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## Abstract

**Title:** How should information be handled to facilitate and benefit from modularity? - A case study of Clarkson Inc.

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**Problem discussion:** How should information be handled to facilitate and benefit from modularity? How should Clarkson Inc. adapt their information handling to modularity and what benefits can be reaped by doing this?

**Purpose:** The purpose of this master thesis is to help Clarkson Inc. adapt their information handling to modularity and to extract theories, methods and tools to guide companies in similar situations.

**Methodology:** This master thesis adopts a systemic approach. Action research has been used on the case study of Clarkson Inc, as the authors have not only observed the case but also participated in the project team on which this study is founded. The study is qualitative, including process mapping in workshop sessions and interviews.

**Conclusions:** Modularity brings standardization on module variant level, which gives increased repetitiveness in the information handling. For information handling to benefit from modularity, the repetitiveness must be used to streamline the information processes and the way information is related to each other.

For information handling to facilitate modularity, the repetitiveness must be protected and developed. Instantiating control mechanisms in the organization, which prohibit the product platform and information platform from eroding, will protect the repetitiveness of the information handling.

An information structure that corresponds to the modular product platform is central. This structure will facilitate for product information to be configured, giving logical access to product information throughout the entire organization.

The analysis of the present state at Clarkson Inc. discovered negative patterns in the information handling. Inconsistency in information handling and lack of trust in information handling reinforced themselves in a vicious circle. Modularity can break this circle as it enables increases repetitiveness in the information handling and since it already has started a change in the organization which can be leveraged.

Implementing information handling adapted to modularity at Clarkson Inc. would reap the potential of generally improved information handling and the potential the increased repetitiveness modularity brings.

**Keywords:**

Modularity, module, module variant, product platform, information structure, information processes, repetitiveness.

## Acknowledgements

This master thesis is the final of the Larsson and Skogö's Master of Business Administration and Master of Industrial Management and Engineering, at Lund School of Economics and Management respectively Lund Institute of Technology. To conduct this study we have had the opportunity of spending nine weeks in the US. For this privilege we are grateful.

We have many people to thank for our great experience this spring, people from Modular Management AB, Clarkson Inc. and Lund University. We will start by thanking our colleagues at Modular Management AB, especially Anders Leine for being a good project manager and coach, Johan Källgren for great support in need and Alexander von Yxkull for trusting us.

Every single person we have met at Clarkson Inc. has been impressively well prepared, interested in the project, knowledgeable about the organization and not least very helpful. We would like to direct special thanks to our project manager Rod and the project team for their great enthusiasm, drive and for their fast wit.

Professor Claes Svensson and Professor Robert Björnemo, thank you for your guidance and for your input, making this not only a good project, but also a good master thesis.

For giving us our US theme song and for lending your name to Clarkson Inc., we thank you truly Kelly Clarkson.

Finally we would like to thank each other for taking this opportunity, resulting in a master thesis, an experience for life and the beginning of a great friendship.

Thank you!

Gustav Larsson  
2006-05-14

Ola Skogö  
2006-05-14

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# 1 Introduction

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*This chapter expresses the problem discussion and the purpose of this master thesis, along with the background from which they derived. The target audience and the delimitations are discussed and a brief outline of the disposition is presented.*

---

## 1.1 Background

Modular Management AB is a consulting agency specializing in modularity. They have products and methods used to implement and maintain a modular platform in design and production. These products and methods make information handling easier for their clients, as they reduce the number of parts the products are composed of and therefore reduce the information that must be maintained by the clients. Though, Modular Management AB does not have a product or method to reengineer the information handling to adapt to the modular platforms.

When the authors contacted Modular Management AB in Stockholm, the company was interested in gaining a deeper understanding of how information handling can support and be supported by their current product portfolio. At the time Modular Management AB was involved with Clarkson Inc.<sup>1</sup>, a client who requested guidance in the field of information handling. Clarkson Inc. is an industrial equipment manufacturer based in the US and is in the middle of an implementation of a modular platform.

Clarkson Inc. had a presentiment of a potential in adapting their current information handling to modularity and they asked Modular Management AB for advice. Together with the authors and Clarkson Inc., Modular Management AB created a team that was assigned to investigate how the implementation of modularity could be facilitated. The authors went to the US to explore the possibilities of using information handling to leverage modularity and to assist Clarkson Inc. with their situation. As students and Modular Management AB representatives the authors used this opportunity of high information access as case study for their master thesis.

## 1.2 Central definition

In this master thesis the authors frequently use the term “information handling”. The expression is discussed in the chapter 2 and its components are explained in chapter 3. Still, a short explanation follows: information handling is a composition of “information structure” and “information processes”. Information structure is the way information is stored, i.e. hierarchies and relations between different pieces of information. Information processes are the way that information is generated, sent, received, deleted etc.

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<sup>1</sup> Clarkson Inc. is a fictitious company name according to a secrecy agreement with the case study company management.

### 1.3 Problem discussion

The implementation of modularity is a big change for Clarkson Inc. The authors believe that a change in the strategic production approach will affect how information handling can facilitate the new production approach, i.e. modularity. Clarkson Inc. is producing products project wise due to the uniqueness of each product. When modularity now is implemented each product can remain custom-built but the use of modularity will enable standardization of the modules, i.e. the sub-systems of the product. This standardization means that combinations of components are produced repeatedly. The authors want to use this increased reuse and repetitiveness in production in the information handling, for the information handling to benefit from modularity. Hence, the assignment formulation is a consequence of the authors belief that standardization can be used to create an information handling that is adapted for modularity. The assignment formulation follows:

- **How should information be handled to facilitate and benefit from modularity?** How should Clarkson Inc. adapt their information handling to modularity and what benefits can be reaped by doing this?

### 1.4 Purpose

The purpose of this master thesis is two folded. The first purpose is to help Clarkson Inc. adapt their information handling to modularity. Clarkson Inc. will be provided with specific recommendations on how the authors think Clarkson Inc.'s information should be handled. The second purpose is to extract theories, methods and tools which can be used in practice to guide companies in similar situations. This purpose will be extracted from the case study of Clarkson Inc.

### 1.5 Target audiences

The target audience of this master thesis will be briefly discussed in this section. The thesis will be presented in a format the authors consider suitable for this audience.

Clarkson Inc., the organization that constitutes the case of this study, will be a main stakeholder on this thesis. Clarkson Inc. will be able to use the recommendations from this master thesis in their organization. Modular Management AB, the host of the authors during the period of the study, is also a targeted audience. An ambition is that Modular Management AB will be able to use the generated knowledge from this thesis to help other companies in similar situations. A third target audience is all organizations which are evaluating, implementing or already using modularity. The final target audience is the academic world within the research field of modularity and/or information handling.

### 1.6 Delimitations

The authors have defined delimitations for the master thesis. These delimitations are presented below:

- Business cases will not be presented due to time constraints. There will be reasoning about economical aspects in our analysis, but no calculations will be made.
- Change Management will not be addressed as this master thesis focuses on more technical aspects of information handling. Still, authors consider Change Management critical in large implementations.
- A theoretical perspective of Enterprise Resource Planning (ERP) systems or the characteristics of SAP, the ERP system Clarkson Inc. uses, will not be discussed. We consider the use of ERP systems to be widespread and presuppose the reader to have the basic knowledge to follow the discussions in this thesis.
- The design phase of the modular product platform will not be discussed. Modular Management AB has well defined methods for this phase and Clarkson Inc. has already passed the phase. The interface between the design process and the Order to Delivery process of Clarkson Inc. will still be addressed.

## 1.7 Thesis Outline

This master thesis has a disposition that correlates with the research design presented in chapter 2.2. The disposition of the chapters is illustrated in Figure 1.1.

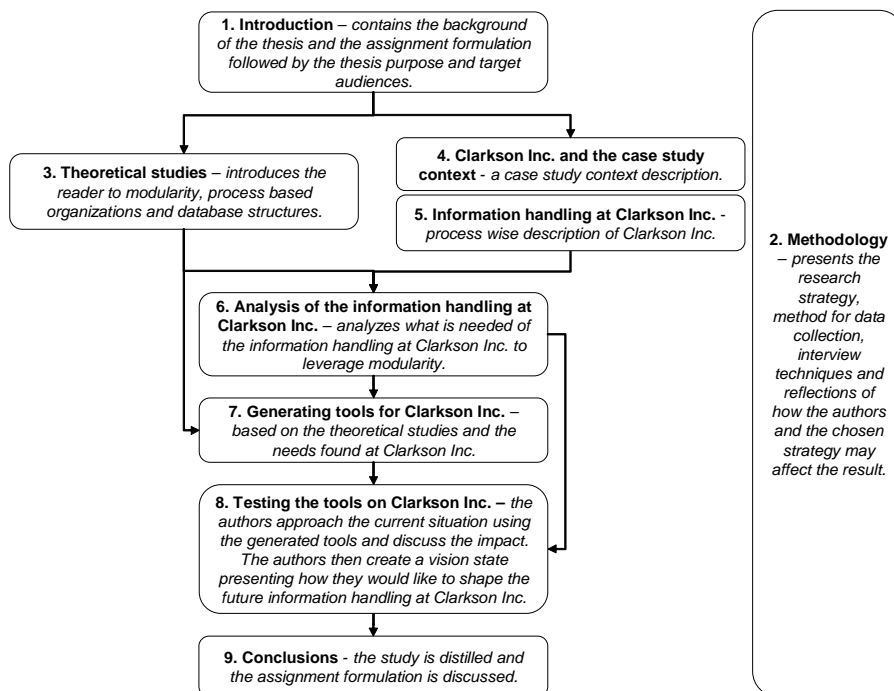


Figure 1.1 The master thesis outline.



## 2 Methodology

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*This chapter outlines how this study has been conducted and which influences that has affected the authors, and consequently the conclusions of the master thesis.*

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Methodology is, according to Arbnor & Bjerke, the discipline of the creation of a method or a paradigm for working<sup>2</sup>. The authors have two main purposes with this chapter. The first purpose is to outline the research design, for the reader to make personal assessment of the conclusions of this master thesis. The second purpose is for the authors to identify how their backgrounds and their relationships to Modular Management AB and Clarkson Inc. might have affected the conclusions of the thesis.<sup>3</sup>

### 2.1 General methodology

This master thesis is based on a case study of a project performed at Clarkson Inc. The authors have not only studied the project; they have also been team members of the project. How this research has been executed will be expressed in chapter 2.3. Clarkson Inc. has designed a modular product platform with the guidance of the consultant company Modular Management AB. The project was chosen for the study by the hosting consultant company Modular Management AB and the authors. The three main reasons for the choice of the case study were:

1. Clarkson Inc. requested guidance from Modular Management AB to adapt its information handling to suite the new modular product platform.
2. Modular Management AB was seeking for a method to help their clients to adapt the information handling to a new platform.
3. Larsson and Skogö were investigating the possibilities to conduct a master thesis in the research field of modularity.

Modular Management AB has a well defined method to modularize products, a result of ten years of practice with continuous refinement of the method. As Clarkson Inc. has used this method, the authors and Modular Management AB believes that other clients of Modular Management AB are likely to go through a similar situation<sup>4</sup>. As the starting point of this study is reproducible, the possibility to reproduce the case can be considered high. This is of interest for Modular Management AB as they wish to be able to help other companies in similar situations. It is also of interest for other companies in similar situation which are not clients of Modular Management AB. Choosing a case study which is possible to reproduce is supported by Eisenhardt as the results easier can be tested<sup>5</sup>.

As the project at Clarkson Inc. was a prerequisite for this study, the method, or guiding principle for generating knowledge<sup>6</sup>, has been adapted to fit these premises.

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<sup>2</sup> Arbnor, I., et al. (1994) p 33

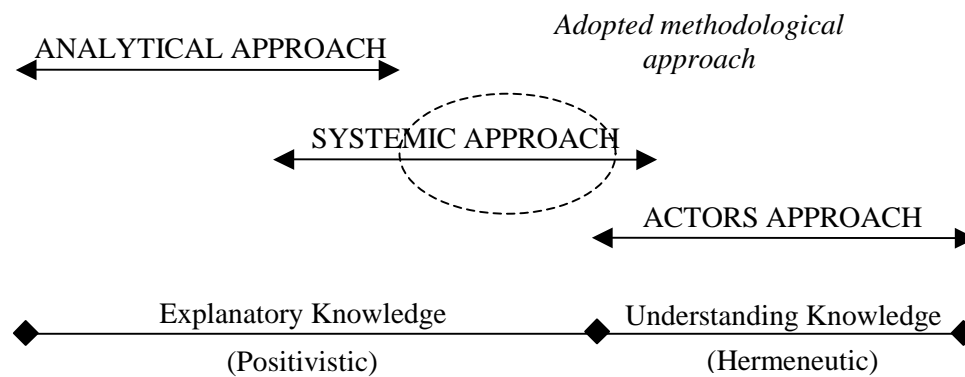
<sup>3</sup> Arbnor, I., et al. (1994) p 35

<sup>4</sup> Leine, A., *Project Manager*, Modular Management AB, (2006-01-12)

<sup>5</sup> Eisenhardt, K., (1989) p 537

<sup>6</sup> Arbnor, I., et al. (1994) p 26

Two major influences from the theoretical framework of the study are process based organizations and modularity. Process based organizations emphasize the value of embracing a systemic approach<sup>7</sup>. Modularity is by the authors regarded as a way to seize control of a complex product, which can be regarded as a system. When the architecture of a product is defined, i.e. how the modules of the product will fit together, the modules can be developed independently. The complex product is in other words decomposed in isolated modules which together add up to the complete product. With this product architecture the sum of the modules equals the system. Changes inside a module will not require changes in the other modules. This is modularity's method of controlling the system.<sup>8</sup> As the systemic approach favored by the theoretical foundation is anchored in the values of the authors, the choice to adopt a systemic approach was natural. The systemic approach assumes that the sum of the parts of a system is not equal to the system<sup>9</sup>. Figure 2.1 indicates the general methodological approach adopted by the authors and how this approach relates to other approaches.



**Figure 2.1** The ellipse indicates the methodological approach adopted by the authors. Based on figure by Abnor & Bjerke.<sup>10</sup>

## 2.2 Action research

The authors have been team members of the project on which the case study is based. Intervention in a case study like this is called action research and is by Richard et al considered the primary methodology for organizational development.<sup>11</sup> In essence the action research is a two stage process. The first stage is a diagnostic stage analyzing the subject of the research. The second stage is when the researcher introduces a change in the studied environment and studies the effects.<sup>12</sup> How this has been implemented will be outlined in the research design, chapter 2.3.

<sup>7</sup> Larsson, E., (2001) p 64

<sup>8</sup> Ericsson, A., et al. (1999) pp 17

<sup>9</sup> Wallén, G., (1996)

<sup>10</sup> Arbnor, I., et al. (1994) p 62

<sup>11</sup> Richard, L., et al. (1996) p 235

<sup>12</sup> Richard, L., et al. (1996) p 237

The main strength of action research is its ability to maintain relevant to the real world. The main challenge is to maintain rigor in the research. To address the risk of lacking rigor, the authors have taken action in accordance with the quality guidelines set by Richard et al.<sup>13</sup>

It would be unethical to perform research without the consent of the research subject<sup>14</sup>. To avoid this, the authors have had an agreement with Clarkson Inc. on how the project will be the foundation of a master thesis. Richard et al. suggests a the researcher should not charge a fee, or charge a discounted consulting fee in return for the access to the case study<sup>15</sup>. This will facilitate impartiality. As outlined in chapter 2.4.2, the authors have received coverage equivalent for costs of traveling and living in the vicinity of the research subject, no further expenditures.

A difference between the action research and consulting is the theoretical foundation on which the actions are based. The document with the suggested actions should contain these theories. If adjustments of the theories are made, these should be recorded in the document.<sup>16</sup> To fulfill these requirements the authors have outlined the theoretical foundation in chapter 3 and the adjustments to the theories in chapter 7. A study well founded and documented on theories will enable certain generalizations<sup>17</sup>.

Validity is considered an issue in action research. Richard et al. recommends an observer who does not interact during the process of data collection.<sup>18</sup> During the interviews performed by the authors at Clarkson Inc. one person has led the interview and one person has taken notes. An interview plan was developed by the authors and the project team to avoid affecting the interviewee during the interview. Richard et al. further discusses the risk of the researcher dominating the diagnosis process.<sup>19</sup> The authors have limited this risk by being subordinate to the project leader at Clarkson Inc. Validity discussions not covered by the action research guidelines of Richard et al will be addressed under section 2.8.

### **2.3 The research design**

The work with this Thesis began with a stakeholder analysis to identify the expectations of the project core team at Clarkson Inc. and to specify the scope of the project. An additional purpose of the stakeholder analysis was to identify individuals and organizational functions which would affect and be affected by the project. The output of this process was the formulation: how should information be handled to

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<sup>13</sup> Richard, L., et al. (1996) pp 241

<sup>14</sup> Eikeland, O., (2006) p 43

<sup>15</sup> Richard, L., et al. (1996) pp 242

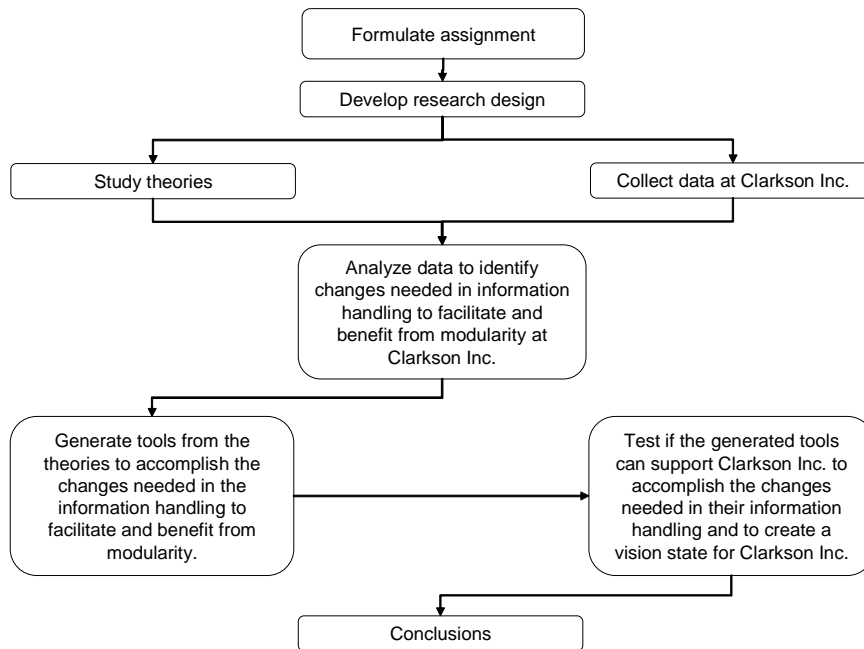
<sup>16</sup> Richard, L., et al. (1996) p 242

<sup>17</sup> Richard, L., et al. (1996) p 243

<sup>18</sup> Richard, L., et al. (1996) p 242

<sup>19</sup> Richard, L., et al. (1996) p 242

facilitate and benefit from modularity? We look upon this process as formulating the assignment (see Figure 2.2).



**Figure 2.2 Schematics of the research design.**

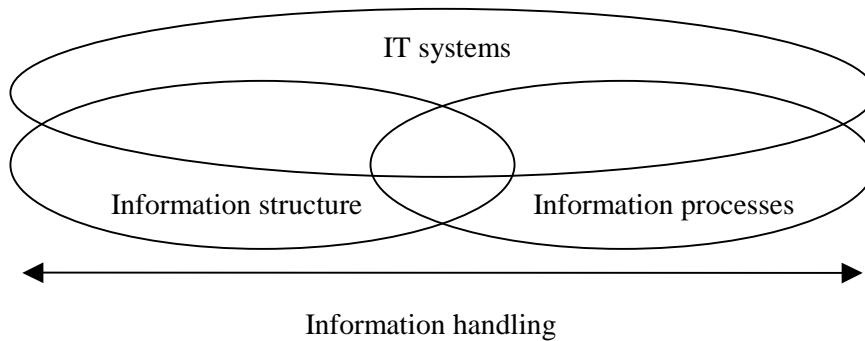
The next step was to outline how the research should be performed to answer the assignment formulation. This step is called “research design” which is what we express in this chapter.

