} \]
\[ \checkmark 8. \text{ The maps should be used to enhance communication (\^{}: with ICT vendors, HT suppliers)} \]
\[ \text{The use of process mapping is included at several points in the automation process to enhance communication. Maps with TOS processes can i.e. be used in communication with the TOS supplier.} \]

\[ \checkmark 17. \text{ The maps should take the current usage of maps and the current design cycles into account} \]
\[ \text{The usage-process includes all purposes of use of process mapping at this moment.} \]
\[ \checkmark 17.1 \text{ The usage of the maps should be incorporated in the ‘project excellence life cycle’} \]
\[ \checkmark 17.2 \text{ Incorporation in the ‘project implementation life cycle’ is necessary} \]
\[ \checkmark 18. \text{ The maps should help in the training process} \]
\[ \checkmark 19. \text{ The maps should help in the set up of standard operating procedures} \]
\[ \text{The usage-process describes how process maps can be used to set up standard operating procedures.} \]
\[ \pm 20. \text{ The maps should help in determining the type of staffing and setting up job descriptions} \]
\[ \text{It is possible to withdraw the processes from the library where a certain role is involved in. HR can use this to set up job descriptions, but because of the big amount of maps it is not possible to do this easily.} \]
\[ \checkmark 21.3 \text{ The maps should support the design of the layout of an automated terminal} \]
\[ \text{The usage-process describes how the design of the layout can be support by the maps.} \]
\[ \checkmark 22. \text{ The maps should serve as information in the ‘virtual terminal’} \]
\[ \text{The maps can be information that can be retrieved from the virtual terminal.} \]

**Figure 25:** Incorporated goals and requirements by the usage-process design

This list can be seen as a checklist presenting the goals and requirements included in the design, because it stays questionable if the goals will be met in practice. If the design really helped, supported or will be used can not be concluded yet, the design however took them into account.
Figure 23 and Figure 25 presented the conclusions from the design of the hierarchical library and the usage-process design. It is however interesting to add the goals and requirements that are not met with these designs. Figure 26 presents the goals and requirements still unsatisfied.

- 1. Provide support by description of the processes
  - 1.3 The maps should provide the desired density
- 2.2 The maps should help in reducing uncertainties
- 3. Support the process of process re-engineering
  - 3.1 The maps should be easily changeable: maintainability
  - 4.3 The maps should be valid with reality
  - 5.1 The maps should be easily re-usable and maintainable
  - 8.1 The maps should be clear without unambiguities (clarity)
- 9. The maps should be used to identify and establish performance measures in the process

- 10. The maps should be usable within different societal systems
- 11. The maps should be usable within different management structures
- 12. The maps should include differences of suppliers
- 15. The maps should include an indication of process time
- 16. The maps should be able to handle dynamics in the processes

- 21. The maps should support the ‘automated yard project’
  - 21.1 The maps should provide insight in the design parameters for an automated terminal
  - 21.2 The maps should provide insight in technical and IT specifications
- 23. The maps should help existing terminals in automation

Figure 26: Not incorporated goals and requirements by the process map, library and usage-process design.

Of course it was the goal to already include these points in the design but this did not succeed yet. But looking at the design methodology this is not an insurmountable problem, because there is still one design round to go. It is however important to notice that when taking the designs into practice these unsatisfied goals should also be explored while consulting the experts. From these expert consults recommendations to meet the unsatisfied goals can come forward.

**Conclusion**

A usage-process for the library is designed. The main focus of usage is within the develop phase of the PELC cycle and the implementation phase of the PEI framework. The description of the usage process creates clarity for the users why to use process maps when, which overcomes the second root cause of the problem.
6. From design to practice

The hierarchical process library and the usage-process are at this point still worked out ideas on basis of existing documents and literature. It should be found out if these ideas could really add value in practice. The goal of this chapter is to validate the library and the usage-process. This is done in two steps: systems testing and acceptance testing (Smith and Kandel, 1993). First the process maps and the library are validated. This is the testing of the system. But logically, this will not be done with for example a sensitivity analysis or an extreme value analysis because there are no values or equations in the system. The system validation will consist of observations and interviews at the semi-automated terminal in Virginia (USA). The terminal in Virginia is used as a test case because this is the terminal within APMT’s portfolio with the most advanced automation and because several of the current local employees were involved from the develop phase of this terminal.

Secondly the library and usage-process are conducted to a face validation with experts, which tests the acceptance of the system. This should result in recommendations for further design or re-design of the process maps, library and usage-process. These recommendations will be implemented in the detailed design in chapter 7.

But before presenting the methodology and the conclusions of the actual validation a preliminary note should made. The final result of validation, acceptance of the process maps, library and usage-process can only be clear if the criteria for acceptance are specified (Smith and Kandel, 1993). So the first step to be set is to define the acceptance criteria. These criteria can be based on the identified performance indicators in paragraph 2.1.

- Validity – does the design comply with reality?
- Maintainability – can the design be changed over time?
- Density – does the design present what is desired?
- Re-usability – is it easy to retrieve and audit information out of the design?
- Clarity – is the presented information unambiguous?

6.1 System validation

The validation of the process maps is split up according to the highest level of the library hierarchy. Each section, marine, yard, gate and rail was validated in two steps. First observations were made on the semi-automated terminal of APMT Virginia by following the real time process outside on the terminal with each and every person actually participating in the process (Interview X, 2008; Interview XV, 2008). Direct observations are very useful tool to provide additional information and it can add new dimensions for understanding the context of the process studied (Yin, 1994). These observations were performed using the tracer method (Woodward and Eilon, 1966). This approach involves isolating a certain process and following its progress through all stages, observing the way in which people became involved in decisions and tasks related to it. The main advantage of this method is that the validation is performed in a real time context. Which results in the positive effect that people involved are not limited to perceptions of reality, they do not need to relate their answers to events taking place somewhere else. Its main disadvantage is however that it is a time consuming research step with the
danger that the observation might change the normal behaviour of the people associated with the process (Reeves and Woodward, 1970). An example of this tracing in practice can be found in Figure 27.

In the second step the process maps were validated by interviewing the involved supervisors or operational managers of each section. These interviews were structured according to the interview protocol of Appendix H. There are two reasons for using such a guide. Firstly, “placing thoughts on paper forces to organize them” (Rasiel, 1999), which prevents the validation to become Virginia’ specific. Secondly, the guide helps the interviewee to identify the topics intended to cover in the interview and prepare accordingly. Within the protocol the questions should reflect the full set of concerns from the design. In order to cover this full set the five levels of questions, identified by Yin (1994), are used. Whereby level one focuses on the specific interviewee, level two on the individual section, level three on findings across sections, level four on the entire design and level five beyond the design. After these two validation steps for each of the four sections the connection between the sections was validated with the operational managers and higher level management involved from the start up of the terminal.

**Tracing marine operations with assistant operations manager Tim at APM Terminals Virginia.**

This tracing session began in the truck standing at the quay side of APM Terminals Virginia. With the process map of the interaction of the quay crane (QC) with the horizontal transport (HT) at hand the loading process is traced. At first the assistant operations manager responsible for the marine operations explains the process in broad lines. After this explanation one shuttle truck (ST), the HT in this case, is followed. The ST drives with a container towards the QC where after it checks if the transfer point it is assigned to is free. This check is a visual check whereby the ST driver can communicate with the QC operator. If the transfer point is free the ST drives to the assigned position, drops his container and exits the transfer point ready for his next move. After this visual observation a conversation with the ST driver further clarifies his interaction with the terminal operating system (TOS). From only this short observation and the two conversations became clear that the check if a transfer point is clear was modeled incorrect. Besides it resulted in a recommendation on the safety at this point of the process (see paragraph 9.2). After this the container was followed onto the ship. In this process the QC operator checks if the transfer point is clear where after it picks up the box and gantries to the indicated ship cell to drop the container. If the container still has pins that need to be locked it stops first at a certain height to allow the pinmen to enter the transfer zone and lock the pins. But this observation did not yet reveal the entire process. After observing the checker present in a different truck at the quay and a conversation on the vessel with the foreman it became clear how the process was really organized resulting in a valid process map for this process.

**Figure 27: Tracing marine operations at APM Terminals Virginia.**

From tracing all processes and the interviews came forward that with the current set up of the hierarchical library all processes can be documented. Besides, the most important overall conclusion was that the processes represented by the maps in the library were clear and valid with the processes in practice. This conclusion implies that requirements 8.1 and 4.3 are met. But, of course, a huge amount of small changes and tips per process map were made which should be taken into account in the detailed design of the library and maps. The following paragraphs present several of these validation
results worth mentioning. These conclusions are already very process specific and one interested in the final design might skip this part.

For the Marine operations validation session (Interview X, 2008; Interview XI, 2008) the following changes should be implemented in the process maps:
- The interaction of the HT with the stack is documented in the library under the section yard operations. In practice this is the responsibility of marine operations.
- The QC operator has in practice no contact with the TOS. His job is about the interaction between him and the machine whereby the vessel foreman assigns jobs to the QC operator by radio.
- The interaction of the HT with the QC takes place at the transfer point in one of the lanes under the QC. In practice the HT driver is visually verifying if this transfer point is clear and safe. It is thus a cooperation between the QC operator and the HT driver.
- The processes for IMO containers and reefers in the marine operations follow in practice the same process as normal containers. It is therefore not necessary to make a distinction between these processes in the library.
- The processes of interaction between the waterside ASC and the HT are in practice decoupled processes. There is no handshake between them which should be clear in the process map.

In spite of the goal of this phase of the research, to validate the map, two conclusions from these observations can be drawn that should be added to the other recommendations of this research. At first efficiency could be gained by letting the QC operator interact with the TOS. The entire task of the vessel foreman assigning the jobs to the QC operator will hereby be made superfluous. Secondly the current organization of the interaction between the HT and the QC is rather unsafe, a container or spreader colliding with HT is only prevented by human cooperation. It is recommended to examine this process to make it safer by for example adding traffic lights.

For Yard operations (Interview XVI, 2008) only one extra note should be taken into account
- The yard planning is not done in advance it is a real time planning of the TOS during operations. It is however important to have general estimates of the container flows, like the number of empties and, IMO (dangerous or hazardous content), reefers and the gate volume, in advance to set the allocations.

Besides the validation and suggestions in the process maps the following conclusions were the result of the Gate operations validation sessions (Interview XIII, 2008):
- The gate operations comprise the steps for the correct entrance or exit of road trucks at the terminal. The goal of the gate is to gather information to fill up the property bag of information for a certain visit. These properties are gathered in Administrative and Physical checks (A&P checks), which are in theory the building blocks of the gate. For every specific gate the sequence of these building blocks can be variable. The gate section in the library can therefore be split up in these building blocks leaving the sequence aside.
• Automation within the gate is changing P checks to A checks. From the validation came forward that because trucking companies deliver very variable quantity and quality of information to the terminal further gate automation is only possible after further standardization in the trucking world.
• It should be clear in the library that the information gathered at the gate is at some point shared with the yard operations. So for example the first RFID check or even the appointment can be used for prepositioning containers in the stack.

For Rail operations (Interview XII, 2008) several general implications for the library were found:
• In theory the way the rail operations are organized is similar to loading or discharging a vessel in the marine operations. In practice there is a Rail Buffer Area (RBA) which can be positioned separate from the rail crane or directly accessible under the rail crane. This should be incorporated in the library.
• Extreme OOG operations obviously do not occur in rail operations because the rail infrastructure cannot cope with extreme dimensions, so this should be left out of the library.
• It should be clear in the library that the rail portal is a sub process within the rail operations issue to many specific situations over the world. As one of the interviewees stated “the ideal rail portal is no rail portal” (Interview XII, 2008) because the containers are already checked at the gate.

Finally several additions were made to the section of Other operations, like the process for petroleum spills on the terminal and for transloading containers, to make the library as complete as possible.

<table>
<thead>
<tr>
<th>Conclusion</th>
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<tbody>
<tr>
<td>All processes within an automated terminal can fit in hierarchical library the set up. By making several adjustments per section the maps within the library can be considered valid meeting requirement 4.3.</td>
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6.2 Acceptance validation

Further validation of the process maps and especially the usage-process is focused on the acceptance and the view on usability. Three different groups of respondents were used. The Virginia operations managers of each section, higher level management and the most important stakeholders identified in paragraph 4.1. The first group was consulted on the usage-process after the interview on the validity of the process maps. For the second group one interview (Virginia) was performed and two e-mail questionnaires (Vado and Rotterdam) were sent out. The third group was invited for a presentation in the The Hague office including a Q&A discussion session. These contact moments were structured using the second protocol of Appendix H. The feedback resulted in the succeeding conclusions on the current design of the library and the usage-process. These conclusions first discuss the suggested purposes of the usage in the PELC cycle (see Figure 24). Secondly the conclusions of the validation of the usability of the current process library design are presented.

6.2.1 Validation of the purposes of process mapping

Acceptance is in this research based on the acceptance for the proposed usage and the performance on the identified usability indicators. This sub-paragraph presents the results of the validation on basis of
the designed usage-process and these indicators. Each of the proposed usage-items of Figure 24 is discussed separately followed by possible additions not yet included in the usage-process. Succeeding the conclusions of the validation of each of the performance indicators is discussed.

The main idea of the usage-process design is that the library can be used as a basis for terminal design teams in their discussions and in the creation of documentation like Standard Operating Procedures (SOPs). Looking at the develop phase of the terminal in Virginia the maps were used to make sure the right things were built. The creation of process maps was a first goal in this process. A lot of iterations took place to get to the final map design, whereby the maps were not the final answer. It was a first start. A set of basis maps like the library would have really supported this process and speeded it up (Interview XVIII, 2008).

“The adding of the hierarchy with the structure is the main added value, to bring the components of the whole system together at a higher level instead of having loose maps (Interview IX, 2008).”

Other interviewees (Interview XI, 2008; Interview XVI, 2008) that actually created the Standard Operating Procedures (SOPs) used the process maps present in the Operational Specifications (Ops. Specs.) of the terminal in Virginia to set up their SOPs. They indicated that they would without doubt have used the process map library instead of the few maps in the Ops. Specs. to support and speed up their task.

“It is a very good idea to have a standard generic set of process maps that can be tweaked for a specific situation, this will save a lot of time (Interview XI, 2008).”

From these validation sessions can be concluded that the use of process maps in the develop phase is very realistic because the intended end users definitely see added value. It is however important to state that the current description of the usage in this phase is brief. It is very important that the users in this phase know for what reason and how the maps could be used to prevent setting false pretences.

The conclusions of the usage for the purpose of process standardization are more critical. When the process map library is used as a basis the end result will never be standard, because the users are free to adjust the maps to their specific situations. But when the same starting point is used, in the end some sort of standardization will be created because all had the same starting point.

Looking at the suggested practical appliance, the usage in compliance with ISO norms, the validation implies that the process maps should not pretend to take all the credits. Process mapping can definitely be the basis for documents that can be used in ISO compliance, but the process maps itself will not be
an issue to the audit for this compliance. An audit for ISO compliance will for example look at the SOPs which will be based on the process maps. To prevent the usage-process being misleading towards the final direct benefits it is suggested to only mention the possibilities to reach more standardization in the ultimate design of the usage-process in stead of pretending that standardization is reached by using the process map library.

The proposed usage of process mapping as a means of communication is also validated critically (Interview IX, 2008). Two examples will make these conclusions on the usage for the means of communication clear, the communication with a TOS vendor and the usage in training. The communication with the TOS vendor can for example be about the choice between custom or standard software. For supportability the Virginia terminal chose standard software, because if a TOS vendor is imposed by process maps which dictate the process the TOS vendor has no flexibility. The results when giving the TOS vendor flexibility will in the end almost be similar, but than guaranteed by the vendor. An assignment for a TOS vendor on basis of a prescriptive document will result in a product only exactly including the prescriptions, without a guarantee.

“If you want to set up a financial balance sheet you create a spreadsheet in Excel and do not rewrite Excel (Interview IX, 2008).”

The usage of process maps in the communication with the TOS vendor is however very useful if the goal of this usage is based on bringing a common ground and not to be prescriptive. Considering this it can again be concluded that the instruction on how to use the library should not set any false expectations. A second example is the usage for training purposes. Process mapping is seen as extra useful when training for an automated terminal. The nature of automation causes the fact that more training is needed, because the technology needs more expertise. Process maps can help in this training by making the process the automation is performing clearer. A structured incorporation within the current training material is necessary to reach this. In Virginia, for example, the maps were directly used to get the first team on site up to speed to what the operations should look like.

The usage of the process maps for legislative compliance sounded useful to the interviewees but they did not have the required insight in this field to base on. What became clear is that the library itself will not directly be used for legislative compliance, but the result, the edited maps or other documents can. Examples could be insurance or safety issues. But it is recommended to perform extra research to the possible usage of the process maps for legislative compliance. This specific purpose should therefore be left out of the detailed usage-process design in the next chapter to prevent setting false pretences.
To use the library for process improvements it should be included in the Process Excellence (PEX) program. Using the library for this purpose makes clear sense according to an interviewee involved in PEX for North-America (Interview XVIII, 2008). In the usage for this purpose, and actually for all purposes, one should be aware that only a small group is able to use process maps. This is the reason why a basis process map library could definitely be useful for PEX. In a PEX workshop the participants will not have to be authors of the process maps but they can be the editors of maps. This will significantly increase the amount of people who can work with these kinds of documents, because it is easier to edit an existing basis map than creating one from scratch.

Using process mapping for establishing performance indicators sounds great, but is found out to be rather opportunistic. To be able to set key performance indicators (KPIs) for a process the indicators should be known, generally accepted and implemented throughout the entire organization. Especially because KPIs are not only for judging the performance of one process but also for benchmarking several processes. The current KPIs within APMT are mainly focused on productivity and speed. By adding process indicators this set of quantitative KPIs can be completed with several qualitative indicators. It was suggested (Interview XVIII, 2008) that by including the goal of setting up performance indicators for processes in the usage-process a first step in the direction to qualitative KPIs might be set.

