Integration of Environmental Aspects in Product Development Process and Ship Design

- a LEAP towards environmental awareness at Kockums AB

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We are grateful for the opportunity of examining Kockums AB and the improvement work that at the time was carried out. We wish Kockums AB, the Environmental Management Group, and all employees all the best of luck in their future improvement work, especially with regards to environmental improvements.

Sincerely,

Karin Källmar    Therese Karlsson Sundqvist
ABSTRACT

The Swedish company Kockums AB, at the forefront within maritime and naval technology, is in need of a tool, document, and/or method to include environmental aspects in their product development process. This is mainly because of additional requirements put on Kockums AB from their main customer. Ship recycling is the major issue that has to be addressed and included in Kockums AB’s working procedures. Moreover, ship recycling is a pressing issue to handle due to horrible conditions in South Asian countries, where most ship dismantling is taking place. For these reasons, the objective of this M.Sc. thesis was to integrate environmental aspects in the product development process at Kockums AB by designing and proposing a way of implementing a tool, document, and/or method.

Environmental product requirements that Kockums AB is demanded to fulfill mainly derives from customers, classification societies, laws and legislations, and themselves. The Hong Kong Convention has been adapted, in 2009, but is yet to enter into force. Ship recycling is covered by the convention, and an ‘Inventory of Hazardous Materials’ has to be provided from the ship builder, and hence this is the main aspect for Kockums AB to consider. Naval ships are, however, excluded from the Hong Kong Convention.

Kockums AB does not have a routine on how to handle environmental requirements nor are environmental aspects included in their product development process. Consequently, Kockums AB’s environmental ambition should not be put too high and rather aim at follow laws. In an empirical study, regarding environmental aspects at Kockums AB, difficulties were identified. Lack of environmental knowledge, communication problems, and misunderstandings regarding the ambiguous term environment showed to be most notable. The three most prominent success factors for a successful integration of ecodesign, from the conducted literature review and empirical findings, are education for employees, existence of an environmental champion, and top management support.

A Long-term Environmental Action Plan (LEAP), which took the success factors into account and contains 18 Actions, was developed for Kockums AB, and is the ultimate result of this research. The LEAP was developed in accordance with ISO 14006, a new standard for incorporation of ecodesign in Environmental Management Systems, with the aim of reducing adverse environmental impacts throughout a product’s lifecycle. Moreover, the proposed way of implementing the LEAP was based on a "Plan, Do, Check, Act” methodology from Product-Oriented Environmental Management Systems (POEMS). POEMS focus on a product’s environmental efficiency throughout its lifecycle, by a systematic integration of ecodesign in the company’s strategies and practices, and hence continual improvements. This way of implementation should be familiar to Kockums AB because the company is certified according to ISO 14001, where continual improvement of environmental performance is a key factor.

The proposed LEAP includes tools, documents, and methods that are to be used in daily work and product development at Kockums AB. It is a step towards environmentally conscious design and enhanced environmental knowledge at Kockums AB. Additionally, as a result of the LEAP, the expectation is that environmental conscious mindsets of employees arise.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BUMS</td>
<td>Business Unit Marine Services</td>
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<td>BUS</td>
<td>Business Unit Submarines</td>
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<td>BUSS</td>
<td>Business Unit Surface Ships</td>
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<tr>
<td>C&amp;T</td>
<td>Composite and Technologies</td>
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<tr>
<td>CV</td>
<td>Commercial Vessel</td>
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<tr>
<td>DfE</td>
<td>Design for Environment</td>
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<td>DfR</td>
<td>Design for Recycling</td>
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<td>DNV</td>
<td>Det Norske Veritas</td>
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<td>DR</td>
<td>Design Review</td>
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<td>EC</td>
<td>European Commission</td>
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<td>EEA</td>
<td>Environmental Effect Analysis</td>
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<td>EMG</td>
<td>Environmental Management Group</td>
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<td>EMS</td>
<td>Environmental Management Systems</td>
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<td>EoL</td>
<td>End-of-Life</td>
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<td>EU</td>
<td>European Union</td>
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<tr>
<td>FMEA</td>
<td>Failure Mode and Effect Analysis</td>
</tr>
<tr>
<td>FMV</td>
<td>Försvarrets materielverk (Swedish Defence Materiel Administration)</td>
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<tr>
<td>GL</td>
<td>Germanischer Lloyd</td>
</tr>
<tr>
<td>I&amp;E</td>
<td>Intelligence and Electrical</td>
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<td>IHM</td>
<td>Inventory of Hazardous Material</td>
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<td>ILO</td>
<td>International Labour Organization</td>
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<td>ILS</td>
<td>Integrated Logistic Support</td>
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<td>IMO</td>
<td>International Maritime Organization</td>
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<td>ISO</td>
<td>International Organization of Standardization</td>
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<td>KV</td>
<td>Kockums Verksamheter</td>
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<td>LCA</td>
<td>Life Cycle Assessment</td>
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<td>LEAP</td>
<td>Long-term Environmental Action Plan</td>
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<tr>
<td>M.Sc.</td>
<td>Master of Science</td>
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<td>P&amp;A</td>
<td>Propulsion and Auxiliary System</td>
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<td>PD</td>
<td>Product Development</td>
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<td>PDP</td>
<td>Product Development Process</td>
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<td>POEMS</td>
<td>Product-Oriented Environmental Management Systems</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>RQ</td>
<td>Research Question</td>
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<tr>
<td>Stena</td>
<td>Stena Recycling</td>
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<tr>
<td>TKAG</td>
<td>ThyssenKrupp AG</td>
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<td>TKMS</td>
<td>ThyssenKrupp Marine Systems</td>
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<tr>
<td>TLS</td>
<td>Through Life Support</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environmental Programme</td>
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<td>VS</td>
<td>Vessel Systems</td>
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DEFINITIONS

Adopt
A convention, or similar, can be adopted. That means it is suggested that it should be followed, for example by an organization, since it may enter into force.

Convention
An agreement in international law.

Design departments
Refers to the departments which are involved in the design process, mainly all Design & Engineering departments except for ILS.

Design process
Refers to the product development phase of the product development process at Kockums AB. The term is used interchangeable with the abbreviation PD.

Dismantling
Term for ship recycling used by the Basel Convention.

End-of-Life
The state a product, for example a vessel, reaches when its useful lifetime is over and the next step for the product is disposal.

Enter into force
A convention, or similar, can enter into force which means that all members of, for instance, an organization are compelled to follow the convention.

Environment
The term refers to a product’s affect on ecological systems with the aim of sustainable development for future generations. In this research, the term does not refer to work environment or environment that the product is effective in, e.g., weather conditions.

Environmental aspects
Element of an organization’s activities, products, or services that can interact with the environment.

Executive Committee
Refers to the top management board of Kockums AB; Ola Alfredsson (CEO), Pontus Kallén (COO), and Arno Pfannschmidt (CFO).

External requirements
Refers to product requirements which derive from external parties, with the exception of customer requirements. Customer requirements were observed separately because of their significant importance for Kockums AB.

Flag State
The state under whose laws the vessel is registered or licensed.

General Arrangement
Drawings that shows the inside of a ship and where the main elements are placed.

Hazardous material
All materials posing harm to human health or the environment that has been identified in the Basel Convention or similar.

Hong Kong Convention
A convention which was accepted by International Maritime Organization (IMO) in 2009, containing rules that cover the entire lifecycle of ships and ship recycling facilities. The convention may enter into force within the next years depending on how many of the member states, of IMO, that ratify the Hong Kong Convention. The convention makes exceptions for naval ships.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>ISO 14001</td>
<td>Standard for certification of environmental management systems.</td>
</tr>
<tr>
<td>ISO 14006</td>
<td>This ISO standard works as support when ecodesign issues are to be implemented in an existing environmental management system.</td>
</tr>
<tr>
<td>Midlife conversion</td>
<td>An update the ship undergoes after approximately half of its operating lifetime. The outer design remains the same while most updates are done on systems and software.</td>
</tr>
<tr>
<td>Operating life (of a ship)</td>
<td>The time when the ship is capable of performing its intended functions.</td>
</tr>
<tr>
<td>Project Schiff</td>
<td>First project in which environmental requirements had significant focus.</td>
</tr>
<tr>
<td>Ratification</td>
<td>A convention, or similar, can be ratified by member countries of an organization, such as IMO. If a convention is ratified it means that the majority of the organization’s members have approved it, agreed to obey, and implement it.</td>
</tr>
<tr>
<td>Recycling facility</td>
<td>Site, yard, or facility that is authorized for recycling of ships by a competent authority.</td>
</tr>
<tr>
<td>Scrapping</td>
<td>Term used historically for ship recycling. One method that is often used is called beaching.</td>
</tr>
<tr>
<td>Ship Recycling</td>
<td>All operations associated with recovery of materials and reprocessing.</td>
</tr>
<tr>
<td>System Manager</td>
<td>Refers to the person who is in charge of managing a specific system of the ship, in Swedish ‘Systemansvarig’.</td>
</tr>
<tr>
<td>ThyssenKrupp AG</td>
<td>Business corporation including, for instance, the business area (ThyssenKrupp) Marine Systems. Kockums AB is a Group Company of ThyssenKrupp AG.</td>
</tr>
<tr>
<td>ThyssenKrupp Marine Systems</td>
<td>Kockums AB is a subsidiary of ThyssenKrupp Marine Systems since 2005.</td>
</tr>
<tr>
<td>Vessel</td>
<td>In this M.Sc. thesis the term are referring to a craft designed for water transportation, i.e., a ship. The terms vessel and ship are used interchangeably.</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENT

1 Introduction ..................................................................................................................................... 1
   1.1 Background .......................................................................................................................... 1
   1.2 Problem Description ............................................................................................................. 1
   1.3 Objective ............................................................................................................................. 2
   1.4 Research Questions ............................................................................................................. 2
   1.5 Company Description ......................................................................................................... 3
   1.6 Delimitations ....................................................................................................................... 3
   1.7 Report Outline ..................................................................................................................... 4

2 Current situation in the Maritime Industry .................................................................................. 5
   2.1 Ship Recycling Today ....................................................................................................... 5
   2.2 Conventions and Regulations .......................................................................................... 6
   2.3 Classification Societies ...................................................................................................... 8

3 Methodology ............................................................................................................................... 11
   3.1 Overview of Research Method ........................................................................................... 11
   3.2 Research Approach ........................................................................................................... 11
   3.3 Research Procedure .......................................................................................................... 12
   3.4 Methodology Discussion ................................................................................................... 19

4 Theoretical Frame of Reference .................................................................................................. 23
   4.1 Product Development Process ......................................................................................... 23
   4.2 Ecodesign ......................................................................................................................... 23
   4.3 Ecodesign Guidelines ....................................................................................................... 33
   4.4 Environmental Management Systems ............................................................................. 33

5 Empirical Case Studies ................................................................................................................. 37
   5.1 Kockums AB ..................................................................................................................... 37
   5.2 Environmental Work at Kockums AB ............................................................................ 47
   5.3 Project Schiff and Lessons Learned ................................................................................. 49
   5.4 Ship Recycling at Stena Recycling .................................................................................. 53
   5.5 External Examples of Implementing Environmental Considerations in PD ................. 54

6 Results ........................................................................................................................................... 57
   6.1 Existing Factors Positively Affecting Environmental Aspects .......................................... 57
   6.2 Identified Difficulties ......................................................................................................... 57
   6.3 Steps to Manage the Difficulties ....................................................................................... 58
   6.4 Long-term Environmental Action Plan (LEAP) ............................................................... 58
   6.5 Result Discussion .............................................................................................................. 59

7 Analysis and Discussion ............................................................................................................. 61
7.1 Environmental Product Requirements for Kockums AB to Fulfill ............................................. 61
7.2 Suitable Environmental Ambition Level for Kockums AB .......................................................... 62
7.3 Integrating Environmental and Recycling Issues in the Product Development and its Process... 63
7.4 LEAP for Integration of Environmental Aspects ........................................................................ 65
8 Conclusion .................................................................................................................................... 75
8.1 RQ1: What Environmental Product Requirements are Kockums AB Demanded to Fulfill? ...... 75
8.2 RQ2: What Level Regarding Environmental Issues is Suitable to Aim for at Kockums AB? .... 75
8.3 RQ3: How can Environmental and Recycling Issues be Integrated in the Product Development Process? ............................................................................................................................................... 75
8.4 RQ4: What Kind of Tool/Document/Method is Suitable For Kockums AB in order to Pursue Environmental Issues? ......................................................................................................................... 75
8.5 Closure ......................................................................................................................................... 76
8.6 Future Studies .............................................................................................................................. 76

**TABLE OF APPENDICES**

Appendix A – Long-term Environmental Action Plan (LEAP) .......................................................... - 1 -
Appendix B – Search Index ................................................................................................................ - 3 -
Appendix C – Interview Questions for Design & Engineering Departments ...................................... - 4 -
Appendix D – Interview Questions for Chief Operating Officer ....................................................... - 5 -
Appendix E – Interview Questions for Procurement Department ..................................................... - 6 -
Appendix F – Interview Questions for Stena Recycling ..................................................................... - 8 -
Appendix G – Interview Questions Regarding Green Sub-project.................................................... - 9 -
Appendix H – Interview Questions for the Project Manager in Project Schiff ................................... - 10 -
Appendix I – Guidelines for Ecodesign ............................................................................................. - 11 -
Appendix J – Implementation of a Green Sub-Project Group at a Telecom Company .................... - 13 -
Appendix K – Suggested Actions Linked to Success Factors for Ecodesign ..................................... - 15 -
TABLE OF TABLES