The following task was to identify the requirements on the information handling at Clarkson Inc. in order to know what had to be changed in the organization. To identify the requirements theoretical studies was conducted in parallel with the case study of Clarkson Inc. The theory study was focused on modularity and information handling.

In the case study of Clarkson Inc. a (17 feet long) process map was developed, based on eight workshop days, 50 interviews and nine weeks at Clarkson Inc. The data collection also rendered other data format than the process map. An important discovery during the theory study and the data collection was how the authors’ perception of information handling changed. Initially the information structure was identified as an important area of information handling. This identification was a result of a theory overview of modularity and database structures. The authors believed that the inherent modular structure of the product could be translated to an equivalent information structure, like studies of modularity and manufacturing had been able to translate the product structure to a corresponding manufacturing structure. As the case study of Clarkson Inc. evolved the authors soon realized that it was more to information handling than just information structures. Merely discussing the information structure was incomplete and would reduce the applicability of the



study. The authors started analyzing the information processes too. The outcome of this progression was a perception of information handling as information structure and information processes, where one can not exist without the other (see Figure 2.3). In reality the information structure and the information processes are integrated through IT systems, which consequently became of relevance. This perception has been a foundation of this master thesis.



**Figure 2.3 IT systems integrate the information structure and the information processes.**

In the next step the theories and the collected data were merged together to analyze and identify changes needed in the information handling to facilitate and benefit from the modularity. In the process of finding patterns in the information handling which needed changes, the project team at Clarkson Inc. was greatly involved. The identified changes needed were then used to mould the theories into tools to change the information handling to facilitate and benefit from modularity at Clarkson Inc.

Hereafter the new tools were theoretically applied to the situation at Clarkson Inc. to test if they could be used to accomplish the changes needed in the information handling. The tools were then used to describe a long term steady state at Clarkson Inc. where the information handling is adapted to modularity. This state is called “vision state” and is so far in the future for Clarkson Inc. so it can be considered an ideal information handling for modularity, regardless of Clarkson Inc. In the final phase of the study we conclude the findings of the master thesis.

The research design of this case study was developed to ensure effectiveness and efficiency in the pursuit to answer the questions formulated in the assignment; hence the authors regard the research design a project plan to the case study.

## **2.4 The influence of the authors, stakeholders and interviewees**

For the reader to gain a personal opinion of the values and conclusions of this master thesis, this section outlines factors of major influence on the result. The section is also of great value for the authors, as Abnor and Bjerke argue that reflection of the

methodology is of great importance to comprehend the value of the knowledge generated<sup>20</sup>.

#### **2.4.1 The influence of the authors**

As this study is based on qualitative data, which is prone to be affected by the interviewer<sup>21</sup>, the authors will briefly present their backgrounds for the reader to personally assess how these might have impacted this master thesis.

Larsson has the last four and a half years conducted his Master of Business Administration studies, specializing in Technology Management, at the Lund School of Economics and Management. Larsson has studied ERP implementations performed by the management consultant agency Accenture. Larsson has professional experiences from VeriSign AS (intellectual property consulting), Gunnebo Physical Security AB (physical fire protection of hardware) and Procter & Gamble AB (consumer goods). This master thesis finalizes Larsson's master studies.

Skogö has the last five years conducted his Master of Science studies in Industrial Management and Engineering at Lund Institute of Technology, options taken in Systems Engineering. The last two years Skogö has finalized in Technology Management at Lund School of Economics and Management, to gain knowledge and skills in developing and managing high tech industry. Skogö has been working as an assisting teacher at the Lund University Department of Engineering Logistics. Skogö has professional experience from Sony Ericsson Mobile Communication AB (mobile software systems) and Rexam Fosie AB (production industry). This master thesis finalizes Skogö's master studies.

#### **2.4.2 The influence of the stakeholders and interviewees**

This section will present the main stakeholders and the interviewee's organization to the reader. Their backgrounds and agendas might affect the collected data and therefore the conclusions of the master thesis. The stakeholder and interviewees might have a preconceived opinion of the result of the research and might, deliberately or unconsciously, affect the research in that direction<sup>22</sup>. The two main stakeholders of this master thesis, and the project on which it is based, are Clarkson Inc. and Modular Management AB. To facilitate for the reader to interpret how their stakes might have affected this study, their interests, interpreted by the authors, will be presented below. Furthermore, the relations between the stakeholders and the authors are briefly commented.

Clarkson Inc. will launch a modularized product platform. The stakes Clarkson Inc. has in this master thesis and in the project, on which the study is based, is that the company wants effective and efficient information handling to support the product platform. Clarkson Inc. has financed the authors nine weeks stay in the US to conduct

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<sup>20</sup> Arbnor, I., et al. (1994) p 305

<sup>21</sup> Holme, I., et al. (1991) pp 92

<sup>22</sup> Paulsson, U., (1999) pp 53

the field study of this master thesis, including three back and forth transatlantic trips, an apartment and a rental car.

Modular Management AB's stake in this master thesis and on the project on which it is based is two folded. First; Modular Management AB wants to satisfy Clarkson Inc.'s needs. Secondly; Modular Management AB wants a new product on harvesting the potential of reducing information complexity due to an introduction of a modular design. Furthermore, the latter stake assumes that an introduction of a modular platform reveals a potential to reduce information complexity, an assumption yet to be proven. Modular Management AB has financed the master thesis with a monthly salary of approximately 1.5 student allowances per author.

## 2.5 Theories

Modularity and information handling were prerequisites of this study. The authors have defined a perspective on information handling, constituted by information structure and information processes. The logical relation of information is captured in the field of data base structures. Information processes is a subset of organizational processes. In fact, most organizational processes are in reality merely creating, changing or using information, i.e. information processes. The above reasoning has rendered three main fields of the theory studies:

- Modularity
- Information structures, based on data base structures
- Information process, based on process based organizations

Though literature searches and interviews with consultants of Modular Management AB were conducted, the authors did not find material addressing modularity and information handling as a whole.

## 2.6 Models

A predominant model used in this master thesis is process mapping. Using this model has made a description of the reality possible, as it has been used to reduce complexity in the interpretation of reality to a manageable set of variables. This is a methodology supported by Hägg & Wiedersheim-Paul<sup>23</sup>. Furthermore, a simplified projection of the reality has been the foundation on which several decisions of great importance to this study have been made. Using models as a tool for decision making is a documented approach<sup>24</sup>, though it requires an awareness of how the choice of models affects the decisions made.

When mapping real processes in the field, it is challenging to cover all the events in detail. Still, the processes at Clarkson Inc. are mapped with high resolution in order to find patterns and potential. It is not practically feasible, nor intellectually necessary to

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<sup>23</sup> Hägg, I., et al. (1984) p 7

<sup>24</sup> Hägg, I., et al. (1984) p 7

communicate the entire process map. The authors consider the findings presented in chapter 5 are representative for the situation at Clarkson Inc.

## 2.7 Collection of data

This section confers how data for this master thesis has been collected, for the reader to assess how this process has affected the study. A high level classification of data is made by sorting it in primary and secondary data. Primary data is new data collected for the purpose of the specific study. Secondary data is pre-compiled data compiled in other purpose than to support the study;<sup>25</sup> hence the data must be evaluated. This study uses foremost primary data.

A study based on a systemic approach generally focuses on qualitative rather than quantitative data collection<sup>26</sup>. Therefore, the central data collection methods of this study were qualitative. When the data collection is qualitative, it is regarded complicated to assess the reliability of the data<sup>27</sup>. To decrease the risk of misinterpretation and consequently increase reliability, several actions have been taken. These are primarily:

- Extensive process mapping has been conducted in a cross functional team at Clarkson Inc., assuring diverse perspectives<sup>28</sup>.
- The majority of the collected data is verified by more than one person in the organization.
- The majority of interviews have been conducted by both authors.
- To reduce the risk of the interview effect, i.e. the interviewer affecting the interviewee<sup>29</sup>, one person has conducted the interview while a secretary has observed the interview without intervening<sup>30</sup>.
- Notes have been taken in real time during interviews and meetings<sup>31</sup>.
- An awareness of the risk of influences from the authors, the interviewees and the organization on the data has been adopted by the authors (see 2.4).
- Multiple data collection methods have been used.<sup>32</sup>

The authors regard the continuous revision of the project plan, with both the cross functionally composed project team at Clarkson Inc. and by Modular Management AB, the main tool to manage validity of data. A validation control when adopting a systemic approach is to execute a pilot to verify the results of the research<sup>33</sup>. Clarkson Inc. will launch a consecutive project on implementation based on the

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<sup>25</sup> Arbnor, I., et al. (1994) p 241

<sup>26</sup> Arbnor, I., et al. (1994) p 248

<sup>27</sup> Arbnor, I., et al. (1994) p. 248

<sup>28</sup> Hägg, I., et al. (1984) p 9

<sup>29</sup> Arbnor, I., et al. (1994) p 243

<sup>30</sup> Eisenhardt, K., (1989) p 538

<sup>31</sup> Eisenhardt, K., (1989) p 538

<sup>32</sup> Patton, E., et al. (2005) p 66

<sup>33</sup> Arbnor, I., et al. (1994) p 251

recommendations made by the authors and the project team. Unfortunately, this project will not be covered by this master thesis, due to limited time.

## **2.8 Concluding discussion**

Eisenhardt presents guidelines on how theory building from case studies should be evaluated. The first evaluation criteria addressed by Eisenhardt is that the theory generated should be parsimonious, testable and logically coherent. The generated models, tools and theories in this master thesis are all molded from the basic principles of information handling and modularity, no frills added. The composition of the models is therefore logically traceable to these theories and easily assessed by the reader. As they are all expressible in a figure or in a few lines they can be considered parsimonious. As mentioned, the models, tools and theories will be tested at Clarkson Inc., but unfortunately this lies outside the scope of this study.

The second evaluation criterion by Eisenhardt concerns the strength of the method of the empirical study performed. This entire chapter, chapter 2, outlines how this study has been performed, which strengthens the method. Several actions have been taken by the authors to compensate for potential hazards related to action research. It is in the field of the action research the authors see the main weakness of this study, i.e. their close relation to Clarkson Inc. The actions to compensate for this were outlined and discussed in section 2.2. Precautions regarding the data collection were outlined in chapter 2.7. This all together indicates that the authors have been aware of how the research method impacts the applicability of the generated theories and that common risks have been addressed.

The third criterion concerns whether the theory building generates new insights. The authors regard their contribution as new to the research field. The main strengths of the models, tools and theories are their intuitive nature and their high applicability, the authors regard.



### 3 Theoretical studies

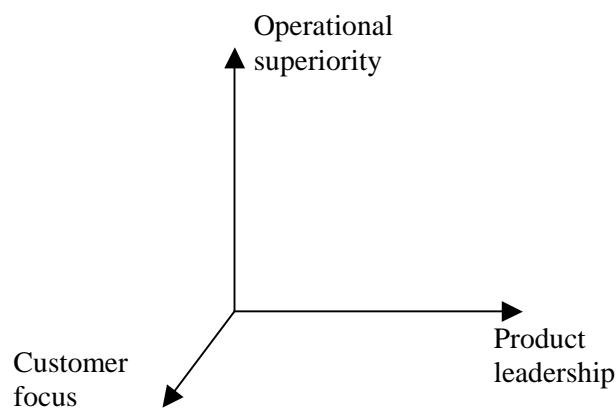
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*This chapter will discuss the theories of modularity and information handling. The choices of theories are outlined in the methodology chapter. The theories will be the foundation of the analysis of the needed changes at Clarkson Inc. The theories will in chapter 7 be adapted to fulfill the needs of Clarkson Inc.*

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#### 3.1 Modularization – implementing mass customization

A paradox of contemporary companies is that they must provide a richer product portfolio than ever before and at the same time reduce costs more effectively than ever before. Maximizing product customization and at the same time leveraging economies of scale has become a hard challenge, traditionally considered impossible to master.<sup>34</sup> Producing companies had to choose between three generic strategies: operational superiority, product leadership or customer focus (see Figure 3.1). Increased focus on one of the generic strategies meant decreased focus of one or both of the other strategies.<sup>35</sup>



**Figure 3.1** The three generic strategies.<sup>36</sup>

Today mass customization is a reality, a reality which has altered the theories of the three generic strategies. Many companies facilitate websites where the customers can compile and order products from a set number of building blocks. At the website of Volvo for instance, the customer can “build” a car from choices of e.g. model, color, engine, transmission and auxiliaries<sup>37</sup>.

Modular products are considered the best way to achieve mass customization. This is especially true when the product is complex.<sup>38</sup> A module is most simply a building

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<sup>34</sup> Carsson, C., et al. (2005) pp 10

<sup>35</sup> Treacy, M., et al. (1995) pp 43

<sup>36</sup> Treacy, M., et al. (1995) pp 43

<sup>37</sup> [www.volvocars.com](http://www.volvocars.com) (2006-04-13)

<sup>38</sup> Carsson, C., et al. (2005) p 5

block with defined interfaces. A modular product is a composition of modules.<sup>39</sup> The concept of modularity is the same as the concept of the toy LEGO.

Transforming mass customization from impossibility to reality using modularity has been a winding road. In the 1960's the Swedish truck manufacturer Scania begun their work of developing a platform for trucks. In the 1970's the computer manufacturer Dell's work on standardizing and reusing components in their computers started. Today the theories of modularity are widely spread, though implementing modularity in development and production is still a major task for many companies.<sup>40</sup>

The benefits of a modular product approach to development and production are documented. In the development process studies indicate that the time to market and the consumption of development resources are decreased by 50 – 80 % (see Figure 3.2).<sup>41,42</sup> Other benefits mentioned in literature about modularity are increased flexibility, decreased production lead time, decreased cost of working capital, reduced procurement costs, increased quality, more effective service and upgrading of products and decreased over head costs.<sup>43</sup> Kratochvil and Carsson point out that the forecast of end-products in a make-to-stock manner no longer is needed, eliminating over-stocking, under-stocking and obsolescence.<sup>44</sup> Kratochvil and Carsson also emphasize that customer loyalty and life-cycle revenues are enhanced.<sup>45</sup> The majority of these benefits are subsets or derivatives of reduced complexity in development and production, e.g. fewer parts to support, fewer ad hoc customizations, etc.<sup>46</sup>

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<sup>39</sup> Ericsson, A., et al. (1999) p xi

<sup>40</sup> Carsson, C., et al. (2005) pp 6

<sup>41</sup> Sanchez, R. *Professor of Management*, Copenhagen Business School, (2005-09-14)

<sup>42</sup> Modular Management AB, (2006) p 3

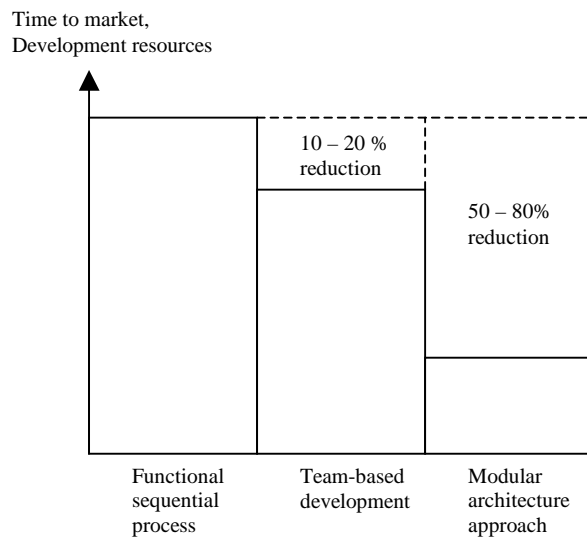
<sup>43</sup> Ericsson, A., et al. (1999) pp 17-18

<sup>44</sup> Carsson, C., et al. (2005) p 11

<sup>45</sup> Ericsson, A., et al. (1999) pp 17-18

<sup>46</sup> Leine, A., *Project Manager*, Modular Management AB, (2006-01-12)





**Figure 3.2 Time to market and consumption of development resources using different development approaches.**<sup>47,48</sup>

Camuffo defines and explores three strategic dimensions of modularization:

- Modularity in design regards the work of creating a modular architecture of a product.
- Modularity in manufacturing refers to organizing manufacturing and assembling to support the modular platform.
- Modularity in organization focuses on the organizational processes and structures supporting the modular platform.<sup>49</sup>

### 3.1.1 The architecture

Architecture is a central term in the community of modularity. The term can be applied to products, processes or organizations. A product architecture defines the essential technical structure of a product. It specifies:

1. The decomposition of the overall functionalities of a product into specific functional components
2. The interface specifications that define how the functional components interact within the product as a technical system.<sup>50,51</sup>

The value of using the term “architecture” rather than “design” implies the existence of an “architect” seeing the entire system. Using the term “architecture” captures the

<sup>47</sup> Sanchez, R., *Professor of Management*, Copenhagen Business School, (2005-09-14)

<sup>48</sup> Modular Management AB, (2006) p 3

<sup>49</sup> Desmond, D., (2004) p 318

<sup>50</sup> Sanchez, R., (2004) p 59

<sup>51</sup> www.connected.org, (2006-04-12)

division of labor between the “architect” with knowledge of the system and the designers with knowledge of each functional component. The value of having an “architect” controlling the system becomes more important when the system not only involves the product, but also the production processes and the organization.<sup>52</sup>

It is important to understand that all products can be expressed as components with interfaces, i.e. to express the architecture of the product. This does not mean that all products have a modular architecture with interchangeable components. In conventional product design component design and product architecture co-evolve in an iterative process. Product architecture is defined in the final design for the product as an output of the development process.<sup>53</sup>

### 3.1.2 Modularity

As mentioned previously, a modular product is a composition of modules, i.e. a composition of a set number of predefined building blocks. When looking for a definition of modularity some deviations are found in the literature, though there seems to be a lowest common denominator to the definition. This is captured by Carliss et al.’s definition of modularity:<sup>54</sup>

“building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole”.<sup>55</sup>

To this definition Ericsson & Erixon adds that the decomposition of the product should be driven by company-specific strategies.<sup>56</sup> Sanchez adds knowledge management and strategic learning as components of modularity.<sup>57</sup> Sako does not limit modularity to products and processes and expands the term to also embrace modularity in organizations.<sup>58</sup> More add-ons to the definition can be found.