The final proposed usage purpose validated is the purpose of information management on terminal processes. The interviewees indicated that having a share point for information about how processes are organized at several places will be very useful. This can be embodied by an automated terminal in a box which further emphasizes the inclusion of this project within the project for the virtual terminal. But several warnings were made that the maintainability and re-usability of the library will be eminent for the success of the usage for information management. The critical notes on these two issues are documented in the next paragraph.

For the other identified usage possibilities in paragraph 2.1.1 that were not included in the initial design (process re-engineering and stakeholder engagement) the interviewees agreed on the exclusion in the usage-process. Summarizing the usage-process must absolutely not be misleading, the users should be aware that the way the map is describing is not THE way to do it, it is just there as a starting point that should be altered. It should be clear that the process maps are input to other documents that will finally be used for other purposes like job-descriptions, training and SOPs. So if the usage-process describes
that process maps are the tool to use in the develop phase and only useful for reference in the implement phase no misleading mindsets can be set, negative to the useful tool that process mapping is.

Concluding can be stated that the content and hierarchical set up of the designed library will add value to the proposed usage. It is important that the detailed usage-process should not set any false pretences for the future users. The usage is accepted for the support of current processes, communication purposes, process improvements and information management. To prevent the usage-process being misleading towards the final direct benefits it is suggested to only mention the possibilities to reach more standardization in the ultimate design of the usage-process in stead of pretending that standardization is reached by using the process map library. Furthermore it is concluded to leave the usage for legislative compliance out of the usage-process until further research is performed. Finally the usage for setting performance indicators must be seen as first step in the direction to qualitative KPIs. Usage at all other points should better be limited to prevent false expectations.

6.2.2 Validation of the usability of the library
Acceptance of the design depends besides the acceptance of the suggested usage purposes on the usability of the process map library itself. This paragraph will discuss the conclusions on the validation of the other identified performance indicators for the library (the indicator validity was already discussed in paragraph 6.1). But before going into this one general remark should be made: the current design of the usage-process assumes that it is already implemented. It is only a description of how to use it and not how the process to come to the point of usage should be managed. It makes no sense to look at the usability of the library when it will not even come to using because of a poor implementation. This lack of the design should be overcome in the detailed design.

Density – does the design present what is desired?
As described in the usage-process the library will be used by several different users with varying preferences. The validation (Interview XIV, 2008) implicated clearly that the current library does not take this into account.

“At several terminals 3rd parties take over some of the processes. This implies even more that the usage of the library should be flexible, that it should be possible to leave out processes that are not of interest to the user (Interview XIV, 2008).”

Several other examples underpin this conclusion. Someone from HR willing to use the library to create a job description for the dock foreman will not be able to easily find the process maps in which the dock foreman is involved. Not only because the library contains over 150 processes, but also because this user probably does not have the skills to work with the used software. Another person willing to use the map in a utility truck training for a west coast American terminal will probably directly assume the library can not be used for this purpose because processes for a utility truck are not documented in the library. But this assumption is wrong because the terminology used in the library is terminal tractor instead of utility truck. This supposed detail of terminology will actually be a huge roadblock for the actual usage of the library.
From these several examples can be concluded that the design does not present what is desired by the several users, because of the quantity of the processes, the skills required for the software and the terminology used. So to be able to show the desired density and meet requirement 1.3 the user should be able to only select the process maps it is interested in, by a simple to use interface presenting maps in the terminology familiar to the user.

Maintainability – can the design be changed over time?
In the previous paragraph was again identified that the maintainability of the library is a very important issue. From the validation (Interview XVIII, 2008) clearly came forward that this is, besides the density, a second problem. The program used, iGrafx, requires specialism and does in the opinion of the Virginia team not work properly with the company standard, Microsoft Office. This problem actually indicates another criterion also used by Smith and Kandel (1993), interoperability, a criterion if the design will be able to interface with another system. But as paragraph 2.1.3 explained iGrafx will be used, however other possibilities can be explored within the detailed design to meet requirement 3.1.

Re-usability – is it easy to retrieve information out of the design?
The ease of retrieving information out of the library logically also depends on the skills and the software used, described in the previous two points. While being conscious of repetition it should be stated that also this criterion will not be met if these problems are not overcome. Furthermore the ease of retrieving information depends on if the information is available, if the library is up to date. This depends on the previous criteria; the library can be up to date if it is maintainable and on the organizational structure for keeping it up to date. This second issue came forward (Interview XI, 2008; Interview XIV, 2008; Interview XVIII, 2008) as a critical point. In the current usage-process there is no structure to keep the information up to date, while this is very important because it was concluded that the dynamic environment will cause that the information will be outdated very quick. And without an up to date library there is no added value for the users. So it can be concluded that requirement 5.1 is not met and that the detailed design (chapter 7) should include a structure to ensure the re-usability of the library over time to cope with the dynamics. Suggestions that should be taken into account in this detailed design are the use of a business process owner, who is responsible for updating the information.

Conclusion
The current usability of the library is insufficient because the design does not present what is desired by the several users. This is caused by the quantity of the processes, the skills required for the software and the terminology used. Furthermore the interface of the used software with other company software is not convenient. Finally it is concluded that the usage-process should include the implementation steps and an organizational structure get and keep the library used.
7. From design through practice to detailed design

Looking back at the research methodology (paragraph 1.2.3) this research step will come to detailed designs that will overcome the main problems of the validation. This will be done by first identifying which parts of the design need to be detailed, followed by identifying how they can be detailed. The result will be the first step towards implementation of the final process map library and usage-process. However, from the validation phase became clear that the first iteration of the design cycle could already result in a satisfactory design that answers the first research question if several small adjustments in the process map library are processed. The modelling effort to include these adjustments resulted in the hierarchical process map library for a standard automated terminal in Appendix E. The first research question is hereby answered:

1. **How can the existing process maps be improved to become tailor made for APMT’s terminal automation process?**

The first design of the usage-process was however not yet an answer to the second research question. The main issue for the detailed design phase will be to overcome the conclusion that the usability of the designed process map library is insufficient, because different users of the library will have different skills and preferences. Furthermore the usage-process does not include implementation steps and does yet satisfy all requirements from research phase I (see Figure 26). These two points could unfortunately lead to the situation in which the library is not used. A practical example will clarify this further. Because the library is such an extensive document the first thought of a user might be that it will be a lot of work to use it and that for their purpose they can better do it themselves from scratch. The amount of information present in the library has an inhibiting effect. This can result in a decision of the user not to use the library although the benefits are clear to its manager.

To overcome this problem, a structure should be set up that enables or motivate the user to use the library. Structures with e.g. incentives are studied in many research fields driving economic activities, decisions making processes (de Bruijn, ten Heuvelhof et al., 2002), political processes and sociological situations. But in this case it is not as far reaching as remunerative incentives, taxes, subsidies, power or honor, the focus should be on simple implementable solutions. To identify these solutions lets look at the *simple* situation in which a child does not want to take a vitamin pill with his dinner even though his parents know that will help him through the winter. The first option is that the parents force the child to eat it, which is a hard job for the parents resulting in the child eating the vitamin pill while crying. A second option is that the parents buy a more expensive pill with the same vitamins but in the shape of a teddy bear tasting like the child’s favourite sweet. The result is that the child will eat the pill right away, even though it knows it is the vitamin pill, because it likes it so much. In this situation there is not a lot of effort of the parents required during eating, but a higher initial investment is needed. The third option is that the parents promise the child to go swimming if it eats the vitamin pill, which creates some sort of a package deal. Finally, a fourth option, is to set up a program that learns the child about the benefits and for example let the child see that other children are using it too, this option gradually works towards taking the vitamin pill. Projecting these options on the problem of usability of the library two solution directions are formulated along which this chapter is structured (obviously the real solutions will be
based on scientific literature). At first, with several changes the libraries *intrinsic value* could be made so high that users want to use it, the benefits for the users are so significant that they do not want to go around it (2nd option from the example). Second, if people do not want to use it they can always be forced or required to use it. An organizational structure with incentives could be the way to reach this (combining the 1st and 3rd option from the example). This option should furthermore include the implementation steps to come to the usage-process (4th option from the example).

**Conclusion**
To overcome that the main problems identified in the validation of the library and usage-process the intrinsic value of the library should be increased and an organizational structure including implementation steps should be set up. This will ensure the actual usage in practice by usage support and by taking into account the preferences of the different users.

7.1 Increase the intrinsic value of the library
Intrinsic value is the value of the library at itself. Increasing the value of the library is an easy statement which is in practice hard to realize. This paragraph will describe three realistic possibilities for APMT to further increase the value of the library. This higher intrinsic value should lead to a higher extrinsic or instrumental value, the value the library can generate, which should overcome the first part of the conclusion of the validation in paragraph 6.2.2.

A first and logical option is to add extra functions to the library. The following extra functions coming forward from the validation phase can make the library more attractive:
- An option can be added to make it possible to feedback the altered maps for specific situations. These maps can form an extra layer of best practices under the library hierarchy. New users can learn from these best practices while setting up their own specific process maps.
- It can be made possible to make a selection of maps from the library. This function will increase the usability for users with specific preferences. An HR user could with this function for example only select maps were the dock foreman is involved, or for usage in communication with the TOS vendor only TOS specific maps can be selected.
- Because the maps can finally result in SOPs it can be considered to include these SOPs in the library at a lower level. This will increase the information management function of the library.
- An option can be added to make it possible to use the specific terminology the user wants. A function to for example replace all terms *terminal tractor* by *utility truck* will enhance the clarity of the maps for specific users. Of course it should be taken into account that this function will result in a decrease of standardization.
- Users should be able to leave their comments to improve the basis maps. This can be made possible for errors in the maps or when the process maps do not result in a specific map or SOP.

A second option is to really enhance the usability by improving the human interaction with the library. There are several possibilities to reach this goal. At first a more user friendly program than iGrafx can be introduced. But as clearly stated in paragraph 2.1.3 this software package has to be used within this research. A second option is to improve the current iGrafx interface. This option is derived from
research to Interactive Learning Environments (ILE) for complex models and simulations. These environments are designed as interfaces of the complex models that should create transparency for the less experienced modeller (Davidson, 2000). A first step towards a more user friendly interface is to more clearly specify user groups. Specific user groups will benefit from different interfaces because they will use the same software for a different reason (Grudin, 2004). From the stakeholder analysis (see paragraph 4.1) and the proposed usage-process (see paragraph 5.2) two broad user groups can be formulated:

1. **The editors**, this group will be the actual users tweaking the maps to the processes at the specific terminals. These users will really use iGrafx to create their own process map package.
2. **The viewers**, this group is interested in the information the basis maps or the created specific process map package withholds. These users do not prefer to work in iGrafx but want flexibility in retrieving the information out of the library.

The first group should have some knowledge about using iGrafx or should be provided with training to gain this knowledge. With this knowledge this group will be able to work with the current library. The focus for enhancing usability should be on the second group. To meet their preferences a *skin* or *shell* could be created around the process maps to make it more user friendly for this second group. This directly creates the opportunity to add some of the identified extra functions. A tailor made interface in iGrafx or a decoupled browser based version of the library are possibilities to create this *skin*. A practical example might clarify this possibility. A *viewer* that is interested in a specific selection of process maps might be imposed with several questions before entering the library. Figure 28 gives an example of such a question.

![Figure 28: Example of a user interface question to make a process map selection.](image-url)
Another function can for example be added to further tune the library to the user preferences in terms of terminology (see Figure 29).

Figure 29: Example of user interface to tune the libraries terminology.

It should however be noticed that the degree of standardization will decrease by introducing this option. Besides, conventions on for example terminology are essential for governing cooperation (Grudin, 2004). Without similar terminology it will be harder to couple the feedback to the standard library. But by including several of these functions the library can be made more specific to the users preferences. Within the scope of this research it is impossible to completely create such a skin, but it is however possible to set a first step in the form of a program of demands and a first interface version. Figure 30 presents this first version accessible through every internet browser (a detailed description is provided in Appendix G).

Figure 30: Interface version of the process map library for a standard automated terminal

Without prior knowledge all maps can by viewed by simply clicking in the interactive screen. It offers functions to zoom in and print and it furthermore provides information on why, when and how to use process maps within a project. This version makes it possible to consult maps during decision making or select maps of interest that should be tweaked to a specific situation. These maps can be exported in four different extensions. Most important to note is that this interface version is decoupled from iGrafx and easy to update. When a new version of the library is created or when a project team created their own specific process maps it can be uploaded in this interface version. This makes it possible to create
an interface version for every project specifically. Figure 31 further clarifies this process of usage of the two versions of the library.

![Diagram](image)

**Figure 31: Usage of the interface and iGrafx version of the library**

The interface is not only created to set a first step towards a separate viewers version, but it also supported several other goals. It was used in the introduction to the project team at Maasvlakte II (MVII) and it provided insight in the possibilities of for a future viewers version.

A third option is not focussed at the functions or interface of the library it is purely focussed on the perceptions of the users and information conveyed to them. The usability of the library will increase when the perception of the users fits the actual performance of the library and furthermore the usability increases when the *manual* of the library is more clear. The interviews held during the validation support this statement. The first step is to bring the usage-process design (see paragraph 5.2) in line with the user perceptions. Secondly the extra design steps from this chapter should be included in the usage-process design creating more clarity and detail for the actual user. Appendix F describes this usage-process including the program of demand for a library interface. A detailed description of the first interface version of the library is presented in Appendix G. This interface version of the library and the detailed usage-process are the first part of the detailed design. They will, according to the methodology, be subject to a second validation presented in the next chapter.

**Conclusion**

To really get the library used the intrinsic value of the library should be increased by adding extra functionalities to meet the specific preferences of the users. Two versions of the library are created: a separate viewers version to meet the demands of users only interested in the information the maps withhold, and an editors version for tweaking the maps to a specific situation.

7.2 Requiring to use the library

This paragraph will elaborate on the second solution direction to prevent that this research will become a one shot effort. The scope of this solution direction is to see if, within the current organizational structure of APMT, a program can be set up which will create a playing field to use the library and to keep it up to date. This program should consist of steps towards implementation of the library and an organizational structure to keep it up to date which will overcome the second part of the conclusion of paragraph 6.2.2. This scope is however beyond the initial thought in the set up of this research. Paragraph 2.2 only looked briefly at how to design the process for using process mapping. But it does not provide for sufficient theoretical background to set up this program. That is the reason why a step
back should be made here by including a theoretical intermezzo that will help in setting up a detailed design of the usage-process which can answer the second research question.

**Intermezzo: software implementation & process management**

With extra options for increasing the libraries intrinsic value (see paragraph 7.1) the final library will even more become a piece of software instead of just several process maps. Because this has not been taken into account when setting up this research, this paragraph looks at the topics of organizational structures and implementation for software.

Software implementation projects often have high failure rates or are delayed significantly (IT Cortex, 2008). By learning from these types of projects the implementation of the process map library can be made successful. There are varying categories of reasons for these failures (see Block, 1983), from these categories several authors agree that the organization can be an important reason for failure. Hong and Kim conclude that there is a significant relationship between the organizational fit of software and the success of its implementation (Hong and Kim, 2002). Furthermore Prieto-Diaz (1991) states that an organizational structure is essential to establish re-usage of software, because the problem is most often not the technology but the unwillingness to address issues like management. But the most important statement for this research is that it is better to re-engineer the business process to fit the software, rather than trying to modify the software to fit the organization’s current business process (Sumner, 1999). A first step in this strategy is set by describing how to change the current process when incorporating the use of process mapping (paragraph 5.2). But adoption of this change is not only about deciding to use it in this way, it is about beginning to use it in the described way: implementing it. Palen and Grudin state that “adoption by users is often bottom-up and unaffected by management attitude” (2002). This implies that the users should not be required to use the library but that they should be supported in using it, a more process focussed approach rather than command and control. This can be reached by establishing an organizational support structure with for example a maintenance, development and support group (Prieto-Diaz, 1991). The implementation of this structure should be done stepwise for several reasons. At first a smaller structure will be easier to manage. Secondly it allows for tuning while the library grows because feedback can be gathered. And thirdly, the confidence within the organization can be built up with a small start rather than handling a large structure from the start.

Besides setting up an organizational structure the implementation should be managed. Especially because, besides organizational failures, people management is often a cause of an unsuccessful implementation (Block, 1983). This can be overcome by focusing on the process aspects of the implementation, the way the changes are implemented. This is in line with the observation that process mapping addresses a minor role to social aspects (see paragraph 2.1.5 on the drawbacks of process mapping) and with the statement that the problem in software implementation is often the unwillingness to address social issues (Prieto-Diaz, 1991). It was already suggested that a process management focussed approach could bring relief. De Bruijn and ten Heuvelhof state that “process aspects concern the manner how changes can be (.) implemented” (2002). Even though the implementation process in this case is not completely similar to a decision making process, used by de Bruijn and ten Heuvelhof (2002), their identified principles of process management could be applied to this situation. The implementation process should provide for:

Mapping to Manage. -65-
- Openness, all relevant parties should be included in the decision on the set up of the organizational structure. Within this structure the implementation steps and management structure should be transparent.
- Protection of core values, the current position of the parties should be respected. With an organizational structure the parties can commit themselves to the process rather than to the result.
- Speed, the design process of a new container terminal takes several years but the implementation steps should create an environment to speed up the implementation process.
- Substance, when implementing the process not only the structure should be implemented. Content related monitoring should be guaranteed.