Table 1. A selection of conventions and regulations regarding ship recycling from 1992 until today.... 6
Table 2. The chosen methods of this research in relation to the research questions......................... 13
Table 3. The conducted interviews and their corresponding appendices containing interview questions. ............................................................................................................................................................... 16
Table 4. Compilation of conducted e-mail correspondence ................................................................. 17
Table 5. Example of colored checklist adopted from Luttropp & Lagerstedt (2006)......................... 27
Table 6. Success factors for implementing ecodesign in the product development process according to (Johansson, 2002). ................................................................................................................................................. 30
Table 7. Overview of the six Design & Engineering departments and their work tasks.................... 39
Table 8. Possible implications due to the green environmental sub-project highlighted by Johansson & Magnusson (2006) ................................................................. 54
Table 9. Overview of the eighteen Actions which are suggested in the LEAP ................................. 59
Table 10. Summary of how success factors are connected to suggested Actions in the LEAP............ 71

TABLE OF FIGURES

Figure 1. Overview of the outline of the chapters, with important topics, in this M.Sc. thesis ............. 4
Figure 2. Ship recycling countries, diagram adopted from UNEP (2010) .............................................. 5
Figure 3. Chosen components for the research approach. ................................................................. 11
Figure 4. The different phases of the research procedure with corresponding research questions...... 13
Figure 5. The product development process according to Ulrich & Eppinger (2003) ......................... 23
Figure 6. Relations between ecodesign practices and philosophies modified from McAloone (2000), blue areas are points of interest for this specific M.Sc. thesis ......................................................... 24
Figure 7. Incentives for sustainable development, adopted from Jönbrink et al. (2011) ................. 25
Figure 8. Classification of ecodesign tools and their use in the product development process, adopted from Tischner et al. (2000, s.65) ................................................................. 27
Figure 9. Philips Fast Five-Checklist, adopted from Tischner et al.(2000) ........................................... 28
Figure 10. Paradox in the design process (Lindahl, 2005) ................................................................. 32
Figure 11. The waste management hierarchy, modified from European Commission (2012a) ........... 32
Figure 12. General steps of a POEMS model modified from Ammenberg & Sundin (2005a) .......... 35
Figure 13. Top management and overview of how Kockums AB is organized. Adapted from Kockums AB (2012) .............................................................................................................. 37
Figure 14. Overview of Business Unit Surface Ships. Adapted from Kockums AB (2012) ........ 38
Figure 15. Kockums AB’s Product Development Process and Design Spiral. (Kembring, 2012) .... 41
Figure 16. Design Process at Kockums AB. (Kembring, 2012) ........................................................... 42
Figure 17. Bar chart over interview answers to question: ”Are environmental aspects integrated in the PD?” ................................................................. 48
Figure 18. Project organization for Project Schiff (Kockums AB, 2012) ......................................... 50
INTRODUCTION

This first chapter contains an overview of this research, its objective, and research questions. The chapter also provides a short description of the case company, Kockums AB, the delimitations for the research, and presents an outline of the report’s remaining chapters.

1.1 BACKGROUND

Ship breaking or ship recycling has been conducted ever since ships have been manufactured. This is because there are a lot of assets in terms of valuable material in the ships to take care of. However, older vessels contain hazardous materials, such as asbestos, which expose humans as well as nature to danger. Recently, attention has been paid to ships that have been brought up at beaches for dismantling (beaching method) in Bangladesh, India, and Pakistan. Working conditions have been showed to be horrible and a lot of waste has ended up in the surrounding nature. (Lloyd’s Register, 2011)

Several laws, regulations, and guidelines have been established to deal with the above mentioned problems. In 1989 a regulation regarding hazardous waste was introduced, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention), and it entered into force 1992 (UNEP, 2007). More resolutions followed regarding ship dismantling aspects where human health also was considered. Resolution A.962(23) IMO Guidelines on ship recycling was presented in late 2003, where the concept of Green Passport, now known as Inventory of Hazardous Materials (IHM), was introduced. IHM is a certification document where the ship builder has listed content of hazardous materials in the ship’s design. The document can be approved by an external classification body. (Lloyd’s Register, 2010)

The most recent convention is the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (Hong Kong Convention) adopted in May 2009. The Hong Kong Convention intends to include several previous regulations and deals with the ship’s whole lifecycle. If this convention enters into force it will mean that more consideration when designing vessels has to be taken, e.g., carefully considered material selections. (Lloyd’s Register, 2011)

A well thought-trough product development process is beneficial to handle the effects of the regulations. Ecodesign is a concept where the whole lifecycle of a product is considered and the objective is to minimize its adverse environmental impact (Jönbrink, Norrblom, & Zackrisson, 2011). When implementing and integrating the ecodesign concept into a company’s product development, issues regarding environment will automatically be included. Consequently, environmental requirements from regulations and laws will be considered and incorporated in the product development. A part of ecodesign is Design for Recycling (DfR), which focuses on how to reduce waste that goes to landfill and addresses matters such as that material needs to be separated before they can be recycled (McAloone, 2000).

1.2 PROBLEM DESCRIPTION

Requirements concerning ship recycling are increasing along with the awareness of the shocking situations in the countries where beaching method is performed. At Kockums AB, a company which designs and builds ships, knowledge on how to design environmentally sustainable and recyclable vessels is not extensive. Hence, these eco-aspects are not well implemented or integrated neither in the development of vessels nor in the daily work. This Master of Science (M.Sc.) research is an important
step towards increased knowledge for the company and a way to help Kockums AB to be more proactive in their work regarding environmental issues.

The thesis project will be carried out at the department Integrated Logistic Support (ILS) at Kockums AB whose main tasks are technical documentation and analysis on maintenance and spare parts. Currently Kockums AB’s largest customers are within Sweden. However, the market for surface and underwater vessels is not extensive in Sweden hence Kockums AB needs to reach international markets. Consequently, it is important to follow international guidelines and regulations when designing ships, their systems, and selecting components. Furthermore, it is also of importance to be proactive concerning environmental sustainability to not end up a step behind the law or competitors. The assumption is that current proposals and conventions will be enforced in the future, e.g., Hong Kong Convention. At this time, the knowledge within Kockums AB regarding environmental regulations and issues is not vastly spread. ILS is presently working on finalizing a recycling manual for one of the ships built by Kockums AB. Moreover, another of Kockums AB’s ships holds a Green Passport certificate. The desire within the company, especially within ILS, is to achieve this for more vessels, commercial as well as naval ones. In order to increase environmental awareness at the company, Kockums AB has expressed a need for a tool, document, method, or similar. Hence, this is the starting point and prerequisite for this M.Sc. thesis.

1.3 OBJECTIVE
The objective of this M.Sc. thesis is to integrate environmental, and especially recycling, aspects of ships in the product development process at Kockums AB by designing and proposing a way of implementing a tool, document, and/or method.

1.4 RESEARCH QUESTIONS
To fulfill the objective, following research questions (RQ), presented below, will be examined. The RQs have been divided into sub-questions which will provide information that will make it possible to answer the corresponding RQ.

Firstly, by examining what environmental requirements Kockums AB are demanded to fulfill, future trends will be projected.

RQ1. What environmental product requirements are Kockums AB demanded to fulfill?
- Where do the requirements derive from (external, internal, customers)?
- What requirements might be demanded in the future?

Moreover, by looking at how Kockums AB is dealing with environmental aspects, e.g., in processes and projects, it will be easier to specify an aspired level and what is needed to be accomplished to be proactive.

RQ2. What level regarding environmental issues is suitable to aim for at Kockums AB?
- Where are environmental and recycling aspects integrated on a strategic level at Kockums AB?
- Are there any ongoing or planned environmental projects?

Furthermore, by looking into Kockums AB’s product development process (PDP) and establish where environmental and recycling issues can be integrated, sufficient information to suggest a solution that will fulfill the objective of this M.Sc. thesis will be attained.

RQ3. How can environmental and recycling issues be integrated in the PDP?
- What does Kockums AB’s PDP look like?
- Where are environmental and recycling aspects integrated in the PDP at Kockums AB?
- Where should environmental and recycling aspects be integrated at Kockums AB?
Finally, with relevant information gathered through the above mentioned research questions and literature studies, an environmental tool/document/method will be designed to fully satisfy the objective.

RQ4. What kind of tool/document/method is suitable for Kockums AB in order to pursue environmental issues?
   - What needs to be included in the tool/document/method?
   - How can the tool/document/method be designed to go well with Kockums AB’s existing processes and how should the implementation process be set up?
   - How could the tool/document/method help increase the awareness of the employees on a more daily basis?

1.5 COMPANY DESCRIPTION
Kockums AB is a company, within the marine industry, located in Karlskrona, Malmö, and at Muskö in Sweden. The company was founded in 1679 in Karlskrona as a shipyard for the Swedish navy, and is nowadays the largest shipyard in Sweden. Moreover, it is one of the oldest industries in Sweden that is still in use. Since 2005, Kockums AB is a Group Company within ThyssenKrupp Marine Systems (TKMS), which in turn is a business area within ThyssenKrupp AG (TKAG). Kockums AB designs, builds, and, maintains submarines and ships both for naval and commercial use. Development of surface ships is carried out at Business Unit Surface Ships (BUSS) in Karlskrona. In the shipyard in Karlskrona all vessels are produced. Business Unit Submarines (BUS) is located in Malmö, where the main activity is development of submarines. The first submarine was completed in 1914 and today Kockums AB is one of the top submarine manufacturers, regarding advanced technologies, in the world. The marine workshops in Muskö are a part of Business Unit Marine Services (BUMS), and are used for service and maintenance of naval and commercial ships. (Kockums AB, 2010)

Kockums AB’s aim is to deliver products with “right quality, in time and, to an agreed price”. The company is certified according to ISO 3834-2, ISO 9001, and ISO 14001, which means that welding, quality, and Environmental Management Systems are included in the overall company management system. (Kockums AB, 2010)

1.6 DELIMITATIONS
Ship recycling is in most cases not only a threat to the environment but also a hazard to human health. However, human health aspects will not be covered in this research.

Ecodesign as a concept covers the whole lifecycle of a product. However, this research will not focus on the manufacturing phase, since only a few ships are produced annually at Kockums AB and the effect on the environment therefore is assumed to be negligible. Neither the usage phase is to be covered by this research even though that phase is of great importance for the ship’s total environmental footprint. Nonetheless, recycling aspects are included in requirements demanded from Kockums AB’s customer as well as in recent laws and regulations. As for that reason, and the limited time frame of this thesis work, the recycling phase is the one to be covered in this research.

When studying what environmental requirements are demanded from customers, not all customers will be considered. Kockums AB’s major customer is FMV1, who has a big influence on the products developed by Kockums AB. Therefore, FMV’s requirements are considered the most important and requirements from other customers will not be included in this research.

The environmental tool/document/method should be general and work for all vessels developed at Kockums AB. Hence the tool/document/method will not go in to details for specific ships. The

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1 Swedish abbreviation for Försvarets materielverk whose basic task is to provide the Swedish Armed Forces with materiel.
tool/document/method will be verified by employees at Kockums AB, however it will not be verified throughout a whole new project since ship development projects are long and smaller projects are rare.

The research will focus on product development at BUSS in Karlskrona in general and specifically on the work conducted at the Design & Engineering departments. Consequently, the business units BUS and BUMS will not be taken into consideration when developing the tool/document/method. However, it is possible that the tool/document/method will be applicable at those units as well since it should be general.

1.7 REPORT OUTLINE
The outline of this M.Sc. thesis is presented below in Figure 1. This first introduction chapter (1) explains the purpose of the report and provides background information on the problem. In chapter 2, the current situation in the maritime industry will be explained. This includes topics such as ship recycling, conventions and regulations as well as classification societies. The third chapter (3), Methodology, will describe the procedure of the research thoroughly. Thereafter, the theoretical frame of reference will be given in chapter 4 and include theory on product development, ecodesign, Design for Recycling, and Environmental Management Systems. The mentioned topics will act as basis of discussion later on. In chapter 5 the outcome of the company case study, as well as external research, will be presented which consists of interviews and first-hand collected data. Theory and empirics will generate the result presented in chapter 6, which consists of an environmental tool/document/method that will satisfy the purpose of this research and consequently help increase the environmental awareness at Kockums AB. Next, in chapter 7, information and data that have been obtained throughout the process will be analyzed and discussed. Finally, this will make up the conclusions of the M.Sc. thesis, presented in chapter 8, that satisfy the objective of the research. In the concluding two chapters, references and appendices will be given.

Figure 1. Overview of the outline of the chapters, with important topics, in this M.Sc. thesis.
CURRENT SITUATION IN THE MARITIME INDUSTRY

The current situation will be described in this chapter to provide deeper knowledge on why it is important to deal with environmental aspects in the maritime industry. This chapter includes topics as ship recycling, conventions and regulations, and classification societies.

2.1 SHIP RECYCLING TODAY

In the first month of 2009 alone, the volume of tonnage, for ships, sent to recycling was 40% of the total amount of recycled material in 2006. Even though the average age of ships sent for End-of-Life (EoL) treatment has increased with seven years from the 1990s until 2007, the amount of recycled ships are growing. This implies that recycling, in the ship industry, will have a greater focus in the near future. (Martinsen, 2009)

There are in general four types of recycling or dismantling methods, where the most common and used is called the beaching method (Shimizu et al., 2011). This method is used in 95% of the cases with key locations in Bangladesh, India, and Pakistan. The ship is driven up on a beach with help of the tidal range and then dismantled at site by cutting. However, in many cases the ships strand on the mudflats before the beach and have to be dragged with winches. In the beaching method it is difficult to ensure safety and manage hazardous materials. (Lloyd’s Register, 2011)

Recycling of ships is carried out in several countries. As mentioned, the beaching method is performed in mainly South Asian countries. Turkey and China are countries where significant recycling of ships takes place as well. (UNEP, 2010) Statistics from 2010 on ship recycling countries and their market shares are displayed in Figure 2 below.