In a modular architecture the functional components are clustered in modules. A module is an abstract class defining a function and its interfaces but does not define how the function is performed within the module. The module is implemented in various module variants, each performing the defined function and staying within the frames defined by the interfaces. A car manufacturer could define the engine as a module, with the function of delivering motional energy using the specified interfaces to its environment. The engine module allows both Wankel engines and Hemi engines, as long as they stay within the frames set by the interfaces. The car manufacturer might offer three different engines with different performances. These engines would be implemented module variants. If the car manufacturer implements the rule-set defined by the module, all engine variants will be compatible with the architecture of the car and hence fully interchangeable. This analogy emphasizes how

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<sup>52</sup> Sako, M., (2002)

<sup>53</sup> Sanchez, R., (1996) pp 121-138

<sup>54</sup> Carliss, Y., et al. (1997) p 84

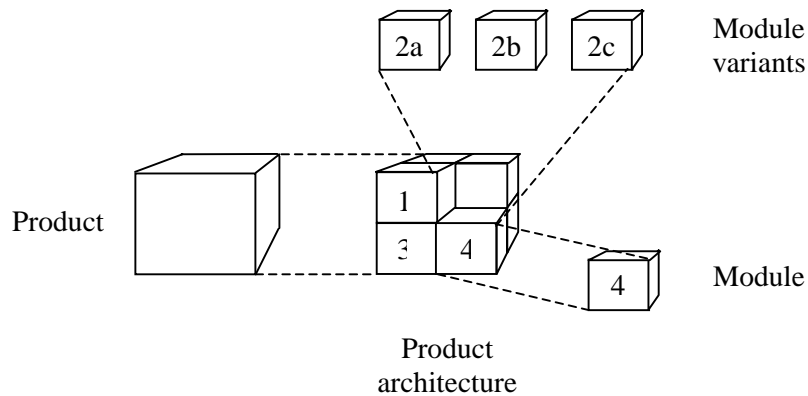
<sup>55</sup> Carliss, Y., et al. (1997) p 84

<sup>56</sup> Ericsson, A., et al. (1999) p 133

<sup>57</sup> Sanchez, R., *Professor of Management*, Copenhagen Business School, (2005-09-14)

<sup>58</sup> Sako, M., (2002)

crucial the interface specifications are to a flexible architecture that allows substitution of components without changing other components. For example, the architecture of most PCs allows you to easily replace a hard disk drive, because the interfaces between the hard disk drive and the computer are standardized.<sup>59,60,61</sup> Figure 3.3 captures the concept of architecture, modules and module variants.<sup>62</sup>



**Figure 3.3 The cubes represent a product architecture and its components.**<sup>63</sup>

### 3.1.3 The product platform

The product platform is strongly correlated with the modular architecture. Muffatto and Roveda defines a product platform as:

“... a set of subsystems and interfaces intentionally planned and developed to form a common structure from which a stream of derivative products can be efficiently developed and produced”<sup>64</sup>

This definition gives that platforms are planned to support whole product families, leveraging product variations and serving a range of market segments.<sup>65,66</sup> In the development of the platform architecture the specifications of the module with its interfaces are set before detail design begins. By fixating the architecture module development can occur concurrently. The product architecture does not change during the development of the modules.<sup>67</sup>

In the definition of a product platform, not only the product architecture is mentioned, but also a strategically motivated process architecture is designed in analogy to the

<sup>59</sup> Ericsson, A., et al. (1999) pp xi

<sup>60</sup> www.connected.org, (2006-04-12)

<sup>61</sup> Sanchez, R., *Professor of Management*, Copenhagen Business School, (2005-09-14)

<sup>62</sup> Grenås, G., et al. (2005) p 11

<sup>63</sup> Grenås, G., et al. (2005) p 11

<sup>64</sup> Muffatto, M., (2002) p 3

<sup>65</sup> Stake, R., (2000) p 29

<sup>66</sup> Sanchez, R., (1996) pp 121-138

<sup>67</sup> Sanchez, R., (1996) pp 121-138

product architecture to allow strategic flexibility.<sup>68</sup> One way of looking at a platform is to regard it as a bag of strategically developed components of products and processes. From the bag components can be pulled in numerous combinations to compile products and supporting processes, to meet various customer demands.<sup>69</sup>

Applying strategic dimensions to the architectural work are required to develop a modular architecture. One systematic way of doing this is by using Modular Function Deployment (MFD). With MFD the customer demands are, in a well defined working method, translated to modules containing clustered functionality. In the clustering process the MFD method uses module drivers, which could be described as driving forces for modularization. MFD defines twelve module drivers, for instance: Common Unit, Carry Over, Styling or Upgrading. Every function of a product gets categorized with one of the module drivers. If a function is likely to be used over the entire product family without variations the function is categorized as a Common Unit. If a function is likely to be carried over to future products it is categorized as a Carry Over. A function used to vary the appearance or the style of the product is called Styling. There are rule sets of how the categorized functions should be clustered. For instance, it is reasonable to cluster Common Unit with Carry Over, as they both are unlikely to change. Scale of economies can be leveraged in production for this cluster. As Styling is a differentiator between products it would be unwise to cluster this with e.g. Common Unit or Carry Over, which are common for most products. When the process of clustering functionality in modules is done the interfaces can be set and the design phase can begin.<sup>70</sup>

#### **3.1.4 Modularization in production**

Just like modularity splits the product into modules, modularity should also split the factory into areas performing certain functions with defined interfaces to its environment (see Figure 3.4). Preferably the factory floor is split analogue to the product; each module is manufactured in a specific area. If the product is software or service the shop floor has to be replaced with corresponding producing facilities. Integrated development of the product and the production system is called concurrent engineering and is considered a favorable development process.<sup>71</sup>

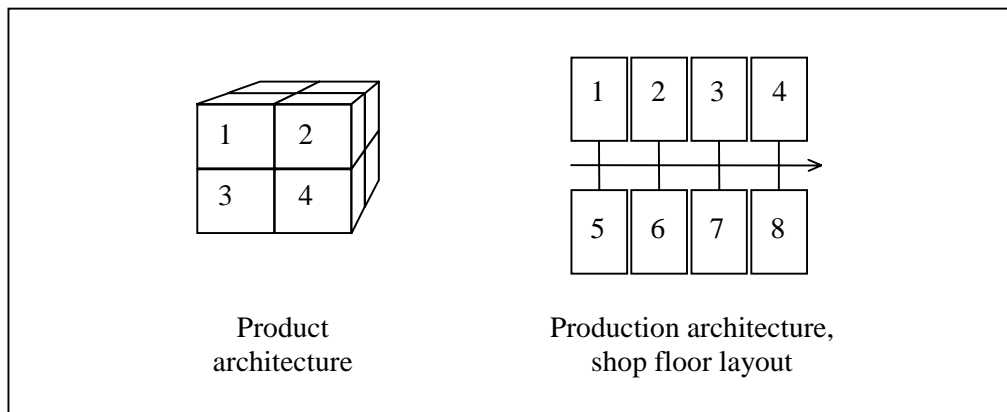
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<sup>68</sup> Sanchez, R., ( 2004) p 59

<sup>69</sup> Erixon, G., *Senior Lecturer*, Dalarna University, (2006-04-19)

<sup>70</sup> Ericsson, A., et al. (1999) pp 17

<sup>71</sup> Ericsson, A., et al. (1999) pp 104



**Figure 3.4 The modular products and its corresponding manufacturing process<sup>72</sup>**

As the modular product allows splitting long production lines into parallel stations, production lead time is decreased. Another benefit is that changes or launches of a new module variant only will require changes in one of the work stations.<sup>73</sup> Furthermore, by pre-producing module variants, customer orders become a matter of assembling the right variants.<sup>74</sup>

### **3.1.5 Quantifying modularity**

A way to assess the benefits of modularity on the internal costs is to use Activity Based Costing adjusted for modularity. When complexity in the organization is reduced the related activities will be reduced. An example of this is the maintenance of part numbers in the IT system of a company. If the number of parts is reduced with 50 %, the activities required to maintain the parts will most likely be reduced. A fundamental principle when measuring the potential like this is that the processes are the same before and after modularity's entrance. This method does in other words not consider potential benefits of changing the processes.

## **3.2 The process based organization**

The functional organization has its origin in England in the 18th century. The access to labor with no or low education was high at the time. To gain efficiency each employee performed only minor repetitive tasks and did not see the entire picture. Firm organizational structures were preferred to supervise and control the labor.<sup>75</sup> At the time there was shortage of products which put production rather than customer satisfaction in focus. The organizational focus laid internally<sup>76</sup>

In the functional organization the functions are often described as isolated silos (see Figure 3.5). Cooperation between functions requires crossings of borders which. The

<sup>72</sup> Leine, A., *Project Manager*, Modular Management AB, (2006-02-24)

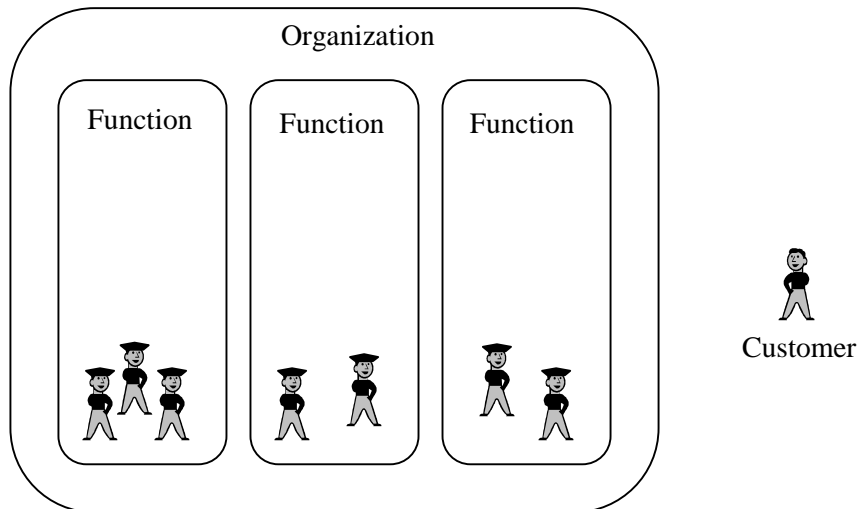
<sup>73</sup> Ericsson, A., et al. (1999) pp 104

<sup>74</sup> Leine, A., *Project Manager*, Modular Management AB, (2006-02-24)

<sup>75</sup> Larsson, E., (2001) p 68

<sup>76</sup> Lundh, P., *Consultant*, XDIN, (2006-01-05)

business is controlled, measured and developed vertically which gives a risk of sub-optimization. Outside of the organization stands the customer.<sup>77</sup>



**Figure 3.5 The functional organization.**<sup>78</sup>

The foundation on which the functional organization was built has changed. Customers can choose between various suppliers and the access to educated employees is higher. The process based organization was developed to meet the new demands.<sup>79</sup>

### 3.2.1 The process model

There are many definitions of a process. We have chosen the following definition as basis for this study:

*“A process is a repetitive chain of activities that creates value for a customer”*<sup>80</sup>

This gives that a process should only exist if it adds value to the customer. Therefore, a successful process based organization requires high knowledge of the customers. An interpretation is that a process based company is a company with customer focus. When the organization understands the entire process, no function will benefit from operations that are not supporting the goals of the company. Therefore sub-optimization is eliminated and the barriers between the isolated functions are reduced (see Figure 3.6). There is generally a process owner with responsibility of each process.<sup>81</sup>

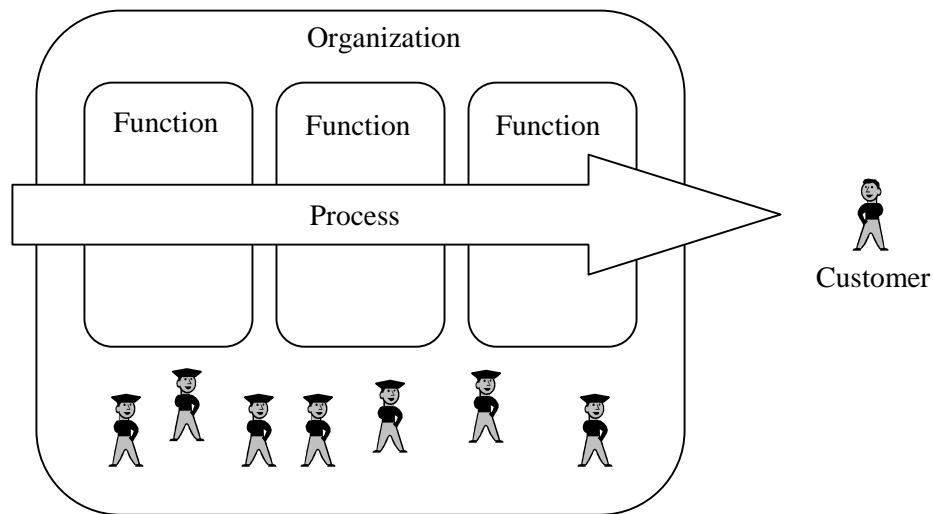
<sup>77</sup> Larsson, E., (2001) pp 76

<sup>78</sup> Larsson, E., (2001) p 75

<sup>79</sup> XDIN, (2005) pp 8

<sup>80</sup> Larsson, E., (2001) p 44

<sup>81</sup> Larsson, E., (2001) pp 64



**Figure 3.6 The process based organization.**<sup>82</sup>

The process based organization facilitates the employees with required information to make the right decisions. This also makes the organization more apt to adapt to its environment.<sup>83</sup> Benefits of moving towards a process based organization is increased customer focus, strengthened comprehensive view, facilitated business control and enhanced quality, effectiveness and service levels.<sup>84</sup>

When measuring processes it is important find a relevant level of resolution in the measured data; too aggregated data is hard to draw conclusions from and too high resolution will lead to data flooding. Amongst measured metrics, a study by the Boston Consulting Group found that focus on time was a common denominator amongst successful companies.<sup>85</sup> Toyota, a cicerone in lean production, applies a different approach to measurement than many companies. Toyota does not allow external production controls on the shop floor and does not allow external management accounting controls. They have developed a culture where everybody in the organization is responsible to rapport and develop the operations and processes. Instead of using metrics on the shop floor Toyota uses the knowledge and common sense of it employees. The employees are in general able to tell whether an alternative process is better than the present process or not, without using metrics.<sup>86</sup>

Processes are categorized in various ways. In the highest level of categorization there are three types of processes:

<sup>82</sup> Larsson, E., (2001) p 46

<sup>83</sup> Rentzhog, O., (1998) p 20

<sup>84</sup> XDIN, (2005) pp 14

<sup>85</sup> Larsson, E., (2001) p 15

<sup>86</sup> Johnson, T., (2005) pp 75 - 84

1. **Main processes** describe how the business concept is realized, e.g. how products are supplied.
2. **Management processes** control and coordinate all processes and set directions, e.g. development of strategies.
3. **Supporting processes** supply main processes and management processes with resources, e.g. maintaining IT systems.<sup>87, 88</sup>

### 3.3 Data base structures

As the companies of the 20<sup>th</sup> century grew more sophisticated, the administration of information became an issue of greater relevance than before. A great invention and enabler of reducing the administrative load was the birth of the computer. Computers facilitated the possibility to store large information quantities in structured manners in databases.

A database is a collection of data, where the data is related to each other in a logical structure. The database also contains a description of the data structure, like a map of the information. Main components of the structure in the data base are relations, attributes and tuples. The relations are data tables, like large spread sheets. Each relation has several attributes, which are names or descriptions of the stored information. A tuple is like a row in the spread sheet. Each relation has an attribute or a set of attributes as a unique identifier, called the primary key (see Figure 3.7).<sup>89</sup>

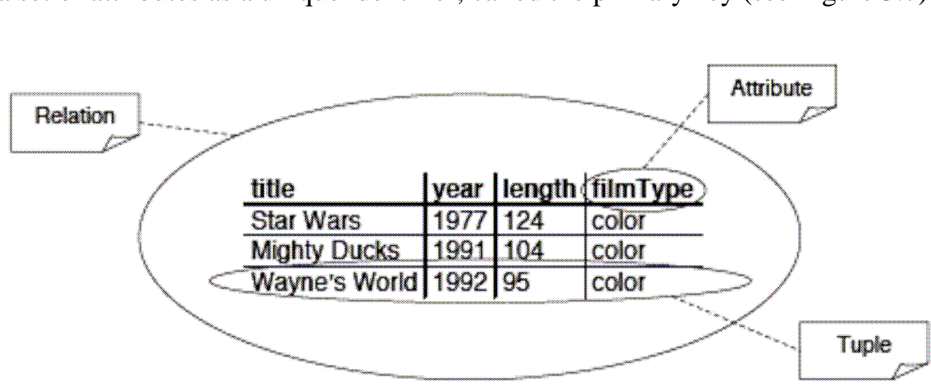


Figure 3.7 A database relation with the tuples title and year as the primary key<sup>90</sup>.

In the database tables are related to each other in logical structures (see Figure 3.8). Together they become a web of logically structured data.

<sup>87</sup> Larsson, E., (2001) pp 82

<sup>88</sup> Carl-Henric Nilsson, *Senior Lecturer*, School of Economics and Management, Lund University, (2005-04-12)

<sup>89</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-10-25)

<sup>90</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-10-25)



accountNo	balance	type	ownerPNo	persNo	name	address
67890	2846.92	checking	790614-2921	730401-2334	Bo Ek	Malmö
12345	1000.00	savings	730401-2334	801206-4321	Eva Alm	Lund
...	...	...	...	...	...	...

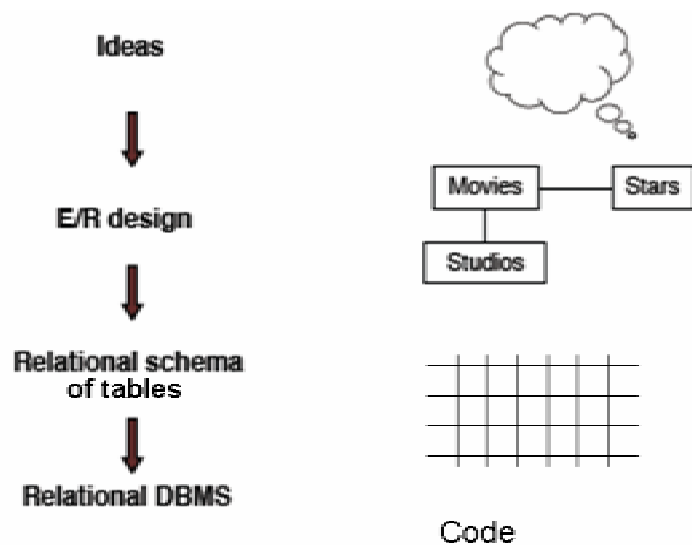
**Figure 3.8** The link between the tables is the personal number. The address of the owner of a specific bank account can be found though the account and address is stored in separate tables.<sup>91</sup>

To access a database a database management system (DBMS) is used. The DBMS:

- manages large amounts of data
- allows users to specify the logical structure of the database
- allows users to enter, alter and delete data
- supports concurrent access to data
- handles backups and crash recovery<sup>92</sup>

### 3.3.1 Database design

To capture all required functionality when developing a database a systematic approach is commonly applied. Though the approach is slightly different in different organizations, the concept of the development process is very much the same all over the world. This concept is expressed in Figure 3.9.<sup>93</sup>



**Figure 3.9** The generic process of database design.<sup>94</sup>

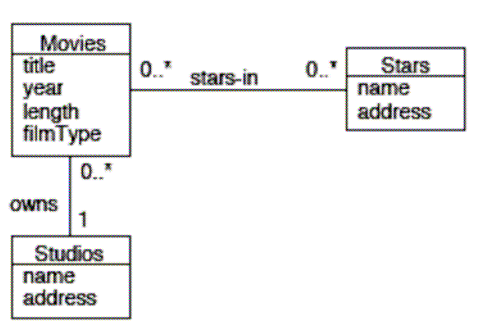
<sup>91</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-10-25)

<sup>92</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-10-25)

<sup>93</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-11-07)

<sup>94</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-11-07)

In the design of a database the first step is to translate the required functionality the database will support into a logical structure of data entities and relations between the entities. This step is called entity/relationship design. In the process of doing this a graphical language is used.<sup>95</sup> One of the most widely spread standards of graphical presentation in entity/relationship modeling is called Unified Modeling Language, or UML. Advantages of UML is that it is a standardized language, it is compact and it expresses multiplicity explicitly in the relations between the entities (see Figure 3.10).<sup>96</sup>



**Figure 3.10 Example of entity/relationship design. Multiplicity is explicit, e.g. each Movie is owned by only one Studio, but one Studio can own many Movies.**<sup>97</sup>

In the entity/relationship design the structure of the database is expressed to get an overview of the system. From the overview the functionality of the system can be tested using certain principles. Data redundancy is also avoided in this process by applying a set number of rules. Redundant data takes more disk space, but the most negative aspect is that data must be maintained and updated in more than one instance. A model with no data redundancy is called a normalized model and is preferable to non-normalized models.<sup>98</sup>

As the phase of implementing the entity/relations design into tables with a supporting database management system is outside the scope of this thesis, this will not be further discussed.

<sup>95</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-11-07)

<sup>96</sup> Andersson, L., (2005-08-22) pp 2

<sup>97</sup> Holm, P., *Senior Lecturer*, Lund Institute of Technology, (2005-11-07)

<sup>98</sup> www.databasktenik.se, (2006-04-29)

## 4 Clarkson Inc. and the case study context

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*In this chapter the case study context is presented. Brief financial facts and organizational structure is followed by why and how modularity entered the scene at Clarkson Inc, a short description of how the ERP system was implemented and how Clarkson Inc. has approached information handling issues.*

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Clarkson Inc. is a global supplier of industrial systems with the mission to improve development and manufacturing processes at the customers. The improved processes reduce lead time and cost and increase quality. Clarkson Inc. leverages half a century of experience when providing high tech and high precision products.<sup>99</sup> The product portfolio is divided in eight segments and covers a wide range of products, generally developed to the customer's requirements in project based teams.<sup>100</sup>

The US based company maintains offices in 50 countries, ensuring local access to service and consulting in large parts of the world. The company employs somewhat less than 2000 individuals worldwide. The revenue of 2005 was approximately USD 450 million.<sup>101</sup>

### 4.1 Organization

Clarkson Inc. has a history of producing all products in projects. The projects cover a wide range of prizes and time horizons. Organizationally, the company is arranged in a classic hierarchy combined with a matrix of product owners and function owners.