These four should haves of a process will be taken into account in the detailed usage-process. Whereby it should be mentioned that it will often come down to deciding between these principles. Because there is for example a clear trade off between speed an substance. The next paragraph addresses the appliance of these elements in the implementation process.

### 7.3 Supporting to use the library

From this intermezzo can be concluded that a stepwise implementation of an organizational support structure should be designed that takes into account the design principles of process management. It is however still unclear what the possibilities for such an organizational structure are. Therefore another step into theory should result in several ways to set up the organizational support. Mintzberg (1983) describes five mechanisms of coordination that explain the fundamental ways in which organizations coordinate their activities. These mechanisms can be considered for the coordination of the use of process mapping with in APMT.

1. **Mutual adjustment**, by informal communication between employees simple processes can be coordinated. Especially internally in projects that will use process mapping this will be useful. A user that created the maps for the marine side of the terminal might help the one responsible for the rail operations by sharing his knowledge on process mapping.
2. **Direct supervision**, by having one person taking the responsibility for the work of others, issuing instructions to them and monitoring their actions coordination can be achieved. In every process mapping project within APMT there should be one person responsible for the overall hierarchy, bringing together the work of others.
3. **Standardization of work processes**, by specifying the content of the work employees can be coordinated. This mechanism will not be incorporated in the organizational structure but is already used when specifying the usage-process in paragraph 5.2.
4. **Standardization of outputs**, by specifying the results that should be reached coordination can be achieved. The outputs within a process mapping project are standardized in such a way that it is known in advanced which representation techniques will be used and which processes should be mapped.
5. **Standardization of skills**, by specifying the kind of training required to perform the work processes can be coordinated. To coordinated the use of iGrafx the actual editors of the basis maps should be provided with training or support in using the software.
Veryard (1994) adds two mechanisms to this list in his book on the management of information models interesting for APMT.

6. Standardization of inputs. This mechanism is actually the basis of the use of the library. The basis library of process maps coordinated the work of other projects by providing common components of input.

7. Standardize through tools. By using a uniform tool for process mapping, iGrafx, the work throughout all projects can be coordinated.

Both authors acknowledge that most of the time a mix of the mechanisms is used in practice, which should definitely be the case when setting up a structure for APMT. Besides these coordination mechanisms Stoner and Freeman (1992) and Hedlund and Dunning (1993) propose an approach to increase the potential of these mechanisms that should be considered. In the beginning of the project a focus should be on lateral relationships. Permitting exchange of information between layers of the organization other than the normal layers can enhance coordination. It should be ensured that there will be communication channels between APMT process mapping projects that cut across the chain of command. When the number of contacts between projects increases, a liaison with an integrating role can be appointed. This liaison ensures the lateral relationships and keeps is responsible for a continuous coordination. In even later stages, when process mapping is broadly used within APMT, such a liaison can be transformed to a managerial linking role, with a formal authority over all projects including budgets.

The next step is to transform the theory from the intermezzo and the theory on coordination to a realistic organizational structure for implementing process mapping in APMT. It was already stated that it is very important that this should fit the organization. The result of this transformation is a conceptual organizational structure for APMT. Figure 32 presents this design for making the library used showing the three possible steps of implementation. This design will be explained further in this paragraph.

![Figure 32: Organizational structure for introducing the library.](image)

This design comes forward from a projection of the theory on the current trajectory in APMT (see paragraph 4.2). The description of the trajectory (Int. Pub. V, 2008) is divided in (1) mandatory
deliverables (2) primary activities and (3) templates, guidelines and best practices. This creates possibilities to require the use of the library. At first the creation of a process package for a specific terminal can be made a mandatory deliverable just like several other documents are required right now during the design cycle. A second option is to include the creation of a terminal specific process package in the list of primary activities during the design cycle without making it a mandatory deliverable. A less direct third option is to suggest the library as a template or guideline that can be used in primary activities or for the creation of other mandatory deliverables.

This type of enforcing is considered as a passive structure. The users are imposed to process mapping through their project description (mapping the processes at their specific terminal is formally included in their task description) or own active attitude. This step assumes that the users are coordinated through mutual adjustment (mechanism 1). But this is a rather unrealistic way of making the results of this research used. Applying the theory from the intermezzo it is especially strange to make the creation of process maps for a terminal mandatory without offering support. Furthermore there is no feedback gathered in this passive structure to keep the library up to date or to share best practices.

To overcome these issues an active approach can be added using the coordination mechanisms. Instead of offering the library to the users the users are introduced in an active way to the library. An example is an introduction of the goal of the library and an explanation, followed by support during the usage. This will achieve coordination through the standardization of skills and work processes (mechanisms 3&5). This can be in the form of a process support centre, similar to the suggestion of Prieto-Diaz (1991), which offers help to create maps or even creates all maps for the project teams just like the current centralisation of CAD drawers within APMT. This centre should furthermore provide the training for the editors and gather the feedback from the users to keep the library up to date.

But when really making process map packages mandatory there should also be a management structure to act upon this obligation. In a third step, with a pro-active structure, the feedback and additional information can be pulled out of the users instead of the situation in which users pushing the feedback up. By making one of the users in a project responsible for the direct supervision (mechanism 2) it is actually realistic to make it a mandatory deliverable. This project process owner should give account to a liaison: the global process owner, which monitors the progress of all processes in all projects. This global function oversees the information and looks for further opportunities between projects (see Rummler and Brache, 1990). With this structure it will be possible to include, and more important share, SOPs and best practices in the library which creates synergy between the projects.

Of course this suggested structure can not be set up all at once. First there should be agreement on what to set up, followed by a gradual implementation. The suggested steps in Figure 32 make sure that the implementation is, according to the theory in the intermezzo, gradual. The only discrepancy of this structure and the analyzed theory is that this structure seems not to be in line with Palen and Grudin (2002) because it looks hierarchical. It is very important to state that this is not the case. This hierarchy does not consist of power, it is set up in the philosophy of Garicano whose research concludes that it “is natural to organize the acquisition of knowledge as a knowledge-based hierarchy” (2000). The role of the global process owner is support by transmitting knowledge about exceptions to other projects instead of requiring to use the library.

The passive first step was initiated in December 2008 by this research. The first editors version of the process map library was offered online, on the company internal network communicate. In January
2009 also the viewers version was offered online. Users interested should at this phase actively retrieve the information themselves from communicate to use it. There was no support given or feedback gathered. In January 2008 the process map library was actively introduced to its first user team, the project team for the new terminal at Maasvlakte II (MVII), Rotterdam, The Netherlands. In this active second step this research project functioned as the process service centre. Besides giving support to the MVII team this resulted in feedback from this first user. To further clarify this second step Figure 33 describes the interaction with the MVII team.

**Implementing the library at Maasvlakte II, Rotterdam January 2009.**

A presentation and discussion on why, when and how to use the library within the design of the new terminal at MVII resulted in the decision to use the library as the basis for the business process model of Maasvlakte II. In these meetings the interface version was used for introducing the model. The model will for example be used to support in creating their SOPs and job descriptions and in communication with future IT and equipment vendors. During a second meeting the support for the usage of the library by MVII was handed over to OIS whereby the roles of all parties involved were defined according to Figure 32. From the reactions in these meetings can be concluded that the interface version is clear and that the steps toward the organizational structure are realistic and set in place for the first time.

**Figure 33: Implementing the library at Maasvlakte II, Rotterdam January 2009.**

After this point the entire research and the first feedback was handed over in February 2009 to the Operations & Implementation Support (OIS) team who became the eventual owners of this library. This first step to a pro-active structure was boosted by supporting this new owner in the start up of the introduction to the second user, the new terminal team of Vado (Italy). With this they took over the role of process support centre and being the precursor of a global process owner. In the future, step three can be fully introduced whereby one of the members of the OIS team can fulfil the function of global process owner.

This approach took the principles of process management into account in several ways:

- **Openness**, at first the stakeholder analysis (paragraph 4.1) was consulted to identify the relevant parties the previous paragraph addressed. Already during the validation phase of this research openness to these parties was ensured. All design steps were first discussed with the stakeholders before bringing them into practice. This gave them a chance to provide input in the design which resulted in an easy acceptance during the handover. Two clear examples are the consultation of OIS during the set up of the organizational structure and the discussions with all stakeholders during the presentation in December 2008. The openness will in the future be preserved by presenting the organizational structure and process steps at every new user introduction and internally publishing the organizational structure and process steps.

- **Protection of core values**, the stakeholder identified the current way of working of the stakeholders. Not only the process usage-design (see paragraph 5.2) but also organizational structure took this into account. Examples are the incorporation of the process in the PELC cycle and the organizational setup (Figure 32) based upon the currently used structure with templates, guidelines and mandatory deliverables. But the most important protection of the
stakeholders, especially the future owners of the library, is that they are committed to the structure of implementation instead of to the content of the library.

- Speed, mostly speed is guaranteed by the dedication of people. After the completion of this research this dedication should be transferred to ensure the speed of the implementation process. This is partly reached by involving the eventual owners of the library in this research and the introduction to the first users. Furthermore a detailed, practical, implementation plan presented in Appendix F should help these eventual owners in to keep the speed after this research is finished. This detailed process suggests next steps and deadlines to stick to which will ensure the speed of the project.

- Substance, this element should prevent decision making processes to result in compromises of little substance, for this reason it is of less relevance for this process. But it is however important to state that this research is in the end about the designed process maps in the library. By gradually launching this library with support from this research and the innovation department in the first step the focus on the substance is guaranteed.

As stated, Appendix F presents the detailed design of the usage-process followed by Appendix G describing the first version of a library. Finally, it is important to add that communication is the key word in the coordination of process mapping within APMT. Effective communication within the set up organizational structure will make process mapping a value adding tool within APMT.

**Conclusion**

To make sure the separate versions of the library are used an organizational structure that creates a playing field to use the library and keep it up to date should is set up. This structure is an incentive to start using the library and overcome the initial doubt of the users, where after the experience of the efficiencies and other benefits creates user satisfaction and bonding.
From the generation of goals and requirements, through the design of a hierarchical process map library, up to the gathering of validation input a final design was created. This resulted in answering the first research question. Now comes the most important part: evaluating what this all means. This phase of the research will consist of the evaluation step of the second iteration in the design cycle (see Figure 3) which will answer the second research question. The result will be an evaluation of the contribution of this research to APMT. After this third phase chapter 9 of this report will present the conclusions of the research together with the recommendations for APMT and for further research. These final conclusions, will try to answer the main research question and complete the research. Succeeding chapter 10 will set a discussion on process mapping by generalizing the research conclusions. Furthermore it reflects on the research itself by evaluating the contribution of this research to the used theoretical methodologies.
8. Evaluation

Before moving on to the definite conclusions this chapter will bring the findings in this research together. This will be done by completing the last step of the second iteration of the design cycle, the evaluation of the detailed design of the previous chapter. This iteration will be described by looking back at the set up goals and requirements after research phase I. It will be considered if the goals and requirements are met and what the implications of these considerations are. The result will be an evaluation of the contribution of this research to APMT in paragraph 8.2.

8.1 Detailed design evaluation

This paragraph discusses the last part of the second cycle in the methodology, the validation of the detailed design of chapter 7. Several preliminary ideas of the detailed design were discussed in Virginia (Interview XVIII, 2008) but the majority of the input for the validation of the detailed plans came forward from discussions with the project manager of the automation process, the OIS team and the first users at Maasvlakte II.

The main conclusion from these discussions is that the organizational structure is a charter for the implementation of this research. All involved stakeholders in this implementation process are willing to follow it to reach the benefits of process mapping within APMT. Figure 34 presents the conclusions on the requirements that had not yet been satisfied by the first design cycle.

1. Provide support by description of the processes
   Figure 10 made clear what should be supported and the usage-process made clear when it should be supported. After the detailed design it is also clear how it should be supported meeting this first requirement.
   1.3 The maps should provide the desired density
   The ‘viewers’ version of the library enables the users to consult the detail they prefer.
   3.1 The maps should be easily changeable: maintainability
   5.1 The maps should be easily re-usable and maintainable
   The support structure ensures that the library is maintained making it re-usable.

10. The maps should be usable within different societal systems
   This broad requirement is partly met by the possibility for users with less skills to consult the library through the ‘viewers’ version. A further fulfilling is uninteresting for APMT.

16. The maps should be able to handle dynamics in the processes
   The dynamics in the processes are taken care of by the feed-back and maintenance of the library in the organizational structure. But, this is a point of discussion in paragraph 10.1.

21. The maps should support the ‘automated yard project’
   As stated in the introduction the goal of the automated yard project is to develop a standard off-the-shelf design for an automated yard. The library provides for all standard processes not only in the yard but in the entire terminal. Which is a component of an off-the-shelf design.

Figure 34: Incorporated goals and requirements by the detailed design.

This list implicates that there are still several goals or requirements unsatisfied or partly satisfied (±). It is at this point of research essential to take a closer look at these issues to see if the second research question can be answered:
2. In which way should process maps be incorporated in APMT’s terminal automation process to fully exploit their benefits?

A first issue is the partly satisfied goals and requirements (±). Figure 23 and 25 bring forward six partly satisfied goals and requirements from the first design iteration. Four of these (2, 2.1, 5 and 20) are not considered satisfied because it is not easy to quickly focus on a certain process of interest. The detailed design overcomes this issue by introducing a second library version and suggesting additions that will increase the ability to search specific maps. This completely overcomes the problems resulting in the conclusion that also these goals and requirements are met (v). This leaves goal 13, stating that the maps should include several automation possibilities and goal 7, aiming to use process mapping to create stakeholder engagement, open. Goal 13 is reason for a recommendation on a follow up on this research to further complete the library. Goal 7 can be considered satisfied when looking forward at the evaluation of the contribution to APMT: the introduction and implementation is already brought into action among the stakeholders which implicates the engagement of these stakeholders.

A second issue is the goals and requirements not met, presented in Figure 35.

- 2.2 The maps should help in reducing uncertainties
- 3. Support the process of process re-engineering
- 9. The maps should be used to identify and establish performance measures in the process
- 11. The maps should be usable within different management structures
- 12. The maps should include differences of suppliers
- 15. The maps should include an indication of process time
- 21.1 The maps should provide insight in the design parameters for an automated terminal
- 21.2 The maps should provide insight in technical and IT specifications
- 23. The maps should help existing terminals in automation

Figure 35: Not met goals and requirements.

Before evaluating the implications of this figure some perspective is necessary. These 9 issues are the unsatisfied goals and requirements from a list of 43. The goal of this list was at first to create an overview of the full potential of the method process mapping. So when setting up this list it was already clear that it would be impossible or undesired to reach all goals. Firstly because there are tradeoffs between these goals and secondly because, with experience from the field, it might be concluded that some of the goals might not be goals after all. The purpose after this diverging first research phase was however to come up to a design that tries to fulfil all the identified possible goals of process mapping. When looking at this figure it can be concluded that the designs do not fulfil all possible benefits of process mapping. That is no surprise because to goal to exploit all benefits was considered as over ambitious or nearly impossible. So it will not result in the conclusion that the research failed but it gives reasons for an evaluation of the goals and requirements and the set up of recommendations.

Starting from the top of Figure 35 the goal was set (2.2) to let the maps help in reducing uncertainties. With the knowledge gained in this research it can be evaluated that the process maps will never reduce uncertainties they can only be used to identify them. Furthermore it was stated (3) that the usage-process should include the use of the process maps for process re-engineering. Because re-engineering
is fundamentally changing the core business process, which will not be the case in APMT, this is and should not be included in the usage-process for APMT. Moving on, goal 11. aims at making process mapping usable within different management structures. Because APMT tries to standardize the organizational structures of their terminals it makes no sense to add this goal in the design for APMT. From these brief evaluations can be concluded that goals 2.2, 3 and 11 are no goals for process mapping within APMT after all. It is however important to keep them in mind in when using process mapping in other projects.

When looking at the other unsatisfied goals and requirements of Figure 35 it can be evaluated that there still room for improvements in the current design, a reason for recommendations. From goal 12 can be recommended to add a layer of supplier specific maps under the library. As already incorporated in the design the process map library is very suitable for being such a sharepoint of other information than maps. It is for example proposed to attach SOPs and location specific maps to the library. Requirement 15 is an example of this process related information. Best practices including sharing what process times can be reached by following the maps could be a useful point of information. These process times could hereby really be added in the maps. Emphasis should however be put here on the words process related because the virtual terminal, which is set up right now within the automation project, will be the information platform for all information related to automated terminals. This directly eliminates recommendations coming forward out of 21.1 and 21.2 because these typically are issues that should be included in this virtual terminal. Process maps only describe what the equipment and IT systems should do and not which specifications they should have. The process maps could however help in setting up these specifications.

This only leaves goal 9 and 23 open, which can directly result in recommendations. Goal 9 leads to a recommendation for APMT because the quality of the process underlies the current KPIs like speed and costs per move. If the quality of the process is ensured the other outputs will follow. Especially with the currently changed focus on customer satisfaction it is essential to, besides measuring through the customer satisfaction survey, measure the quality of the process. So, APMT should use process maps to set qualitative performance indicators. Finally, goal 23. The fact that this research was not able yet to use process mapping to help current terminals in automation does not influence the success of the results of this research. This goal is still unsatisfied because of the scope of this research project and should therefore lead to a recommendation in paragraph 9.2.

Looking besides the set up goals and requirements at the identified constraints of process mapping (see paragraph 2.1.5) it can be concluded that these drawbacks are prevented. The time and thus costs of setting up process maps, the two main drawbacks, will in the future just be the points of improvement instead of constraint. Efficiencies will lead to a decrease of time used to set up process maps.