![Figure 2. Ship recycling countries, diagram adopted from UNEP (2010) with original data source N. Cotzias Shipping Group 2010.](image-url)

Average age of recycled ships is hard to determine and it is dependent on variables such as ship size and type. In general, ships reach their EoL stage after 25-30 years. However, more statistical data is required in order to assess an accurate average age for ships. (Mikelis, 2007)
2.2 CONVENTIONS AND REGULATIONS

Ship scrapping was brought to the public’s attention as early as in 1998 when two reporters, Will Englund and Gary Cohn, ran a series of articles on this issue. These articles exposed the worst ship breaking around the world and the horrible circumstances associated with it. The subject of scrapping soon became known as ship recycling instead and the International Maritime Organization (IMO) assigned a committee to propose work on how this issue can be dealt with. This organization, along with others, worked on different documents on better handling of ships after their EoL. Green Passport, or IHM, was introduced in 2003, by the IMO, and is meant to facilitate recycling of a ship and indicates where hazards can occur, since it contains a list of the ship’s materials. In May 2007, a proposed Green Paper on better ship dismantling was adopted by the EU. Moreover, EU proposed An EU Strategy for Better Ship Dismantling in 2008 to fill gaps regarding health and environmental issues when dismantling ships, while waiting for the next planned IMO convention. The IMO convention in 2009 and latest work lead to an adopted convention in May 2009, Hong Kong Convention. The Hong Kong Convention addresses all issues concerning ship recycling and contains a Ship Recycling Plan. It is expected to be accepted in 2013-2014 at earliest, since it needs to be ratified by the members of IMO before it enters into force. (Lloyd’s Register, 2011)

Table 1 below shows conventions and regulations that have been important steps towards safer and more environmentally sound ship recycling. A few of the mentioned conventions, that have been vital in the progress towards a more sustainable ship recycling, will be highlighted in the next four headings.

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Organization</th>
<th>Content</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2003</td>
<td>Resolution A.962(23) IMO Guidelines on ship recycling</td>
<td>IMO</td>
<td>Gives advice on recycling aspects to all stakeholders in the recycling process and introduced the concept of a Green Passport/IHM.</td>
<td>(IMO, 2003)</td>
</tr>
<tr>
<td>May 2007</td>
<td>Green Paper</td>
<td>EC</td>
<td>Presents the basic facts on ship dismantling and explains the problems.</td>
<td>(EC, 2007)</td>
</tr>
<tr>
<td>Nov 2008</td>
<td>An EU Strategy for better ship dismantling</td>
<td>EU</td>
<td>Objective is to ensure dismantling of ships in safe and environmentally sound facilities worldwide, in line with the draft of Hong Kong Convention.</td>
<td>(EU, 2008)</td>
</tr>
<tr>
<td>May 2009</td>
<td>Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (Hong Kong Convention)</td>
<td>IMO</td>
<td>Rules covering ships whole lifecycle, from construction to recycling of ship, and covers previous regulations and guidelines.</td>
<td>(IMO, 2009)</td>
</tr>
</tbody>
</table>

Table 1. A selection of conventions and regulations regarding ship recycling from 1992 until today. The concept and regulations in bold letters will be further explained since they are of importance for this research.
2.2.1 Basel Convention

The Basel Convention aims to protect the environment and human health from undesirable effects resulting from the generation, management, transboundary movements, and disposal of hazardous and other waste. The convention was adopted in 1989 and entered into force 1992. (UNEP, 2007) The Basel convention has 178 member states (parties) and Sweden has been a member since 1991 (UNEP, 2011).

The Basel convention controls the movements of hazardous, and other, waste over borders by use of the Prior Informed Consent system. Shipment that has not got consent is illegal as well as shipments to and from non-member states without special agreement. Appropriate legislation is required to be introduced by all parties to prevent and stop illegal traffic. Each party is also obligated to ensure that hazardous and other waste is managed and disposed in an environmentally sound manner. Lastly, the member states are expected to minimize the amount of waste that move across borders, to manage the waste as close to the source as possible, as well as reduce and prevent the generation of wastes. (UNEP, 2007)

Ships that are destined for ship dismantling are regarded as waste in the Basel Convention, and the ships contain hazardous waste in most cases. Hence, the ships are considered hazardous waste and must comply with the rules of the Basel Convention. However, problems can occur since it is hard to define when a ship is considered waste. Moreover, it is possible to hide the fact that the ship is destined for ship dismantling in order to avoid being a subject of the Basel Convention. Consequently, there is a loophole in the Basel Convention. (Green Peace International / Basel Action Network, 1999)

2.2.2 Green Passport/IHM

IMO published a resolution in December 2003 that included the concept of Green Passport that now is more known as IHM (IMO, 2003). The IHM document is meant to present a reasonable number of hazardous materials used in the design of the vessel. The purpose is not to list accurate amounts of materials nor provide detailed information of each hazardous substance. (Lloyd’s Register, 2010) It is intended to facilitate handling of materials that are potentially hazardous. The document is dynamic and should be updated throughout the life time of the ship independent of the ship owner. As a result, recycling of the ship should be facilitated since an accurate IHM document is delivered along with the ship to a recycling facility. (IMO, 2003)

The objective of the IHM is given in Resolution A.962(23) and is described as

"These guidelines seek to:

1. encourage recycling as the best means to dispose of ships at the end of their operating lives;
2. provide guidance in respect of the preparation of ships for recycling and minimizing the use of potentially hazardous materials and waste generation during a ship’s operating life;
3. foster inter-agency co-operation; and encourage all stakeholders to address the issue of ship recycling. ” (IMO, 2003, p.5)

2.2.3 An EU Strategy for Better Ship Dismantling

An EU Strategy for better ship dismantling was presented in 2008 as a response to the weak implementations of the current law on hazardous waste in the Basel Convention. The general objective of the strategy is to ensure safe and environmentally sound dismantling of ships strongly linked to the EU. Ship dismantling and recycling facilities should be in line with the draft on the Hong Kong Convention. The strategy does not apply to all ships, e.g., warships are excluded. (EU, 2008)
The operational objectives of the EU strategy are:

- "Provide the necessary encouragement and guidance for the implementation of EC (European Commission) waste shipment law with regard to end-of-life ships.
- Work towards effective and early transposition of the forthcoming international Ship Recycling Convention in the EU.
- Assess the need and possible options to supplement the Ship Recycling Convention with the necessary measures to address negative impacts of ship dismantling that are not covered by the Convention and promote its practical effectiveness." (EU, 2008, p.5)

### 2.2.4 Hong Kong Convention

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships was adopted in 2009 by the IMO. This convention is also known as Ship Recycling Convention or, as referred to in this research, Hong Kong Convention. It includes important aspects concerning ship recycling such as Ship Recycling Plan, IHM, and other elements of the mindset "cradle to grave". However, the Hong Kong Convention does not cover naval vessels. (IMO, 2009) Even though naval ships are excluded, it is stated that "such ships act in a manner consistent with this Convention, so far as is reasonable and practicable" (IMO, 2009, p.3).

Different organizations have developed guidelines for ship recycling independently of each other. The Hong Kong Convention is meant to cover all stages from design to recycling of ship, and covers previous regulations and guidelines. (Hirabara, 2008)

Industry partners have different responsibilities according to the Hong Kong Convention. The manufacturer or supplier of parts needs to provide a material declaration to the ship builder, who needs to develop an IHM. Inventories need to be completed for new as well as existing ships. The owner of the ship then needs to keep the IHM updated, decide upon a ship recycling facility, and develop a Ship Recycling Plan in cooperation with the ship recycling facility. Furthermore, the recycling facility in turn needs to be authorized by IMO and prepare a Ship Recycling Facility Management Plan. (Hirabara, 2008)

The Hong Kong Convention has three conditions for ratification. Only 24 months after the conditions are met the convention will enter into force. (IMO, 2009) The conditions are the following:

1. not less than 15 States have either signed it without reservation as to ratification, acceptance or approval, or have deposited the requisite instrument of ratification, acceptance, approval or accession in accordance with Article 16;
2. the combined merchant fleets of the States mentioned in paragraph 1.1 constitute not less than 40 per cent of the gross tonnage of the world’s merchant shipping; and
3. the combined maximum annual ship recycling volume of the States mentioned in paragraph 1.1 during the preceding 10 years constitutes not less than 3 per cent of the gross tonnage of the combined merchant shipping of the same States. (IMO, 2009, p.9)

### 2.3 Classification Societies

Ship classification is used to make sure that important functions and features of a ship, for instance strength of the hull and reliability of the propulsion system, are built in a dependable way. Classification societies develop rules and ensure the compliance with international and national regulations. A ship that is designed and built in accordance with rules of a specific classification society may apply for a certificate of classification from that society. The ship is assigned a class after the design is reviewed and surveys during the design are completed with a satisfying result. (International Association of Classification Societies, 2011) There are more than 50 organizations
working with classification services and three of those, which are important for this research, are presented in more detail below.

2.3.1 Det Norske Veritas
Det Norske Veritas (DNV) is an independent foundation established in 1864. Their purpose is “safeguarding life, property, and the environment”. DNV offers services such as certification, classification, and risk management to, for instance, the maritime industry. The foundation acts globally and has offices in 100 countries. (Det Norske Veritas, 2011)

New ships and ships in operation can get an additional class notation "Recyclable” if requirements in chapter 27 of DNV’s ‘Rules for classification of ships’ are fulfilled (Det Norske Veritas, 2010a). The class notation is voluntary and was developed as a mean for ship owners to have visible proof that their ship is in compliance with Hong Kong Convention’s requirements. IHM is the basic requirement of both the Hong Kong Convention and the Recyclable notation. Part 1 of the IHM must be completed in order to obtain the Recyclable notation. Hazardous materials that are defined in the Hong Kong Convention’s Appendices 1 and 2 must be identified and listed. One person must be responsible throughout the ship’s operating life for maintaining and updating part 1 of the IHM. (Det Norske Veritas, 2010b)

2.3.2 Germanischer Lloyd
Germanischer Lloyd (GL) acts in the maritime and energy industry within the areas of classification, consulting, and assurance. The company’s mission is to make these three areas ”safer, greener, and smarter”. GL develops rules, guidelines, and procedures for the maritime industry and emphasizes on energy efficiency and environmental issues. (Germanischer Lloyd, 2012a)

GL has a class notation called Environmental Passport, which is voluntary and can be used to underline the commitment to maritime environment. This Environmental Passport focuses on making shipping ”green” hence emphasizing on operating life of ships and their emissions into sea and air. (Germanischer Lloyd, 2012b)

2.3.3 Lloyd’s Register
Lloyd’s Register has the mission “to protect life and property and advance transportation and engineering education and research”. Since 1760, Lloyd’s Register has worked with assessing products to international standards, both developed by Lloyd’s Register themselves and by major independent bodies. The organization is located in 186 countries and work together with other organizations, such as IMO and ISO, to support development of standards and legislation. (Lloyd’s Register, 2012a)

Lloyd’s Register has a class notation for ship owners that want to demonstrate their commitment to the environment beyond legislative compliance, the ECO notation. The ECO Rules set standard for ship design, construction, and operation. (Lloyd’s Register, 2012b)
METHODOLOGY

This chapter explains the outline of the research, procedure, and chosen approaches. The selected methods and components are discussed and the execution of the project is explained thoroughly. Finally, the chosen methodology is discussed and evaluated.

3.

3.1 OVERVIEW OF RESEARCH METHOD
There are different aspects and components to consider when choosing research method. Figure 3 shows the chosen components for this research. Information was collected through qualitative methods, mainly literature study and interviews. One case company was studied and several elements of this specific case were examined. The research purpose was a combination of mainly exploratory but also explanatory and descriptive type. Moreover, the research type was qualitative, meaning that in-depth understanding was the goal and primary as well as secondary data was collected. However, some quantitative data were presented to provide a holistic picture for the reader.

Figure 3. Chosen components for the research approach.

The research method and its components will be further discussed, motivated, and explained in following headings.

3.2 RESEARCH APPROACH
Research can be qualitative or quantitative; this depends on how gathered information is generalized, processed, and analyzed. Furthermore, the collected data can also be of qualitative or quantitative type. Quantitative research are referring to research that contains measuring when gathering data and has statistical processing and analyzing methods. Meanwhile, the data collection in qualitative research is focused on ”soft data” such as interviews and interpretations. (Patel & Davidsson, 2011) There are different approaches that can be chosen for a research. In a case study approach the focus is on one single object and goes deeper into different variables. In comparison, a cross-sectional study only investigates one variable but for different objects or cases. A case study is a research strategy which is empiric and often used within qualitative research. A specific case is chosen such as an individual, a group, or an organization and scrutinized in its natural environment. (Eriksson, 1997)

The chosen general approach for this research was qualitative, and a case study on one company was carried out. Consequently, in-depth understanding regarding the company could be gathered and worked as a knowledge base for decisions in the research process towards fulfilling the objective.
3.2.1 Purpose of Research
Different types of research strategies and ways of structuring a research purpose can be used, such as exploratory or descriptive. Exploratory research aims at gathering as much information as possible from a predefined area. The research purpose should be elucidated in an all-round way where different techniques for gathering information often are used. Descriptive research is used when a lot of research and knowledge concerning the defined problem already exist. More in-depth research is carried out where selected aspects are described thoroughly and detailed. (Patel & Davidsson, 2011) Moreover, research purposes can be explanatory, in which cause and effect of problems are looked into as well as reasons for them. (Wallén, 1996) Exploratory studies are useful in the sense that the gained knowledge and result can be adjusted while researching. It is common to combine research purposes, for example start exploratory to investigate the problem and continue in a more explaining and descriptive way. (Eriksson, 1997)

This thesis consists of a research purpose which started off as exploratory to investigate exactly what the problem was and what needed to be done. Next, a more descriptive strategy was used when trying to map the development process of Kockums AB and its departments. When developing a solution for the explored and described problem the research was of explanatory purpose since cause and effects needed to be outlined.

3.2.2 Type of Data
As mentioned, the research as well as the type of data can be categorized into qualitative or quantitative. Qualitative data aims at giving understanding and description, in words or pictures, of the surrounding world. Quantitative results are often given in numbers and derive from objective methods. Furthermore, the gathered data can be collected empirically, in the real world, or analytically, in a simulated environment, and refers to the source of the data. (Bohgard et al., 2008) Empirical data is called primary data and can be, for instance, experiments, surveys, interviews, or focus groups. This type of data is collected first hand by the researcher while the analytically collected data, or secondary data, is collected by someone else, e.g., statistics provided by an agency. (Eriksson, 1997)

The collected data for this research was mainly qualitative and both of primary and secondary type. An exception of data that was quantitative was statistics of ship recycling and was presented to give an understanding of the ship recycling problem. The case study, which included interviews and a focus group, resulted in primary data while literature review resulted in secondary data.