### 4.2 Changing business environment

The engineering spirit at Clarkson Inc. has kept the performance of the products on a high level and the company is considered to be high-end market leader. The product qualities have been in focus rather than process effectiveness and efficiency. The competition has hardened the last years and Clarkson Inc. contacted Modular Management AB to get guidance towards a new strategic approach.<sup>102</sup>

Modular Management AB and Clarkson Inc. chose to begin the modularity approach on one specific product segment. The chosen product segment represents approximately 5% of the total turnover.<sup>103</sup>

### 4.3 The modularization project program

Modular Management AB created a project program that will guide Clarkson Inc. through the different phases of a modularity implementation. Modular Management

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<sup>99</sup> Clarkson Inc.'s corporate website, (2006-03-24)

<sup>100</sup> *Documentation Team Project Manager*, Clarkson Inc., (2006-01-07)

<sup>101</sup> Clarkson Inc.'s corporate website, (2006-03-24)

<sup>102</sup> *Product Manager*, Clarkson Inc., (2006-01-18)

<sup>103</sup> Leine, A., *Project Manager*, Modular Management AB, (2006-03-02)

AB considers it crucial that the customer gains understanding of the implementation process and most of the preparations are made together with the customer.<sup>104</sup>

Three teams were created to take on different tasks: the Design Team, the Production Team and the Documentation Team. The teams consist of a mixture of Modular Management AB consultants and Clarkson Inc. employees with different areas of expertise, approximately 7-10 people per team.

- **The Design Team** concerns the development of a product. The team divides the product into modules, defines interfaces and constructs a designing method that protects the platform from eroding. The new modular design reduced the necessary part numbers required with 90% but the new design is not yet implemented. The part number reduction is a consequence of standardized module variants and common components shared between product variants.
- **The Production Team** focuses on the manufacturing and assembly processes. The team considers matters like design of assembly instructions, shop floor layout and optimization of the production processes to modularity.
- **The Documentation Team** regards the information handling so that it supports modularity. The team mapped the information and material processes to find areas where modularity might generate issues and to identify areas where modularity can leverage the information handling.

The project program is now in the phase where the organization prepares for launch of the modularized platform. Discussions about a long term goal for an optimal modular platform for Clarkson Inc. goes on parallel with the practical preparations during early 2007.

#### 4.4 The ERP implementation

Clarkson Inc. implemented SAP in 1997. The company chose not to work through their processes in the implementation which left them with an unchanged functional oriented organization. To keep down the cost obliged with implementation the company limited the number of licenses to the key users. The rest of the organization used software which are not part of SAP but had access to the SAP databases.<sup>105</sup>

#### 4.5 Earlier attempts to prevent information overflow

Clarkson Inc. has the ambition to reduce the part numbers in circulation in the information system. There have been multiple attempts to clean up the registers from the many part numbers generated in the organization<sup>106</sup>. The last major register

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<sup>104</sup> Leine, A., *Project Manager*, Modular Management AB, (2006-02-12)

<sup>105</sup> *Documentation Team Project Manager*, Clarkson Inc. (2006-01-07)

<sup>106</sup> *SAP specialist*, Clarkson Inc. (2006-03-14)

analysis showed that of the 400.000 registered part numbers was 220.000 not active and therefore deleted. Another 100.000 needed review due to low quality data<sup>107</sup>.

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<sup>107</sup> *SAP specialist*, Clarkson Inc. (2006-01-16)



## 5 Information handling at Clarkson Inc.

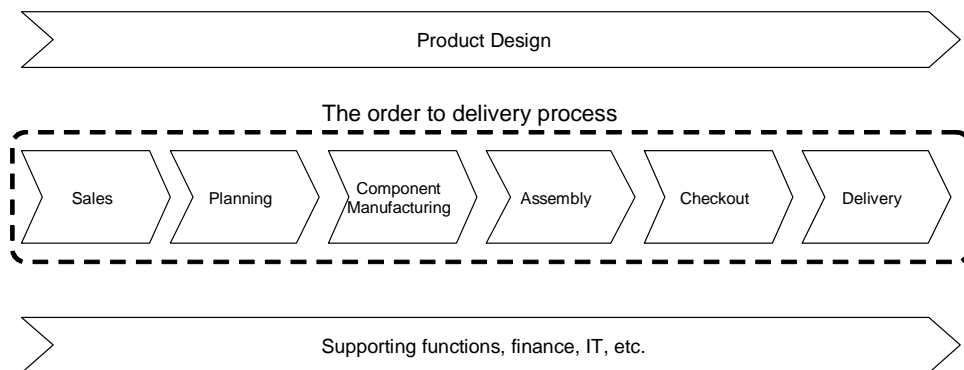
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*In order to find in what areas the information handling can facilitate and benefit from modularity, process mapping and data collection has been conducted. In this chapter the authors describe the information handling processes at Clarkson Inc. A presentation of the Product Design processes is followed by a step-by-step journey through the Order to Delivery process.*

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At Clarkson Inc. there are two major parts of the organization: Product Design and Production. The collaboration between these is intense. The examined product in this research is the one that Clarkson Inc. considered to be best suited for a strategic shift from project based production to standardized production. This change was initiated before modularity entered. The ambition was to have both project and standardized production and the greater part of the studied product should be produced in the latter. In accordance with the delimitations of this study, the focus will be on the Order to Delivery process, and just briefly touch on the design process.

In Figure 5.1, a high level map of the main processes is presented. It is a description of the information flows within and between these processes that are presented in this chapter.



**Figure 5.1 High level process map of Clarkson Inc.**

### 5.1 Product Design

Product Design is the part of the company that designs the products. Almost everyone working with product design at Clarkson Inc. is engineers<sup>108</sup> and their ability to meet customer requirements is acknowledged<sup>109</sup>.

Until recently all products produced at Clarkson Inc. was the result of a project. All the projects had at least one Product Design representative involved. The company is now in the process of launching a Configure to Order process that will relieve a

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<sup>108</sup> *Manufacturing Engineer Manager, Clarkson Inc., (2006-01-16)*

<sup>109</sup> *Product Manager, Clarkson Inc., (2006-01-18)*

substantial part of the designers involvement in smaller projects. The Configure to Order process is further described in chapter 5.3.

There are numerous tools used in the development process of a product, e.g. stress and finite element analyze programs, hydraulic analyze programs, MathCAD, McCush, MatLab, to mention a few. In communicating the output of the Product Design the CAD program<sup>110</sup> is the primary tool used. Digital two dimensional drawings are also commonly used for this purpose.<sup>111</sup>

## 5.2 The Order to Delivery process

The Order to Delivery process will be described process wise, starting with the interaction between sales and the customer and ending when the product is shipped (see Figure 5.1).

## 5.3 Sales

The sales department uses software called “Salesforce.com” that has a built-in compatibility with SAP<sup>112</sup>. There is an available sales department module from SAP that the company chose not to install<sup>113</sup>. The employees we interviewed are all satisfied with the functionality in the current program. Salesforce.com is used to keep track of customers, numbers, orders etc. The sales personnel do use SAP when the customer needs shall be translated into a specific configuration of the product.<sup>114</sup>

### The Variant Configurator

To avoid that all products need a product design engineer’s attention an intelligent sales tool was designed. The sales force collects the customer requirements and put it into an SAP software that extract a customer specific product. The underlying logic is a sheet of compatibility relations between components. A customer requirement is translated by a sales representative into the choice of a certain component that is compatible with already chosen ones. This way a complete product specification is composed. In a standard order all the customer needs can be satisfied with the enable configurations. If there is a customer need which the existing components can not satisfy a component design request is sent to Product Design from sales. This request can result in two things: a Design to Order process or an Engineer to Order process.<sup>115</sup>

### The Design to Order process

If the customer’s special need is not obviously a big scale project a Design to Order evaluation is conducted. This evaluation is done by Product Design and takes only about an hour. The evaluation decides whether the designing of the components needed to meet the customer needs takes less than 20 working hours. If that is the

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<sup>110</sup> Due to secrecy the CAD program will not be further specified.

<sup>111</sup> *Product Manager and Documentation Team Project Manager*, Clarkson Inc., (2006-03-13)

<sup>112</sup> [www.salesforce.com](http://www.salesforce.com), (2006-04-02)

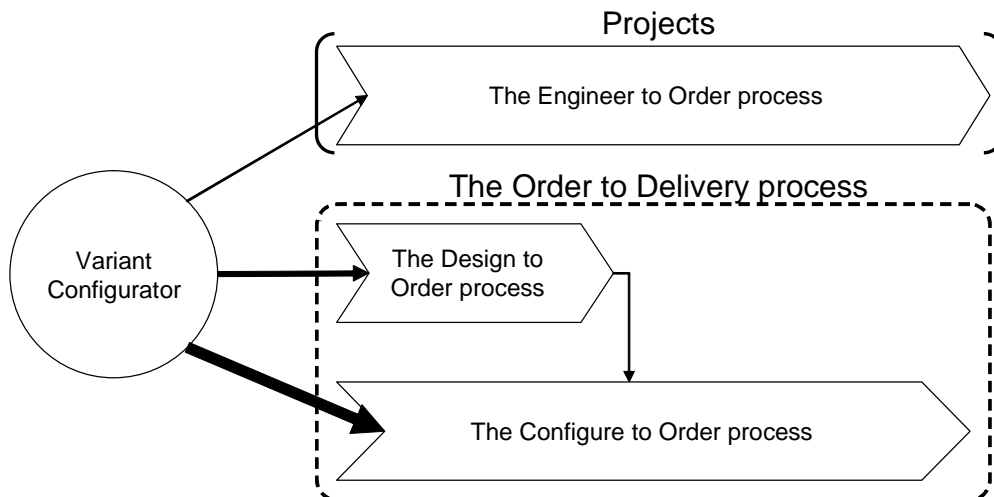
<sup>113</sup> *Documentation Team Project Manager*, Clarkson Inc., (2006-04-04)

<sup>114</sup> *SAP specialist*, Clarkson Inc., (2006-02-13)

<sup>115</sup> *Product Manager*, Clarkson Inc., (2006-03-01)



case the Designer returns an approval and a cost estimate. When the particular newly designed component is done, it is released into the Configure to Order process. If the Designer considers it to take more than 20 working hours to design a satisfying component the request becomes a matter for the Engineer to Order process. (See Figure 5.2)



**Figure 5.2 The Variant Configurator and its outcomes.**

### **The Engineer to Order process**

The orders that generate projects are not to the same extent applicable to modularity and are not within our scope. The projects have fundamentally different processes and modularity is not planned to be implemented in this part of the organization.<sup>116</sup>

### **The Configure to Order (CtO) process**

The Variant Configurator output is the first step in the Configure to Order process. The company started to implement the Variant Configurator and the Configure to Order process before the implementation of modularity. The CtO process is a part of the Order to Delivery process with the characteristics of standardized production. As mentioned, some parts are made outside the CtO process if the customer needs can not be met but most of the production is done in the CtO process.<sup>117</sup>

### **Rule of thumb in the Sales process**

To be able to give the customer a delivery date the sales department uses a rule of thumb<sup>118</sup>. This method of setting customer expected delivery date is based on a time estimate and gives a situation where most of the products gets to the customer too late<sup>119</sup>.

<sup>116</sup> Documentation Team Project Manager, Clarkson Inc., (2006-02-02)

<sup>117</sup> Manufacturing Engineer Manager, Clarkson Inc., (2006-03-19)

<sup>118</sup> Planner, Clarkson Inc., (2006-03-14)

<sup>119</sup> Planner, Clarkson Inc., (2006-03-14)

### 5.3.1 Planning

The planners get their input from two primary sources: sales and forecasting. When sales release an order through the Variant Configurator it takes approximately one month until the planners get to see the order<sup>120</sup>. It is unclear for the authors where in the system the information stays in the meantime.

#### Forecasting

There is one role at Clarkson Inc. that is dedicated to forecast the future demand of the product. This role is called Master Scheduler. The need of forecasting was a result of the customers considering the Order to Delivery time to be too long<sup>121</sup>. By forecasting the demand Clarkson Inc. was able to cut the time to delivery by 30%<sup>122</sup>. The Master Scheduler uses Excel as main program, she usually print out empty Excel sheets that are edited by pen and paper together with the Product Manager. The information is then put into Excel by hand. To communicate the forecasts to the rest of the organization she needs to put the information into SAP, field by field.<sup>123</sup>

#### Another way to get instructions

SAP is the way that the planners usually get their instructions, regardless if it is from sales or forecasting. It is not unusual that, for example, a Product Manager wants a certain product to be prioritized and he or she walks to the planners desk and ask for changes in the plans. The planners find these unpredictable orders challenging since they dislodge the plans already made.<sup>124</sup>

#### The planning process

Planners have their own dedicated resources and are specialized in certain products. When a planner, for example, plans the work load for an assembly station he or she gives certain employees tasks. The planning horizon is approximately one month. By default, the planning is executed via SAP but some of the planners do not think that that system offers the flexibility necessary. These planners use alternative tools, usually planning in Excel and emailing sheets to individuals in, in our example, the assembly area.<sup>125</sup> The routines are designed so that the planners have approximately two months from receiving an order until the products shall be released to production<sup>126</sup>. The two months are used to prepare production by planning resources and purchase components if necessary<sup>127</sup>.

#### Planners do not like the rule of thumb

Planners are provided with order specifications and, by sales promised, delivery dates from the Sales department. The planners try to plan the products to be delivered in time but the rule of thumb used by sales does not regard the capacity available or the

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<sup>120</sup> *Planner*, Clarkson Inc., (2006-03-14)

<sup>121</sup> *Master Scheduler*, Clarkson Inc., (2006-02-26)

<sup>122</sup> *Product Manager*, Clarkson Inc., (2006-02-26)

<sup>123</sup> *Master Scheduler*, Clarkson Inc., (2006-02-16)

<sup>124</sup> *SAP specialist*, Clarkson Inc., (2006-03-14)

<sup>125</sup> *Product Manager and Documentation Team Project Manager*, Clarkson Inc., (2006-03-13)

<sup>126</sup> *Planner*, Clarkson Inc., (2006-03-14)

<sup>127</sup> *Planner*, Clarkson Inc., (2006-03-14)

warehouse levels of components.<sup>128</sup> This causes delayed deliveries and the planners are not satisfied with the communication with sales.<sup>129</sup>

### 5.3.2 Component manufacturing

In component manufacturing the components are produced. Basically component manufacturing's input is the production order and the output is all components needed for the next process, assembly, to put the pieces together. Component manufacturing does not actually produce all the components from scratch, some are bought and refined, some entirely outsourced and others totally in-house produced.<sup>130</sup>

#### The Shop Packet

The production order, the instructions of which products and how the products are produced, is delivered as a "shop packet". The shop packet is a transparent plastic folder filled with documents about the product that is about to be produced. The shop packet is produced in the "Documentation Center" that receives the specifications when the planners release a production order. The Documentation Center personnel have scripts that fetch data from SAP and libraries of digital drawings. The data is then printed and manually sorted, put in the plastic folders and distributed by the internal post.<sup>131</sup> The lead time from production order release until the shop packet reaches the receiver is two days.<sup>132</sup>

#### Instructions from planners

It is the planners that decide in what order the components and products are produced and not the order in which the shop packets arrive to the shop floor. There are usually a stack of shop packets in cue at the different stations waiting for processing. Still, stations sometimes run out of shop packets. When that happens the lead time is two days to get them new working instructions and the station stands still. The workers usually spend that time to help surrounding stations or clean up the working area.<sup>133</sup>  
<sup>134</sup>

#### Parts availability

The planners communicate component manufacturing's need of parts and the internal logistics function brings them from the warehouses. The parts are left in smaller storage points close to the station where they are about to be used. When a component is processed it usually is sent back to the warehouse for storage until it is needed in another process<sup>135</sup>. When the parts are sent from the warehouse they are marked as

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<sup>128</sup> *SAP specialist*, Clarkson Inc., (2006-01-16)

<sup>129</sup> *Planner*, Clarkson Inc., (2006-03-14)

<sup>130</sup> *Production Team member, SAP specialist, Manufacturing Engineer Manager*, Clarkson Inc., (2006-02-15)

<sup>131</sup> *Documentation Center Manager*, Clarkson Inc., (2006-03-22)

<sup>132</sup> *Documentation Center Manager*, Clarkson Inc., (2006-03-22)

<sup>133</sup> *Assembly worker*, Clarkson Inc., (2006-02-21)

<sup>134</sup> *Production Team member, SAP specialist, Manufacturing Engineer Manager*, Clarkson Inc., (2006-02-15)

<sup>135</sup> *Stock room and warehouse worker*, Clarkson Inc., (2006-03-21)

“component in process” and not “component at storage point”. This is a way for the planners to avoid that other planners take components from “their” storage points.<sup>136</sup>

### **The use of IT systems**

In component manufacturing the use of both SAP and CAD is limited since most of the information needed is delivered in the shop packets. Still, the IT system is used at some points. The Manufacturing Manager is not satisfied with the way the information handling is done. He thinks that the information processes should be properly worked through instead of doing short-term fixes of issues that are results of an “inadequate IT system”, “We do so many workarounds... little tricks we’ve learnt to get around the system”<sup>137</sup>

### **5.3.3 Assembly**

Assembly gets the components, or kits as the grouping of relating components are called, from the warehouse. The work planning is received via SAP or e-mails and instructions is received in the shop packets like in component manufacturing. When information is missing in the shop packet the assembly workers use a database called “Document on Demand” (DoD) where drawings and assembly instructions are stored<sup>138</sup>. The DoD database is used by many departments at Clarkson Inc. when product specific information is needed. When Product Design releases a component or product they usually publish the drawing in DoD.<sup>139</sup>

### **Getting the information**

The assembly workers sometimes find it hard to know what dates to relate to since the planners use different tools for planning. When the received work plans are delivered via mail using Excel sheets the information is usually not updated in SAP. SAP is the delivery date source when the shop packet is produced.<sup>140</sup> In assembly there is a routine that the workers call their respective planners every morning to double check the plans and the work load.<sup>141</sup>

### **Work-time specified in SAP**

In SAP there are work-times specified related to operations. For example, a certain kit is supposed to take 0,75 hours. That time specification is communicated to assembly in the shop packet. The assembly workers know that the given time is not enough but there is no feedback loop function where they can change it.<sup>142</sup> “I try not to look at the work-times in the shop packet, it’s only confusing”<sup>143</sup>

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<sup>136</sup> *Stock room and warehouse worker*, Clarkson Inc., (2006-03-21)

<sup>137</sup> *Manufacturing Manager*, Clarkson Inc., (2006-03-08)

<sup>138</sup> *Manufacturing Assembly Manager*, Clarkson Inc., (2006-02-14)

<sup>139</sup> *Technical Communication Manager*, Clarkson Inc., (2006-01-09)

<sup>140</sup> *SAP specialist*, Clarkson Inc., (2006-03-14)

<sup>141</sup> *Assembly worker*, Clarkson Inc., (2006-03-13)

<sup>142</sup> *Assembly worker*, Clarkson Inc., (2006-02-15)

<sup>143</sup> *Assembly worker*, Clarkson Inc., (2006-02-15)

### **When parts are missing**

The assembly workers can use SAP to order parts. The needs usually occur when a part is delivered broken or not delivered at all. It takes approximately two days for a part to get delivered. If the assembly worker wants a part faster than that he or she usually walks to the warehouse and get the part right away.<sup>144</sup>

### **5.3.4 Checkout**

When a product is assembled it is sent to checkout. Checkout makes sure that the product works properly and that all the necessary cords, software and documentation are on a pallet and ready to be shipped.