From this evaluation can be concluded that all partly met goals and requirements are now fully met by the detailed design. The not satisfied goals and requirements do not obstruct the successful use of process mapping. It can however be questioned if this research was able to identify all possible benefits. With the completion of this evaluation it can be stated that the detailed usage-process and organizational structure answer the second research question. The usage-process, Figure 24, shows when process maps should be incorporated in the APMT’s terminal automation process. The organizational structure for introducing the library together with the detailed implementation plan,
Figure 32 and Appendix F, subsequently show how it should be used at the specific points in the automation process. The benefits that will be exploited, Figure 10, by following this sketched trajectory describe why to use process mapping.

This positive evaluation on the proposed implementation structure should however be placed in the reality of today. Because the statement that this research is situated in a dynamic environment also resulted to be valid: the economic climate changed during the time span of this research. Recent newspapers (Daily Press, 2008; Lloyd’s List, 2009; The Straits Times, 2009) show that the container throughput currently falls caused by the economic crisis which has implications for APMT. All internal management reactions on this issue are confidential but one can imagine that especially management actions in the HR area might thwart the proposed implementation. Where the organizational structure proposes the appointment of business process owners per project and a global project owner the resources strategy is currently a bit more conservative. The proposed three steps towards implementation can however cope with this challenge by simply adjusting the timing of the steps according to the possibilities within APMT. Besides this possible challenge it should be mentioned that a tougher climate with an increasing competition could actually be the reason to use the results from this research. As described the process map library support can definitely help in improving processes, making them more efficient and thus competitive. Furthermore the introduction of the library will save time and decrease costs for the several project teams. A reason to exactly now use the library to get the best out of the crisis and come out of it stronger than competitors.

8.2 Evaluation of the contribution to APMT
Since this research is performed in cooperation with APMT it is important to question at the end of this research what the results for APMT are. This question can be answered by looking back at the introduction (paragraph 1.2) where the two deliverables for this research from APMT’s point of view were formulated. Firstly it was expected that this research project results in several process maps of an automated container terminal. Secondly APMT wishes to create internal stakeholder engagement for the use of process maps. These two deliverables should in the end contribute to the process towards further automation of container terminals. The problem discovered however was that it was unclear how these static process maps could be usefully incorporated in this dynamic process. This paragraph will elaborate on the contribution of this research to APMT in a tangible way. First the clearly visible results for APMT are stated followed by a discussion on the completion of the required deliverables.
This research resulted in the following tangible results for APMT:
- A validated hierarchical structured model, the process map library, that can accommodate all processes within an automated terminal.
- Over 60 validated process maps of the most essential standard processes within this library and an identification of more than 30 other possible standard processes to include.
- An iGrafx version of the library to edit the maps and hierarchy.
- A first version of a web-based interface to view the library.
- A description of the way to use this library and the process maps within the current organizational structure of APMT.
- A practical implementation plan to come to this use of the library.
- The start of this implementation plan by an introduction to the first user the project team responsible for the new terminal at Maasvlakte II, Rotterdam. The design of the operational processes for this new terminal will be based upon the model created during this research.
- The handover to the final owners of the library the Operations Implementation Support team.
- The support of the Operations Implementation Support team by a joint effort in introducing the library to its second user the new terminal team at Vado, Italy.

With these results the first deliverable can be checked off. It is however hard to measure the completion of the second deliverable: the creation of stakeholder engagement for the use of process maps. But it was already stated in paragraph 1.2 that this deliverable will not be realized but that instead a process will be designed how to reach this engagement and actually use the process maps. Looking at the last four results in the list above it can be concluded that also this second deliverable is reached. Not only because the introduction of the implementation was already brought into action but also because the discussion about process mapping is primed and the topic process mapping is set on the monthly agenda.

### Conclusion

The viewers and editors versions of the process library and the usage-process are evaluated as value adding for APMT. Furthermore all set up goals and requirements are settled. The successful introduction to Maasvlakte II and the handover to Operations & Implementation Support support this conclusion. The set up usage-process and organizational structure will ensure the continuation of these steps in the future.
9. Conclusions and recommendations

The previous chapter evaluated the research results and discussed the outcomes for APMT. This chapter will present the conclusions stemming from these results answering the main research question. Subsequently, all findings from the previous chapter together with the conclusions in this section will be translated into recommendations for APMT and further research.

9.1 Conclusions

Automation of processes at container terminals is a possibility for APMT to meet the expanding volume of container traffic. The first step in the path towards automation is the understanding of these processes. Process mapping, a method to visually represent processes, is one of the most widely used methodologies to create this understanding. Besides understanding, literature showed that process maps can support in: process standardization, storing information, indentifying opportunities and risks, creating process ownership, improving communication and establishing process performance measures. APMT has the preference to use this method in the trajectory towards container terminal automation. There is however no unity in the application of process mapping within APMT and there is no clarity on how and why to use process maps. Besides these problems in practice at APMT, theory showed that process mapping projects often do not reach the full potential of this method. Creating process maps is most of the time more important than using them. They are ends instead of means. To overcome these problems this research was set up around the following main research question:

0. How can process mapping be implemented in APMT’s container terminal automation process to fully exploit its benefits?

Two findings emerged from this research that can make process mapping a value-adding tool. The first finding is that the ability of process maps to cope with changes should be increased. The second key finding is that a playing field should be created to actually use process maps. This research proofed that the introduction of the following research results can achieve this:

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<th>Conclusion</th>
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<td>A hierarchical coupling of basis maps, creating a process map library, will increase the resistance to changes. Because the basis process will in general be the same at different locations and over time the maps will be reusable. These basis maps should be tweaked to specific situations making the users editors instead of authors of process maps. This will create efficiencies and even ensures process standardization. Furthermore a hierarchy can, because of its connections, show implications of changes and ensure coherency in other process documentation.</td>
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This will ensure that process maps can cope with dynamics but does not secure that the implementation will be successful. Therefore:
Conclusion
It should be acknowledged that there are different users. Process maps should take these differences into account. At a high level the specific characteristics of the organization and at a practical level the different skills and preferences of users. This can be reached by incorporating the usage of process maps in the current trajectory of the organization and creating different interfaces for the process map library. An interface for viewers, users interested in the information the maps withhold, and for editors who will actually be tweaking the process maps to create their own project specific process map package.

With a clear view on when en how to use process maps the actual implementation should be ensured.

Conclusion
Implementation can be reached by gradually embedding the responsibility and support for process mapping in the organizational structure. This can be done by appointing process owners per project and a global process owner who provide support to the users and are responsible for the gathering of feedback.

The fact that the implementation of these research results are already successfully implemented at APMT underpins the drawn conclusions. Within APMT two versions of a library of basis process maps for an automated container terminal are incorporated in their trajectory, the Process Excellence Life Cycle and Project Implementation Framework. The usage is supported by their Operations and Implementation Support department, the process owners. Realistic direct consequences will for example be more efficient and coherent creation of standard operating procedures and job descriptions in automated terminal projects.

The results of this research support the idea that process mapping is a value-adding tool. It is however questionable if it is the complete answer. To discuss this issue one word deserves more attention: the conclusions do not provide for a complete decisive answer if the result fully exploits the possible benefits of process mapping. An analysis of the methodology process mapping, the organization APMT and the technological implications of the system lead to an extensive list of goals and requirements. This list represents the full possible potential of process mapping for APMT. Due to the scope of this research not all of these goals and requirements are met but it was evaluated that this has no direct influence on the success of the results. It gives however reasons to continue this research and to set up recommendations, which will be done in the next paragraph.

9.2 Recommendations for APMT
Taking into consideration the conclusions and the fact that this research already brought the results into the first step of implementation the main recommendation is: continuation. It is recommended to continue the introduction of the process maps into the several projects. All preparations for this introduction are set up within this research project. After the hand over to the Operations and Implementation Support department it is up to these new process owners to reach the sketched
benefits. But, besides this general statement several other recommendations came forward from the evaluation of the goals and requirements set up in the analysis phase of this research.

**Recommendation**

The hierarchical library should become the sharepoint of process related information.

Process maps are at itself process information, but with the ordering of the maps in a hierarchical structure this research created a possibility to further enhance the management of process information. It is recommended to add several layers of process specific information under the library.

![Diagram](image-url)

**Figure 36: The hierarchy as a sharepoint of process related information.**

Figure 36 gives a first conceptual setup of such a structure. Every sub process will be worked out for e.g. different modes of operation. For each of these modes best practices from different locations including the documentation on standard operating procedures can be added. In this way this documentation can be exchanged between projects creating efficiencies due to learning. Furthermore it is suggested to include the process descriptions for each specific vendor of the equipment and job descriptions for all functions in these processes. It should however again be emphasised to only add process specific information because the virtual terminal, that is currently under construction, will be the information platform for all information related to automated terminals.
**Recommendation**

APMT should use the process maps to set qualitative key performance indicators.

The current KPIs within APMT are quantitative, focused on productivity and speed. The quality of the process determines these indicators. If the quality of the process is ensured the other outputs will follow. Especially with the currently changed focus within APMT on *earning the customer* it is essential to measure the quality of the process. Terhürne and ter Welle (2007) suggest that KPIs of processes can not only be measured at the input or output but also in the process itself. This research supports this idea and suggests that with process maps a first step in the direction of measuring the process itself can be made. These indicators can be identified by searching the process maps for key moments that determine for example the safety or speed of the process. By comparing practice with the process design it can be examined if the indicators are met. To implement this recommendation further research within APMT is necessary. Because to be able to set key performance indicators (KPIs) for a process the indicators should identified, generally accepted and implemented throughout the entire organization. Especially because KPIs are not only for judging the performance of one process but also for benchmarking several processes.

**Recommendation**

A program should be set up to use the process map library to support and improve existing terminals.

It was observed during this research that the use of process mapping at the existing terminals of APMT differs widely. Several terminals use or have used process mapping but the majority of the terminals do not use it at all. Table 1 made clear that existing terminals that do use process maps do not reach the full potential of this method. Furthermore a comparison of the maps showed that there is no uniformity in the used representation techniques. To also reach the benefits of process mapping within the existing terminals it is recommended to set up a project to gradually introduce the existing terminals to process mapping. This project should (1) set up basis maps for non automated terminals and (2) design an implementation plan. This could ensure a uniform use of process maps; uniformity is the criteria to cooperate between terminals and to conduct reliable benchmarks.

With the experience form this research finally several practical recommendations for APMT can be made:

- Research the possibilities to use extra functionalities in the software package iGrafx. As stated in paragraph 2.1.3 iGrafx will be the software within APMT to create process maps. The usability of this software is good but after the extensive use within this research several suggestions for additions can be made. A list of ideas for these extra possibilities is added at the end of Appendix G. Because the version of the process map software used within APMT is created in 2006 it is well worth for APMT to investigate if newer versions might bring extra opportunities.
- To further complete the library it is recommended to add maps for processes including lift AGVs and automated shuttle carriers. Furthermore the creation of maps on the handling of exceptions will be a useful addition to the library.
- It is recommended to add a functionality to directly gather feedback from users of the viewers version of the library. This can easily be done by adding a feedback box under the maps in the viewers version offered at the internal company website.
- Efficiency in the marine process at a container terminal could be gained by letting the QC operator interact with the TOS. The entire task of the vessel foreman assigning the jobs to the QC operator will hereby be made superfluous.
- The current organization of the interaction between the HT and the QC is rather unsafe, a container or spreader colliding with HT is only prevented by human cooperation. It is recommended to examine this process to make it safer by for example adding traffic lights.
- To overcome the ambiguity of all the different terms used for different equipment it is recommended to create a list of synonyms, or to make the usage of standard terms obligatory to enhance standardization.

9.3 Recommendations for further research
Besides direct recommendations that can be picked up by APMT several recommendations can be made for further research. Mainly because of the limited time span of this project several issues could only be touched upon briefly in this research. But already in a quick exploration of these issues it became clear that they will be very interesting for further research:
- Activity Based Costing (ABC) and process mapping – ABC transforms overhead costs into direct costs by assigning the costs to activity pools. Process mapping could help in identifying these activity pools. At first it should be researched if process mapping can be coupled to ABC (for further information see Amsler, Busby et al., 1993) furthermore it might be interesting for APMT as well to see if an introduction of ABC adds value to their organization. This especially comes forward on discussion with the MVII project team on process mapping and ABC.
- Legislative compliance and process mapping – From the validation of the usage of process mapping for legislative compliance (paragraph 6.2) was concluded to perform extra research to see if this purpose of usage is realistic.
- Representation of time in process mapping – For making process maps useful in comparing alternatives, identifying critical paths and bottlenecks it is recommended to further research the possibility to include the element of time in process maps.
- Incomplete contracting and process mapping – This research already identified the possibility to use process mapping to complement a contract, but since this topic only was a side step in this research which got minor attention it is recommended to study the topic of incomplete contracting in relation with process mapping in depth.
10. Discussion and reflection
This research report has described the design of a hierarchical process map library and usage-process of process mapping for APMT. It resulted in the implementation of these designs to reach several benefits the method process mapping is set up for. Furthermore several recommendations have been made on how to extent the value of process mapping even further. With all the experience gained in the process towards these results it is now time to discuss and reflect. This chapter is split up in three parts. Firstly, in paragraph 10.1, the conclusions of the research are further generalized to set a discussion on process mapping. This section will discuss the added value of this research to the method process mapping. Furthermore the question if, after this research, process mapping can be called a dynamic method will be addressed in this section. This will try to answer the third research question, which was already on forehand set up as discussion question. Secondly in paragraph 10.2, a collection of insights in all other used methodologies within this research will be described with the goal to see if the application of these theories added value and if questions or additions could be made. The third part, paragraph 10.3, provides a personal reflection on the research project.

10.1 Discussion: Process mapping in a dynamic environment
Paragraph 9.2 summarized some clear tangible results of this research for APMT. Besides APMT it is important to see if there are intangible results and other fields that can benefit from this research. This paragraph will look at the possibilities to generalize the research results. It will try to see if from the for APMT specific designs points can be added to the use of process mapping in general. In doing so this paragraph will try to answer the third research question:

3. How can process mapping deal with the tension between it’s static characteristics and a dynamic distributed multi-actor environment?

To be able to answer this third question it should first be clear how the spectrum from static to dynamic looks like, and what the positioning of process mapping in this spectrum is. This will be followed by discussing how process mapping can deal with dynamics, which will answer the third research question.

10.1.1 Is process mapping static or dynamic?
There is no black and white classification of what static and dynamic is. This depends on the issue analyzed and the viewpoint over time. In light of this research there are three viewpoints. The dynamics of the system: the container terminal industry. The dynamics of the modelling method: process mapping itself. And, the dynamics of the trajectory: the implementation and usage-process of process mapping within APMT.

“A static system is one having structure without activity, as exemplified by a bridge. A dynamic system combines structural components with activity” (Blanchard and Fabrycky, 2006). But, this only holds for a limited time frame of reference because a bridge is constructed over a period, is maintained and finally demolished: a dynamic trajectory. In the field of modelling the static aspect of a model shows “the static structure of a system, in particular, the kinds of things that exist, their internal, and relationships to other things” (Rumbaugh, Jacobson et al., 1999). The dynamic view distinguishes from the static view showing “the aspect of a model dealing with the specification and implementation of behavior over time” (Rumbaugh, Jacobson et al., 1999). In other words the static view defines the processes, values,
and connections that can exist in a single snapshot in contrast to the dynamic view which defines how
the system moves from one snapshot to another. Static models describe situations as is and dynamic as
what if (Barber, Dewhurst et al., 2003). To clarify this view even further Klein gives a view on static
versus dynamic simulation models. “Static simulation model elements do not change during the
simulation model execution and are therefore constant. They may be hard-coded into the simulation
model or read in during the initialization phase of the simulation model, but remain the same during the
model execution. Dynamic simulation model elements have the potential to change their properties or
attributes during the model execution” (Klein, Schulze et al., 1998). From these views static is, in light of
this research, formulated as a stationary, not active, changing or moving method. A user of a static
method receives the method in its fixed end state and if desired it should actively change things in the
method itself. The antonym of static, dynamic is considered as active and changing. A dynamic method
could result in different outcomes. This however does not implicate anything about the dynamics of the
trajectory. A trajectory of a static model can be dynamic. The code of a simulation model itself is for
example static but when a user interacts with the model different outcomes can be created. This
exploration confirms the statement that the determination whether something is dynamic depends on
the viewpoint.

But what does this mean for the method process mapping in this research. The uncertainties about the
future, the innovative aspects of automation and the distributed characteristics of APMT clearly make
the system dynamic. The created basis maps however are static models, snapshots in time. So it can be
concluded that there is a tension. The maps are static and have to be used in a dynamic system. The
usage trajectory should therefore be dynamic. The succeeding paragraph will discuss this topic.

10.1.2 Six ways to deal with dynamics

As stated process maps are in the viewpoint of this research considered as static. So if something
changes in the dynamic environment a static map might not be that useful anymore. This research came
up to several tools to overcome this problem. This paragraph will discuss which of these tools can be
generalized to be used in other process mapping projects, which will answer the third research question.
The first most obvious way to let process maps cope with dynamics is to make it easier to change maps.
By creating basis generic process maps this can be enhanced. These basis maps can be tweaked to
correspond with a changed environment or represent different scenarios. By having generic basis maps
the users become editors instead of authors which increases the efficiency of map creation and thus
enhances the use of this static tool in a dynamic environment. It is however a trade off between
standardization and detail level.

1. Basis standard process maps turn users from process map authors into editors which will
increase their productivity. Furthermore it sets a basis for process standardization and makes it
easier to adjust the static process maps to changes in a dynamic environment.

Continuing on the previous point, there are several other methods to enhance the changeability of
maps, which makes it easier to cope with dynamics. At first a software tool can be created that allows
for huge intra-map changes, for example to change certain terminology. The type of tool to make it
easier to change maps depends on the software package used and the demands of the users. Besides
improving the software, the changer itself (the user) can also be improved by providing training. These
two possibilities will not make the maps dynamic but the trajectory of usage. This will make it easier to meet changes in a dynamic system.