3.3 Research Procedure
The performed research was divided into four different phases, as described in Figure 4. The first phase, problem framing, was conducted to get an overall perspective of the research, the current situation, and the objective of the thesis. When the purpose of the research was clarified, data was collected to gain knowledge about Kockums AB’s processes along with theory regarding ecodesign to support the next phase, development. In the development phase, the tool/document/method was developed to fulfill the objective of this M.Sc. thesis. This resulted in a Long-term Environmental Action Plan (LEAP), which was designed to suit existing processes and to emphasize environmental issues. In Appendix A, the LEAP is presented. The LEAP was then verified together with key personnel at Kockums AB, in a focus group, to ascertain that it could function as intended and was in line with the level of ambition the company was aiming for. This phase could also be seen as a handover to the company since it was made sure that key personnel, suggested to continue working with the LEAP, had the necessary knowledge to carry on the work.
3.3.1 Problem Framing
Initially, the objective of the thesis needed to be examined thoroughly to concretize the purpose of the research. A literature review on the current situation regarding regulations and conventions in the ship industry was carried out. This was done to assess what laws were important to focus on and would be of importance in the future for Kockums AB. Moreover, qualitative interviews with key personnel, such as the Environment Manager and Environment Consultant, were conducted initially to get an outline of the company, its working procedure, existing environmental work, and found out where problems existed. Studies on Kabinet, the intranet of Kockums AB, were carried out to complement the interviews. Consequently, this enabled the research questions to become more specified and detailed to bring up all necessary issues to satisfy the objective. Table 2 shows an overview of the different methods chosen in relation to the different research questions. The methods will be further described in 3.3.2 Data collection and 3.3.4 Verification.

### Table 2. The chosen methods of this research in relation to the research questions.

<table>
<thead>
<tr>
<th>Methods:</th>
<th>Literature review</th>
<th>Interviews</th>
<th>Case study</th>
<th>Brainstorming</th>
<th>Focus group</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>RQ2</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>RQ3</td>
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<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>RQ4</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

3.3.2 Data Collection
The chosen methods for the collection of data were literature review, case study, and interviews. All three methods are well-known and proven.

Through an extensive literature review, important knowledge for the research could be gained. A case study can be used for different applications, e.g., explain, describe, explore, illustrate, and evaluate (Yin, 1994). The purpose of this research was of exploratory, explanatory, and descriptive nature which makes case study a suitable method to use. Yin (1994) mentions that there are different possible sources of case study information, e.g., documentation, interviews, and observations. These sources complement each other and it is recommended to use various sources. However, the most important source is the interview. (Yin, 1994) Since this research was carried out at site in Karlskrona at Kockums AB, the natural source of information was interviews and dialogues with employees at the company.

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2 What environmental product requirements are Kockums AB demanded to fulfill?
3 What level regarding environmental issues is suitable to aim for at Kockums AB?
4 How can environmental and recycling issues be integrated in the PDP?
5 What kind of tool/document/method is suitable for Kockums AB in order to pursue environmental issues?
**Literature Review**

A literature review is a comprehensive process where a lot of literature is gathered and needs to be reviewed. In this way, reliable sources can be selected. Furthermore, it is important to make limitations at this stage so that the research does not expand too much. Keywords, central for the research, should be defined and searched for in different databases. Finally, chosen literature should be evaluated and assessed according to reliability and relevance. (Patel & Davidsson, 2011)

When the research purpose had been determined in the problem framing, a literature review on ecodesign, Design for Recycling (DfR), and Environmental Management Systems (EMS) was conducted. Plenty of articles were gathered and examined to select the most relevant and reliable as foundation for the literature review. Primary sources were mainly chosen. However, in a few cases secondary sources were used when the primary source could not be found, in order to mediate important information. Moreover, literature by authors that had been cited multiple times was preferably chosen. Important keywords were decided upon in the problem framing phase as well as in the initial phase of the literature review. These words can be found in Appendix B and were used when searching in different databases throughout the literature review process. Moreover, bibliographies of particularly relevant articles were used to find additional sources. To find most recent research on the subject of ecodesign, as well as ship recycling, electronic resources such as articles, conference proceedings, and reports were gathered. Complementary literature, which is more experienced and proven, was collected from books.

**Case Study**

A case study is conducted when examining a certain limited event or case such as a company, situation or organization. The study is made in a holistic perspective where as much in-depth information as possible is collected. To attain a thorough holistic viewpoint of the case study it is important to gather information of different variables and characters. A case study is useful to perform when a process or change is desired to examine. Depending on how the different variables within the case study have been chosen, the result is able to be generalized to more cases than the one studied. (Patel & Davidsson, 2011)

In this research, the case study was carried out at the company Kockums AB with focus on their product development process and how the different departments were connected to each other within the process. This was done to be able to examine the product development process at the company in order to assess where environmental aspects needed to be incorporated. It was important to try to identify what level of environmental ambition should be aimed for. Moreover, what kind of tool/document/method was needed, to integrate environmental aspects at Kockums AB, had to be identified. In addition, it had to be assessed where in the process components, such as tools and methods, should be implemented and how they should be designed, e.g. choose existing, modify, or develop new tools. Consequently, by conducting the case study at Kockums AB, the research questions for this M.Sc. thesis could be answered.

**Interviews**

Interview is a technique for collecting information that is built on questions and is often personal; conducted face-to-face (Patel & Davidsson, 2011). There are different levels of structure that can be used for interviews; structured, semi-structured, and open. The level of structure depends on the focus, research questions, and selection criteria. A structured interview might get relatively mechanical and decrease the interaction between the interviewee and the researcher. However, a well framed structure can reduce the risk of gaining redundant information and, instead, helps achieving what is aimed for. An open interview is preferable if the objective is to capture the interviewee’s perspective. The most commonly used is the semi-structured interview in which main questions and themes are prepared, without detail or a specified sequence. (Ryen, 2004)
It might be difficult to act as an interested listener at the same time as taking notes. Therefore, it is recommended to record the conversation. However, if the interviewee feels uncomfortable with the interview being recorded, no technical recording equipment should be used. Whether or not the interview is recorded, notes should be taken during the interview. In addition to documenting the conversation, personal thoughts and reflections should be noted. (Ryen, 2004)

Qualitative interviews were held with key personnel at different departments at Kockums AB and with external pertinent parties, presented in Table 3. All interviews except for two were internal, conducted at Kockums AB, and provided information from the interviewees’ viewpoint. The two external interviews were conducted in the development phase of the research and are indicated as external in the table. To be able to map the product development process the head of each Design & Engineering department at Kockums AB were contacted by e-mail to find employees with profound knowledge on the procedures. Moreover, employees at departments with product development related activities were also contacted by e-mail. As answers were received, the interviews were planned and carried out. Most interviews were conducted in a semi-structured way to ensure that relevant information could be captured. Questions were formulated in advance to ensure that the objective of the interview would be fulfilled. The questions prepared for each interview are presented in the appendices, referred to in Table 3. During the problem framing and data collection phases the questions were not sent to the interviewee beforehand since the subject of those interviews were of general type to get an overview of the daily work. In the development phase, on the other hand, the content of the interviews was more specific and the interviewee therefore got access to the questions in advance to be able to prepare. The questions were used to support the discussion with the interviewee and were not necessarily asked in the same order as prepared. Instead, emphasis was on the discussion and gaining the desired information. Some interviews were held in an open way and in those cases no questions were prepared in advance. Instead, an open dialog on a particular subject was held.
Table 3. The conducted interviews and their corresponding appendices containing interview questions.

<table>
<thead>
<tr>
<th>Date</th>
<th>Interviewee</th>
<th>Position</th>
<th>Interview content</th>
<th>Duration [h]</th>
<th>Interview questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Problem framing phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Feb</td>
<td>Marie Ekvall, Rolf Peterson</td>
<td>Environmental Consultant, Environment Manager</td>
<td>Recycling manual, general environmental work at the company</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>7 Feb</td>
<td>Leif Kembring</td>
<td>Systems Engineer</td>
<td>Presentation of the new product development process</td>
<td>1</td>
<td>Appendix C</td>
</tr>
<tr>
<td>14 Feb</td>
<td>Anders KE Karlsson, Jonas Möller</td>
<td>Senior System Engineer, Head of Intelligence &amp; Electrical</td>
<td>The work at Intelligence &amp; Electrical department, product development process, requirements</td>
<td>1.5</td>
<td>Appendix C</td>
</tr>
<tr>
<td>16 Feb</td>
<td>Thomas P Johansson</td>
<td>Product area Manager MCM, previously employed at Vessel systems department</td>
<td>The work at Vessel Systems department, product development process, systems engineering, requirements</td>
<td>1</td>
<td>Appendix C</td>
</tr>
<tr>
<td>21 Feb</td>
<td>Rolf Peterson</td>
<td>Environment Manager</td>
<td>Environmental Management System</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>22 Feb</td>
<td>Ulf Arbin</td>
<td>Head of Composite &amp; Technology</td>
<td>The work at Composite &amp; Technology department, product development process, requirements</td>
<td>1</td>
<td>Appendix C</td>
</tr>
<tr>
<td>23 Feb</td>
<td>Pontus Kallén</td>
<td>Chief Operating Officer</td>
<td>The executive office's view point on product development and environmental questions</td>
<td>1</td>
<td>Appendix D</td>
</tr>
<tr>
<td>23 Feb</td>
<td>Peter A Nilsson</td>
<td>Employee at Commercial Vessel department</td>
<td>The work at Commercial Vessel department, product development process, requirements</td>
<td>1</td>
<td>Appendix C</td>
</tr>
<tr>
<td>28 Feb</td>
<td>Mikael Rodin</td>
<td>Employee at Procurement department</td>
<td>The work at Procurement department</td>
<td>1</td>
<td>Appendix E</td>
</tr>
<tr>
<td>29 Feb</td>
<td>Johan Lindström</td>
<td>Head of Propulsion &amp; Auxiliary</td>
<td>The work at Propulsion &amp; Auxiliary department, product development process, requirements</td>
<td>1</td>
<td>Appendix C</td>
</tr>
<tr>
<td>1 Mar</td>
<td>Mari Åkesson</td>
<td>Employee at ILS department</td>
<td>The work at ILS department, product development process, requirements</td>
<td>1</td>
<td>Appendix C</td>
</tr>
<tr>
<td></td>
<td><strong>Data collection phase</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>13 Mar</td>
<td>Nils Jonasson, Rikard Petersson</td>
<td>Managers at Stena Recycling (External interview)</td>
<td>Recycling of ships at Stena Recycling</td>
<td>1</td>
<td>Appendix F</td>
</tr>
<tr>
<td>19 Mar</td>
<td>Thomas Magnusson</td>
<td>Assistant Professor at Linköping University (External Interview)</td>
<td>Implementation of a green sub-project group at a telecom company and examples of best practice</td>
<td>1</td>
<td>Appendix G</td>
</tr>
<tr>
<td>5 Apr</td>
<td>Daniel Nyström</td>
<td>Project Manager in project Schiff</td>
<td>The work in project Schiff related to environmental issues and lessons learned overall</td>
<td>1</td>
<td>Appendix H</td>
</tr>
</tbody>
</table>

During the interviews, one of the researchers was responsible for taking notes while the other one asked the questions. By dividing the tasks in this way, the person asking questions could be focused on the answers given from the interviewee and were able to ask appropriate follow-up questions which made the discussion run smoothly. At the same time, the other person had time to take notes to ensure that important information and own reflections were thoroughly documented. The notes were compiled and examined by both researchers after the interview to make sure that everything was correctly understood and that nothing important had been forgotten. Furthermore, during the development phase the interviews were also recorded to enable the possibility of listening to the interview again. This was done since those interviews were more detailed and the risk of missing important facts was higher than during the data collection phase. Moreover, in the data collection
phase, recording was considered more as a distraction for the interviewee than support for the researchers.

Throughout the research a number of questions were answered, by contacting people with expert knowledge, via e-mail, presented in Table 4. Since the questions were straightforward, e-mail was found to be the easiest and most suitable way to get them answered.

Table 4. Compilation of conducted e-mail correspondence

<table>
<thead>
<tr>
<th>Date</th>
<th>Interviewee</th>
<th>Position, Company</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 Jan</td>
<td>Mia Pousette</td>
<td>Investigation secretary, Enterprise Ministry Sweden</td>
<td>N2011:02, Investigation regarding the ratification of Hong Kong Convention</td>
</tr>
<tr>
<td>27 Jan</td>
<td>Reidar Grundström</td>
<td>Employee at Sjöfartspolitiska enheten, Swedish Maritime Administration</td>
<td>Ship Recycling and Hong Kong Convention</td>
</tr>
<tr>
<td>1 Feb</td>
<td>Caroline Petrini</td>
<td>Employee at Maritime Environment Section, Swedish Transport Agency</td>
<td>Ship Recycling and Hong Kong Convention</td>
</tr>
<tr>
<td>2 Feb</td>
<td>Anders Höfnell</td>
<td>Lead Client Manager, Swedish Lloyd’s Register</td>
<td>Ship Recycling and Hong Kong Convention</td>
</tr>
<tr>
<td>29 Feb</td>
<td>Environmental Coordinator A</td>
<td>Environmental Coordinator, FMV</td>
<td>Customer requirements</td>
</tr>
<tr>
<td>16 Mar</td>
<td>Marie Ekvall</td>
<td>Environmental Consultant, Kockums AB</td>
<td>Lessons learned from project Schiff</td>
</tr>
<tr>
<td>26 Mar</td>
<td>Environmental Coordinator B</td>
<td>Environmental Coordinator, FMV</td>
<td>Customer requirements</td>
</tr>
<tr>
<td>30 Mar</td>
<td>Johan Edvardsson</td>
<td>Head of Design &amp; Engineering, Kockums AB</td>
<td>Level of ambition for sustainable development at Design &amp; Engineering</td>
</tr>
</tbody>
</table>

The interviews and e-mail correspondence were held in Swedish since that is the native language of both the researchers and the interviewees. However, during the compilation the answers were translated into English. To ensure that no information got lost in translation or were misunderstood the translated compilation was sent to the interviewee for confirmation. If no answer was received from the interviewee, after several e-mail reminders, the text was assumed to be correct. As a precaution, Mari Åkesson, the researchers’ advisor and an employee of ILS since ten years, was asked to read the text as well to ensure that the content was correct.