#### **Four things that must match**

When the products are received at checkout four things must match:

- **The bill of material** that is received with the products and shall represent which components that are on the pallet.
- **The quote** represents what the customer bought. The bill of material is based on what the customer bought but there can be changes in the order specifications in manufacturing or assembly. In checkout the workers know from experience that the quote should be considered. The quote is not automatically sent to checkout but the checkout workers know how to find it.
- **The customer needs** is not always the same thing as what the customer bought<sup>145</sup>. Checkout do not have any contact with the customer but if, for example, the customer ordered a certain extra performance and another part of the product restrict that quality checkout reacts.<sup>146</sup>
- **The actual content on the pallet.**

If these four does not match, checkout tries to find the source and solve it by contacting the Product Manager who sorts out what has happened and makes sure to align any questions with sales, manufacturing and assembly.<sup>147</sup>

### **5.3.5 Shipping**

When the checked out products reaches shipping they are packed. In shipping Excel is used to keep track of planning and SAP is used to get information from the rest of the organization. The Shipping Manager is not satisfied with the access he has to SAP; he can not see what the pipeline in production looks like. This makes it hard for him to allocate resources for packing and shipping.<sup>148</sup>

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<sup>144</sup> *Assembly worker*, Clarkson Inc., (2006-02-15)

<sup>145</sup> *Checkout worker*, Clarkson Inc., (2006-03-15)

<sup>146</sup> *Checkout worker*, Clarkson Inc., (2006-03-15)

<sup>147</sup> *Checkout worker*, Clarkson Inc., (2006-03-15)

<sup>148</sup> *Shipping Manager*, Clarkson Inc., (2006-03-27)

### 5.3.6 Supporting functions

#### Storage

The program Access is used in the warehouse to keep track of how long the different operations take. In order to do that, information is copied from SAP and put into the Access database.<sup>149</sup> In storage there are problems with “walk-ups” where employees from components manufacturing, assembly or service walk to the warehouse and get components or products without registering it in SAP. In storage the employees are annoyed with this behavior; one warehouse employee ironically talked about “lots and lots of clever people who find their way around the system” that do not understand how they undermine the system by generating a differential between the warehouse actual content and the databases.<sup>150</sup>

#### Documentation Center

As mentioned earlier in this chapter is the Documentation Center the department where the shop packets are produced. Every released production order generates approximately fifteen shop packets. These plastic folders reaches multiple stations in component manufacturing, assembly, checkout and shipping.<sup>151</sup>

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<sup>149</sup> *Stock room and warehouse worker*, Clarkson Inc., (2006-03-21)

<sup>150</sup> *Shipping worker*, Clarkson Inc., (2006-03-21)

<sup>151</sup> *Manufacturing Assembly Manager*, Clarkson Inc., (2006-02-14)

## 6 Analysis of the information handling at Clarkson Inc.

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*In this chapter the authors analyze the case study of Clarkson Inc. using the theories presented in the chapter 3. Recurrent issues are identified and grouped. Parts of the issues can be approached with existing theories and common sense, other need new tools. The need of solutions to the latter is the basis for the theoretical tools created in the chapter 7.*

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### 6.1 Present state analysis of Clarkson Inc.

In our theoretical studies we found the principles that we believe should be part of the foundation of the information handling at a modular platform, e.g. process based organization and normalized database structures. We will focus on areas with potential for improvement within information handling while keeping the characteristics of modularity in mind. We expect differences between the theories and present state at Clarkson Inc. due to the fact that the current information handling is created for a project based platform and not for modularity. Still, processes, regardless if they concern information handling or not, can be more or less efficiently planned and carried through.

#### **Many well working processes at Clarkson Inc.**

Clarkson Inc. has many well working information handling processes on a detailed level. The operators of certain information processes usually have a good understanding of where to find information, how to edit it and where to send it. On a higher level there are some fundamental information processes well prepared for modularity according to the theories presented in chapter 3. One part of the information handling that has potential to leverage the implementation of modularity is the Variant Configurator. The Variant Configurator requires standardization of components and documentation, much like modularity. It provides the opportunity to have a Configure to Order process with an appropriate information handling start as a consequence. The Configure to Order approach was initiated before modularity was on the agenda but its fundamentals suits modularity.

#### **Enthusiasm and understanding as assets**

A strength at Clarkson Inc. is the organizational awareness of the information handling issues. The majority of the employees we have met at Clarkson Inc. have a good understanding of not only their own function but also about the entire organization and the challenges they face. The employees put pride in their core competence and their positive attitude and understanding of the current change process might be the single most important aspect in the modularity implementation. Our analysis will not dig deeper into Change Management, the way employees or management will be affected or other personal aspects of implementation of modularity. Still, we would like to note that we consider the unmistakable enthusiasm for, and belief in, the project as critical for success.

### **6.1.1 Information processes**

The information processes are of great importance at Clarkson Inc. During our research we found patterns in the way potential is not utilized in the information handling. In this chapter we give account for the potentials we found that regard the way employees find, edit, add, send, receive, own and think of data – the information processes.

#### **Ownership is needed**

The information processes at Clarkson Inc. do not always have clear owners and this generates implications. The respective functions have managers but the information processes are not always well defined. In the interface between the functions the responsibilities are vague, and the potential to improve the processes is high. The need of clear ownership leaves Clarkson Inc. with a situation where most of the information is handled correctly, but the processes are fragile and dependent on individuals' will of taking responsibility.

#### **More process focus on the shop floor**

The current project based structure combined with a function based organization, as in the case of Clarkson Inc., lead to sub-optimization of the information processes. When the information processes are improved, the focus is not on the entire Order to Delivery process but on separate parts, processes or functions. Clarkson Inc. does not standard produce any product that represents more than 10 % of the total turn over. Still the standardized production and project production share the shop floor, IT system, designers etc. with the rest of the portfolio. As the standardized production constitute such a small portion of the over all production, it is hard to control and influence the functions with the requirements of the standardized production. We think that for modularity to truly succeed at Clarkson Inc. more authority must be allocated to managers that will have a systemic view of the entire Order to Delivery process.

#### **Product documentation is required**

As a result of the tradition of working in projects, Clarkson Inc. has not had much reason to archive documentation for reuse in another project. Still, documentation has been done to be able to provide after sale product service and support. Clarkson Inc. will have to change the way of storing information from project wise to platform wise. This would provide an opportunity for Clarkson Inc. to make incremental improvements of the information as it is reused. Modularization drives the use of routines. Such documentation may generate higher upfront costs but lower information handling costs in the long run. When information is planned to be used over and over again the information quality requirements initially gets higher to avoid planting issues that will stay in the system. Such issue could for example be a need of double checking or storing redundant information.

#### **Start pulling information**

The principle that information should be pushed to the receiver is something that is hard to manage in an organization as Clarkson Inc. The inverse principle is that information is pulled when needed. In a customer relation pushing information like



invoices is the preferred method of information delivery. At Clarkson Inc. we suggest a switch from pushing information to pulling information as an overall information strategy. This would reduce the time of producing information since not all information is wanted but equally important; the time spent sorting and trying to find specific information in a stack of information would decrease.

### **Use feedback loops**

Another important potential when it comes to the way information is received and sent is the ability to loop back errors in the information. Regardless if the information is pushed or pulled we consider a feedback loop to be a powerful function for information quality improvement.

### **Trust must increase**

In an organization that produces high-end technical products it is very important that the information handling is correct on a detailed level. The lack of trust can erode the attempts to structure the routines and the situation at Clarkson Inc. Since there is no well working feedback system to improve the information handling itself, employees start to find their own ways of get the work done. When someone needs a quick decision or a check of information a “walk-up” usually is done. The “walk-up” does not only interrupt the information holder and the information consumer; it also manipulates the original information handling.

### **Time has become a critical aspect**

Regardless if the information processes are temporarily created or carefully designed, time has not been a critical aspect at Clarkson Inc. The oligopoly and market leadership have not pushed the need of fast information handling. The focus has been on product performance and the company gained market leadership thanks to their excellent products. The internal information handling has not been in focus. As process time now turns into a key success factor when the competition gets harder, the information handling speed must obtain a prominent and prioritized part of the strategy.

## **6.1.2 Information structure**

In the start of this study Clarkson Inc. had not yet launched their modular product platform. A result of this is that Clarkson Inc. does not have a modular information platform for us to analyze. The Documentation Team, which has been the core of this field study, was assembled to develop the proper information handling to support the product platform. As this is not an issue of altering the information platform of Clarkson Inc., but rather launch a new platform, we will cover this in the theoretical generation of an information platform in chapter 7.1.3.

### **Enhance the VC logic**

Today Clarkson Inc. has the Variant Configurator (VC), which configures products from a smaller non-modular platform. This is a big step towards a modular configurator. The logics of the VC support the concept of a modular product platform. Though, there are still potentials to enhance the performance of the VC. Today the VC is like choosing a three course meal from a menu, choosing starter, main meal and

dessert. To some dishes there are additional restrictions, for instance you can not have fish and cream caramel in the same dinner. With the VC logic you might get a different dinner depending on which order you look through the menu. If you begin by looking at the main meal and decide for fish, you will not be able to choose the cream caramel. If you begin with the dessert and choose cream caramel you will not get the fish. So, if you feel like fish and cream caramel and you can not have both, you are going to get fish if you read the menu from the first page and cream caramel if you start reading the menu from the back. In this example it is possible to get the overlook of the menu and choose whether you will go for fish or cream caramel. In reality the choices and restrictions are more complex and the overview is hard to capture. Instead of choosing module variants, like the menu analogy, the VC can be programmed to configure the product on conditions better describing the requirements of the customer, e.g. force interval, maximum price, minimum frequency etc.

When the modular information platform is launched the VC will facilitate a VC key which will be the access point to the information regarding the configured product. A VC key contains a string of information with the module variant codes. We find Clarkson Inc. well prepared for this section.

### **6.1.3 IT Systems**

Clarkson Inc. has many IT systems supporting the information handling in the organization. The backbone of the IT systems is the ERP system SAP, implemented in 1997. In this section we will discuss how the IT systems affect the information handling at Clarkson Inc.

#### **A cost efficient implementation with consequences**

The way Clarkson Inc. implemented SAP as their ERP system was likely to generate problems in the future. Clarkson Inc. squeezed down SAP on the functionally based organization and did not only need to bend the built-in structure in SAP but also missed the opportunity to thoroughly work through the processes and evaluate the way they worked. We consider the separate functions to be too isolated when it comes to information handling. This might be the reason why SAP was implemented the way it was in the first place. Each function took responsibility for their own information handling needs while the system as a whole gained too little attention. Adding to this, Clarkson Inc. tried to keep down costs by limit the number of licenses.

#### **Not too late for SAP**

We do not think that it is too late to use the current ERP system to leverage a change towards a process based organization. We think that Clarkson Inc. should use the momentum of the change process to break the functional silos within SAP and direct the information flow horizontally rather than vertically. The cut down on licenses was an economical maneuver that made a substantial impact on the spreading and use of the ERP system. To save money, additional systems were implemented that could access the SAP databases. Since we do not regard the financial benefits of the chosen implementation strategy we leave out whether Clarkson Inc. did right or wrong, but we do derive a considerable amount of today's challenges to it.

### **Open databases in good and bad**

The SAP databases are the heart of the information storage at Clarkson Inc. Parts of this vast information are open for other programs to use, like a company internal library where employees can borrow edit and add data. This opens up for the use of other programs than SAP for information handling. Internal websites are connected directly to the databases and enable valuable and user friendly interfaces for employees and customers; Excel can fetch information by the use of macros etc. Unfortunately, this has also caused a situation where incorrect information is generated in the system. When information once is incorrect it leads to a new employee behavior; people starts to double check the information. ERP systems could be considered the backbone of the information flow in the company and it is of utmost importance that the information is correct and stored in a structured way in order to utilize the potential.

### **Do not collect unnecessary information**

It is important that all information that is generated is relevant and useful. SAP is for example used to keep track of the product specific times spent on different stages in production. Parts of this information are used as a basis for the product cost calculations. Every measurement itself takes time for the operator and is done by putting an order number and report an action into SAP. Our belief, and according to the way measurements are done at Toyota, is that a large part of the measurements can be taken away when processes get repetitive to a larger extent.

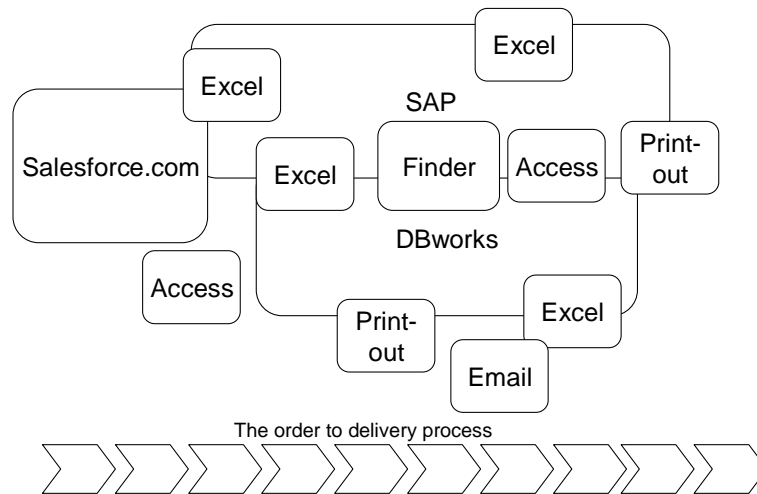
### **Additional programs**

The way that SAP was implemented required additional systems to manage the information handling. Some of the programs from before the implementation were kept alive and new ones were introduced. The growth of various complementing systems was sometimes due to “work arounds”, i.e. ad hoc applications which have been developed without regard to an over all information handling strategy.

During the mapping of the information flows at Clarkson Inc. we revealed improvement potential in the way the programs interact. We do not consider multiple information systems to be a problem. It is when the systems do not work together as a whole problem occurs. We consider SAP and CAD to be the primary information systems at Clarkson Inc. In addition to these fundamental applications are a number of other ways of transferring information within the company. MartinFinder, Salesforce.com, Scripts, Excel, Access, Email and printouts are other information carriers that are actively used at Clarkson Inc.

### **The patchwork quilt of systems**

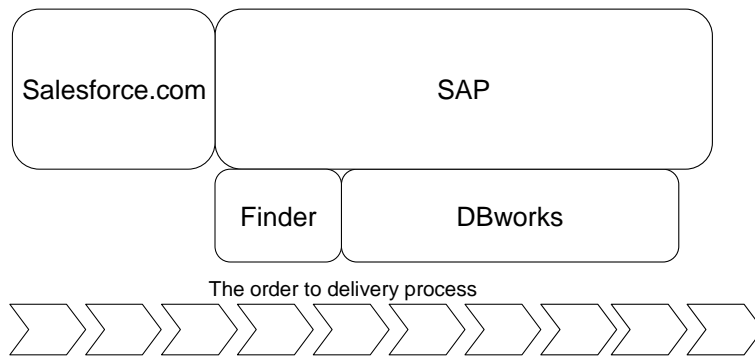
We think that the use of many different programs generates challenges at Clarkson Inc. To illustrate this we use *the patchwork quilt of programs* (Figure 6.1). Where the program fields are overlapping symbolizes redundant storage of information. The fields that are not connected to the rest of the systems represent information that is isolated from the rest of the system. The information that is stored isolated must be transferred to the rest of the systems manually. We will address some of the issues with *the patchwork quilt of systems* below.



**Figure 6.1 The patchwork quilt of information systems**

- **The programs overlap each others functionality.** There are multiple ways of doing the same information handling operation. In planning, for example, SAP can be used to plan and communicate with production but some planners use Excel to plan and then email the sheets to individuals in production. Besides the fact that the production workers experience inconsistent information deliveries, the Excel sheets are outside the system and out of reach for the rest of the organization. In this case this means that the planner that are using Excel conceal the use of resources if he/she does not register the same information in SAP. We think that the planning should be done in SAP to enable the rest of the organization to see the level of occupation in production.
- **The programs generate redundant information.** When MartinFinder twice a day fetches large amounts of data from SAP, redundant data is stored. We did not come across any problem that was a result of this explicit example but we consider redundancy to be an unnecessary risk. Whenever the same information object is stored in more than one database there is a risk that one of them gets changed but not the other. This gives a situation where the information consumer may find it hard to know whether he/she got the latest version. The use of master data would eliminate that kind of risks. We believe that Clarkson Inc. should clean up the use of multiple sources to the same information in order to gain clarity in information ownership and quality. We think that an information owner is able to control the information in one database but when information is copied to other places in the organization it gets difficult to maintain the quality. The information owner can ensure quality when he/she controls the information and other uses it from its source.
- **Manual work is required to move information between systems.** Information is needed in almost every process step. As mentioned, there are different systems and ways to get, generate and pass on information. If the

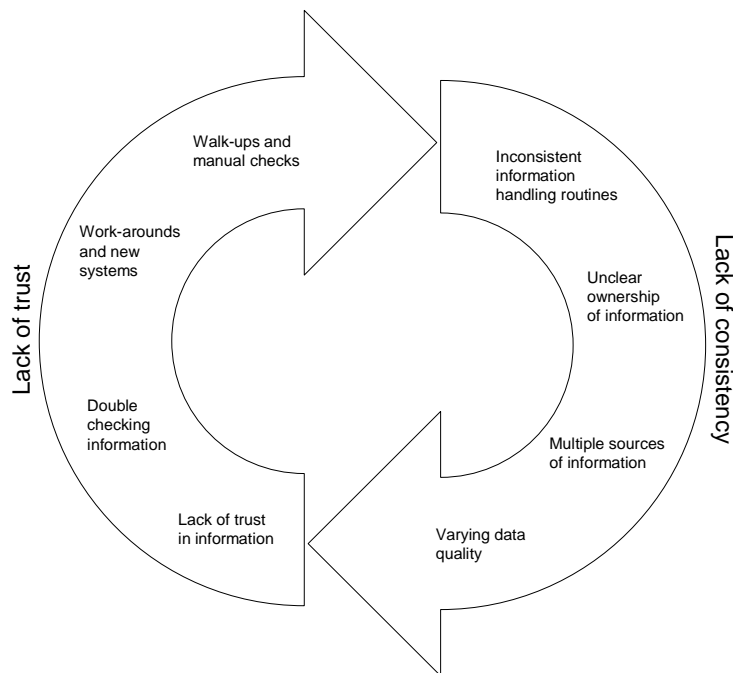
current systems would not overlap each others functionality and there where no generation of redundant information the many different systems would not be a problem. If the interface between Salesforce.com and SAP was well defined and the programs had access to each others databases without generating redundant information they could be considered a seamless system (See Figure 6.2). There would be no need of manual information transfers, for example from printed papers to Excel. The manual transfers are not only a time consuming task but also brings the risk of incorrect data due to the human factor.



**Figure 6.2 A possible, well functioning, system with coexisting programs**

## 6.2 The vicious circle of information handling

During the information and process mapping of Clarkson Inc. patterns started to show; inconsistency in information handling and lack of trust in information handling frequently recurred as issues. Half way through the study a relation between these problems came clear; they interacted in a self-reinforcing system. The lack of consistency results in lack of trust that bring various solutions that makes the system even more inconsistent. We call this system *the vicious circle of information handling* (see Figure 6.3). Below we will brake down the lack of consistency and the lack of trust in components.



**Figure 6.3 The vicious circle of information handling**

The lack of consistency can be divided into four major areas:

- **Inconsistent information handling routines.** When there is more than one way of doing a certain information operation the repetitiveness is not used and the same result is not always reached.
- **Unclear ownership of information** can result in a situation where multiple individuals claim the right to ensure quality but it can also lead to a situation where no one does. Regardless of which is the information quality in favor of one dedicated owner.
- **Multiple sources of information.** The redundancy of information drives uncertainty of which source that is preferable. When information is changed in one database and not in the other and the unchanged information gets used problems may occur.
- **Varying data quality.** The three issues mentioned above all affect the quality of the information.

The psychological effect of the lack of consistency is lack of trust. We identified four key occurrences related to skepticism to information quality:

- **Lack of trust in information.** The employees' knowledge that parts of the information input they got might be incorrect.
- **Double checking information.** When information is doubted employees starts to double check the information. This is usually done by using a system with overlapping functionality.
- **“Work-arounds” and new systems** are common when certain information use to be corrupt or if information systematically needs double checks. The solution

at Clarkson Inc. is usually to find a way to work around the current system or install a new program or script.

- **“Walk-ups” and manual checks** are ways of handling the lack of trust. When employees do not trust that the system will handle their input in a proper way, it is not unusual that they actually walk to the receiver of the information and make sure to be prioritized.

### **6.2.1 Grouping of issues**

Some of the issues analyzed in this chapter can be approached and solved with the use of presented theories, but not the issues where we believe that the combination of modularity and information handling might leverage each other. The theories used in this analysis gave insight in the available potential in combining modularity with a suited information handling but we needed practical tools and guidelines that could take the analysis to the next level. The structure in which the information is stored, the information processes and *the vicious circle of information handling* are areas in which we needed an approach to get further than where the basic theories can guide. In the next chapter we will present the authors own tools and models, created to solve the problems find at Clarkson Inc.