2. By changing the process map software or changing the user by training, the ability to change process maps can increase making them more resistant to dynamics. Instead of changing the maps it could also be prevented that changes are necessary. This research showed this can be reached by organizing the connections between process maps in a hierarchical way. Because changes are often at lower levels with much detail the higher hierarchical levels will not be influenced by the dynamics. Looking at an example of discharging a vessel will clarify this. At the top level the process map is describing the interaction of the quay crane with horizontal transport. At a lower level this horizontal transport is split up in specific maps for SCs and AGVs. If the SC or AGVs are replaced by a new innovative type of transport the higher hierarchical process map does not have to be changed. Furthermore a hierarchy can, because of its connections, show the implications of changes at one side of the process. So the consequences of dynamics will be supported.

3. Instead of having loose maps a hierarchical structured connection between process maps can help in dealing with dynamics. Detailed changes will not affect the general basis maps at the top of the hierarchy. Furthermore a hierarchy shows the implications of changes at one end of the process supporting the consequences of dynamics.

Another way to prevent changes is to accept that process maps themselves are not dynamic and let them be the input for other tools than can cope with dynamics. In this way process mapping itself does not cope with the dynamic environment but it supports in dealing with it. An example can be to set up a dynamic simulation model on basis of the processes mapped.

4. By making process maps the input to other tools, they can support dealing with a dynamic environment instead of having to cope with it themselves. These four tools to cope with changes do however not weather the storm. An important aspect when dealing with a dynamic environment is to be aware of what is changing in this environment and what the implications are of these changes on the process maps. In order to get informed a playing field should be created for feedback on the processes and their environment. The spectrum of gathering this feedback stretches from no possibility for feedback to a completely open source model. Depending on the situation a clear position should be taken in this spectrum because it is undesirable not to gather feedback but also unwelcome that every user is able to change the model.

5. Coping with dynamics starts with being aware of dynamics. By creating a playing field to gather feedback about process changes and their implications it will be easier to keep the process maps in line with the dynamic environment. When aware and capable of dealing with dynamics a final step should be set. Because, if there is no pressure and goal to keep the maps up to date to changes, this will not happen. This research proved that process maps will always stay ends and will never become means if there is no organizational process that increases coordination of the use of process mapping. This organizational structure logically depends on the current structure of the organization where the mapping project is situated in. Examples can be introducing the function of a process owner per project who is connected to a global process owner. But it is not only about this hard fit with the organizational structure it is even more important to focus on the soft process management issues of this structure. Because, without a transparent structure that takes into account the values of the stakeholders involved in this structure the of an organizational
A special point of attention is the implementation of this structure. Speed of this implementation should be ensured while in the meantime the focus should still be on the substance: up to date process maps.

6. Without a goal or pressure to cope with changes, this will not happen. An organizational structure that fits within the current organization and an implementation process to introduce this structure are essential to prevent process mapping to become a one shot effort.

These tools together are the answer of this research to the third research question. It should hereby be noted that process mapping just never will be dynamic. A process map itself is like a movie script and thus by definition static, when interested in the changes in processes one should make a game instead of a movie script. It is however possible to keep the process maps up to date creating multiple scripts over time which is the closest a script will get to a game. These tools are a charter to reach this making the usage trajectory dynamic instead of the maps.

10.2 Reflection
Paragraph 1.2 made clear that this project is practical in nature but formulated and defined as a scientific project. Meaning that there might be possibilities to apply, question or add things to current theory. Therefore the research was based on several theoretical pillars related to process mapping, design theory, theory on complex logistic systems, stakeholder methods and theory on validation. This paragraph will critically reflect on the used pillars, with the goal to see if the application of these theories added value and if questions and additions could be made.

10.2.1 Further reflection on process mapping
Besides the new tools for working with process maps presented in the previous paragraph it is important to reflect on some other process map related issues.

First the view on setting up process maps: currently there are two methods the bottom up- and the top down approach (see paragraph 2.1.4). From the experience gained in this research it can be concluded that neither of these methods is correct. Creating process maps is about classifying processes, creating detail level and puzzling how to cope with all the interdependencies between processes. Setting up a hierarchical structure to come to a certain level of detail goes hand in hand with creating the actual process maps because all these interdependencies will not be known yet. So process maps will never fit into a hierarchy created beforehand in a top down approach. But the other way around a bottom up approach could only come to a clear hierarchy after several time consuming iterations. Besides it is not necessary to create all the bottom processes to be able to create the higher connections. So it is recommended that classifying process maps should go hand in hand with the actual creation of process maps. It is a process of learning by doing.

A second remark on the current thoughts on process mapping is that some of the identified benefits might not be realistic benefits of process mapping at all. Instead, stating these benefits could only set false pretences. It is therefore essential to identify these false benefits and eliminate them from the possible potential of process mapping. First, the usage for legislative compliance, which came forward from the statement by Ferla (2004) that the legislative driver is one of the most important drivers behind process mapping. From the findings in this research it is concluded that an audit for legislative reasons will not be performed upon the process maps but on other more detailed process documents.
This conclusion is however only valid for processes similar to the logistic process in this research, because it could be that in business processes of for example financial institutions a process map could help in legislative issues. It can however be added that process maps are found to be useful in the legal field of contracting. Paragraph 5.2.2 extensively described that process maps have the ability to further complete contracts. A process map can decrease the information asymmetry between for example a buyer and vendor by adding to which process the product should comply with. This will give the parties something to refer back to in the renegotiations or legal interventions at later stages. Furthermore it might be misleading to state that process mapping is a platform for process information management. Process maps are indeed a way of storing information, but will more likely be a component of a knowledge sharing platform. Maps show were information is but, because of limitations in representation, do not show all information about processes. Finally it is important to state that it can not be concluded that process mapping is absolutely univocal the best way for describing processes, several other methods (analyzed in Appendix C) could also do the trick. The choice which method to use depends on the situation in which it will be used, for example the experience within the current situation could be main driver behind this choice. So not the possibilities a method provides for are decisive but the situation like the organization and the users are. It is worth researching if the above stated tools could also be generalized to these other methods.

10.2.2 Reflection on the validation theory

Looking back at the validation of the designs by using the tracer method (Woodward and Eilon, 1966) and expert interviews several critical evaluating notes can be made using Cook and Campbell (1979). Because parts of this research can be quickly related to the project that is being set up in Rotterdam at the Maasvlakte II the respondents in the interviews might attempted to present themselves more competent providing extra positive reactions on the project which can bias the validation. An example might clarify this. The project at MVII, being the first candidate for using the library, was sometimes used as an example in certain validation questions. Because respondents might have an eye on a position in this project the reliability of some parts of the validation might be at stake. It is hard to pinpoint this threat, named evaluation apprehension by Cook and Campbell (1979), at certain parts of the design to overcome it, but it is a reason to always question if the design really is what we think it is. This is further supported by the critical thought that the validation might be jeopardized by the interaction some of the respondents had before and in other situations. Some of the interviewees involved were also consulted in the preceding research (Farré, 2008; Oya, 2008) which might have changed their input. Maybe it enhanced their feedback because they had better prior knowledge or it limited their thinking because the route the preceding research took might not have been completely in line with the used validation techniques in this research. The following imaginary example will clarify this further. If the preceding research did not completely take into account the core values of a respondent, by only focusing on a specific process without making the role and benefits of the respondent clear, the respondent might not take a sequential interaction just as seriously.

But it should be mentioned that not only a preceding research can influence the validation reactions of a respondent also the interaction within the research might be of importance. In this research for example, because some of the respondents were also interacting in the design phase they might have learned and changed which influenced their reactions in the validation phase. From these three
reflections can be concluded in general that when validating by consulting experts one should take into account the history and future interactions of the expert with the issue at hand to prevent a bias of its responses.

10.2.3 Reflection on process management and organizational theory

Even though the method of applying process management principles and organizational theory were not the main pillars of this research it is worth setting a brief comment on the way it can have affected this research.

De Bruijn and ten Heuvelhof state: “strategic behaviour is a fact” (2002), even though the implementation process in this case is not completely similar to a decision making process it also became clear that even here stakeholders behaved strategically. During the span of this research a re-organization took place within APMT which could have increased this strategic behaviour. In theory there maybe is a logically best way to organize the project but in practice some stakeholders might keep some parts for themselves which makes them irreplaceable, these are threats as effects of events other than the research itself. This is maybe magnified by the threat that Cook and Campbell (1979) call the threat of experimenter expectancies, the expectancies of the researcher (notwithstanding the unremitting effort of being objective) and the innovation team might have biased the results in a positive way. From this can be concluded that it should not be a surprise if bumps in the road towards complete implementation occur, because some tasks will have to shift from one stakeholder to another which will incite strategic behaviour in times of job insecurity.

Reflecting further on the used process management theory (see 7.2) it can be stated that the four process principles of de Bruijn and ten Heuvelhof (2002) were and will in the future be very important for the success of the implementation process. It is however experienced that with a focus on openness, protection of core values, speed and substance the success of the implementation is not absolutely guaranteed. The success of the implementation of the research results is absolutely not only determined by the content and the four process management principles. The experiences confirm that the non-substantive skills of the manager of the implementation process are even as important. For example enthusiasm, perseverance and people skills. De Bruijn and ten Heuvelhof (2002) briefly touch upon this issue in their description of the role of the process manager, but it is in my opinion the fifth process design principle. When the manager of implementation would ensure a totally open process, protected all core values and manages the trade off between speed and substance of the process the process could still fail. When the manager itself for example is totally not inspirational and is not able to boost other participants in the process.

Besides the process management principles the set up organizational structure (see paragraph 7.3) was based on several theoretical concepts. The coordination principles of Mintzberg (1983), Veryard (1994), Stoner and Freeman (1992) and Hedlund and Dunning (1993). The reflection on these principles is less critical because they fitted very well into the set up organizational structure. The principles directly served as a starting point for this structure. Time should however tell if these messages are transferred to the eventual users of this research, because it is always easier to state theory than to actually implement and use it in practice. It could however be added that the coordination principles will in practice be mixed and implemented gradually. This project is at first based on standardization of inputs (the basis maps), the use the same tools (iGrafx) and mutual adjustment. Only at a later stage the work
processes and skills can be standardized to further coordinate the use of process mapping. This will be done by the liaison of the OIS department. This implementation of the theory in practice showed that a ranking on importance and over time should be considered when using the principles of coordination.

10.2.4 Reflection on the design theory

The approach to the problem statement in this research was based upon a combination of the metamodel (Herder and Stikkelman, 2004) and the design cycle (Takeda, Veerkamp et al., 1990). After the use of this methodology in practice, this section will evaluate the combining of these approaches. The first step in the combined approach, where the metamodel was leading, is about coming to a design space by performing a system analysis. Figure 37 presents the parts of the metamodel present in research phase I.

Figure 37: Metamodel components of research phase I (Herder and Stikkelman, 2004).

Reflecting, with the experience gained in this research, this structure should be considered questionable. Firstly because, in practice the objectives turn out to come forward from the analyses of the system instead of from the requirements. Some objectives are requirements or constraints, but constraints certainly also come forward from the system analysis. Furthermore the solution space is not developed separately from the requirements, the requirements determine the solution space. In this sense the solution space is similar to a linear programming optimization but with multiple dimensions determined by socio- and technical factors. Figure 38 is a simple representation of this idea.

Figure 38: Simple representation of a solution space.
The second perceived flaw of the metamodel, is the lack of a feedback loop after testing the design. This was overcome by introducing an iteration in the model based on the Takeda’s design cycle (1990); the design is tested (validation) to come up to a detailed design instead of directly selecting it. In practice it turned out that one part of the design (the process maps) did not need a full second iteration because several smaller adjustments after the validation phase already resulted in a satisfactory design. Concluding, introducing a cycle in the design is useful to come up to a more realistic design but the number of iterations should not be pre-determined. A single iteration could already be satisfactory and multiple iterations could be necessary in other design projects.

10.3 Personal reflection

In addition to the reflections on the used methodologies in this research, which are logically also personal reflections, this paragraph will add some further personal remarks to this research project.

First, I would like to add a remark on the generalization of the research results. The final results and the start of the implementation within APMT are very promising, in my opinion this research has a high usability. Therefore it might also be useful to implement the designs in this research in other process mapping projects. The proposed six tools in the discussion are hereby the most usable in other projects.

But, this project was performed only in one situation, a very specific situation, the container terminal sector. So to be really able to generalize the conclusions several other mapping projects in other sectors using the designs of this research should be performed. Especially because the stakeholders involved in this research, in the end, all had the same objective, automation of their container terminals. It might be very interesting to see what the effects on the designs would be in a situation with even more conflicting interests.

Secondly, by an extensive literature research within this research I tried to come up to the full potential of the method process mapping. I identified all possible purposes to use process mapping and requirements to reach these purposes. It is in my opinion however always questionable if I was able to identify all purposes from literature. Besides, the most beneficial purposes will differ between projects or in some projects there will even be trade-offs between purposes.

After these critical notes it is in my opinion worth mentioning the way Bots (2005) described design at the faculty of Technology, Policy and Management (TPM, the faculty at which this research is performed):

\[ \text{Client problem } \rightarrow \text{Design problem formulation } \rightarrow \text{Design } \rightarrow \text{Artefact} \]

Whereby Design is seen as a “representation of an artefact (the library of process maps) and of the environment in which this artefact is realized (the usage-process)” (Bots, 2005). This artefact is eventually implemented in the client’s problem situation. Looking back I conclude that this research was designing in the TPM way.
References
References

Literature


Maier, M. W. and Rechtin, E. (2002). The art of systems architecting, Boca Raton (USA), CRC Press LLC.


Interviews
All personal information on interviewees is confidential and therefore not visible.


**Internal documentation**
All detailed information on internal documentation is confidential and therefore not visible.


APMT Standards and guidelines (2007). Process map of marine harbor crane and RTG and SC.


Int. Pub. XI (2008). Narrative document to support operations managers in using the operations project plan 7.0.


Gottwald port technology (2003). APMT Virginia Portsmouth simulation study: Simulation supported design of a RMG yard and horizontal transportation system for a future import-export terminal.

Appendices
Appendix A: Positioning of the research project within the organization.

The goals for this research project come forward from goals stated at a higher level. This appendix makes the positioning of the project within the organization clear to fund further why it is performed. Figure 39 presents the project in the entire organizational chart of the A.P. Moller-Maersk group.

**Figure 39: Positioning of the project within the organization.**

It should be noted that for example the existing terminals and project implementation activities take place all around the world. APMT is a very distributed organization and decisions can be different all over the world due to different circumstances.

The automated yard project should in the end contribute to the goals of APMT. To see how the means of automation helps to reach (Int. Pub. VIII, 2008) the goals of the organization Figure 40 is set up:

- Automation logically decreases labour costs.
- CAPEX of an automated terminal will be higher than of a normal terminal. But the land use can be minimized.
- The increase in speed and efficiency with automation will increases the capacity which will make the terminal able to handle higher demands. Besides that these higher speed and efficiency will also decrease the cost per move.
- Other benefits of automation include a decrease of emissions and an increase in safety and quality. For example more precise promises can be made to the customers about the service level.
All these influences at a lower level in the end contribute to the overall goal of APMT to enhance continuity of the company.

Figure 40: Influence of automation on the goals of APM Terminals.

With this description it is made clear that the automation serves a useful purpose within the goals of APMT. To first step to automate processes is to understand the processes. Process understanding is created within APMT by describing the processes in process maps.
Appendix B : Adaption of the design methodologies

Paragraph 1.2.3 suggests the methodology to be used in this research. This methodology is based on two existing design approaches: the metamodel and the design cycle. In the left side of the adopted Figure 3 the metamodel is leading: the top left three boxes of the metamodel are taken together in one block the system analysis this is the awareness of the problem in the cycle. By looking at the entire system consisting of the methodology, the technology and the organization, the list of goals and requirements are formulated stretching the design space (the suggestion). In the right side of the adopted Figure 3 the design cycle is leading. The development will be evaluated by a developed test. This cycle will be gone through twice to come to the final conclusion of design.

Figure 41: The metamodel: a generic model of the design process (Herder and Stikkelman, 2004).

Figure 42: Design cycle (Takeda, Veerkamp et al., 1990).
Appendix C: Analysis of process representation techniques

In this appendix various techniques to represent processes (see Mayer, Benjamin et al., 2000) are discussed. The goal of this analysis is to identify extra possibilities to incorporate in the representation method process mapping that is currently used within APMT and will be used within this research. Furthermore the discussion of other techniques can show the flaws of process mapping, these flaws show what the potential benefits of representing processes could be. The conclusions of this appendix are incorporated in paragraph 2.1.

Workflow patterns

Workflow patterns are based upon the patterns language (Alexander, Ishikawa et al., 1977). This is a structured method of describing good design practices within a field of expertise. Using this pattern language as a basis several perspectives on workflow modelling are distinguished by van der Aalst (2002). “The control-flow perspective (see Russell, ter Hofstede et al., 2006) captures aspects related to control-flow dependencies between various tasks (e.g. parallelism, choice, synchronization etc). The data perspective deals with the passing of information, scoping of variables, etc, while the resource perspective deals with resource to task allocation, delegation, etc. Finally the patterns for the exception handling perspective (see Russell, van der Aalst et al., 2006) deal with the various causes of exceptions and the various actions that need to be taken as a result of exceptions occurring” (Workflow patterns initiative, 2007). Analyzing these perspectives and comparing them to process mapping lead to several conclusions:

- It should be considered to further include the flow of data (see Russell, ter Hofstede et al., 2004) in a process map because this can enhance the purpose of communication with IT parties.
- Further inclusion of resources, than the currently included swimming lines, in the process maps like Russel and ter Hofstede (2004) suggest will not have any added value for this project because it would only make the maps unnecessary complex.
- The handling of exceptions (Russell, van der Aalst et al., 2006) however provided a useful insight for process mapping. The following figure provides an overview of the incorporations of exceptions.