3.3.3 Development

The development phase started with an analysis of the information gained from interviews and literature study. The existing areas where environmental work is already done and areas of improvement were identified. The second step consisted of finding solutions for the existing improvement areas. This was conducted in a two stage brainstorming session. First, the researchers performed a brainstorming individually and tried to come up with as many solutions as possible that would work well according to the reviewed literature and that would suit the routines and processes at Kockums AB. During the brainstorming sessions, the ISO 14006 standard, the product development process of Kockums AB, and the methods and tools from the literature were used as inspiration and guidance. Secondly, the outcome from the first individual brainstorming sessions were compared and compiled, which then resulted in a number of solutions. A few solutions were discarded based on empirical findings, since they were not suitable for or realizable at Kockums AB. Lastly, the solutions were prioritized according to two parameters; how important they were to implement within the
nearest future and how easily the solutions could be implemented, without being seen as an obstacle instead of an aid. Consequently, the solutions were prioritized according to complexity.

When the solutions were decided upon they were thoroughly described in a Long-term Environmental Action Plan (LEAP) as individual Actions. Appendix A presents the entire LEAP with its Actions. For each of these Actions; objective, solution, how it should be used and/or implemented, when and where it should be implemented, and responsibilities, were described. Additional documents to complement the LEAP, such as tools in terms of checklists and guidelines, were created. These documents were developed according to Kockums AB’s existing templates. In this way, implementation and integration of the LEAP was facilitated.

### 3.3.4 Verification

To ensure that the LEAP was in line with Kockums AB’s level of ambition and suitable for the existing processes and knowledge available, the suggested Actions in the LEAP were verified. The verification was performed by the use of a focus group. However, to make sure that the material that were to be presented at the focus group was sufficiently elaborated, reasonable, and relevant for Kockums AB, it was first presented at an ILS department meeting. From that presentation, feedback was gained and aspects that at that time were unclear could be straightened out before the focus group was carried out. Consequently, a better result from the focus group was possible to achieve. The main focus during the department presentation was on the implementation; whether or not the implementation plan was suitable, an estimation of the time needed for the implementation, and which suggestions were believed to be most important. The LEAP was then revised according to the feedback. During the focus group, on the other hand, focus was on how realizable the Actions were.

**Focus Group**

A focus group is a group interview where the group discusses predefined subjects. The focus group should consist of, preferably, six to ten people. A moderator participates to make sure that planned topics will be discussed. An assistant to the moderator is often participating to take notes from the meeting that normally is recorded as well. Mediating objects, such as photographs, pictures or real products, can be used to increase the creativity of the participants without the moderator influencing too much. Focus groups can be time saving and work well in assessment processes or development processes. A lot of and spontaneous information can be gathered in comparison to when one-to-one interviews are used. However there are disadvantages like unnatural situations and personality clashes. Moreover, there is a risk that only one or a few people take over conversations entirely while other sits quiet. (Bohgard et al., 2008)

Employees, who had been involved in the research up to that time, as interviewees or advisors, were invited to participate in the focus group. The conducted focus group had six participants who represented different departments at Kockums AB: ILS, Intelligence & Electrical, Vessel Systems, Systems Engineering, and System Safety. Different perspectives on the LEAP could be received since the focus group was cross-functional. A draft on the LEAP was sent to the participants in advance to provide the chance for preparation. During the two hour long session, the LEAP was presented to the participants, one Action at a time, which was then followed by a discussion. Throughout the focus group session, the responsibilities of taking notes and act as a moderator for the discussion were divided between the researchers. Questions which were important to discuss for each Action were prepared in advance and the moderator ensured that these questions were handled and added new ones as the discussion went on. However, the moderator strived to not interfere too much but rather let the participants be the centre of the discussion. The discussion was documented and the notes were then used to revise the LEAP.
3.4 Methodology Discussion
The methods used throughout the research have been evaluated in terms of relevance, validity, reliability, subjectivity, and objectivity. Furthermore, what could have been done differently when conducting the chosen methods and what alternative methods there have been discussed.

When collecting facts and information it is important to discuss and examine the reliability, validity, and relevance. To accomplish a credible research high validity and reliability is needed. (Eriksson, 1997) Validity considers how valid measurements and assessments are, meaning if the intended research actually has been examined. The extent of the validity is how well answers correspond to true value or reality. Reliability, on the other hand, implies if answers or results would be the same if measurements or methods would be done in the same way again. High reliability means that the data is trustworthy. (Bohgard et al., 2008)

Objectivity and subjectivity is dependent on the type of collected data. Objective collected data is direct measurements while subjective data is personal experience. For instance, an objective data can be to measure how high a person’s pulse is while running whereas subjective data would be how exhausting the person perceives the activity. (Bohgard et al., 2008)

3.4.1 Problem Framing
The problem framing phase was comprehensive and meticulous, however no specific method was used other than the performed literature review. For example, a SWOT-analysis could have been carried out in order to determine where in the research weaknesses in terms of problems and risks could occur. Moreover, a risk assessment could have highlighted which of the identified problems had the highest risk of disrupting the research hence should most importantly be avoided. However, it was decided that focus should be on carrying out the literature review. In that way, a sufficient level of knowledge in the research area was gained, and carefully considered and relevant research questions could be determined upon. Consequently, it was assumed that the research would be on the right track, which indirectly meant that risks could be reduced. Moreover, the fact that the research was carried out on site at Kockums AB also decreased risks of misdirection since employees could be consulted at all times.

3.4.2 Data Collection
In the data collection phase a literature review, case study, and interviews were conducted. The literature review was comprehensive and provided a solid foundation for the research. The literature review consisted of mainly primary sources hence the validity of the review is assessed to be high. In addition, sources that had been cited multiple times were used. On the one hand, since mainly qualitative facts were collected there is a risk of facts having been subjectively interpreted by the researchers in order to fit the case company. On the other hand, opponents, advisors, and Kockums AB personnel have scrutinized the research which implies objectivity. This also contributes to an increased validity.

When gathering information during the literature review, information was chosen that was considered suitable for Kockums AB hence it was assessed to be relevant. However, because of the limited insight in the company’s procedures and processes, some information that could have been important might have been excluded from the study.

The case study included many aspects at the departments that were studied; product development, projects, requirements, and environmental characteristics in general. Focus was on where environmental aspects were included and the interviews complemented the Kabinet study of Kockums AB’s PDP. One aspect that the case study did not cover was a study of a best practice project at Kockums AB. This would have been beneficial to carry out in order to have a reference point on how ecodesign can be carried out at Kockums AB. However, there was no evident project that could be
studied that included environmental aspects to the extent needed to be able to act as a best practice equivalent to the suggested ecodesign implementations. Another way could have been to study a best practice case at a competitor. Unfortunately, that was not possible due to cost limitations since there are no major competitors within Sweden. Moreover, companies in the ship industry may not be willing to share information that can be advantageous for their competitors. This was also the reason why a competitor analysis was not carried out even though that would have been beneficial as well. On the other hand, a best practice study could have been carried out in companies, in other industries, which are used to work with ecodesign matters. However, it was assessed that the character of the maritime industry, and especially development of naval ships, is too differentiated from other kinds of industries. Therefore, it was decided to not look further into other industries’ best practice cases since the result would most likely not have been applicable at Kockums AB.

Interviewees were chosen based on suggestions from head of departments. Several of the interviewees had a high management position. It would have been preferable to conduct several more interviews with employees working directly with design, in addition to the ones that were carried out. This could have further increased the validity of the case study. Moreover, it can be argued that more interviews per department should have been conducted hence various employees with different work tasks and responsibilities could have had the chance to provide their perspective. However, this was not possible due to the limited time the employees of Kockums AB had to offer, since they had other deadlines to meet. Nonetheless, a broad perspective was gained since most of the interviewees had worked at Kockums AB for a long time and had held different positions, both in rank and at different departments. Hence, the interviewees had wide-ranging knowledge, which also was one reason for them being suggested as an interviewee. In order to gain more information from various employees, including more designers, focus groups could have been used. However, this was not possible since employees of Kockums AB had a very busy schedule at the time when the research was carried out.

During the first interviews with the Design & Engineering departments more and more knowledge was gained which might have affected the way the questions were asked in the latter interviews and how the interviewee answered the questions. Moreover, the questions were not asked in the same order as prepared, which would decrease the reliability of the research since it obstructs the possibility of repeating the study in the exact same manner. If structured interviews were held, the reliability would have been increased. However, the advantages of a semi-structured interview and the increased knowledge made it possible to ask more follow-up questions that resulted in an improved outcome of the interviews since more relevant information could be attained.

Since the interviews were held in Swedish and then translated into English, both the reliability and validity is believed to be decreased. However, the fact that the interview compilations were sent to be reviewed by the interviewees increases the validity. Another aspect to consider is the subjectivity of the interviews. As stated, the interviews provided the subjective opinions of the participants. This aspect does not decrease the validity. Nevertheless, it is important to take into account that the way Kockums AB is described in the empirical study is subjective, according to how the interview participants perceive Kockums AB and their work conditions. A general perspective on Kockums AB is, however, provided in the first chapter, where the company is described according to how they present themselves at their public website.

When carrying out the interviews during the data collection phase, the interviewee did not have access to the questions beforehand. This was because the interview questions were of simple structure and no prior preparation from the interviewee was needed since the questions concerned familiar daily work. By not having the possibility to prepare the interviewee could answer straightforward and maybe more honest, which then would increase the validity of the study. Still, the answers might have been more detailed if the questions were sent in advance. The reliability would perhaps also been increased if the interviewee knew the questions beforehand since the questionnaire might have been followed to a
greater extent. However, it was decided that it was not necessary at this stage of the research since spontaneity and open minds when answering questions were preferred.

The data collected from the interviews was subjective and the researchers’ background and personal thoughts have most likely influenced the interpretation of the answers. However, changes which are to be introduced at a company need to be suited for that company and its employees, which supports the use of subjective data.

A complimentary method that could have been used is observation. A designer could have been observed in his or her daily work in order for the researchers to gain knowledge regarding how designers at Kockums AB work, what tools are used, how the tools are used, and how internal communication functions. In this way, relevant data could have been collected that would have resulted in even better tool suggestions in the LEAP. Another method that could have been used is carrying out a survey. In this way, more people could have been able to give their view on the subject or the survey could have been used to verify that the subjective opinions of the interviewees corresponded to the perspective that the most employees have.

3.4.3 Development

Brainstorming was the only method used during the development of the LEAP. It was carried out in two stages which increased the probability of the result being more valid and suitable for Kockums AB. However, it would have been beneficial to have more direct input from the employees of Kockums AB, for example conducting a brainstorming session with several employees. More participation from the designers, who are mostly affected by the results, would have broadened the perspective of the developed LEAP as well as improved the validity. Still, the problem regarding lack of time for Kockums AB employees remained. It was assessed that the researchers had sufficient knowledge to carry out the development thanks to the comprehensive literature review and the empirical findings. Focus was instead on verifying the result together with employees of Kockums AB. Nevertheless, external input was provided hence the validity and relevance of tools can be assumed to be improved.

3.4.4 Verification

As mentioned, the LEAP was developed by the researchers which can imply that it is subjective. However, since different employees of Kockums AB participated in two verification sessions the objectivity of the LEAP can be assumed to be increased.

The conducted focus group was not set up in accordance with any specific method, nor was any methods used. The Actions were merely discussed in order, which makes it easy to repeat and consequently the reliability is high. However, no specified structure for how the Actions were presented existed. This made the discussions go in different directions that were difficult to anticipate hence difficult to repeat. The agenda could have been more set in stone and provided to the participants in advance. Nonetheless, the LEAP was distributed far in advance in order for the participants to have time to prepare for the focus group.

The way the focus group was set up, one researcher acting as a moderator while the other researcher took notes, proved to work well. The discussions answered the desired questions regarding the relevance, credibility, and validity of the LEAP and all of the important aspects were put down in writing.

The composition of the participants in the focus group could have been considered more carefully. Everyone in the focus group had been involved in the research at a previous stage. It might have been beneficial to get an external point of view on the presented LEAP. However, all the participants were well informed about the LEAP and the research which could improve the quality of the discussion. Moreover, additional employees with positions as designers should have been invited to participate.
This would have been especially advantageous since the designers are supposed to use several of the suggested tools. Furthermore, designers have a large influence on how large environmental impact the designed ships have. Although not as many designers as would have been beneficial participated in the focus group, head of departments that did participate have held positions as designers in the past. Hence, they had knowledge from a designer’s perspective as well as from a management perspective. In addition, it would have been desirable to have participants from the Procurement department. This was the intention and an employee from Procurement was invited. However, in last minute it turned out that the person unfortunately could not make it.

The number of people participating in the focus group was exactly as strived for and was within the recommended range suggested by theory. Unfortunately, the discussion in the group was a little slow, which could be an effect of the combination of participants, who were not used to working together. To have a brain warm-up exercise in the focus group, before the Actions were presented, could have made the participants more comfortable and facilitated discussion. Nevertheless, the atmosphere in the focus group was relaxed.

The fact that two verification sessions were conducted increases and improves the validity of the result considerably. The result could have been further evaluated and verified by mediating the LEAP to all of the employees of Kockums AB. However, it was decided that key personnel’s opinions were enough.

The LEAP could also have been verified in a smaller pilot project in order to increase the validity of it. However, small projects are rare at Kockums AB and no suitable project was currently available when conducting the research. This part of the verification thus had to be left for Kockums AB to perform.
**THEORETICAL FRAME OF REFERENCE**

In this chapter, concepts as product development, ecodesign, Design for Recycling, and Environmental Management Systems will be defined and explained. This will provide the theoretical basis for the development of the environmental tool/document/method, which will be presented in the results in chapter six.