## 7 Generating tools for Clarkson Inc.

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*In this chapter tools are generated from the theories in chapter 3 to accomplish the changes needed in the information handling to facilitate and benefit from modularity at Clarkson Inc. The changes needed were identified on a high level in the previous chapter as information structures for modularity, information processes for modularity and tools to break the vicious circle of information handling.*

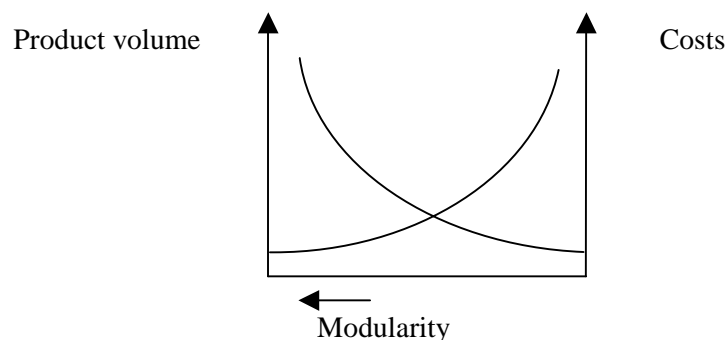
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### 7.1 Modularity's theoretical impact on information handling

Clarkson Inc. needs to adapt their information structure and their information process to modularity and they need to break *the vicious circle of information handling*. In order to generate tools for this purpose the aspects of modularity and the aspects of information handling, i.e. information structures and information processes, will be broken down. The broken down components will then be built up as one integrated system, considering both modularity and information handling.

#### 7.1.1 Leveraging the repetitiveness in modularity

When an organization, used to manufacture products in a project based manner, move towards configuring products from a modular platform, the organization is greatly impacted. Internally the impact is often captured in two words: reduced complexity. The internal reduction of complexity is due to the standardization, primarily on module and module variant level. From an information handling perspective the reduced complexity means increased repetitiveness. The final products can often be configured in thousands of variants, but the number of module variants is limited. Repetitiveness is increased on module level, not on final product level. The repetitiveness increases volumes of modules and lowers costs (see Figure 7.1).



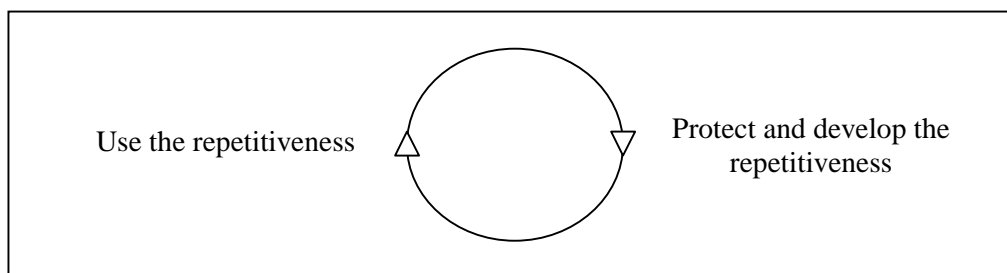
**Figure 7.1 Modularity increases volumes of modules and reduces over costs.**

We have found two aspects on leveraging repetitiveness in a modular platform and hence reduce overhead costs:

1. **Use the repetitiveness** to cut costs, through standardizing processes, streamlined information handling, etc.

2. **Protect and develop the repetitiveness** so that the benefits of the repetitiveness continuously can be reaped, through formalized processes and security controls when changing the modular platform, through roles such as platform owners, through continuous development of processes etc.

These two aspects of leveraging the modular platform reinforce themselves in a positive loop (see Figure 7.2). As the benefits of the repetitiveness are used the organization will try to defend the foundation of the benefits through protection of the repetitiveness. When the protection of the repetitiveness is rigid the organization will have the trust required to put in the effort of developing structures reaping the benefits of the repetitiveness. The circle is closed.



**Figure 7.2 The self-reinforcing circle of repetitiveness**

### 7.1.2 Information processes and modularity

As a process is a *repetitive* chain of activities and the greatest benefit of modularity on information handling is gained through leveraging the *repetitiveness*, we find that there is an opportunity to combine modularity and information handling, using repetitiveness as the common denominator.

Modularity can help organizations focus on processes. Modularity increases repetitiveness and processes are in its definition repetitive. Therefore modularity can leverage the present focus on processes to spread throughout the entire organization. Another reason why modularity can increase the focus on processes is the change which has been set in motion due to modularity. The momentum of the change to modularity can be used to put focus on processes too. Thirdly, the modularization of a product begins with the requirements of the customers. The process based organization also puts the customer in focus.

Process based organizations apply well to the two dimensions of modularity's self-reinforcing circle of repetitiveness: *use the repetitiveness* and *protect and develop the repetitiveness*.

#### **Use the repetitiveness**

*"If you know you will bake the same bread thousands of times, you better save the receipt"*

In essence, this sentence captures what we mean by using the repetitiveness. Modularity will increase the repetitiveness on module level. When an information

process, or any process, is new there are in general problems with it. As the process is repeated it should be trimmed and enhanced to high performance. When the performance is high, the benefits of the repetitiveness are reaped in low overhead costs. Having process owners with responsibilities penetrating the functions of an organization is a recommended way to keep the processes trimmed and up to date.

There are various ways to measure if a process change will make the process better. Though, sometimes measuring the effectiveness of a process is affiliated with additional process steps lowering the performance of the process. As the process steps should add value to the customer, one can argue if measuring the process is value adding. A straight forward way to measure a process is by using time in various ways.

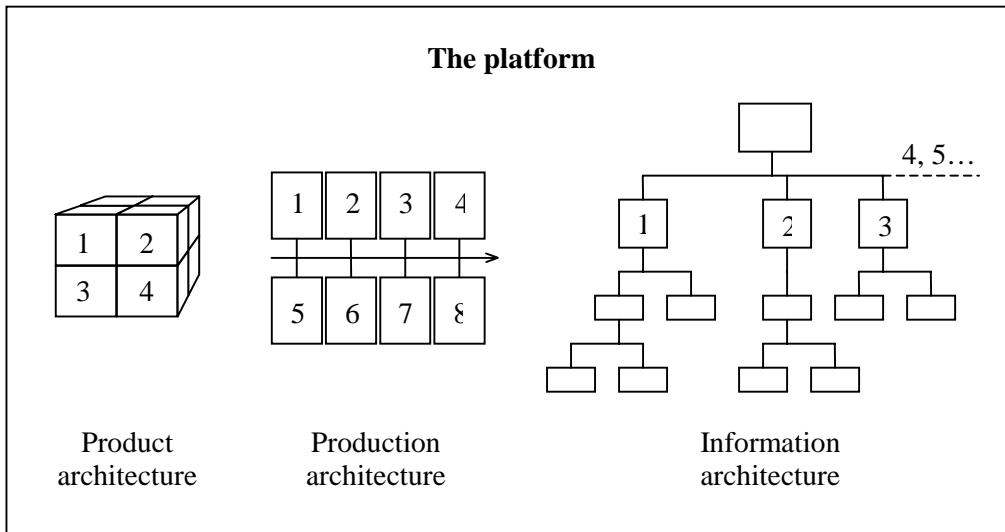
### **Protect and develop the repetitiveness**

A main threat to the repetitiveness in the information processes supporting a modular platform is the deterioration of the platform. The platform will deteriorate and part number count will explode if customizations and changes will be allowed in the platform, without a rigid control function like a board protecting the platform. There are many areas where roles can serve as a protection to the repetitiveness.

If all information is not 100 % trustworthy in an organization, time will be spent on double checking information in various ad hoc ways. Therefore quality is a central area of information processes. Un-formalized or sub-optimal information processes will lead to ad hoc processes, which lead to varying information quality, which lead to down stream issues, like double checking information etc. The same down stream issues appear when information is manually moved between IT systems with the risk of mistyping, leaving lacking quality as a result. Therefore, rigid information processes are protection of the information quality and therefore protection of repetitiveness in the down stream processes. Rigid information processes are also usage of repetitiveness in itself. This is a good example of both using and protecting the repetitiveness, hence a good example of the self-reinforcing circle of repetitiveness.

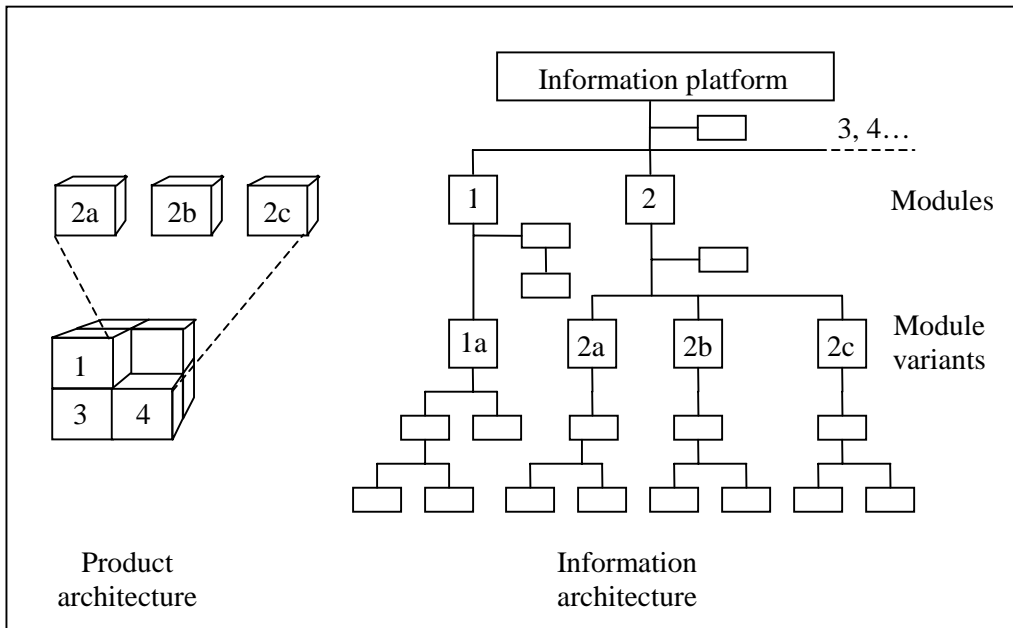
### **7.1.3 Information structure and modularity**

When this study began we believed that the inherent modular architecture of the product could be translated to an equivalent information architecture, just like studies of modularity and manufacturing had been able to translate the product architecture to a corresponding manufacturing architecture. We have found that such an information architecture or structure, also called information platform, would conceptually look like Figure 7.3.



**Figure 7.3** The product architecture and the corresponding production and information architectures. The information architecture is expressed in a UML light version, i.e. the relations between entities are shown, though multiplicity and entity specifications are not explicit.

The concept of the information platform is that it should contain all master data needed to build and service any product configured from the platform. To do this the information must be structured hierarchically, like the modular product is structured. The highest form of information is information concerning the entire platform, for instance instructions on how the modules should be assembled to a final product, or platform generic manuals. Next level of information is tied to the module, e.g. interfaces to the environment of the module. These interfaces show how the module variants of this module have to attach to its surroundings, in accordance with the basic principles of modularity. The third level of information regards the specific module variants. This level contains the bill of material for the specific module, the CAD drawings of components, the information on suppliers used for parts, etc. Under each level of information, additional sub-levels can be attached to express the information hierarchies within the level. Figure 7.4 shows how the nature of the product with modules and module variants corresponds to the information platform. Note the sub-levels of information tied to each level. It is important to understand that the modules and the module variants are the key information carriers of the information platform.



**Figure 7.4 Master data structure of the platform.**

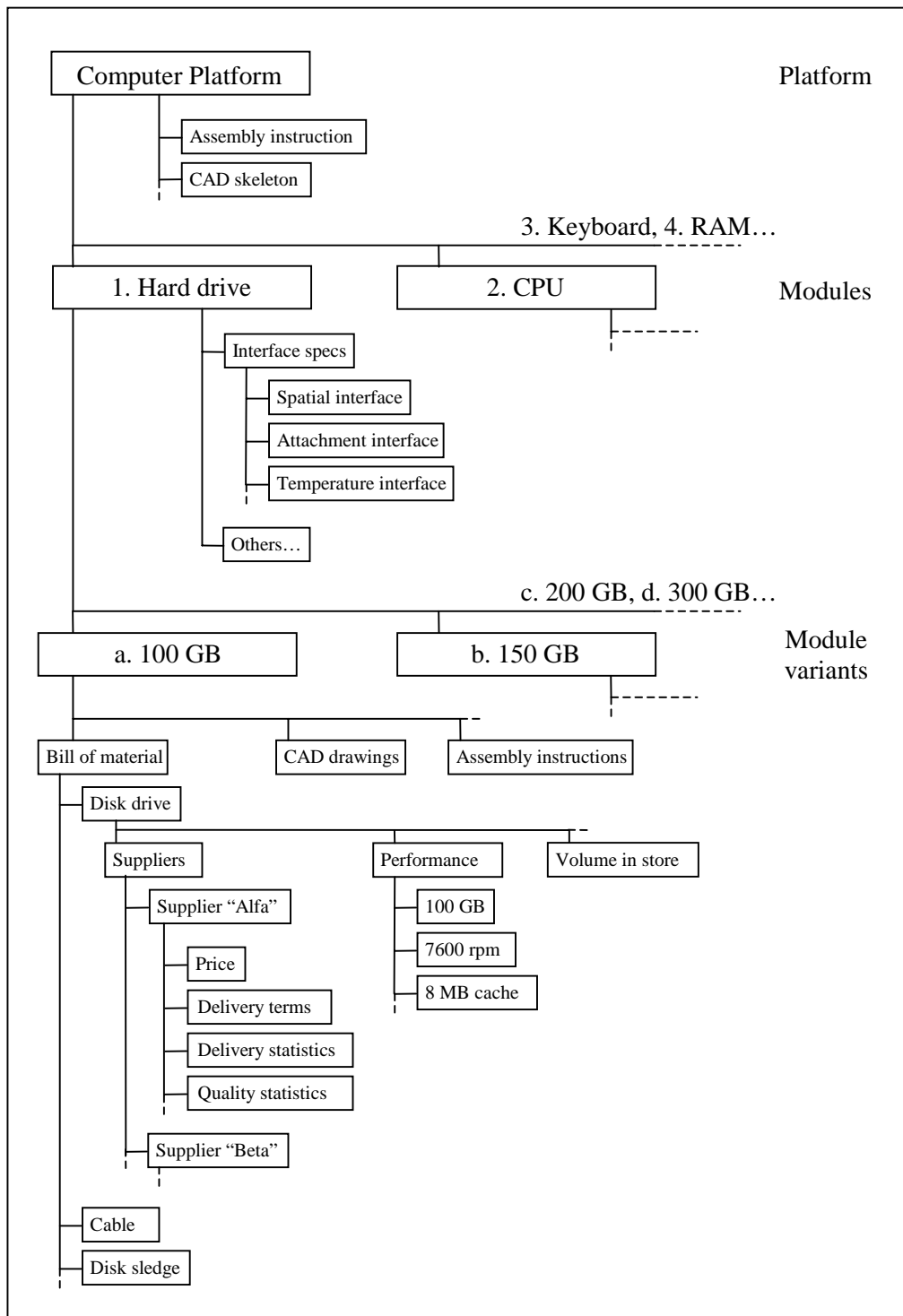
To give an example most of us can relate to, we show an information platform of a computer in Figure 7.5. Sub-levels of information of a 100 GB hard drive is shown in the figure. It is a reasonable assumption that the information structure of the 150 GB hard drive would have a similar, if not identical, structure. This indicates that it is possible to make an information structure template tied to a module, which could be implemented in the module variants as they are launched. We believe that such a template would reduce lead times and reduce the risk of not adding all relevant information to the module variant information structure.

When the information platform is set, any product configured from the product platform will be supported by the information platform. This means that all information regarding the configured product instantly will be available. The only requirement is the information of which module variants that have been chosen to build the product. This information is captured in what we call the Variant Configurator key, or VC key. In words, using the example in Figure 7.5, this could look like:

**VC key – computer platform**

Module: 1. Hard drive	Module variant: b. 150 GB
2. CPU	c. 2.4 GHz
3. Keyboard	a. standard
...	

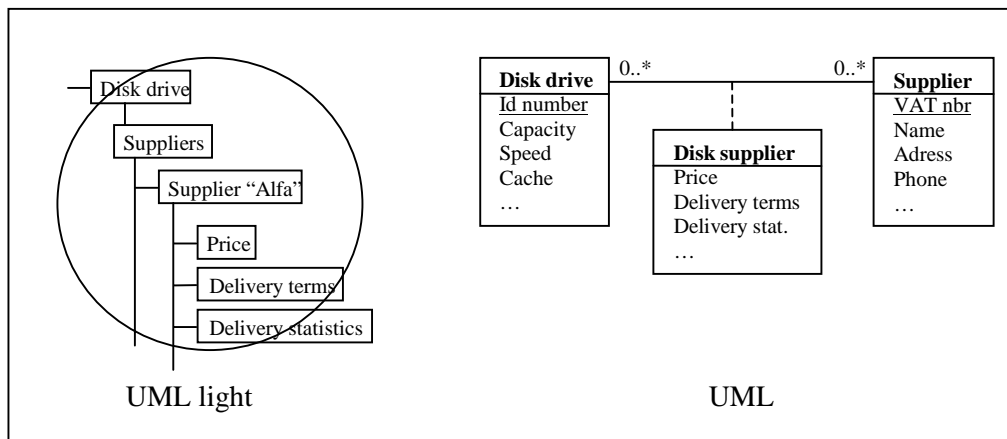
A short version of this could be: 1b2c3a...



**Figure 7.5 An example of an information platform of a computer.**

It is important to understand that in the connections between the information entities of Figure 7.5 are information carriers. The UML light language used in the figure can

easily be translated to normal UML showing the hidden information in the connections. In doing this we do not only show the legitimacy of the UML light language developed for this purpose<sup>152</sup>, it also becomes merely a standardized exercise to secure that the data entities are normalized, i.e. that there is no redundant data. In Figure 7.6 a section of the UML light language from Figure 7.5 has been cut out and translated to normal UML.



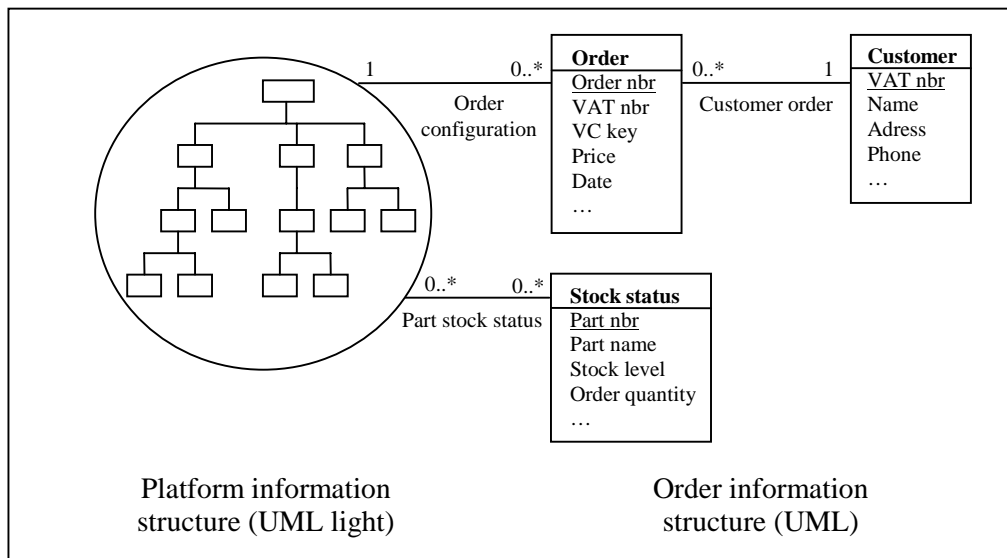
**Figure 7.6** A section of UML light and its corresponding standard UML.

In the UML light version of Figure 7.6 the entity *Disk supplier* is represented by a link. In adding the *Disk supplier* as a separate entity, identified by the primary keys of *Disk drive* and *Supplier*, normalization is secured. If we had not added the *Disk supplier* we would have to add the *VAT number* of *Supplier* to *Disk drive*. If this would have been done, the same type of disk drive supplied by different suppliers would have to have its own entity. In doing this we would have to repeat the *Capacity*, *Speed*, etc. of the same disk drive for every supplier. In short: there would be redundant information.