![Figure 43: Exceptions handling (Russell, van der Aalst et al., 2006)](image-url)
For reasons of readability one can imagine that this type of modelling will not directly be implemented in the process maps. But the way exceptions are identified by Russell could give grip in the identification of exception processes in the terminal. By structuring the brainstorm for exceptions along his five distinct groups: work item failure, deadline expiry, resource unavailability, external trigger and constraint violation. Testing all processes on these five exceptions could significantly expand the list of other operations.

- Finally the control-flow perspective (Russell, ter Hofstede et al., 2006) describes how to, for example, handle parallel and exclusive processes. Paragraph 2.1.2 takes these issues into account.

**Flowcharting**

“Flowcharting is a graphic representation of the sequence of steps that make up a process” (Damelio, 1996). So one can imagine that this technique is very similar to process mapping. The main difference is that a flowchart usually does not attach functions to activities. Besides, the flowcharting methods make more use of intelligence in the chart than process mapping. By intelligence, the use of symbols to represent what actually takes place in the work process is meant. Symbols for documents and databases will be familiar for many. This is directly the main learning point for process mapping from the analysis of this method. Including several symbols in the process map can increase the information a map can represent and enhance the insight in the process for the users.

**IDEF (Integration DEFinition or Icam DEFinition language)**

“IDEF0 was developed in order to represent activities or processes (comprising partially ordered sets of activities) that typically are carried out in an organised and standard manner” (Kim, Weston et al., 2003). Whereby a function is “a set of activities that takes certain inputs and, by means of some mechanism, and subject to certain controls, transforms the inputs into outputs” (Institute of Electrical and Electronics Engineers, 1998). Figure 45 presents this type of representation. Generally an entire IDEF model consists of a context diagram which comprises all related diagrams hierarchically decomposed.
under this context diagram. “This hierarchical decomposition results in both wide-scope and detailed representations of environmental or system activities” (Kim, Weston et al., 2003).

This is a very important result from the IDEF method that is also a goal for the models that need to be set up in this research because this hierarchical setup allows to include details. A second learning point from the IDEF method is the process documentation around the model itself. Each and every model is clearly tagged with for example the author and status. So in conclusion in should be considered to create the process maps in the form of a hierarchy whereby each map itself is clearly documented.

American Society of Mechanical Engineers (ASME) mapping standard
For detailed level mapping Peppard (1995) recommends the widely used ASME standard, because in this standard an evaluation is inherited of whether a step is value adding. This standard comes forward from the field of total quality management (see Oakland, 1998) with the goal to split non-value-adding or waste processes from value adding steps.

Figure 45: IDEF model with documentation (Institute of Electrical and Electronics Engineers, 1998)

![Figure 45: IDEF model with documentation (Institute of Electrical and Electronics Engineers, 1998)](image1)

Figure 46: ASME mapping standard (Peppard and Rowland, 1995).

![Figure 46: ASME mapping standard (Peppard and Rowland, 1995)](image2)
In Figure 46 can be seen that the processes in the first column are the value adding processes. This might be interesting to include in this research for the purpose of process improvement (see identified purposes in paragraph 2.1.1). The other elements of the method shown in the figure will not add any value to process mapping because the representation differs too much.

**Conclusion**

From the analysis of other techniques for representing processes can be recommended that the following points should be included in the used method in this research.
- The identification of exceptions processes should be structured by the exceptions handling perspective of the workflow patterns approach.
- The intelligence of the symbols from flowcharting should be considered in the visualization design choice.
- By using the hierarchical set up of IDEF, both a wide-scope and detailed representations of the processes can be achieved.
- The documentation of the IDEF model should be considered in the process map design.
- Splitting up processes in value added and non value added steps like in the ASME standard could improve the support for process improvement.
Appendix D : Stakeholder analysis.
The six step procedure for this stakeholder analysis of Hermans (2005) is used in this analysis.

1) Define the purpose, questions and conditions for stakeholder analysis:
The purpose of this stakeholder analysis for this research is twofold. The first goal is to identify which stakeholders can provide further input in the research. Secondly the end-users should be identified, bringing forward requirements and goals. Three different theoretical perspectives can be used to describe stakeholders and/or their interactions, focusing either on networks, perceptions or the resources of stakeholders (Hermans, 2005). For the first goal, providing input to this research, the resources of the different stakeholders are of interest. For the second goal it is important to have a clear insight in the perception of the stakeholders on the use of process mapping, so what are their goals and interest in this research? Besides that it is a condition to clearly demarcate the research with this analysis by focusing only on a few critical stakeholders. So it should also become clear which stakeholders will be excluded.

2) Preliminary scan of stakeholder network
A brought brainstorm supported by several internal documents, the existing process maps and a discussion with the project manager of the automated yard project resulted in an extensive list of possible stakeholders summarized in Figure 47.

Figure 47: Preliminary scan of the stakeholder network.
It should be noted that some indentified stakeholders in this figure does not seem real persons or parties, they are projects. The stakeholders are the teams or project managers behind these projects.
3) Identify stakeholders & 4) Collect primary input data

From this extensive list the stakeholders are identified and the primary input data on goals, interests and perceptions is presented in Table 3 according to Enserink, Koppenjan et. al (2004). This table gives insight in the goals, the main objectives, the stakeholders want to achieve. What these different goals mean in relation to the usage of process mapping is reflected in the interest. Finally their opinion on process mapping is reflected by the describing the current situation in the perception / current situation on process mapping. Besides that it shows which stakeholders fall outside the scope of this research.

The list of stakeholders is created along the new organizational design (Int. Pub. VII, 2008) implemented in the summer of 2008. The goals come forward from the general internal documentation of the several departments (Int. Pub. VIIII, 2008). The interests in process mapping mainly come forward from the different interviews (Interview II, 2008; Interview III, 2008; Interview IV, 2008; Interview V, 2008; Interview VI, 2008). The entire stakeholder analysis is finally validated in a discussion with the project manager of the automated yard project (Interview VIII, 2008).

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Goal</th>
<th>Interest in process mapping</th>
<th>Perception/ current situation of process mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal stakeholders(APMT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. New terminals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. HR</td>
<td>Create an organization that can win in the marketplace.</td>
<td>Help in determining type and amount of staffing. Usage of job description created on basis of process maps.</td>
<td>Not used in current situation.</td>
</tr>
<tr>
<td>1.2. Implementation</td>
<td>Implementing new projects; managing all aspects of an upstart business, develops tools &amp; processes, project planning, and some expert resource pools.</td>
<td>Help in communication with contractors. Support the project implementation manager (PIM). Incorporate in business process manual for an automated terminal.</td>
<td>Incorporated in the current business process manual. Serves as a basis for training and set up of standard operating procedures and job descriptions.</td>
</tr>
<tr>
<td>1.3. Design &amp; Innovation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.1. Design &amp; costing support</td>
<td>Support business development with operational input into business cases, including due diligence visits and the</td>
<td>Support in design of the terminal layout. Process maps will represent what should be handled in layout</td>
<td>Not used in current situation.</td>
</tr>
<tr>
<td>1.3.2. Operations &amp; implementation support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.3.2.1. Standards and guidelines</strong></td>
<td><strong>1.3.2.2. Terminal in a Box</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardize the operational processes by publishing standards, tools, templates and guidelines for both new terminal projects and existing terminals</td>
<td>Facilitate the sharing of information and tools used during the startup of new terminals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use process maps to set up of standard processes. Or compliance with ISO norms.</td>
<td>Add process maps of an standard automated terminal to the terminal in a box.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currently several basis process maps should be used by terminals to standardize process maps, this is in practice hardly used. For ISO it is only used on terminal level in North America. Not used on corporate level in the current situation.</td>
<td>Process maps are seen as an input for the terminal in a box.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.3.3. Innovation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.3.3.1. FastNet</strong></td>
<td><strong>1.3.3.2. Automated yard project</strong></td>
</tr>
<tr>
<td>Develop and implement new quay crane to double berth productivity and cutting vessel port stays in half.</td>
<td></td>
</tr>
<tr>
<td>Help in clarification of the FastNet crane process and help in communication to stakeholders</td>
<td></td>
</tr>
<tr>
<td>Process maps should be made in the future of this new crane concept.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.3.3.2. Automated yard project</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.3.3.2.1. Decision support tool</strong></td>
<td><strong>1.3.3.2.2. Procurement package</strong></td>
</tr>
<tr>
<td>Support in decisions on dimensioning of automated terminals.</td>
<td>Set up of standard agreements preferred suppliers on buying automated equipment.</td>
</tr>
<tr>
<td>Input of design parameters forth coming from the mapping</td>
<td>Help in setting up the functions of the too procure material in the package</td>
</tr>
<tr>
<td>Process maps are seen as an input for this deliverable.</td>
<td>Process maps are seen as an input for this deliverable.</td>
</tr>
<tr>
<td></td>
<td><strong>1.3.3.2.3. Design template</strong></td>
</tr>
<tr>
<td>Create template drawings that can be used to design the layout of an automated yard.</td>
<td>Input on which process should be incorporated in the design</td>
</tr>
<tr>
<td>Process maps are seen as an input for this deliverable.</td>
<td></td>
</tr>
<tr>
<td>1.3.3.2.4. Technical and IT specifications</td>
<td>Set up of technical and IT specifications for an automated terminal focusing on the yard (ASC).</td>
</tr>
<tr>
<td>1.3.3.2.5. Virtual terminal</td>
<td>Present a virtual environment wherein users can access and share information on an automated terminal in order to have quick and clear access to required information.</td>
</tr>
<tr>
<td>1.4. Process Excellence</td>
<td>Improve current business processes</td>
</tr>
<tr>
<td>2. Existing terminals</td>
<td>Manage a profitable independent terminal.</td>
</tr>
<tr>
<td>3. Corporate support team Safety</td>
<td>Provide a Global Competence Center to support the worldwide organization in the areas of Health, Safety, Security and Environment.</td>
</tr>
<tr>
<td>4. Corporate support team Legal &amp; Tax</td>
<td>Give legal advice to the business with a main focus on assisting in concluding contracts for project development.</td>
</tr>
</tbody>
</table>

**External stakeholders**

| Covering governments / local governments | Economic growth: efficient, safe and reliable mobility creating a wealthy, sustainable and enterprising | i.e. EU can come up with regulations on i.e. safety or obliged process description. APMT can show they are complained with these regulations with the help of process | Local government regulations differ around the world and set up implications for the standardization of the processes. |
### Table 3: Goals, interest and perceptions of the stakeholders.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Goals, interests and perceptions</th>
<th>Maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers</td>
<td>Profit maximization, quality, service, customer binding.</td>
<td>Use the process maps to make their products/services compliant with APMT’s processes.</td>
</tr>
<tr>
<td>Contractors (constructors of the actual terminal)</td>
<td>Profit maximization, quality, service, customer binding.</td>
<td>Use the process maps in the delivery of their services, adapting it to APMT’s process.</td>
</tr>
<tr>
<td>Consultants</td>
<td>Profit maximization, advice quality, service, customer binding.</td>
<td>Use the process maps as input for analysis (i.e. simulation models).</td>
</tr>
<tr>
<td>Customers (Shipping lines, rail operators, truck operators, logistics companies, etc.)</td>
<td>Profit maximization, quality, service, customer binding.</td>
<td>Use the process maps to adjust their process in able to create a better fit.</td>
</tr>
</tbody>
</table>

**Excluded stakeholders in this research**

- Terminal owners, Terminal operators, Labor unions / groups, Community stakeholders, World shipping council, Federation of European Private Ports Operators, etc.

4) **Structure and analyze data**

The previous table already was a first step in structuring the data. The clear view of the goals, interests and perceptions of the different stakeholders served the second goal of this stakeholder analysis. It is therefore still necessary to create insight in the resources of the stakeholders for this research. In the table below the resources of the different stakeholders are made clear and a step is made to create insight in the importance the stakeholders. This is done by identifying the dependency on the stakeholder and the possibility to replace the stakeholder within this research.
<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Resources / input</th>
<th>Possibility to replace</th>
<th>Dependency</th>
<th>Critical stakeholder ?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal stakeholders (APMT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. New terminals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. HR</td>
<td>No input in the research</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.2. Implementation</td>
<td>Input for the research from their current business process manual. End-user for the set up of a business process manual for an automated terminal</td>
<td>No</td>
<td>Medium</td>
<td>Yes</td>
</tr>
<tr>
<td>1.3. Design &amp; Innovation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.1. Design &amp; costing support</td>
<td>No input to the research</td>
<td>No</td>
<td>Medium</td>
<td>Yes/no</td>
</tr>
<tr>
<td>1.3.2. Operations &amp; implementation support</td>
<td></td>
<td></td>
<td></td>
<td>Yes (1)</td>
</tr>
<tr>
<td>1.3.2.1. Standards and guidelines</td>
<td>Input for research from their standard basic process maps. End-user for standardization in an automated terminal.</td>
<td>No</td>
<td>Medium</td>
<td>Yes/no</td>
</tr>
<tr>
<td>1.3.2.2. Terminal in a Box</td>
<td>No input in the research.</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.3.3. Innovation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.3.1. FastNet</td>
<td>No input, but can be used as a test end-user.</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.3.3.2. Automated yard project</td>
<td></td>
<td></td>
<td></td>
<td>Yes (2)</td>
</tr>
<tr>
<td>1.3.3.2.1. Decision support tool</td>
<td>No input,</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.3.3.2.2. Procurement package</td>
<td>No input</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.3.3.2.3. Design template</td>
<td>No input</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.3.3.2.4. IT specifications</td>
<td>No input</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1.3.3.2.5. Virtual terminal</td>
<td>Brings forward minor requirements and will be an end-user.</td>
<td>No</td>
<td>Medium</td>
<td>Yes/no</td>
</tr>
<tr>
<td>1.4. Process Excellence</td>
<td>Input for the research from their current</td>
<td>No</td>
<td>Medium</td>
<td>Yes/no</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Input for the research from process maps made for current terminals.</td>
<td>Yes, different terminals can be consulted.</td>
<td>Medium</td>
<td>No</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>--------</td>
<td>----</td>
</tr>
<tr>
<td><strong>2. Existing terminals</strong></td>
<td>Input for the research from process maps made for current terminals.</td>
<td>Yes, different terminals can be consulted.</td>
<td>Medium</td>
<td>No</td>
</tr>
<tr>
<td><strong>3. Corporate support team Safety</strong></td>
<td>No input</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td><strong>4. Corporate support team Legal &amp; Tax</strong></td>
<td>No input</td>
<td>No</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td><strong>External stakeholders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covering governments</td>
<td>Minor input in how to comply with legislation.</td>
<td>Covering: no; Local: yes, different governments can be consulted.</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Suppliers</td>
<td>No input</td>
<td>Yes, different suppliers can be consulted.</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Contractors</td>
<td>No input</td>
<td>Yes, different contractors can be consulted.</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Consultants</td>
<td>Minor input on how they use process maps in their models/simulations.</td>
<td>Yes, different consultants can be consulted.</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>Customers (Shipping lines, rail operators, truck operators, logistics companies, etc.)</td>
<td>No input</td>
<td>Yes, different customers can be consulted.</td>
<td>Low</td>
<td>No</td>
</tr>
</tbody>
</table>

**Table 4: Resources, input and criticality of the stakeholders.**

1. The operations & implementation support department as a whole can be seen as a critical stakeholder being an end-user of this research.
2. The automated yard project as a whole is a critical stakeholder being the most important end-user of the research, the individual deliverables within this project are not critical at itself though.

Furthermore it is important to mention that this analysis is performed to seek for the input for this research and to identify the users of process mapping. For the automation project or for example for the design and implementation of a specific automated terminal almost all stakeholders will be critical.
5) Interpretation of results

From the overview created in the previous tables the most important stakeholders can be subtracted. The classification of these stakeholders is important for the communication internally in this research and externally to the stakeholders themselves. Because the majority of the stakeholders are internal stakeholders an internal representation method is chosen (see Figure 49). This method is based on the stakeholder classification matrix in Figure 48. By using this method the internal stakeholders can identify themselves with the position in the matrix which binds them to the research.

Filling the matrix with the identified stakeholders results in the following conclusion for the stakeholder analysis.

Further interpretations of these results are presented in paragraph 4.1.
Appendix E: Hierarchical process map library for standard automated terminal

This appendix is set up to further describe how the actual design choices are filled in described in paragraph 5.1. This appendix presents the practical results of these choices. The goal of this appendix is to inform the one that is interested in the actual hierarchical process map library for a standard automated terminal on how this library is set up. This will be done by giving a description of the several sections in the library followed by an example. The final models can be found on the internal website communigate because they are considered confidential. This all together is the answer to the first research question and the result that satisfies the first requested deliverable (see paragraph 1.2).

As paragraph 5.1.1 on classifications described the library falls apart in five major sections. The first four sections are split up according to how the organization operates the terminal. Within these sections a split up is made between runners, repeaters (irregular runners) and strangers (Parnaby, 1988). These are defined by Armistead (1996) as:

- Runners are processes which are part of the regular routine.
- Repeaters are intermittent processes
- Strangers are processes whose occurrence is much less predictable.

Within the sections all processes that can be considered runners are represented. In the fifth section, other operations all processes considered strangers of all sections are documented. The process in between the runners and strangers the repeaters are presented or in the corresponding section or in the section of other operations.