### 4.1 PRODUCT DEVELOPMENT PROCESS

A product development process (PDP) is a sequence of activities, stages, or phases that are carried out at a company and results in a new product/service, a new design, or a commercialization of a product/service. There are several product development processes and models that can be used and implemented in companies. According to a product development model by Ulrich and Eppinger, the product development process consists of six phases where four of them are the design phases where the actual product development (PD) is carried out, see Figure 5. (Ulrich & Eppinger, 2003)

![Four design phases](image)

*Figure 5. The product development process according to Ulrich & Eppinger (2003)*

### 4.2 ECODESIGN

Ecodesign is a concept that can be described by different terminology such as Design for Environment (DfE), green design, and environmentally conscious design (International Organization for Standardization, 2011). The holistic concept of ecodesign means "environmentally conscious product development and design" (Tischner, Schmincke, Rubik, & Prösler, 2000, p.12). According to the ISO 14006 standard, the definition of ecodesign is: "Integration of environmental aspects into product design and development, with the aim of reducing adverse environmental impacts throughout a product’s life cycle" (International Organization for Standardization, 2011, p.2). Figure 6 shows relationships between different environmental design practices and philosophies.
In ecodesign the product is examined in a holistic lifecycle perspective with focus on aspects such as material, life-span, and recycling. Efficiency of resource use is of importance in ecodesign. (Jönbrink et al., 2011) Design choices need to be made, and those choices are a balance between ecodesign considerations and other important aspects such as function, quality, business risk, and economical aspects (International Organization for Standardization, 2011). Motivation among the employees is vital for successful implementation of ecodesign. Another vital aspect is to include environmental aspects early on in the product development since the freedom of decision making decreases with time and the assertion of production costs, functionality, and other product related aspects. (Charter & Tischner, 2001; Jönbrink et al., 2011; Lindahl, 2006) Moreover, the ISO 14006 standard of ecodesign also states that ''lifecycle thinking” should be implemented in the product development as early as possible where most opportunities for making changes exist (International Organization for Standardization, 2011).

In the planning phase of the product development, an analysis of environmental and legal requirements ought to be completed (International Organization for Standardization, 2002). A requirement specification is an important element in product development. It is vital to address environmentally driven issues in an early stage of the product development process and include those aspects in the requirements specification since that specification defines the goal of the process (Luttropp & Lagerstedt, 2006). Moreover, environmental issues need to be weaved into the existing product development and activities for it to become a natural part of the process (Jönbrink et al., 2011).

Environmental aspects should be considered in design reviews to make sure that the product meets the specified targets. (International Organization for Standardization, 2011) As mentioned, environmental matters must be balanced against all requirements of the product, especially functionality and economy. Consequently, environmental matters need to be integrated with all other relevant elements to be able to successfully implement it in the product development. A dilemma which often occurs is that both environmental solutions and cost allocations are made early on in the product development. These decisions are often contradicting hence both cannot be pursued in an optimal way. As a result, the product will either be low in environmental impact or in economic cost. (Luttropp & Lagerstedt, 2006) In many cases, designing for the environment has been seen as something that has to be done because of laws and regulations. However, a new mindset is arising where designing for environment is seen as an opportunity. Environmental improvements can give competitive advantage. (McAloone,
Consequently, standards, legal regulations, and growing awareness from customers on environmental issues have lead to the fact that engineers have to change direction from design to ecodesign (Russo, Regazzoni, & Montecchi, 2011).

### 4.2.1 Benefits of Ecodesign
Benefits of ecodesign that the organization, its customers, and other partners can achieve can be, for instance, economic benefits through increased competitiveness and reduced costs (International Organization for Standardization, 2011). This can be realized by means of optimizing material and energy use (International Organization for Standardization, 2002). Enhanced public image and improved creativity and innovation are other possible outcomes of implementing ecodesign (International Organization for Standardization, 2011). Additionally, ecodesign can contribute to improved customer loyalty and is a way to meet and even surpass customer expectations (International Organization for Standardization, 2002).

It is important to decide how the company wants to be strategically positioned when choosing what ambition and level the company should aim for concerning ecodesign. When reasoning about environmental ambition, incentives for sustainable development, as shown in Figure 7, can be taken into consideration. (Jönbrink et al., 2011)

![Figure 7. Incentives for sustainable development, adopted from Jönbrink et al. (2011)](image)

### 4.2.2 Shortcomings of Ecodesign
One hurdle that needs to be overcome, when implementing ecodesign, is to change the environmental interest from external to internal to the company. Interest in ecodesign should, preferably, come from within the company and not due to customer or legal requirements. Furthermore, ecodesign needs to be integrated in the product development process where it can have an impact on the product design. (Karlsson & Luttropp, 2006) Findings in a study show that companies feel that they have too little influence on their products to fully integrate desired environmental aspects, e.g., customers are managing requirement specifications in detail. Furthermore, available tools for handling environmentally related issues in product development seem to be too complex and time-demanding for companies. (Ammenberg & Sundin, 2005a)

It has been assessed that a problem that occurs when methods and tools for ecodesign are not used is that employees forget how to use them. Consequently, the start-up time when applying the tools in a project is longer. Furthermore, for a tool or method to be used it must provide benefits and be easy to use and understand. Obstacles for using tools or methods are that they are often too complex and training of personnel is required. Another difficulty, when implementing a method or tool that requires a lot of cooperation is that more coordination is necessary as well. In the end, there is a risk that the
tools or methods become more important than the goal itself. Moreover, it is vital that the purpose of
the method or tool is mediated to the primary user. For example, utilization of a method can facilitate
and give relevant information for the marketing department even though the designer found the same
information irrelevant. It is important to increase the designers’ awareness about environmental issues
since they have a key function when integrating ecodesign and are often the primary user of the tools
and methods. (Lindahl, 2006)

4.2.3 Ecodesign Tools
Tools can be used throughout the product development process to facilitate the process and make it
more efficient. Moreover, tools can be means to collect information, be creative, make decisions, and
review concepts. (Charter & Tischner, 2001) It is vital to customize methods and tools to fit the
company’s practice and culture in order to make successful use of them. This requires extensive
knowledge about the company, its procedures, and the industry the company is effective in. (Vezzoli
& Sciami, 2006)

There are multiple tools to use when designing for environment and several attempts to classify the
tools have been done. These ecodesign tools can be used to facilitate decision-making for designers
and guide them to a more environmentally conscious design. In general, ecodesign tools are often
divided into the two groups; quantitative or qualitative tools. LCA is an example of a quantitative
method while guidelines or best practices are examples of qualitative tools. (Allione, Giorgi, Lerma, &
Petrucelli, 2011) Tools to support the conceptual design stage are, for instance, guidelines and
checklists regarding environmental impacts of materials, recycling, and assembly/disassembly.
Moreover, manuals and material data bases are additional examples. (International Organization for
Standardization, 2002)

Another way of classifying ecodesign tools is by dividing them into four categories depending on their
purpose:

- "Analysis of environmental strengths and weaknesses
- Setting priorities and selecting the most important potential improvements
- Implementation: providing assistance for design, brainstorming and specifying the details of
  ideas
- Coordination with other important criteria: cost-benefit analysis, economic feasibility studies”
  (Tischner et al., 2000, p.66).

This classification of tools is shown in Figure 8, where the ecodesign tools also are displayed in terms
of complexity.
Material Selection and the Designer’s Role
A common starter for integrating ecodesign into the product development process is to use colored checklists when choosing what materials are going to be used in the company’s products (Allione et al., 2011; Luttropp & Lagerstedt, 2006), see Table 5 for an example.

Table 5. Example of colored checklist modified from Luttropp & Lagerstedt (2006).

| White lists contain materials that should be used | Steel is an example of a material that should be used in ship building since it is easy to recycle |
| Gray lists contain materials that might be used if there is a good reason | Chrome should not be used if it is avoidable, however there is currently no better solution for surface treatment of ships hence there is a sufficient reason for using it |
| Black lists contain materials that are forbidden and should not be used | Asbestos is a typical material that is not allowed as a material choice since it is hazardous to the human health and the environment |

The designer can influence the environmental product behavior hence is a key person in product development and products’ relation to environmental issues. Designers make material selections and these decisions can improve and affect the environmental performance of a product. However, these decisions are often based on technical or economical performance due to low knowledge about environmental aspects. (Allione et al., 2011) A study shows that it can be problematic to involve and motivate designers in environmental issues. In addition, other hold-ups are stated to be too complicated tools, a lack of resources, and low environmental knowledge in terms of staff and competence. (Ammenberg & Sundin, 2005b)
**Philips Fast Five-Checklist**

Philips, a multinational electronics company, has developed a fast and qualitative method for assessing the products environmental awareness, which is called Philips Fast Five-Checklist or Fast Five Awareness. The method is suitable at a managerial and strategic level for a first assessment of new product concepts. It can be used during brainstorming sessions or work as a quick check in the product development. There are five categories of questions that should be discussed and answered by yes or no. The product concept should be compared with a predefined reference concept which may be a best practice, a previous company product, or a competitor’s product. Depending on how many yes-answers the product concept receives, it may be interpreted in different ways. For example, zero yes implies that it is not a “green” product concept while five yes suggests that it is an excellent alternative. Figure 9 shows an adopted version of the Philips method. (Tischner et al., 2000)

<table>
<thead>
<tr>
<th>Product/Project</th>
<th>Person in charge</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categories of questions</td>
<td>Yes or No?</td>
<td></td>
</tr>
</tbody>
</table>

**Category 1 – Energy**

Does the proposed design require less energy than the reference counterpart?
Consider manufacturing, transportation, product use (both in normal operation as well as in stand-by mode)

**Category 2 – Recyclability**

Is the proposed product more recyclable than the reference product?
Consider whether the larger components can be easily separated into mono-material sub-assemblies. Special care should be given to the separation possibilities of non-compatible metal or plastics. What is the amount of actually recycled material in the product?

**Category 3 – Hazardous waste content**

Does the product design contain and/or produce less chemical waste than the reference alternative?
Consider whether any restricted materials are used, e.g. halogenated flame retardants, cadmium pigments, or ozone depleting chemicals (ODCS).

**Category 4 – Durability, reparability and preciousness**

Does the proposed design have better durability, reparability or affection level than the reference product?
Consider whether the new design will last longer or be easier to upgrade than the reference. Also consider whether the precious qualities of the new design will make the owner/user keep the product longer than the reference.

**Category 5 – Alternative ways to provide service**

Are there ways to provide the service that produces lower ecological load?
Consider whether there are techniques that require much less energy or material, but provide the service at the same level of quality.

*Figure 9. Philips Fast Five-Checklist, adopted from Tischner et al.(2000)*

**Life Cycle Assessment (LCA)**

Life Cycle Assessment (LCA) is a quantitative tool for identification and assessment of potential environmental impacts of a product. The product is studied from a lifecycle perspective, meaning that all phases of the product’s lifecycle are analyzed, e.g., extraction of raw materials, production, distribution, usage, and EoL. The result can be used for comparison of product concepts or evaluation of a specific product. (Tischner et al., 2000)

An LCA is performed in four phases; Scope and goal definition, Life Cycle Inventory, Life Cycle Impact Assessment, and Interpretation. LCA is a complex tool hence very time consuming. However, a reliable and comprehensive result can be achieved under the condition that accurate assumptions and
reasonable limitations have been set. Software tools to ease the analysis exist and these may shorten the time needed to perform the analysis. (Tischner et al., 2000)

**Environmental Effect Analysis (EEA)**

Environmental Effect Analysis (EEA) is a systematic study of a product’s environmental effects from “cradle-to-grave”. The analysis aims to identify the largest expected environmental impact, so-called “hot spots”, and generate an action plan for how to decrease the total environmental impact of the product. EEA is performed in cross-functional teams and provides a qualitative result. The method is carried out in five stages; Preparation, Inventory, Analysis, Implementation, and Follow-up. The EEA is less time consuming and complex than an LCA which was the motive for the development of the method. (Lindahl & Tingström, 2001)

EEA was developed based on Failure Mode and Effect Analysis (FMEA), which is a method used for identifying possible ways in which a design could fail, the causes, and their resulting effects. Because of the familiarities with the FMEA, EEA is believed to be easier implemented at a company if the FMEA method is already established. EEA is in literature sometimes referred to as Environmental-FMEA or E-FMEA, but the name was changed to EEA due to legal problems since FMEA was a protected name. (Lindahl & Tingström, 2001)

### 4.2.4 Successful Integration of Ecodesign

For a company to be able to benefit from implementing ecodesign, it needs to be an integrated part of the organization’s business processes (International Organization for Standardization, 2011). As stated, awareness of companies’ environmental activities has been highlighted recently. Consequently, companies need to reduce the environmental impact of their activities and become more environmentally conscious. Focus is shifting from "end-of-pipe solutions” towards environmental performance of the products, and hence also the product development and its processes. (Johansson, 2002)

As previously emphasized, how product related issues are handled in relation to environmental aspects is closely linked to how much environmental knowledge companies have. Consequently, companies with a lack of knowledge in this area will encounter problems when dealing with environmental issues related to products. (Ammenberg & Sundin, 2005b) How well ecodesign can be integrated in product development depends on several success factors. These factors can be divided into six areas of concern; management, customer relationships, supplier relationships, development process, competence, and motivation. (Johansson, 2002) A literature review conducted by Johansson (2002) resulted in Table 6 and displays the different success factors divided into their corresponding area of concern.
Table 6. Success factors for implementing ecodesign in the product development process, where the three most frequently mentioned ones are highlighted in bold letters, according to (Johansson, 2002).