The example of Figure 7.6 also shows how the platform specific information ties to non-platform specific information. The supplier of the disk drive might supply parts to other platforms supported by the producing company. In that case we do not want to repeat the information of the entity *Supplier*. Instead of repeating the information of the entity we simply define a new entity linking the supplier to the new part, just like the entity *Disk supplier* is the link in this case. This would ensure normalization. In UML light this would be expressed by simply drawing a line between the boxes.

Figure 7.7 shows how the order information structure ties to the platform information structure using the VC key, leaving a completely integrated structure of the information needed to support a customer order. The information structure is greatly condensed, though the concept is captured.

<sup>152</sup> We are aware that this UML light language most likely has been developed by many before us.



**Figure 7.7 The integrated information structure.**

With the conceptual information structure of Figure 7.7 information is easily accessed. If a product is configured, for instance by a customer via a website, the VC key can be fed into the platform information structure extracting the bills of material for each module variant of the configured product. For each part number of the bills of material the stock levels can be accessed in real time, returning the information to the customer. When lead times from suppliers, labor resources, shipping times, etc. are tied to the information structure too, a delivery time estimate can be returned to the customer in real time.

The UML language does not consider whether the entities are stored in the same server and/or database or not. The information can very well be located in different databases and servers; the important thing is that the databases are related to each other with the links/relations of the UML language. For instance, stock levels of parts are generally stored in a MRP<sup>153</sup> database, while the drawings of the same parts are stored in a CAD database. The link is the unique part number and the systems have to be programmed to communicate.

We will end this section by showing how the cross-fertilization of the information structure and modularity map with the characteristics of the two dimensions of modularity's self-reinforcing circle of repetitiveness: *use the repetitiveness* and *protect the repetitiveness*.

<sup>153</sup> MRP means Material Resource Planning and is generally a part of the ERP system.



### Use the repetitiveness

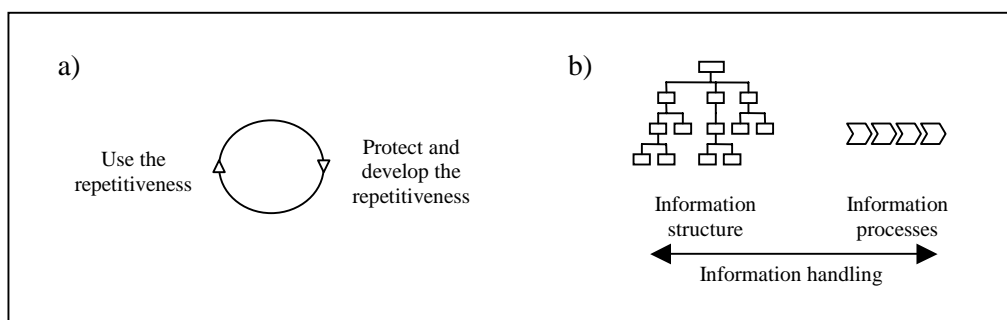
On a product level the source to the repetitiveness is that the limited number of module variants, which gives that each module variant is repeatedly produced. This is also the source to the repetitiveness in the information handling. When the master data in the information platform is defined, all product combinations and the corresponding information combinations can be reached with the VC key, thanks to the information platform structure. This enables easy access to information in every step of the process, e.g. painting instructions in the painting process, product performance metrics in the sales process and test programs in the test process. As the information is accessed over and over again, the repetitiveness is used.

### Protect and develop the repetitiveness

Ensuring that the inherent modular structure of the product is correctly transferred to the information platform structure is the main part of protecting the repetitiveness in the information platform structure. The logical structure of the product is then reflected in the structure of the information. Important areas concerning this are to keep the platform, the modules and the module variants as the most important information carriers. If this is done correctly there will be only one set of master data for the information platform. One set of master data gives reliability to the platform.

#### 7.1.4 The modularity information handling matrix

In the beginning of chapter 7.1 we declared that we would break down the aspects of modularity and the aspects of information handling and then build them back up together as an integrated system. We have now broken down modularity and information handling (see Figure 7.8). In this chapter and in chapter 7.1.5 we will synthesis the components of modularity and information handling to models applicable in the process of implementing an information platform supporting a modular product platform.



**Figure 7.8 a) The self-reinforcing circle of repetitiveness b) Information handling.**

The greatest affect modularity has on information handling is increased repetitiveness. To leverage the repetitiveness we must *use the repetitiveness* and we must *protect and develop the repetitiveness*. Information handling regards the *information structure* and the *information process*. We can combine the models in a four field matrix with modularity on one axis and information handling on the other

(see Figure 7.9). This matrix is called the Modularity Information Handling matrix, abbreviated the MIH matrix.

		<b>Modularity</b>	
		Use the repetitiveness	Protect and develop the repetitiveness
<b>Information handling</b>	Information processes	<b>1</b>	<b>2</b>
	Information structure	<b>3</b>	<b>4</b>

**Figure 7.9 The Modularity Information Handling matrix – MIH matrix.**

The MIH matrix is used in the development of an information platform supporting a modular product platform. To ensure stable information handling all four fields need to be covered for. The MIH matrix can be applied on various levels in the organization, e.g. high level – covering the entire platform, or low level – covering a minor process step on the shop floor. On low level all four fields do not necessarily need to be covered for, as long as the levels above have covered for the areas missing. On high level, it is important to cover for all four fields to protect and use the repetitiveness in both the information structure and in the information processes.

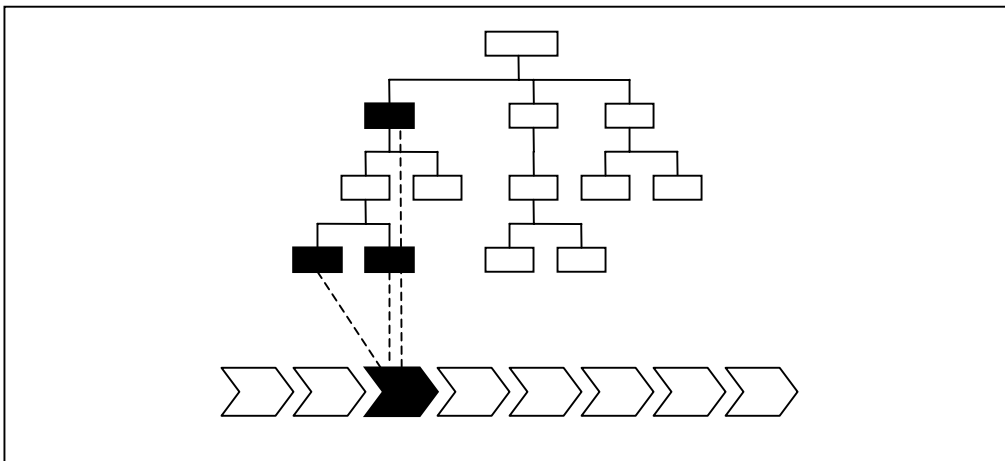
**Low level example of using the MIH matrix**

On the shop floor a process step is to gun drill a steel rod into a steel pipe. Instead of programming a NC file for the gun drilling every time this task will be performed, the driller simply confirms the job he is performing in the system. The system takes the VC key affiliated with the job, feeds it into the information platform and finds the NC file. The file is automatically loaded to the drill (MIH field 1, enabled by MIH field 3). The driller does not have access to change the NC file (MIH field 4). To change the file he must contact the platform owner who will investigate the case and present his findings and recommendation for a platform board. The platform board will accept or reject the change (MIH field 2).

The conceptual level of using the MIH matrix was covered in chapter 7.1.2 under the heading *use the repetitiveness* (MIH field 1) and under the heading *protect and develop the repetitiveness* (MIH field 2) and in chapter 7.1.3 under the heading *use the repetitiveness* (MIH field 3) and under the heading *protect and develop the repetitiveness* (MIH field 4).

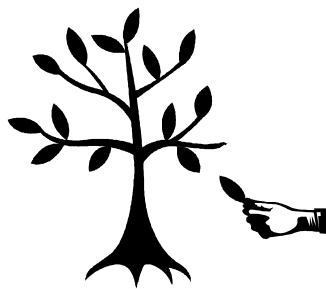
### 7.1.5 Integrating information structure and information processes

In this chapter we will launch a method of developing an information platform supporting a modular product platform. The prerequisites of the method are a map of the Order to Delivery process with supporting processes, a rough platform information structure and a project team assembled for its knowledge of the processes. The team virtually walks through the process map, step by step. At each step all information required to perform the step is defined. For each information object the team asks if this is platform, module or module variant level information. Information is then tied to the platform information structure at the correct level. There are generally sub-levels within the platform, module or module variant levels which have to be considered when adding information to the structure. Information can also be outside the information platform. Some of this information has a connection to the platform. This connection can then be added to the platform. Figure 7.10 illustrates how the method is executed.



**Figure 7.10 A process step and the supporting information structure. The information used is identified by the module variant.**

We call the method *adding leaves to the tree*, due to the similarities between the platform information structure and a tree (see Figure 7.11). In the work of adding information to the platform information structure there is a possibility to identify information in the structure which is never used and should not be maintained. At each process step the project team should ask them how the specific process step adds value to the customer; if not, the step should be eliminated or redefined.

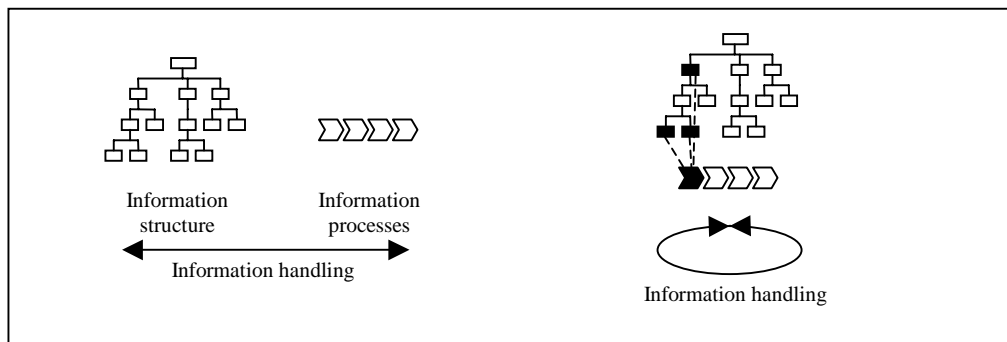


**Figure 7.11** The *adding leaves to the tree* method. The trunk is the platform level, the branches are the module level, the small branches are the module variants and the leaves are information objects/data.

***Adding leaves to the tree* example**

As the project team walks through the sales process they find that there are no performance metrics on the actuator module variants of the platform. The sales staff needs this information in the discussions with the customers. The information should also be found in the product configurator on the web site. The performance metrics are added as leaves to each module variant.

The simplicity of the *adding leaves to the tree* method is also the strength of the method. We look upon this method as closing the circle of information handling, as we integrate the two dimensions of information handling: information structure and information processes (see Figure 7.12). When this integration is implemented in the organization it is supported by an ERP system.



**Figure 7.12** Mapping the processes and the information structures close the circle.

### **7.1.6 Concluding discussion of the generated tools**

In this chapter tools and models to facilitate and benefit from modularity have been created. These tools and models can be categorized as affecting the information structure, affecting the information processes and finally tools integrating information structure and information processes. The authors believe that these tools can be used to break *the vicious circle of information handling* at Clarkson Inc.

#### **Information processes**

Modularity enables increased standardizations and hence increased repetitiveness in the processes. The processes should be designed so they use the repetitiveness and protect and develop the repetitiveness. An example of using the repetitiveness is when the assembly staff learns the assembly procedure by heart and therefore will not need to consult the instructions for every assembly. Protection and development of the information processes is for instance protected and developed as process owners are given responsibility of the processes.

#### **Information structure**

The authors have developed a model of a platform information structure to facilitate and benefit from modularity. The basis of this information handling is its correspondence to the modular product platform, using the platform, the modules and the module variants as information carriers.

Modularity increases repetitiveness in the organization. To facilitate and benefit from modularity the repetitiveness must be used and protected and developed in the information structure. An example of using the repetitiveness is to use a Variant Configurator key. An example of protection of the repetitiveness is to keep one set of master data, and hence avoid issues when master data is updated.

#### **Integrating information structure and information processes**

To integrate the information structure and the information processes the MIH matrix has been developed. The MIH matrix is sprung from the increased repetitiveness of modularity and the perspective of information handling as information structure and information processes. The MIH matrix is used as a checklist to ensure that the information handling facilitate and benefit from the repetitiveness of modularity. If all four fields of the MIH matrix are not covered for on a high level in the organization, there is a great risk that the platform might erode or that the repetitiveness is not leveraged to its full extent.

The *adding leaves to the tree* method is a practical way of aligning the information structure with the information processes. The method's primary purpose is to develop an information structure, but it is also used as a way to work through the processes.



## 8 Testing the tools on Clarkson Inc.

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*In this chapter the tools generated in chapter 7 are tested on Clarkson Inc.'s situation by theoretically applying them on the vicious circle. The potential revealed is discussed and the tools are then used to create a vision state scenario of how information handling can facilitate and benefit from modularity.*

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### 8.1 Use modularity to break the vicious circle

We think that Clarkson Inc. need to change the way they handle information and modularity is an opportunity to change this way. The two main reasons why this change can be facilitated by the implementation of modularity are:

1. Modularity brings a possibility to increase the repetitiveness in the information handling, due to reduced complexity.
2. Modularity is a change already impacting the organization to a large extent.

Changing the way Clarkson Inc. handle the information can break *the vicious circle of information handling*. We believe that it is impossible to convey people to trust the information handling, without changing the actual handling. This reasoning leaves us with the right hand side of *the vicious circle of information handling*, i.e. the information handling must be changed. An information handling with a modular information platform and new information processes will affect the right half of *the vicious circle of information handling* and strengthen the consistency in the information handling. We think that this is the only way the trust in information can be earned and the vicious circle can be broken.

We are aware that breaking *the vicious circle of information handling* is not an easy task. We believe that the MIH matrix and the *adding leaves to the tree* method are valuable tools in this process. Change Management is an important factor in the implementation, though this is outside our scope and will not be further addressed.

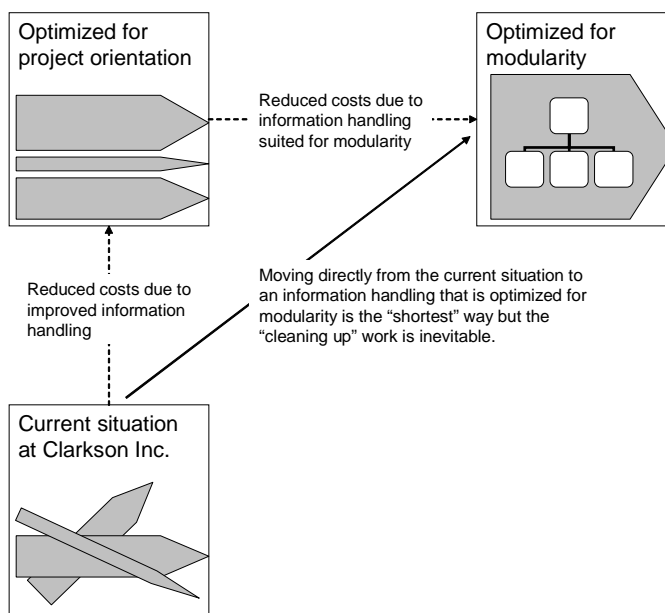
### 8.2 Modularity reaps two kinds of potentials

Our study revealed substantial potential in making the information handling more effective and efficient. We can not enough stress the importance of a systemic view of the information handling issues found at Clarkson Inc. Local fire fighting may save the day but not long term effectiveness and efficiency and at the end profitability. Modularity drives change at Clarkson Inc. And change is needed. But what part of the revealed potential can we credited to modularity?

Our assignment formulation was based on the belief that the characteristics of modularity could be utilized in information handling. The potential we revealed can be divided into two areas:

- **The reduction of costs due to generally improved information handling.** Potential is found in the information processes and the information structure that is not directly related to modularity.
- **The reduction of cost due to information handling facilitating and benefiting from modularity.** This potential is derived from the increased repetitiveness modularity imposes in the information handling and an information structure that reflects the product.

The implementation of modularity at Clarkson Inc. gives the possibility to reap the two areas of potential outlined above. Figure 8.1 illustrates how this is done.



**Figure 8.1 Clarkson Inc.'s information handling shortcut**

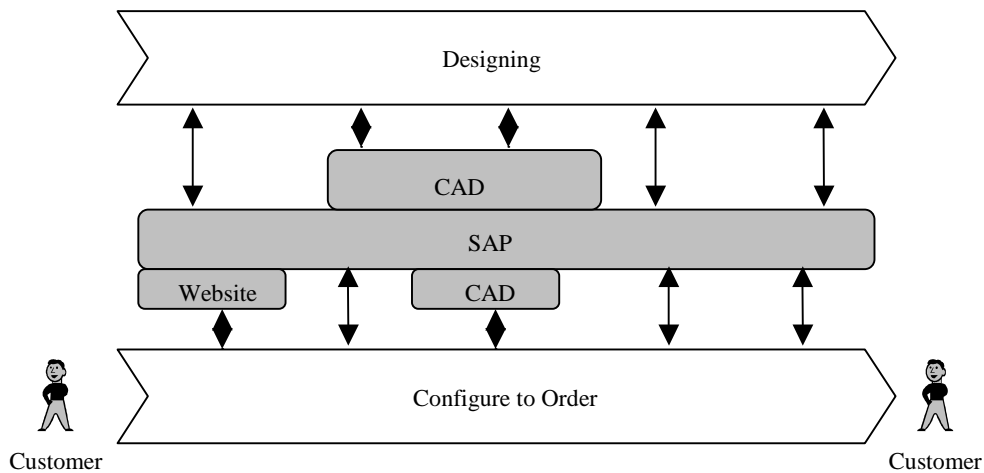
The potential of the modular platform is usually thought about as tied to the new product structure and the production processes. We consider the information handling to be a bottleneck at Clarkson Inc. already today. To facilitate the potential in modularity the information handling needs to be faster, more accurate and suited for modularity.

### 8.3 Information handling in Vision State

By extracting our learnings from Clarkson Inc. and our generation of tools we paint a picture of how we consider an optimal information handling should look like. Clarkson Inc. will stand as an example for the Vision State, but since this state is so far from Clarkson Inc.'s present state it can be considered a generic description of a vision state.



This vision is presented as Clarkson Inc.'s future steady state after a successful implementation of a modular platform with a supporting information platform structure. This chapter is a way for us to communicate how our findings can leverage information handling supporting a modular product platform. In the analysis we broke down information handling into information processes and information structure. When we now synthesize the analysis, we want to build up the information handling as a system, rather than breaking it down in components. To do this we will describe the vision state of information handling at Clarkson Inc. starting with the source: the customer. To fulfill the customer needs in the vision state, Clarkson Inc has three main processes: Configure to Order, updating the platform and developing a new platform. The two latter processes are performed within the process of designing (see Figure 8.2). Developing a new platform is not within the scope of this master thesis discussed.



**Figure 8.2 The vision state organization at Clarkson Inc.**

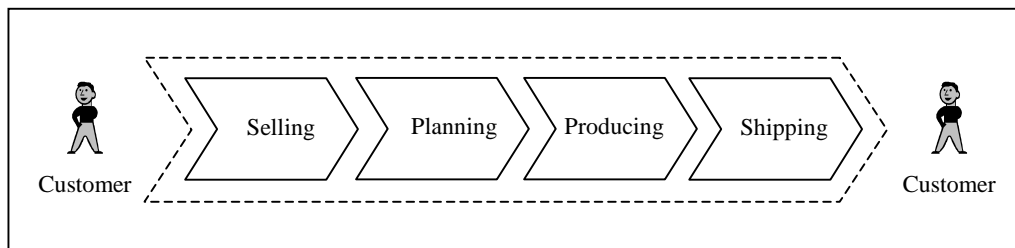
As we will describe the information handling in the three main processes, we will use the Modularity Information Handling matrix (MIH matrix) to use, develop and protect the repetitiveness modularity brings to the information handling (see Figure 8.3). To show how a text section ties to the MIH matrix, we will incorporate a reference to the specific MIH field in the text. Organizational roles are initiated with capital letters, like Product Manager.