1. Marine operations

This section provides the process maps for the marine operations. This section is split up in pre-operations, including the berth- and vessel planning and managing the marine operations. The marine operation is considered with loading and discharging the vessel into the stack. Considered are loaded, empty, reefer, OOG, break-bulk, damaged and hazardous containers. So within this section the following two interactions are documented:

- Interaction of the Quay Crane (QC) with the Horizontal Transport (HT)
- Interaction of the Automatic Stacking Cranes (ASC) with the HT

These interactions can be in the form of twin lifts, tandem moves or dual cycling. Documented for several types of HT like as Shuttle Carrier (SC), Shuttle Truck (ST), Terminal Tractor (TT) or Utility Truck (UTR) and Automated Guided Vehicle (AGV).

Furthermore this section includes the sub processes like: mooring, lashing and booming.

2. Yard operations

This section provides the process maps for the yard operations. This section is split up in pre-operations, including the yard planning and managing the yard operations. Yard operations comprises the execution of the various interactions with the stack and the control of the stack itself. These moves can be moves from the gate, rail, empty depot or maintainance area. The interactions with the Automated Stacking
Crane (ASC) are documented for several types of Horizontal Transport (HT) like road trucks, Terminal Tractor (TT) or Utility Truck (UTR) and Automated Guided Vehicle (AGV). Controling the stack includes performing shuffle moves and handling reefers. Several exceptions for stack management like severe weather or ASC breakdowns are included in the other operations section.

3. Gate
This section provides the process maps for the gate operations. This section is split up in pre-operations, including the appointment system and managing the gate operations. Gate operations comprises of the steps for the correct entrance or exit of road trucks at the terminal. The goal of the ingate is to gather information to fill up the property bag of information for a certain truck. Properties are gathered by A&P checks (Administrative and Physical checks): RFID check, driver identification, weight scaling, MT inspection, damage inspection, seal check, loadtype determination, container number, chassis number, and hazardous information. Whether this information is present depends on the type of visit, it can either be a loaded container, MT, reefer, hazardous, OOG, only a truck (bobtail) or a truck with an empty trailer. This information is transferred into a route for the visit with mission items, these mission items are checked at the outgate to verify the the trucks visit. The different subprocesses of gate operations can be seen as building blocks for the gate set up, which will differ for specific terminal characteristics.

4. Rail operations
This section provides the process maps for the rail operations. This section is split up in pre-operations, including the rail planning and managing the rail operations. The rail operation is considered with loading and discharging trains till the point they are ready to go into the stack. The split between the rail operations and yard operations is at the rail portal, the point were inbound containers are checked. The process of the horizontal transport (HT) from the yard to this rail portal and vice versa is documented in the section of yard operations.

When loading or discharging containers from a train they are temperarly stored in the Rail Buffer Area (RBA). There are two positions for this RBA documented:
1) Directly under the rail crane, whereby the rail crane loads or discharges the containers directly from the RBA on or off the train.
2) Separately, whereby HT is needed between the RBA and the rail crane. The rail crane loads or discharges the containers directly on these HT units.
From this RBA the containers are checked at the rail portal. They are subject to similar A&P checks as in the gate operations. Hereby it should be noted that for outbound containers the ideal rail portal is no rail portal, because containers are already checked at the gate or at the terminal of origin.

5. Other operations
This section provides the process maps for all other operations. In the process map library other operations comprises repeater and stranger processes from all other sections. Examples are M&R operations and exeptions link the process for severe weather conditions.
Within each of these the actual process maps are documented. The following example will further clarify the setup of the library.

**Example**

This example will take a closer look at how to retrieve the map of a road truck interacting with the automated stacking crane in the yard at the landside.

The first step is to look in the hierarchy at yard operations.

- **0. Terminal operations**
  - **1. Marine operations**
  - **2. Yard operations**
  - **3. Gate operations**
  - **4. Rail operations**
  - **5. Other operations**

**Figure 51: The library hierarchy, Yard operations.**

The user is provided with an overview of the processes documented in the section yard operations.

**Figure 52: Overview of Yard operations.**

Looking in the hierarchy the user is interested in the actual process during operation so it opens the process of managing yard operations.
The process map for managing the yard operations occurs. This high level process map shows the big picture wherein the pickup process at the landside is included.

Figure 54: Process map for managing Yard operations.

Opening the actual process for a landside pickup / drop shows the user the general steps in this process. This process shows the user that the actual process of picking up or dropping a container follows exactly the same process steps.
Figure 55: Process map for a landside pickup / drop.

This process map comprises the process interaction ASC – HT landside. Looking in the hierarchy shows the user the pickup / drop process at the landside is exactly the same for several types of horizontal transport but that the interaction process with the automatic stacking crane does differ per type of horizontal transport.

Figure 56: Types of interactions with the ASC at the landside.

Opening the process of the ASC with the road truck the process map of interest is retrieved.
Figure 57: Process map for the interaction of the ASC with a road truck.

Within this process map all visualisation techniques described in paragraph 5.1.2 are used. The user can furthermore see that within this map there are two sub processes. For example the landside automatic stacking crane move is modelled as sub process because this process also takes place in several other processes like the interaction of the automatic stacking crane with a terminal tractor. Taking general processes out of specific processes ensures that the library is mutually exclusive.
Appendix F : Detailed usage-process

This appendix consists of a detail of the usage-process set up in chapter 7. Figure 58 presents a detailed insight in the entire process. In this detailed design the implications coming forward from the suggested organizational structure (see Figure 32) are included creating a complete picture of how the results from this research can be implemented and used.

**January 2008**
The library of standard process maps for an automated terminal is introduced in Rotterdam. The automation team of the innovation department will act as process support centre. Feedback will be gathered and processed.

**February 2008**
The project is handed over to design or implementation support who will become the process support centre. The automation team of the innovation department will start the set up of a second release including an interface version.

**March 2008**
The library of standard process maps for an automated terminal is introduced to the Vado team. Whereby design or implementation support acts as the process support team. Feedback will be gathered and processed.

**June 2008**
The second version including an interface version will be released.

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**Global process owner**
Oversees the information and looks for further opportunities creates coupling to other projects.

**Process support centre**
Provide support to the users and processes feedback, best practices and SOPs back into the library.

**Project process owner**
Responsible that the entire package (often an editor) is coherent and used during the PELC cycle. Gathers and communicates feedback, best practices and SOPs.

**Editors**
This group will be the actual users tweaking the maps to the processes at the specific terminals. These users will use iGrafx to create their own process map package.

**Viewers**
This group only consult the process maps for information. These users will use the interface version of the basis maps or of their own specific package created by an editor.

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Figure 58: Detailed usage-process / implementation plan.
Appendix G: The interface version

To set a first step in the direction of a separate version for viewers a browser based interface is created. Paragraph 7.1 elaborated on the reasons for setting up this version, Figure 30 in that paragraph provided an overview of the interface version. This part of this appendix will explain the component so the interface version in detail which will help in the introduction to users and the handover to OIS. Furthermore recommendations for the editors version in iGrafx are documented at the end of this appendix.

Within the version an active applet is created to browse through the process maps in the library. In this applet the toolbar (Figure 59) makes it possible to zoom in and out and pan to consult the specific map. Sub-processes can be clicked to go deeper into the library.

Figure 59: Interface toolbar to consult the library

Beside the process maps, information about the process mapping project within APMT can be found (Figure 60) at by clicking at the ABOUT button.

Figure 60: About section in the interface version
Besides the information about the research there is information for users that get into contact with process mapping for the first time. To directly create a positive mind set information is displayed in several section on why, when and how to use the library (Figure 61). Further detailed information on how to use the interface version in this report is therefore unnecessary because the version explains itself.

Figure 61: Why?, When? and How? sections in the interface version

The Export section (Figure 62) provides the user to download the library in .pdf, .doc. or .ppt format. Furthermore the Editors version in iGrafx can be downloaded from this section.

Figure 62: Export section in the interface version

The entire version adjusts itself to the screen settings (resolution) of the user. For users with a high resolution it is possible to activate the hierarchy function. This adds the library hierarchy besides the applet.
Mapping to Manage.

**Add hierarchy**

---

**Figure 63: Hierarchy option in the interface version**

To be able to continuously use this version it is made possible to update interface version in case a new library or project specific library is created. This makes it possible to create an interface version for every project specifically. The added document to the library directory explains how to perform this update in five simple steps.

- **HOW TO UPDATE THE INTERFACE VERSION**

All these functionalities together result in a usable tool for this moment, paragraph 7.1 however already suggests possible additions that can be added when programming a second version.

Besides additions to the interface version several recommendations can be made to the software used for the editors version, iGrafx:

- Should be possible to adjust page setups for all process maps at once.
- Should be possible to add shape properties for all shapes in all maps at once, for example the layout and positions of fields like a note.
- It is currently possible to draw lines through processes, but after each adjustment in the map a line through a process repositions itself around the process it ran through.
- If a process is added to the hierarchy, the hierarchy should refresh itself automatically.
- It should be made possible to add departments twice to one map.
- It should be made easier to switch between two maps, for example by making it possible to start up the program multiple times so you can switch with the ALT-Tab function of windows.
- It should be made possible to create internal cross references in the process maps. For example to include the name / number of another map in the note of a process.
- Make it possible to automatically number processes in the hierarchy, which automatically renumbers when processes are set in a different order.
Appendix H: Validation protocols

Systems validation protocol
The validation is split up according to the four sections in the process map library: marine, yard, gate and rail. For each section two general validation steps are set up each containing sub steps with questions. These questions are based upon goals and requirements for the design (see Figure 18). Each question below makes a reference to the goal or requirement that is validated with the question. This protocol is not a prescription it serves as a guidance to prevent overlooking certain items.

Step 1: Real time process tracking on the terminal with the process participants. This step uses the tracer method (Woodward and Eilon, 1966) (see paragraph 6.1):
1.1 The process is tracked under guidance. While observing the process al process steps in the process map are validated (req. 4.3).
1.2 Every process participant briefly explains its tasks creating a full picture of the entire process. These participants do not have interaction with the process maps but when certain steps do not come up in their task description questions are asked on these missing steps (req. 4.3).

Step 2: Interview and a process walk through with operations managers
Using the described questions below this interview is a focused interview, remaining open-ended because it is held in a conversational manner (Yin, 1994). Whereby the role of the interviewee can also be considered as an informant rather than a respondent. After each question the level of the question is identified to make sure the entire set of the design is covered (see paragraph 6.1)
2.1 The interviewee is asked to introduce him/herself including a brief description of responsibilities and previous experience (Level 1).
2.2 The interviewee is introduced to the project by a presentation, to make clear why the interview is performed and what the interviewee can contribute. In this presentation the process maps and library are introduced and an example of the usage-process is shown to make clear what the contribution to APMT is.
2.3 The interviewee can react and ask questions during the presentation and after the presentation (Level 4).
2.4 The process maps are walked through in chronological order. At every activity, process and decision in the map the following questions are asked:
   • Is this step valid with reality (req. 4.3)? Is the terminology of the process uniform and clear (req. 4.1)? Is it at the right point in the overall process (req. 14)? Is it performed by the correct person (req. 1.2) (Level 2) Does it need any extra description (Level 5) (req. 1.3 & 8.1)?
   • Calling upon your experience, is the step specific for Virginia or will this be performed in this way in other terminals as well (Level 3) (req. 4.2)? Will there be other ways this process is performed in other terminals (Level 3) (req. 1.1)?
2.5 After the walkthrough the following generic issues are discussed:
   • Are there any processes or process steps missing (Level 2) (req. 1.1 & 1.3)?
• Is the linkage with the other sections logically incorporated in the hierarchical library (Level 3) (req. 14 & 14.2)?
• Looking at the section of other operations, are there any extra other operations for your field of expertise (Level 2) (req. 1.3)?

Acceptance validation protocol
The interviews performed for validating the acceptance will be based upon the following questions. This protocol is not a prescription it serves as a guidance to prevent overlooking certain items, especially because not all interviewees will have knowledge about all topics.

1. Validation of the purposes of process mapping
   1.1. What is/was/would be the position of process mapping in the develop phase of the terminal (req. 17)?
       1.1.1. Will the design be helpful in the creation of other documentation (like SOPs) and design discussions (req. 19)?
   1.2. Can this design support process standardization within APMT (req. 4)?
       1.2.1. Can the design for example support ISO compliance (req. 4)?
   1.3. Where and how will this design enhance communication throughout the process (req. 8)?
       1.3.1. Will this design be useful in for example communication with the TOS vendor or a simulation consultant (req. 8)?
       1.3.2. Can this design be used for training purposes (req. 18)?
   1.4. Can this design be used in for legislative compliance (req. 6)?
   1.5. Will this design be useful for process improvements (req. 2)?
       1.5.1. How could it be used in the PEX program (req. 17.1)?
   1.6. Will it, with this design, be possible to establish performance indicators in the process (req. 9)?
   1.7. Would you see this design as a form of information management (req. 5)?

2. Validation of the performance criteria
   2.1. Does the design present the information desired (req. 1.3)?
   2.2. Clicking around and looking at the design will this design be easily changed over time (req. 5.1)?
   2.3. Is it easy to retrieve and audit information from the library?
   2.4. Is the presented information ambiguous (req. 8.1)?

Looking at the tested goals and requirements it can be concluded that all important issues are covered, especially the performance indicators (see Figure 11). The issues not included in these question are related to topics the interviewees have no insight in, for example about the automated yard project (req. 21, 21.1 & 21.3) the virtual terminal (req. 22), HR activities (req. 20) or management structures (req. 11). These issues are discussed in with the third group (see paragraph 6.2) in the validation phase.
Appendix I: Argumentation structure research report

The statement was made in the pre-face of this research report that all statements made within the report together form a story line, the argumentation structure. As a guide to the reader these statements are brought together in this appendix to follow the line of reasoning ones more and to get convinced that the drawn conclusions follow logically from the research performed. Figure 64 shows the argumentation structure of analysis phase coming up to the root causes of the problem.

Container traffic volumes have been projected to double to one billion TEUs by 2020. APMT has the ambition to meet this expanding demand by managing 200 million TEUs in 2020. It is assumed that with automation this stated ambition can be reached.

Process mapping will be used in APMT’s automation process but it is unclear how this static method can be usefully incorporated in this dynamic process to be able to use it to its full potential and reuse it in the future.

The research objective is to design a process to exploit the full potential of process mapping within APMT’s automation process.

Process maps at their full potential ensure standardization, store information, identify opportunities, create ownership, improve communication, establish performance measures, reduce risks and increase the efficiency of creating other process documentation. But they need to comply with the indicators of density, maintainability, validity, re-usability and clarity to be usable to reach its full potential.

The indicators for process maps can be influenced by altering the design choices on classifications, the detail level, the type of visualization used and the procedure to create the process maps. The design choices are directly imposed by constraints and generate several drawbacks that should be taken into account. The most threatening drawback is that the process maps will become a one shot effort that cannot cope with a dynamic environment. So by only creating the maps the full potential of process mapping will never reached therefore the map should be used.

The design space from the perspective of the methodology is set up resulting in the full potential of process mapping. It became clear that if APMT will continue using process mapping in the automation process they should try to exploit this potential while preventing the drawbacks to occur. This can be reached by integrating the use of process mapping in the automation process taking into account the current usage.

The confrontation of theory and practice made clear that there are two root causes for not using process mapping: (1) there is no unity in the application of process mapping within APMT and (2) there is no clarity on how to use process maps. From the analysis of the methodology, technology and organization a list of requirements and goals is conducted which stretches up the design space for the two deliverables within this research that will tackle the two root causes: (1) a hierarchical library of basis process maps and (2) a usage-process.

Figure 64: Argumentation structure system analysis
The analysis phase is followed by a design, validation, detailed design and eventually evaluation of the design results. This phase is based upon the argumentation structure of Figure 65.

A **hierarchical process library** is designed. The detail level is chosen in such a way that the maps in the library can be changed for a specific situation. So the maps provided in the library will never be used directly, but will always be altered to the specific purpose of use. Standardization will be reached because this set of basis maps will provide for unity in the usage of process mapping within APMT, which overcomes the first root cause of the problem. Furthermore the hierarchical setup able to cope with changes due to dynamics in the system.

A **usage-process** for the library is designed. The main focus of usage is within the develop phase of the PELC cycle and the implementation phase of the PEI framework. The description of the usage process creates clarity for the users why to use process maps when, which overcomes the second root cause of the problem.

The current usability of the **library** is insufficient because the design does not present what is desired by the several users. This is caused by the quantity of the processes, the skills required for the software and the terminology used. Furthermore the interface of the used software with other company software is not convenient. Finally it is concluded that the usage-process should include the implementation steps and an organizational structure get and keep the library used.

To overcome that the main problems identified in the validation of the library and usage-process the **intrinsic value** of the library should be increased and an **organizational structure** including implementation steps should be set up. This will ensure the actual usage in practice by support and by taking into account the preferences of the different users.

To really get the library used the **intrinsic value** of the library should be increased by adding extra functionalities to meet the specific preferences of the users. Two versions of the library are created: a separate **viewers** version to meet the demands of users only interested in the information the maps withhold, and an **editors** version for tweaking the maps to a specific situation.

To make sure the separate versions of the library are used an **organizational structure** that creates a playing field to use the library and keep it up to date should is set up. This structure is an incentive to start using the library and overcome the initial doubt of the users, where after the experience of the efficiencies and other benefits creates user satisfaction and bonding.

The viewers and editors versions of the **process library** and the **usage-process** are evaluated as value adding for APMT. Furthermore all set up goals and requirements are settled. The successful introduction to Maasvlakte II and the handover to Operations & Implementation Support support this conclusion. The set up usage-process and **organizational structure** will ensure the continuation of these steps in the future.