<table>
<thead>
<tr>
<th>Area of concern</th>
<th>Success factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>▪ Commitment and support are provided</td>
</tr>
<tr>
<td></td>
<td>▪ Clear environmental goals are established</td>
</tr>
<tr>
<td></td>
<td>▪ The environmental issues are addressed as business issues</td>
</tr>
<tr>
<td></td>
<td>▪ Ecodesign are not only treated on an operational level, but also on a strategic level</td>
</tr>
<tr>
<td></td>
<td>▪ Environmental issues are included when establishing a company’s technology strategy</td>
</tr>
<tr>
<td>Customer relationship</td>
<td>▪ A strong customer focus is adopted</td>
</tr>
<tr>
<td></td>
<td>▪ Companies train their customers in environmental issues</td>
</tr>
<tr>
<td>Supplier relationship</td>
<td>▪ Close supplier relationships are established</td>
</tr>
<tr>
<td>Development process</td>
<td>▪ Environmental issues are considered at the very beginning of the product development process</td>
</tr>
<tr>
<td></td>
<td>▪ Environmental issues are integrated into the existing product development process</td>
</tr>
<tr>
<td></td>
<td>▪ Environmental checkpoints, reviews and environmental milestone questions are introduced into the product development process</td>
</tr>
<tr>
<td></td>
<td>▪ Company-specific environmental design principles, rules and standards are used</td>
</tr>
<tr>
<td></td>
<td>▪ Ecodesign is performed in cross-functional teams</td>
</tr>
<tr>
<td></td>
<td>▪ Support tools are applied</td>
</tr>
<tr>
<td>Competence</td>
<td>▪ Education and training are provided to the product development personnel</td>
</tr>
<tr>
<td></td>
<td>▪ An environmental expert supports the development activities</td>
</tr>
<tr>
<td></td>
<td>▪ Examples of good design solutions are utilized</td>
</tr>
<tr>
<td>Motivation</td>
<td>▪ A new mindset emphasizing the importance of the environmental issues is established</td>
</tr>
<tr>
<td></td>
<td>▪ An environmental champion exists</td>
</tr>
<tr>
<td></td>
<td>▪ Individuals are encouraged to take active part in the integration of Ecodesign</td>
</tr>
</tbody>
</table>

The most frequently mentioned success factors in Johansson’s (2002) literature review showed to be management commitment and support, education and training of product development personnel and the presence of an environmental champion. Nevertheless, this does not necessarily imply that these factors are more important than others. (Johansson, 2002)

It is important to consider organizational strategic factors, such as competitors’ activities, customer needs, and demands and activities of legislators and regulators, when integrating environmental aspects into the product development process. Having a communication strategy, both internal and external, is also an essential part that needs to be considered. The employees should be provided with information regarding the organization’s policy and the environmental impacts related to the produced products. A multidisciplinary approach is significant since several functions of the organization are involved in the product development process, e.g., engineering, design, procurement, and environment. (International Organization for Standardization, 2002)

The initiative for ecodesign can come either from management (top-down) or from designers and developers (bottom-up). Whatever the case may be, the support from the top management is of
significant importance for a successful implementation. (International Organization for Standardization, 2002) To integrate ecodesign in product development, new routines need to be created and existing activities need to be adjusted. Appropriate and useful ways to accomplish this is to make sure that environmental requirements are included in the requirement specifications as well as to discuss them in early stages of conceptual design. Furthermore, ecodesign aspects should be considered in the actual design and structure of a product. (Jönbrink et al., 2011) Top management has two important tasks in order to achieve a successful integration of ecodesign in the organization. Firstly, strategic aspects of ecodesign need to be considered. That includes aspects such as strategic product planning and setting objectives for environmental performance. The second task is management of internal processes, for example, to make sure that the chosen ecodesign strategy is implemented and integrated into all relevant processes and procedures. It is essential that the environmental aspects are considered both at management and design level. Ecodesign issues need to be built into management reporting, practice, and thinking. (International Organization for Standardization, 2011)

4.2.5 Design for Recycling
Design for Recycling (DfR) is one aspect of ecodesign and focuses on how to reduce waste that goes to landfill and addresses the matter that material needs to be separated before they can be recycled (McAlone, 2000). By paying attention to the End-of-Life (EoL) phase when designing the product, the chances of an environmentally friendly and economically feasible treatment of the product at the end of its operating life increases. Factors that affect the possibilities to do so and that are determined by the designer are for example: (Furuhøjelm, 2000)

- Hazardous substances: need special treatment that can be expensive
- Material content: determines the value of the recycled product by means of its ingoing materials’ different value
- Product structure: determines how fast the product can be disassembled
- Joining techniques: also have an effect on the disassembly process, for instance, glue or welding can rule out the chances of recycling
- Identification markings: facilitates sorting of the disassembled materials

DfR needs to be included in early stages of product development since there are more possibilities to make well thought-through DfR-decisions if this aspect is considered during concept development (Nilsson, 1998). It can be costly and difficult to introduce changes when the product’s design has advanced and become more detailed. Figure 10 shows a paradox that occurs as time passes during the product development process. It illustrates that freedom of action in decision making decreases at the same time as product knowledge and modification cost increases. (Lindahl, 2005) This graph supports the statement that it is important to pay attention to DfR, as well as any other ecodesign aspect, in early stages of product development.
In Figure 11, the waste management hierarchy stated in ‘Directive 2008/98/EC’ is presented. The different waste management options are arranged in a prioritized order where prevention of waste is the most favorable option. (European Commission, 2012a) Designing a product suitable for efficient EoL treatment has its challenges. There is a significant time gap between the design of a product and its EoL. Consequently, there are difficulties in predicting what the EoL treatment techniques will look like in the future, which makes it more complicated to develop a product suitable for recycling. Furthermore, designing for EoL adds more requirements to an already complex product specification. (Furuhjelm, 2000) When compiling a product’s requirement specification, issues concerning waste management of the product should be considered. This ought to be done regardless of how detailed the specification is since design of the product is strongly linked to how well it can be taken care of at the EoL stage. A proper waste management assessment can make sure that focus is on the correct part of the design and right prioritizes, regarding DfR, are being made. (Nilsson, 1998) For example, optimizing for disassembly will have little effect if the product’s EoL strategy is reuse. Consequently, it is important to know what EoL strategy is relevant and appropriate for the product. If recycling is the best option, effort should be directed at material choices and disassembly processes. (Rose, Ishii, & Stevels, 2002)

![Figure 10. Paradox in the design process. By implementing supporting methods in the beginning of product development more knowledge will exist when the freedom of decision making is high and cost is still low (Lindahl, 2005)](image1)

![Figure 11. The waste management hierarchy, modified from European Commission (2012a)](image2)
New methods, for design and development, need to be generated in order to overcome the difficulties with design for EoL. These methods should be incorporated in the product development process in a structured and systematic way, in all stages of product development. It is therefore important to define the development process to be able to further look into how EoL aspects can be integrated. (Furuhjelm, 2000) Guidelines can be used to handle the, previously mentioned, factors for DfR, mentioned above, that are affecting environmental performance of products. DfR-guidelines include issues such as using recycled materials, designing for disassembly, and reducing hazardous materials or making them easy to access for removal. DfR covers a holistic view of design issues. (McAloone, 2000)

4.3 **ECODESIGN GUIDELINES**

Design principles that facilitate ecodesign have been in considerable focus in the 90’s. Consequently, there are a lot of research conducted that identifies guidelines and design principles. (Furuhjelm, 2000) A guideline should indicate the direction for the decision making process, for issues with large environmental impact, and inspire employees towards the objective. Hence, guidelines are not fixed and can in some cases be misleading if interpreted as set in stone. How well used guidelines are is mainly depending on two factors; how employees makes use of the guidelines and how well integrated they are in the company’s processes. (Vezzoli & Sciama, 2006)

There are concrete recommendations and advice on how to environmentally adjust products in areas such as: optimize function, lesser impact during using phase, material, optimize life-span, optimize production, optimize waste management, and optimize distribution. (Jönbrink et al., 2011) In Appendix I, a compilation of ecodesign guidelines from different sources, authors, and viewpoints are presented. This set of guidelines includes DfR as well as other ecodesign aspects.

4.4 **ENVIRONMENTAL MANAGEMENT SYSTEMS**

There is an increasing demand on companies to be certified according to an Environmental Management System (EMS) to control the environmental impact of the company. Integration of environmental issues in companies, and their daily business, can be facilitated with help of EMS which is a set of management tools and principles. (Gibson, 2005) There are two main standards that are most often used; the European Eco Management and Audit Scheme (EMAS) and the international ISO 14001 (Furuhjelm, 2000).

EMAS is an EMS developed by the European Union (EU). The standard is based on ISO 14001 with some additional elements that supports companies in their work with continual improvement. (Miljöstyrningsrådet, 2012)

ISO 14001 is a standard, including guidance of use, developed by the International Organization of Standardization. The methodology described in the standard consist of three phases; planning (regulatory requirements identified), implementation (commitment to continual improvement), and regular evaluation of environmental performance. (Magerholm Fet, 1998) One of the key factors in ISO 14001 international standard is continual improvement of environmental performance, which is described as "a process of enhancing the environmental management system in order to achieve improvements in overall environmental performance consistent with the organization’s environmental policy” (International Organization for Standardization, 2004, p.7).

According to the ISO 14001 standard the company should establish an environmental policy which describes how laws and regulations are fulfilled, focus on the company’s specific environmental effect, demonstrate that work is performed for continual improvement, and that preventive actions are taken. Additionally, the policy should be available to the public. The environmental policy should act as a framework within which the environmental objectives and targets can be set. The environmental objectives and targets should be measurable, feasible, and in line with the environmental policy. For
each of the objectives a plan of action should be established. (International Organization for Standardization, 2004)

An external organization can certify or register the company with a standard if the EMS fulfills the demanded requirements. These requirements or mandatory activities can be, for instance, an establishment of an environmental policy or a review of the company’s activities’ impacts. (Furuhjelm, 2000) There is a connection between EMS and enhanced environmental performance. However it is not certain that certified companies are obtaining better environmental results than companies without EMS. (Ammenberg, 2003; Gibson, 2005)

In ISO 14001 it is stated that goals should be set regarding the environmental performance of the product (Furuhjelm, 2000). Nevertheless, products are often left out when introducing the EMS and there is a distinction between the product design and the EMS (Eagan & Pferdehirt, 1998, referred to in Furuhjelm, 2000). According to Charter and Clark (1999 referred to in Furuhjelm, 2000), having an EMS is an opportunity to incorporate environmental aspects into product development in a structured way. For EMS, as well as ecodesign activities, it is central to involve the right people within the company (Ammenberg & Sundin, 2005a).

4.4.1 Product-Oriented Environmental Management Systems
Recent studies indicate that it can be profitable to integrate ecodesign into EMS. A result of this can be that a more holistic perspective on the company’s product is gained. (Ammenberg & Sundin, 2005a)

Companies that are certified in accordance with ISO 14001, or similar, and are conducting product development should have environmental aspects included in their processes. However, product development is not incorporated in ISO 14001, and thereby are environmental matters connected to products not emphasized. (Ammenberg & Sundin, 2005b) A new standard, ISO 14006, has been developed to support the incorporation of ecodesign within an EMS. ISO 14006 provides guidelines on the establishment of ecodesign and are not intended for certification purposes. The ISO 14006 standard helps cover the gap between the EMS and product related issues. (International Organization for Standardization, 2011) There are a few suggestions to consider in order to strengthen the connection between ecodesign and EMS. Firstly, the customer demands need to be emphasized since they are drivers to motivate companies to engage in ecodesign activities. Moreover, tougher legislation is an important driver. Lastly, simpler tools and better databases would facilitate environmental activities for companies. Increased environmental training and strengthened motivation are important factors as well. (Ammenberg & Sundin, 2005b)

Environmental impacts are closely linked to flows of energy and material. For manufacturing companies, these flows are strongly connected to the products. Therefore, to include the products in the EMS and how EMS relates to ecodesign is motivated. Product-Oriented Environmental Management Systems (POEMS) is an EMS focusing on the product’s environmental efficiency throughout its lifecycle, by a systematic integration of ecodesign in the company’s strategies and practices. (Ammenberg & Sundin, 2005a)

An iterative four-step management method, called "Plan, Do, Check, Act", can be used for continual improvement of processes and products. With the "Plan, Do, Check, Act” methodology as a base, Ammenberg and Sundin (2005a) presents a four step model for the implementation of POEMS, see Figure 12. The first step (1) is to make a lifecycle review of the company’s product portfolio and the organizational aspects of ecodesign. These reviews contribute with knowledge about the product’s environmental performance and the company’s strengths and weaknesses. It also gives a clarification of the product development process. Furthermore, it is beneficial to do a review on both existing and future markets to gain information about customer needs. The second step (2) is to include environmental aspects in the product development process. Environmental issues is recommended to be treated equally to other requirements and included from the beginning of the development process.
Having top management support and making sure that the environmentally adopted product development is in line with the company’s visions and strategies is important. Additionally, resources for the product development ought to be allocated at this stage. As a third step (3), ecodesign projects should be carried out by following the processes that were set up in the second stage. Examples of key factors for success are motivated personnel, tools, and methods usable for the company. The last step (4) is evaluation, an important step towards continual improvement. In the evaluation, the performed product development should be revised. (Ammenberg & Sundin, 2005a)

<table>
<thead>
<tr>
<th>1. Product-specific environmental review</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Identification of environmental impacts/aspects.</td>
</tr>
<tr>
<td>- Review of ecodesign organization and capabilities.</td>
</tr>
<tr>
<td>- Review of the product development process.</td>
</tr>
<tr>
<td>- Market investigation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Responsibilities and procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Definition of roles, responsibilities, and authorities for product development.</td>
</tr>
<tr>
<td>- Establishment of policies, objectives, and targets.</td>
</tr>
<tr>
<td>- Revision of the product development process. Establishment of procedures for staff involved in product development and other product-related activities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Ecodesign projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Development of environmentally compatible products with competitive price, performance, and quality standards.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Audit/Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Revision of existing procedures and products aiming for continual improvement.</td>
</tr>
</tbody>
</table>

Figure 12. General steps of a POEMS model modified from Ammenberg & Sundin (2005a)
EMPIRICAL CASE STUDY

The fifth chapter contains a compilation of the data collected from the company case study that was carried out. A detailed description of Kockums AB’s organization and processes is given in this chapter. Furthermore, information gathered from external interviews is presented.