		Modularity	
		Use the repetitiveness	Protect and develop the repetitiveness
Information handling	Information processes	1	2
	Information structure	3	4

**Figure 8.3 The Modularity Information Handling matrix – MIH matrix.**

### 8.3.1 Configure to Order

Configure to Order (CtO) is the process where the customer’s requirements are fulfilled with the present modular platform (see Figure 8.4). We will walk you through the process step by step, but first we will discuss the process as a whole.



**Figure 8.4 The Configure to Order process.**

The CtO process at Clarkson Inc. has a Process Owner responsible for developing and ensuring that the process is correctly performed. The Process Owner premieres development suggestions from the employees using the process. As this is internalized in the organization, “work arounds” and “walk ups” do not occur, since the staff knows they can change the process if they do not find it satisfactory. This behavior protects the deterioration of the processes (MIH field 2). The behavior also makes sure that the processes are used in an effective and efficient ways, using the repetitiveness to the full extent (MIH field 1).

Throughout the CtO process there is no pushing of paper, or information in any format, to the next process step. Instead information is attached to the information structure in the central IT system. This allows for more than one process step to use the information (MIH field 3). When information is needed in a process step it is pulled from the central IT system. The backbone of the IT system at Clarkson Inc. is SAP, but additional programs attach to SAP seamlessly. CAD drawings and manufacturing instructions are for instance stored in separate databases, as they require separate functionality to be viewed. As no manual work is performed to move information between the programs and databases, the risk of manual mistyping is reduced and the data quality is high (MIH field 4). The integrated programs, i.e. the IT system, assures that no data is stored in two isolated databases. As there is no

redundant information, there is no risk that information is updated in one database but not in the other. This increases the reliability in the information (MIH field 4).

The platform information structure in the IT system is developed to mirror the product hierarchies. The information is tied to the platform, modules or module variants. Sometimes improvements in the processes require new information to be tied to the information platform structure (MIH field 2, MIH field 4). At these occasions the CtO Process Owner and the Platform Owner launch what they call a *adding leaves to the tree workshop*, where the new information is put on the information platform map (this is the UML light map of the data entities and its relationships in the platform). The new map then need to get acceptance from the Platform Board before it is implemented in the platform information structure (MIH field 4).

The platform information structure allows all platform related master data to be retrieved with the Variant Configurator key (VC key), i.e. the code describing the configuration of a product. This facilitates extensive reuse of information (MIH field 3). As the platform information structure reflects the hierarchies of the product, it is easily described to the personnel who know the product.

We will now step through the CtO process step by step, looking at how Clarkson Inc. perform their information handling supporting the main process.

### **Selling**

Selling is the main customer interface at Clarkson Inc. A strong information handling tool here is the Variant Configurator (VC). When the customer requirements are fed into the VC, the program returns the product configuration best fulfilling the requirements. The VC can also be accessed directly by the customer via the website. At the website the customer can get cost, delivery time, performance, etc. for the configured product. The delivery time can be estimated because the website has an interface to the MRP system and because we can now benefit from the repetitiveness of producing modules which gives us more accurate and consistent process times. When an order is placed, either by the sales personnel or via the website, the VC key is tied to the order. The configuration of the product is made possible by the platform information structure and its correspondence with the product architecture (MIH field 3).

### **Planning**

As the ERP system keeps track of stock levels, resource usage, supplier delivery times etc., much of the planning is automated. (MIH field 3). As operative tasks are automated, the Planner has a strategic and tactic focus, e.g. deciding which module variants should be pre-manufactured, optimal batch quantities, order points, etc.

Instead of having one Planner per shop floor section, one Planner plans the manufacture of the products through the entire process. Doing this, the Planner can reduce moving products back and forth to the warehouse between operations. This reduces unnecessary transportation of the products and it also reduces status changes in the system (MIH field 1).

### **Producing**

The shop floor is divided into production sections per module. Within the sections the module variants are produced in line production. There are only SAP registrations when production begins and when production is finished, no matter how many operations are performed in the section (MIH field 1). Since the VC key is tied to the order number, all information regarding a product is instantly accessed. When production begins in a section the order number is fed to the system and the bill of material, NC files, CAD drawings, assembly instructions, etc. are retrieved using the affiliated VC key (MIH field 3).

There are a couple of module variants which are frequently ordered. Clarkson Inc. has found that there is economy in batch producing these variants and keep them in stock. One batch can be produced with one SAP registration when production begins and one when it is finished, even though there are several units produced at a time (MIH field 1).

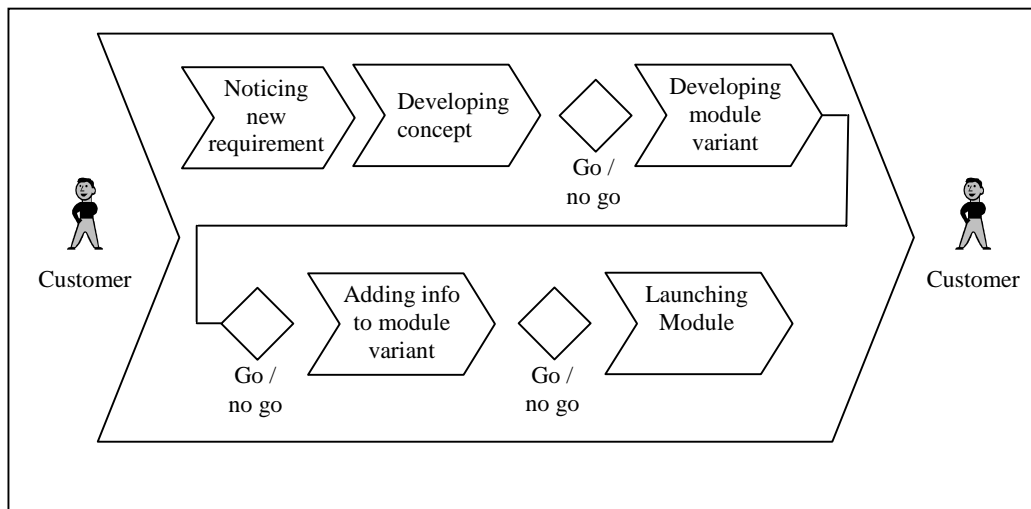
In the final assembly of the product, the interfaces are the same regardless the module variants chosen. Therefore the person doing the assembly only needs to learn to assemble one product, though there are actually thousands of product variants produced. After a few assemblies the person does not need to look at the instructions. (MIH field 1).

### **Shipping**

The shipping personnel feed the order number to the IT system and the delivery notes with customer details are printed. Attached to the order number is the VC key. The system takes the VC key and pulls technical specifications for each chosen module variant. The specifications are compiled with generic instructions to a customized manual (MIH field 1 and 3).

### **8.3.2 Updating the modular platform**

Updating the modular platform is the process when a new module variant, or sometimes even a new module, is implemented in the platform (see Figure 8.5). This process is developed to fulfill new requirements without eroding the platform (MIH field 2 and 4). The process has a Process Owner with responsibility of developing the process (MIH matrix 2). As this process is viewed from an information handling perspective, some areas will be mentioned just briefly.



**Figure 8.5 The process of updating the modular platform.**

### **Noticing new requirements**

For a new module variant to be developed a customer requirement, spoken or unspoken, must be noticed. Clarkson Inc. has developed an open atmosphere encouraging all employees to make recommendations on updates, though most of the times the suggestions come from the sales department (MIH field 2). Sometimes the updates are driven by new technologies.

### **Developing concept**

When an update recommendation is received by the Platform Owner a business case is developed. At Clarkson Inc. the platform is such a complex product so they have given responsibilities of the modules to Module Owners. The Module Owner develops the business case with customer input from sales and marketing.

### **Toll gate – go / no go decision**

The business case is presented to the Platform Board, for the board to decide whether the module variant or module should be implemented in the platform. At Clarkson Inc. the Platform Board is the last outpost protecting the platform (MIH field 4). If the business case gets a no go, it can be further developed and presented at a later occasion. If it gets a go the business case moves on to the development phase.

### **Developing the module variant**

The development of the module variant or module is a task which is not within the scope of this master thesis. There are most likely several tollgates within this process we have not regarded. The developed module variant or module need acceptance from the Platform Board (MIH field 4).

### **Adding information to the module**

When the module variant or module is developed it will need a set of master data. If it is a module that will be launched there is no information template to start the information structure from. This template has to be developed and it has to be filled in

with the right information. Clarkson Inc. has a method of doing this called *the adding leaves to the tree method*. In this method a cross functional team is assembled to develop the information structure (MIH field 4).

If it is a module variant that will be launched there is, in accordance with the procedures of Clarkson Inc., a template developed saying which information needs to be added and how it relates to the platform information structure. A cross functional team is assembled to add the information (MIH field 4). Typical information that is added to the platform information structure are painting instructions in the painting process, product performance metrics in the sales process and test programs in the test process.

**Launching module variant**

If the new module variant or module passes the last toll gate with the Platform Board, it will be released into the CtO process. This means that the module variant will be ready for configuration and that all information regarding the module variant is available in the master data of the platform information structure. As this information will be accessed over and over again, the repetitiveness will be used (MIH field 3).

## 9 Conclusions

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*This chapter will outline a concluding discussion on how information should be handled to facilitate and benefit from modularity.*

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### 9.1 How information should be handled to facilitate and benefit from modularity

This section of the conclusions contains the generalized ideas that have been extracted from the case study of Clarkson Inc. For information handling to facilitate and benefit from modularity it is important that the nature of modularity is understood and leveraged. From a customer perspective modularity enables customized configuration of the products. From an internal perspective the product is configured from a set number of standardized sub-systems, so called module variants. The standardization on module variant level means fewer parts to support, fewer production processes, etc. The information handling perspective of modularity means increased repetitiveness.

**For information handling to benefit from modularity**, the repetitiveness of modularity must be used. The repetitiveness is used to standardize the information processes and the way information is related to each other. The standardization of information handling reduces cost due to reuse of information, reduced information maintenance, standardization of information processes, decreased lead time, etc.

**For information handling to facilitate modularity**, the repetitiveness must be protected and developed. Instantiating control mechanisms in the organization, which prohibit the product platform and information platform from eroding, will protect the repetitiveness of the information handling.

**Modularity Information Handling matrix (MIH matrix)** should be used to ensure that the information is handled so that it facilitates and benefits from modularity (see Figure 9.0). The horizontal axis of MIH matrix is founded on how information handling will facilitate and benefit from modularity, i.e. to protect, develop and use the repetitiveness. The vertical axis is founded on the perspective of information handling as a constitution of information processes and information structures. For an organization to facilitate and benefit from modularity in its information handling, all four fields of the MIH matrix must be covered for. This should be done on all organizational levels, i.e. on the shop floor, in the management processes etc.

		Modularity	
		Use the repetitiveness	Protect and develop the repetitiveness
Information handling	Information processes	1	2
	Information structure	3	4

**Figure 9.0 the Modularity Information handling matrix**

An information structure that corresponds to the modular product platform is central to facilitate and benefit from modularity. The platform, modules and module variants should be used as information carriers in the information structure. This structure should facilitate for information to be configured, just like the products are configured, from the platform. With this information structure all information regarding a specific product can be easily accessed throughout the entire organization. This easy access to the product master data enables reuse of information and repetitiveness in information processes.

## **9.2 How Clarkson Inc. should adapt their information handling to modularity and what benefits can be reaped by doing this**

The analysis of the present state at Clarkson Inc. discovered negative patterns in the information handling. Inconsistency in information handling and lack of trust in information handling frequently occurred as issues. The analysis showed that the inconsistency led to lack of trust, and the lack of trust resulted in ad hoc solutions which worsened the inconsistency. This pattern is called *the vicious circle of information handling*.

Several of the findings which negatively affected *the vicious circle of information handling* had no connection to modularity. These findings indicate potential to make the information handling at Clarkson Inc. better, whether or not modularity would be implemented.

### **9.2.1 Adapting the information handling for modularity**

As it is impossible to break *the vicious circle of information handling* through conveying people to trust the information handling, the consistency of the information handling must be addressed. To address the consistency of the information handling the information structure and the information processes must be attended to. The authors derive two main reasons why modularity can help Clarkson Inc. break *the vicious circle of information handling*:

1. Modularity brings **increased repetitiveness** in the information handling.
2. Modularity is **a change already impacting the organization**.



To ensure that the information is handled so that it facilitates and benefits from modularity, Clarkson Inc. should develop an information handling in accordance with the guidelines of the Modularity Information Handling matrix (MIH matrix).

In the development of the information structure the authors recommend Clarkson Inc. to use the *adding leaves to the tree* method. In the method all process steps of the Order to Delivery process is virtually walked through step by step. At each process step all product related information needed to perform the process step is identified and its place in the information structure is defined. This method provides a basis for the information structure and the information processes to be correctly integrated.

### 9.2.2 Benefits of the adapted information handling

Implementing information handling adapted for modularity at Clarkson Inc. will reap two kinds of potential:

1. **The reduction of costs due to generally improved information handling.** Potential is found in the information processes and the information structure that is not directly related to modularity.
2. **The reduction of cost due to information handling facilitating and benefiting from modularity.** This potential is derived from the increased repetitiveness modularity imposes in the information handling and an information structure that reflects the product.

### 9.3 Information handling and modularity at Clarkson Inc. in the future

The recommendations given to Clarkson Inc. are based on the importance of taking advantage of the repetitive characteristic of modularity and the idea that the way information is stored should reflect the product structure. Clarkson Inc.'s vision state should be founded on three main, parallel processes:

1. **The Order to Delivery process** where the customer's requirements are fulfilled with configured products from the present modular product platform.
2. **The process of updating of the platform**, where customer requirements drive the development of new module variants and modules to the platform.
3. **The process of developing new platforms** where needs, which can not be met with the current platform, drive the development of new platforms.

### 9.4 Recommendations on further research

To validate the tools and models generated from this master thesis, we recommend a study where the tools and models are tested in the implementation phase of adapting information handling for modularity.

This master thesis has been practically focused to aid Clarkson Inc. It would be of interest to look upon information handling and modularity with a stronger focus on

theoretical perspectives. For instance would a deeper study of database theories and modularity be a relevant field for further research.

## References

### Books

- Alvesson & Sköldbörg (1994) *Tolkning och Reflektion*; Studentlitteratur; Lund
- Arbnor, I., & Bjerke, B., (1994) *Företagsekonomisk metodlära*
- Aronsson, H., (2004) *Modern logistik*
- Burell, G & Morgan, G. (1979) *Sociological paradigms and organisational analysis*
- Carsson, C. & Kratochvil, M., (2005) *Growing modular – Mass customization of complex products, services and software*
- Ericsson, A. & Erixon, G., (1999) *Controlling design variants – Modular product platform*
- Feldmann, C., (1998) *The practical guide to Business Process Reengineering using IDEF0*
- Holme, I. & Solvang, B., (1991) *Forskningsmetodik; Om kvalitativa och kvantitativa metoder*; Studentlitteratur; Lund
- Hägg, I. & Wiedersheim-Paul, F., (1984) *Att arbeta med modeller inom företagsekonomi*
- Larsson, E. & Ljungberg, A., (2001) *Processbaserad verksamhetsutveckling*
- Paulsson, U., (1999) *Uppsatser och rapporter – med eller utan uppdragsgivare*; Studentlitteratur; Lund
- Rentzhog, O., (1998) *Processorientering – en grund för morgondagens organisationer*
- Wallén, G., (1996) *Vetenskapsteori och forskningsmetodik*

### Electronic references

- Clarkson Inc.'s corporate website, 2006-03-24
- www.connected.org, 2006-04-12
- www.databasteknik.se, 2006-04-29
- www.scandinavica.com, 2006-04-10

www.volvocars.com, 2006-04-13

www.salesforce.com, 2006-04-02

## **Interviews**

*Assembly worker*, Clarkson Inc., 2006-02-15, 2006-03-13, 2006-02-21

*Checkout worker*, Clarkson Inc., 2006-03-15

*Documentation Center Manager*, Clarkson Inc., 2006-03-22

*Documentation Team Project Manager*, Clarkson Inc., 2006-01-07, 2006-02-02, 2006-04-04

Erixon, Gunnar (Ph.D), *Senior lecturer*, Dalarna University, *Management consultant*, Modular Management AB, 2006-04-19

Grenås, Gustav, *Consultant*, Modular Management AB, 2006-05-03

Holm, Per, *Senior lecturer*, Database Technology, Lund Institute of Technology, 2005-11-07

Källgren, Johan, *CEO*, Modular Management Inc., 2006-03-20

Leine, Anders., *Project Manager*, Modular Management AB, 2006-01-12, 2006-02-12, 2006-02-24, 2006-03-02

Lundh, Peter, *Consultant*, XDIN AB, 2006-01-05

*Manufacturing Assembly Manager*, Clarkson Inc., 2006-01-16, 2006-02-14, 2006-03-19

*Manufacturing Manager*, Clarkson Inc., 2006-03-08

*Master Scheduler*, Clarkson Inc., 2006-02-16, 2006-02-26

*Planner*, Clarkson Inc., 2006-03-14

*Product Manager and Documentation Team Project Manager*, Clarkson Inc., 2006-03-13

*Product Manager*, Clarkson Inc., 2006-01-18, 2006-02-26, 2006-03-01

*Production Team member, SAP specialist, Manufacturing Engineer Manager*, Clarkson Inc., 2006-02-15

*SAP specialist*, Clarkson Inc., 2006-01-16, 2006-02-13, 2006-03-14

*Shipping Manager*, Clarkson Inc., 2006-03-27

*Shipping worker*, Clarkson Inc., 2006-03-21

*Stock room and warehouse worker*, Clarkson Inc., 2006-03-21

*Technical Communication Manager*, Clarkson Inc., 2006-01-09

## Articles

Andersson, Lennart (2005) *UML Syntax rapport*, Dept. Of Computer Science, Lund Institute of Technology.

Appelbaum, Steven H., Patton, E. (2003), *The Case for Case Studies in Management Research*, Management Research News Volume 26 Number 5

Baskerville, Richard L., Wood-Harper, A. Trevor (1996), *A critical perspective on action research as a method for information systems research*, Journal of Information Technology, Number 11

Carliss, Y., Baldwin, C.Y. & Clark, B. (1997), *Managing in the age of modularity*, Harvard Business Review, September-October

Doran, Desmond, (2004) *Supply chain implications of modularization*, Strategy and Operations Group, Kingston Business School, Kingston upon Thames, UK

Eikeland, Olav. (2006) *Condescending ethics and action research*, Action Research vol. 4, Work Research Institute, Oslo

Eisenhardt, Kathleen, (1989), *Building theories from case study research*, The academy of Management review, October

Grenås, Gustav & Martin, Tobias, (2005), *Metoder för aktivitetsanalys och val av drivare vid ABC-kalkylering i modulariseringsprojekt*, master thesis, Kungliga Tekniska Högskolan, Stockholm

Johnson, Thomas, (2005), *Work lean to control costs*, About the money, December

Muffatto, Moreno & Roveda, Marco (2002) *Product architecture and platforms: a conceptual framework*, Int. J. Technology Management, Vol. 24

Sako, Mari., (2002), Professor of Management Studies, *The Nature of Co-Evolution of Product Architecture and Organisation Architecture in the Global Automotive Industry*, Said Business School, University of Oxford Modularity and Outsourcing

Sanchez, Ron, (2004), *Creating Modular Platforms for Strategic Flexibility*, Design Management Review

Sanchez, Ron, (1996), *Strategic Product Creation: Managing New Interactions of Technology, Markets, and Organizations*, European Management Journal Vol. 14

Sanchez, Ron. (2000), *Interview by Alan McCluskey*, IMD Lausanne, www.connected.org, 2006-04-12

Stake, Roger (2000), *On conceptual development of modular products – development of supporting tools for the modularisation process*, Doctoral Thesis

Treacy M. & Wiersema F., (1995), *The Discipline of Market Leaders*, New York, USA: Basic Books. ISBN: 0-201-40719-1

### **Other sources**

Nilsson, Carl-Henric, *Tech. Dr. and Senior lecturer*, School of Economics and Management, Lund University, Handout, 2005-04-12

Holm, Per, *Senior lecturer Database Technology*, Lund Institute of Technology, Handouts, 2005-10-25

Modular Management AB, (2005), Brochure

XDIN (2005) *Business Modeler™ - Basic modeling with the MBM-concept*, Education material