**Figure 65: Argumentation structure design, validation, detailed design and evaluation.**

This argumentation leads to the drawn research conclusions and set recommendations. For the sake of completeness they are not added here but it is advised to read chapter 9.
Appendix J: Record of changes

This appendix presents the extra changes made since the examination committee mid-term and green light meeting. These changes refer back to the notes of these meetings.

Record of extra changes from mid-term meeting:
- A clear overview of the benefits of process mapping is added in figure 10 in the wrap up after analyzing the method process mapping.
- A link to earlier process mapping projects within APMT is added in paragraph 2.3.1
- The evaluation is clearly separated from the validation including a reflection on the issue that the designer and user are involved in the validation phase.
- Paragraph 2.1.6 is rewritten and a higher level view is added to the figures
- All conclusions in the statement blocks are revised, sharpened and made coherent with each other to one argumentation structure. This structure is added in Appendix I.
- The goals and requirements are revised and numbered, furthermore they are brought in the text in the chapters of research phase I, instead of one full list in the wrap up. Finally they are added to the validation protocols in Appendix H.
- More theoretical background on software implementation and process management in the intermezzo between paragraph 7.2 and 7.3, which resulted in changes in the organizational structure.
- The confrontation of the theory and practice resulted in the conclusion of two root causes of the problem in the wrap up of research phase I. These root cause result in the two main deliverables for the second research phase.
- A practical implementation plan is added in Appendix F.

Record of extra changes from green light meeting
- Structure: all sub-conclusions (statements) are reviewed on relevance and argumentation structure. This resulted in the removal of 26 sub-conclusions and the set up of a clearer argumentation structure presented in Appendix I.
- Evaluation: chapter 8 is completely rewritten and now only addresses issues that wrap up the research. The set up list of goals and requirements is evaluated including the implications of not meeting certain goals or requirements.
- Conclusions: chapter 9 is completely rewritten. The argumentation towards the conclusions is added with brief arguments from theory and evidence from practice. The conclusion is readable at itself whereby the three main conclusions clearly stick out.
- Recommendations: the recommendations in chapter 9 are updated, bringing recommendations at a lower level or new ideas to the list of small recommendations and moving the arguments to the evaluation chapter to prevent bringing up new issues.
- Discussion/reflection: a chapter 10 is added with the discussions on several theoretical topics, presuming the reader already read the conclusions. Furthermore the reflective part, paragraph 10.2, of this chapter addresses what I personally found out during this research.
- Organizational aspects: An underpinning based on scientific literature is added to the design of the organizational structure in paragraph 7.3. Several mechanisms for coordination are now the basis of the organizational structure for APMT. Furthermore, a reflection on the used theory is added in chapter 10.

- Visualization: the type of visualization for the process maps is limited by other aspects in the project. Firstly, the fact that a representation was already used and secondly by the software package. Paragraph 2.1.3 and Appendix C are however further based on theory from the field of visualization were possible.

- Static / dynamic: The theoretical basis on what static and dynamic is is rewritten and reflected in the discussion chapter.

- Software choices: the scattered information on iGrafx and the choices to stay with this package are bundled in paragraph 2.1.3 to make this boundary absolutely clear at the beginning of the research.

- Style: the complete report is reread on spelling errors and sentence structures.

- Article: the article now only focuses on an organizational structure that coordinates the implementation and usage of process mapping to make it a value-adding tool instead of a one shot effort. The discussion on how process mapping can cope with dynamics is left out and added to the discussion of the research report. The proposition of a hierarchical structure, included in an earlier version of the article, is also left out to be able to only focus on just one topic.
This article should be seen as a separate piece of work. For this article the author guidelines of the Business Process Management Journal have been followed. Next to the Business Process Management Journal it is suggested to look at the International Journal of Operations & Production Management or The TQM Journal for a possible submission. It should however be noted that each journal has its specific target and lay-out guidelines. This paper could therefore first be improved by organizing a peer-review session or submitting it as an article for a conference.
Mapping to manage or managing to map?

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**Keywords** Process mapping, coordination, organizational structure, container terminal automation

**Abstract** Process maps are a value-adding tool for organizations. But, process mapping projects often do not reach the full potential of this method. Creating process maps is in practice most often more important than using them. They are ends instead of means. Resulting in a one shot modelling effort, because it is unclear why, how and when to use process maps.

To make process mapping a used and value adding tool this research proposes to introduce an organizational structure to coordinate the implementation, and support the usage of process maps over a longer time period.

These results come forward from research performed into the use of the process mapping within a complex logistic system situated in a dynamic multi-user environment. It proved that coordinating process mapping, with the implementation of an organizational support structure, was useful within the design of automated container terminals, making process mapping a value-adding tool.

**Introduction**

The design, implementation, operation, maintenance and eventually change or re-engineering of complex business processes are delicate trajectories with various decisions. Consider reorganizing an entire manufacturing control system, implementing a new baggage handling system or introducing an innovative warehouse system with automated guided vehicles. All share the similarity that deep understanding of the system behaviour is required to underpin a decision.

Process mapping is one of the most widely used methodologies to create this understanding (Fenton, 2007). But in practice process maps are frequently only useful within a short time following their set up: “a one shot effort” (Fresco and Pederiva, 2003). This is provoked by the unfamiliarity of the purposes of process mapping. Which can be seen in practice, where the creation of process maps is often more important than the intended purpose itself (Peppard and Rowland, 1995). It is not clear nor coordinated how process maps should be used. Resulting in the situation where the maps are used as ends instead of means (Damelio, 1996).

To transform process mapping into a value-adding tool this article presents the results of research performed into the use of process mapping within a complex logistic system situated in a dynamic multi-user environment.

This paper structures the definitions in this field of research resulting in the full theoretical potential of process mapping. To reach this potential an organizational structure to coordinate the use of process mapping is designed. The findings were taken into practice by performing a case study at APM Terminals (APMT) with the goal to fully exploit the benefits of process mapping within the trajectory towards container terminal automation. A first step towards implementation of this organizational
structure, proofing the usability of the results of this research, was set by an introduction to the new terminal project team at Maasvlakte II, Rotterdam, The Netherlands.

Process mapping
To construe what process mapping is it should first be considered what a process is. Hammer and Champy define a process as “a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer” (1993). From this definition several characteristics of a process can be identified. At first a process has boundaries, the inputs and output. Secondly a process has a customer wherefore the process adds value, the third characteristic. Looking at Davenport’s definition another characteristic can be added. “A process is a specific ordering of activities across time and space (.)” (1993). Finally Ould adds two more features: “it is carried out collaboratively by a group, i.e. we are concerned with more than the work of an individual” and “it often crosses functional boundaries” (1995).

A process map is a visual graphical representation of a process (see Rummler and Brache, 1990; Damelio, 1996). But one can imagine that a concept with so many characteristics is difficult to grasp in a single visual representation. This results in various techniques to make this representation (Mayer, Benjamin et al., 2000) for example workflow modelling (van der Aalst, Hofstede et al., 2002), flowcharting (Damelio, 1996) and IDEF (Institute of Electrical and Electronics Engineers, 1998). These techniques vary depending on the purpose of use. So, it is essential to take a closer look at the purposes of process mapping.

To be able to make process mapping a value adding tool, by using it as means, it should be clear what the potential ends are. Before setting up an organizational structure to coordinate the usage of process mapping it should be clear what the potential of process mapping is. Especially because according to Malone and Crowston (1994) a basic requirement for coordination are “goals with goal-relevant interdependencies between activities”. Figure 1 summarizes the potential goals of the activity process mapping that will be further explained in this section.

Figure 1. Potential of process mapping.

Process standardization - First of all process maps can be used to identify standard processes, support the standardization of non standard processes and support the
implementation of standardization. For example by using basis process maps a starting point for several specific process mapping projects or to become ISO9000 (International Organization for Standardization, 2008) certified (Terhürne and Welle, 2007).

Means for other ends - Process mapping encourages a process orientation and overview of the entire process (Buchanan, 1998). Creating insight is most of the time the main purpose. Not only the insight the map itself creates but also the actual procedure of creating it can help people to define roles and create insight in who does what (Greasley, 2006). This gained insight should be used to support other processes in the project. For example the creation of standard operating procedures or job descriptions in the new or changed business process can be more efficient and coherent when they are based upon process maps.

Process improvement – In the design phase or after the new business process is implemented process maps can be used to identify opportunities and reduce risks and uncertainties (Terhürne and Welle, 2007). They can e.g. help to evaluate or establish alternative ways to organize processes and to identify risks inside the process (Damelio, 1996; Fenton, 2007).

Process information management - Process maps store knowledge and show where knowledge originates within the organization (Fenton, 2007). Rather than only storing the knowledge it is important to take advantage of what is known to maximize the output.

Stakeholder engagement - The process maps can be used to create ownership of the change process among all people involved (Fenton, 2007). They could e.g. make automation real for the stakeholders by involving them in the process of creation and use of the process map.

Establish performance measures – Process maps can be used to evaluate, establish, or strengthen performance measures (Damelio, 1996). They can be used to make switch from quantitative to qualitative, process orientated, key performance indicators.

Process re-engineering – Hopefully proper process mapping leads to smooth processes but when necessary process mapping can be used to completely re-engineer the process. When a core business process is fundamentally changed or a new way of working is set up, process maps can support all phases of this change process.

Mean of communication - Process maps can be used as means of communication. Process maps make work visible and increased visibility improves communication and understanding. Process maps make change concrete and negotiable for groups; they are more easily processed than other forms of communication (Fenton, 2007). Besides, process maps can be used to get people up to speed to what is happening in the rest of the organization and vice versa (Damelio, 1996; Fenton, 2007).

When these goals will actually be the ends, process mapping is used for, it can be concluded that the method will add value. But, with a clear view on why process maps should be used it has absolutely not been ensured that the process maps will add this value. This research is convinced that process maps will always stay ends if there is no organizational process that coordinates the use of process mapping.

Coordination
It is however questionable how the use of process mapping can be coordinated to reach the described purposes and make process mapping a value adding tool. Mintzberg (1983) describes five mechanisms of coordination that explain the fundamental ways in
which organizations coordinate their activities. These mechanisms can be considered for the coordination of the use of process mapping.

M 1. Mutual adjustment: by informal communication between employees simple processes can be coordinated. This will have to be the case internally in process mapping projects between the different users.

M 2. Direct supervision: by having one person taking the responsibility for the work of others, issuing instructions to them and monitoring their actions coordination can be achieved. In every process mapping project there should be one person responsible for the overall connection between the maps, bringing together the work of others. This will prevent the execution of repeated work.

M 3. Standardization of work processes: by specifying the content of the work, employees can be coordinated. So by making clear when to use process mapping in a project to reach a certain benefit the usage can be coordinated.

M 4. Standardization of outputs: by specifying the results that should be reached coordination can be achieved. The outputs within a process mapping project can be standardized by determining in advanced (to a certain extent) which representation techniques will be used and which processes should be mapped.

M 5. Standardization of skills: by specifying the kind of training required to perform the work, processes can be coordinated. The use of process mapping can thus be coordinated by supporting the users or training them.

Veryard (1994) adds two mechanisms to this list in his book on the management of information models interesting for the application in this research.

M 6. Standardization of inputs: by starting up a process mapping project with a standard set of maps the project can be coordinated. The users can be transformed from authors of their own maps to editors of this standard set of basis maps.

M 7. Standardize through tools: by using a uniform tool for process mapping, the work throughout all projects can be coordinated.

It should be taken into account that both authors acknowledge that most of the time a mix of the mechanisms is used in practice.

Besides these coordination mechanisms, Stoner and Freeman (1992) and Hedlund and Dunning (1993) propose an approach to increase the potential of these mechanisms that should be considered. In the beginning of a process mapping project a focus should be on lateral relationships. Because permitting the exchange of information between layers of the organization other than the normal layers can enhance coordination. It should be ensured that there will be communication channels between process mapping projects that cut across the chain of command. When the number of contacts between projects increases, a liaison with an integrating role can be appointed. This liaison ensures the lateral relationships and is responsible for a continuous coordination. In even later stages, when process mapping is broadly used, such a liaison can be transformed to a managerial linking role, with a formal authority over all projects.

Applying these principles could make process mapping a value adding tool. But it is unclear how these principles can be incorporated in the method process mapping. Sumner (1999) states that it is better to re-engineer the business process to fit the software, rather than trying to modify the software to fit the organization's current business process. This is also the case for process mapping. Implementing the
coordination principles can be reached by establishing an organizational support structure instead of fiddling around with the maps itself. For example with a maintenance, development and support group (Prieto-Diaz, 1991) as the liaisons.

The implementation of this structure should be done stepwise for several reasons. At first a smaller structure will be easier to manage. Secondly, it allows for tuning while the set of process maps grows because feedback can be gathered. And thirdly, the confidence within the organization can be built up with a small start rather than handling a large structure from the start.

From the exploration of the theory on process mapping and coordination can be concluded that a stepwise implementation of an organizational structure that coordinates the use of process mapping should be designed.

**Case: coordinating process mapping for container terminal automation**

Applying the principles for coordination in practice will show if they can transform process mapping into a value adding tool. In a case study at APMT an organizational coordination structure was set up and implemented that embodied the described principles. This section will underpin figure 2 that presents this structure for coordination of process mapping applied at APMT.

![Figure 2. Potential of process mapping.](image)

The first part of the research at APMT resulted in a library of basis process maps for an automated container terminal. After an extensive validation with experts and at the semi-automated terminal in Virginia (USA), the second research part focussed on the actual usage of the process maps. A walk through the steps of implementation will make clear how the coordination mechanism were brought into action.

The goal of the created basis maps is to standardize the input (mechanism 6). All basis maps that the created library provides can be tweaked to specific APMT project situations. The first issue to acknowledge is that there are different types of users of the basis process maps. The editors who will actually be tweaking the process maps to create their own project specific process map package and the viewers who are only interested in the information the maps withhold. All users in the first group spanning different projects are provided with the basis maps in the same software tool. This ensures coordination over the projects by standardizing the tool (mechanism 7). The second group does not prefer to work with specific process map software and longs flexibility...
in retrieving information from the library. To meet the preferences of this second user group a *skin* or *shell* was created around the process maps to make it more user friendly. Besides changing the interface to the maps the users can also be changed by providing training (mechanisms 5).

Taking into account that the introduction of the usage of process mapping should be done gradually the two library versions were offered to the users online. This first step towards the usage is considered as a **passive** step based on mutual adjustments (mechanism 1). The users are imposed to process mapping through their project description (mapping the processes at their specific terminal is formally included in their task description) or own active attitude. Users interested should in this phase actively retrieve the information themselves and support each other. But this is a rather unsatisfying answer to really make process maps a value adding and used method. Furthermore there is no feedback gathered in this passive structure to keep the basis maps up to date or to share best practices.

To overcome these issues an **active** approach can be added. Instead of offering the maps to the users the users are introduced in an active way to process mapping, followed by support during the usage. An example is an introduction of the purposes of process mapping and a basic training. This will further achieve coordination through the standardization of skills. The usage support can be in the form of a process support centre, similar to the suggestion of Prieto-Díaz (1991).

After such an active introduction it is advised to also coordinate the output (mechanism 4) to a certain extent. By making a process map package a mandatory deliverable for a project a goal or pressure can ensure the usage. But when really making certain maps mandatory there should also be a management structure to act upon this obligation. In a third step, with a **pro-active** structure, the feedback and additional information can be pulled out of the users instead of the situation in which users pushing the feedback up. This step, that tends to make the greatest contribution to lasting process mapping, would be the appointment of a project and global process owner. By making one of the users in a project responsible for the direct supervision (mechanism 2) it is actually realistic to make it a mandatory deliverable. This *project process owner* should give account to a liaison: the *global process owner*, which monitors the progress of all mapping activities in all projects. This global function oversees the information and looks for further opportunities between projects (see Rummel and Brache, 1990). With this structure it will be possible to include, and more important share, best practices which creates synergy between the projects.

All together this gradual introduction standardizes the work process of the implementation, but it does not standardize the actual working with process maps (mechanism 3). For the implementation it is essential to, beside why and how, make clear when to use process mapping. Within the case at APMT this resulted in an extensive description of the usage trajectory of process maps. Figure 3 is the final time line summarizing this trajectory.

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**Figure 3.**

Process map usage-process at APMT
This figure makes clear when to use process maps by putting the identified purposes inside APMT’s trajectory towards container terminal automation. This description informs the users within APMT when to use process mapping, bringing in line the perceptions of the users with the possibilities process mapping provides. With this last step also the standardization of work processes is ensured, completing the coordination structure for the use of process mapping.

After taking the theoretical concepts into practice several conclusions can be drawn. Without any changes to the current way of process mapping within APMT the identified purposes would probably not be fully exploited. The gradual introduction of an organizational structure that coordinates the use of process mapping proved to make process mapping a value-adding method. The successful introduction to the project teams for two new terminals (Maasvlakte II, Rotterdam, The Netherlands and Vado, Italy) and the handover of the research to the global process owner within APMT support this conclusion.

**Conclusion**

As stated process mapping can be a value-adding tool if it is clear why, how and when to use process maps. This research resulted in an overview of the purposes of process mapping from literature describing *why* to use process maps. Furthermore an organizational structure to coordinate *how* to use process maps is proposed. And finally, by projecting the purposes in time, it is clear *when* to use process mapping.

Several notes to this conclusion should however be added. This research tried to identify all possible purposes to use process mapping. It is however questionable if it is possible to come up to all purposes. Besides, the most beneficial purposes will differ between projects or in some projects there will even be trade-offs between purposes. Furthermore, it should be taken into account that an organizational structure and description on when to use maps depend on the specific project situation. Because these notes impugn the generalizability of this research it is recommended to research the usability of the proposed organizational structure in other process mapping projects.

**References**