5.1 KOCKUMS AB

Kockums AB is providing advanced solutions within naval technology and has a lot of expertise within this field. Designing naval warships require a variety of different competencies. Kockums AB has been doing this for a long time, and hence acquired a lot of implicit knowledge that is imprinted in employee’s minds and the company’s procedures. (Arbin, 2012) Even though Kockums AB’s main expertise is naval ships, they also design and provide commercial solutions, mostly on inquiries. (Nilsson, 2012) State-of-the-art solutions regarding ship design exists at Kockums AB, ships are high-technologically designed in carbon fiber. Since carbon fiber is a light-weight material, the ships are lighter and hence consume less fuel. (Arbin, 2012)

Following headings include organization schemes and further descriptions of the company, projects, and departments. This gives a knowledge base and a holistic view of the company, which will facilitate the apprehension of how processes work within Kockums AB.

5.1.1 Organization

The top management consists of a Chief Executive Officer (CEO), Chief Financial Officer (CFO), and Chief Operating Officer (COO), see Figure 13. The CEO is ultimate responsible for all the departments and in charge of the total management. The main responsibility of the CEO is to act as a leader and motivate the employees, as well as promote Kockums AB on the market. CFO has the responsibility of financial matters, while COO is responsible for the daily operation at Kockums AB. (Kockums AB, 2012)

![Figure 13. Top management and overview of how Kockums AB is organized. Adapted from Kockums AB (2012)](image)
Kockums AB is organized into three business units; Business Unit Submarine (BUS), Business Unit Surface Ships (BUSS), and Business Unit Marine Service (BUMS). Submarine development is carried out at BUS, while surface ship development is carried out at BUSS. Maintenance and service are carried out at BUMS. All the business units are placed under the COO since operative activities are taking place. (Kockums AB, 2012)

BUSS consists of five departments, see Figure 14. The product development is performed at the Design & Engineering department, which in turn consists of six sub-departments. These Design & Engineering departments will be further explained in heading 5.1.3 Departments. ILS is a sub-department of the Design & Engineering department from where this M.Sc. research was initiated.

5.1.2 KRAFT Project
KRAFT\(^6\) is an initiative that was introduced as a means to increase the efficiency of processes and facilitate the possibility for continual improvement. The goal for the project is to increase the economic growth at Kockums AB. Within the project there are sub-groups, ”workstreams”, consisting of cross-functional teams, which are focusing on different areas of improvement. These areas are: (Kockums AB, 2012)

- Competence
- Engineering
- Integrated Planning
- Management Control and Reporting System
- Overhead
- Project Management Office
- Production
- Sourcing

Each workstream has its own site on Kabinet where all employees can follow the progress. Continuously, the progress is also mediated to the employees through blogs, news feed posts, and printed news posters. (Kockums AB, 2012) The new COO at Kockums AB, Pontus Kallén, is responsible for KRAFT which started in the fall, 2011. The project is planned to run over a seven year period where changes will be implemented incrementally (Kallén, 2012).

5.1.3 Departments at Design & Engineering
There are six sub-departments of the Design & Engineering department, see Table 7. These six departments are responsible for carrying out the product development of ships.

---

\(^6\) Swedish abbreviation for "Kockums Rikade Ansträngning För Tillväxt” which can be translated to "Kockums Aimed Effort for Growth"
Table 7. Overview of the six Design & Engineering departments and their work tasks.

<table>
<thead>
<tr>
<th>Department</th>
<th>Main work tasks</th>
<th>(Reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Systems (VS)</td>
<td>Hull design, outfitting, calculations and interior layout</td>
<td>(Johansson, 2012)</td>
</tr>
<tr>
<td>Propulsion and Auxiliary System (P&amp;A)</td>
<td>Design and integrate propulsion and auxiliary systems</td>
<td>(Lindström, 2012)</td>
</tr>
<tr>
<td>Intelligence and Electrical (I&amp;E)</td>
<td>Electrical, automatic, and weapons systems</td>
<td>(Karlsson &amp; Möller, 2012)</td>
</tr>
<tr>
<td>Composite and Technologies (C&amp;T)</td>
<td>Research and development within composite material, ship signature and electromagnetic capacity</td>
<td>(Arbin, 2012)</td>
</tr>
<tr>
<td>Commercial Vessels (CV)</td>
<td>Design commercial ships</td>
<td>(Nilsson, 2012)</td>
</tr>
<tr>
<td>Integrated Logistic Support (ILS)</td>
<td>Technical information, spare part proposals, maintenance analysis, and administrate education</td>
<td>(Åkesson, 2012)</td>
</tr>
</tbody>
</table>

The departments connect to each other in projects and perform department specific tasks in line functions (Johansson, 2012). The majority of the tasks are carried out in projects (Karlsson & Möller, 2012; Lindström, 2012; Nilsson, 2012; Åkesson, 2012). One exception is the Research and Development (R&D) that is carried out in line functions (Arbin, 2012).

**Vessel Systems**

Vessel Systems (VS) department has a general responsibility for the development of ships and a lot of the department’s work tasks are directing and affecting other departments. Deciding the parameters for the ship, such as length and width, is one work task which is called hull design or “lines drawings”. Other tasks, that the VS department is responsible for, are defining parameters for engine capability, weight calculations, stability calculations, and outfitting, which refers to layout of the ship as well as its equipment. (Johansson, 2012)

**Propulsion & Auxiliary System**

Propulsion & Auxiliary System (P&A) department has responsibility for designing the propulsion system for the ship as well as auxiliary systems. P&A also needs to integrate these systems in the ships’ overall design. P&A is involved in the entire product development. Another more commonly used term for product development, at Kockums AB, is design process. P&A also works as support in the later stages of the product development process. The personnel of P&A are not working simultaneously in parallel projects or multiple projects. At the moment, there is one particular project that all personnel are involved in and working with. (Lindström, 2012)

**Intelligence & Electrical**

The main task at the Intelligence & Electrical Systems (I&E) department is to decide the electrical system for the ship, as well as design the electrical system. Other tasks are development of automatic systems and integration of weapons system. I&E is involved throughout the whole design process and cooperates mainly with P&A regarding the propulsion design. Furthermore, they also collaborate with VS, and this cooperation is important all through the design process. (Karlsson & Möller, 2012)

**Composite & Technology**

Composite & Technology (C&T) department serve as a resource pool for projects when needed. R&D is performed at the department, mainly in the areas of composite materials, ship signature, and electromagnetic capacity. Their expertise is, above all, within the field of composites. (Arbin, 2012)
C&T is not a part of or aligned with the design process since they are functioning more as a consulting department with R&D. An employee at C&T has various competencies within multiple fields and can have different roles at the department. Personnel can be involved in projects at other departments when additional resources or competences are needed. (Arbin, 2012)

**Commercial Vessels**

Commercial Vessels (CV) department was founded with the objective to offer commercial ships for wind farms, passenger ferries, and catamarans to use as service ships. All employees which are working at the CV department have different areas of responsibility; electrical & automation, hull & ship structure, outfitting & furnishing, auxiliary systems, or propulsion. With the department’s combined competence and knowledge they have the ability to design an entire ship. (Nilsson, 2012)

The work at CV is carried out in projects and all personnel within the department are placed close to each other, which facilitates communication. CV is involved throughout the whole product development process, from project start to delivery. CV is capable of carrying out projects on its own. However, when it is required CV asks for resources, for instance personnel, from other departments through their head of department. (Nilsson, 2012)

The design process is used at the department and is adjusted depending on the project. Customer, legal, and Kockums AB internal requirements are used as a starting point in the projects. On the contrary to naval projects, CV further develops the requirements on their own without customer involvement. Proposal & Contracts Management have the external contact with the customers. Contact between CV and customer only occurs when it is requested, by Kockums AB or the customer. There are, however, contact between the selected classification society and CV. Since ship classification is a quality assurance for the customer, there is no need for the customer to get involved in the design process to make sure that the requested ship quality will be provided. (Nilsson, 2012)

**Integrated Logistic Support**

The main work tasks of Integrated Logistic Support (ILS) are to generate technical information, make spare part proposals, conduct maintenance analysis, and administrate education and training. ILS has its own process that runs in parallel with the overall product development process at Kockums AB. The ILS-process is carried out in accordance with the overall product development process to the greatest extent possible. As a result of the KRAFT-project, the ILS process will be reviewed to suit the overall process even better. (Åkesson, 2012)

The ILS-process is becoming more and more integrated with the product development process and co-workers, at other departments, are starting to pay more attention to ILS than before. This facilitates for ILS since they more often receive the information they need to perform their work tasks without having to "hunt it down". It is important that ILS is provided with the right information from suppliers, designers, and the Procurement department in order to complete their work tasks. (Åkesson, 2012)

**5.1.4 Product Development Process**

The product development process (PDP) needs to be suitable for the incremental product development (PD) present at Kockums AB (Lindh, 2012). At the moment, Kockums AB is in a transition to update and improve their PDP. This is one step in the KRAFT project that is currently being carried out (Kallén, 2012).

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7 Department at BUSS, responsible for proposals and contracts with customers.
The new PDP aims to ensure that activities are carried out in parallel and in a better way, in order to guarantee that they coincide at the decision gates which they correspond to. The new PDP at Kockums AB will follow an iterative process, a design spiral. This process will take the product from concept and preliminary design to critical design, where manufacturing drawings will exist. The PD, also referred to as the design process, at Kockums AB is performed in the "Study", "Project", and "Design" phases which add up to the design process while the overall PDP includes all the phases from "Offer" to "Deliver". In Figure 15, the PDP is illustrated atop in the figure and the design spiral below. (Kembring, 2012)
The PDP is initiated by an "Offer" to a customer, after receiving a proposal from the customer. Depending on the precision of the proposal and offer, the process can start at either one of the phases "Study", "Project", or "Design". When the opening phase is decided upon, the development enters the "design spiral". There are eight activities in the design spiral; Requirement specification, General Arrangement, Hull & Hull Equipment, Energy & Propulsion Systems, Auxiliary Systems, Weapon Systems, Combat Systems, and Interdisciplinary analysis. The activities in the design spiral are looped as many times as necessary until specified requirements are met and the critical design is decided upon and "Production" phase can commence. For example, the "Study" and "Project" phases can be performed in two loops each while the "Design" phase can be finished after three loops. Moreover, design of the ship takes place in the "Design" phase but takes also place over time throughout the "Study" and "Project" phases. It all adds up to manufacturing and installation drawings. The last three phases in the PDP consists of manufacturing the ship ("Produce"), testing and verifying that the design is functioning properly ("Test"), and lastly delivering the ship to customer ("Deliver"). (Kembring, 2012)

5.1.5 Product Development

The maritime industry that Kockums AB is active in is very different from "usual" supply and demand driven industries, for instance, markets for conventional household products. The customer is in control and Kockums AB needs to adjust themselves for their main customers (Arbin, 2012; Johansson, 2012; Karlsson & Möller, 2012; Lindström, 2012; Nilsson, 2012). Consequently, the PD at Kockums AB is conducted in corporation with the customer. Projects are based on what single customers require instead of a perceived need in the market. Moreover, it is difficult to be innovative and quickly develop new designs. In general, innovation is incremental. In the ship industry, it takes time before innovations are fully implemented. (Lindh, 2012) Nevertheless, R&D of naval technology at Kockums AB can be focused on market-pull, just as in a normal market economy. However, the developments will not rapidly be integrated in products. (Arbin, 2012)

Mikael Rodin, at the Procurement department of Kockums AB, has worked in automobile industries earlier and stresses the difference between making two ships in a 10-year period compared to how many cars a car manufacturer produces every month (Rodin, 2012). The time perspective, of projects, at Kockums AB is very long since a ship is a very high-technologic and complex product. Moreover, there are several departments at Kockums AB that need to be involved in the PDP (Kembring, 2012). PD, or the design process, at Kockums AB, is performed in the "Design" phase in the design spiral, which was presented in the previous heading. This design process is divided into different phases with Design Reviews (DR) after each, see Figure 16. In the DRs, the ship design is evaluated in order to assure that all necessary requirements for each phase are met. (Kembring, 2012)

DRs can be carried out both in-house and together with the customer. The number of DRs conducted together with the customer is assessed in the contract. Several departments need to cooperate in the PD and work in parallel to achieve time efficient projects and high quality results. (Kembring, 2012)
5.1.6 Product Development Projects

Project work is carried out in accordance with Kockums AB’s PDP and design process (Nilsson, 2012). Even though the design process is not deeply rooted at Kockums AB, it is followed as far as possible (Johansson, 2012).

Projects often start with a "request for quotation" from a customer. Kockums AB then proposes a requirement specification and an arrangement on how the ship will look like back to the customer. This will work as a reference point from which requirement analysis and different scenario analysis will be conducted in different teams. A "General Arrangement" is drafted to visualize the different decks of the ship and ship equipment. (Karlsson & Möller, 2012)

Cooperation between departments is generally taking place regarding selection of systems and ship design. One person, per department, is responsible for systems design and administration. Official meetings are held and they work as checkpoints to assure that information and details from different departments correspond. (Karlsson & Möller, 2012) Communication within projects is of great importance to make sure that decisions, for the ship design, coincide (Johansson, 2012). Overall, Kockums AB needs to be better at retaining acquired knowledge within the company (Arbin, 2012).

Tools

Tools that are used within projects and the PD are mainly 3D-modelling programs and planning tools (Johansson, 2012). Another tool is the design checklist, however it is not used extensively (Arbin, 2012; Lindström, 2012; Nilsson, 2012). A reason for this can be that the design checklist is not enclosed as an appendix in the requirement specification (Nilsson, 2012). Nevertheless, the company employees have a lot of implicit knowledge which means that the design checklist is indirectly followed. (Lindström, 2012; Nilsson, 2012) The design checklist is often used in retrospect when something has gone wrong. This is done in order to find out if important checkpoints have been left out. (Lindström, 2012)

There are not that many tools or methods used to increase creative thinking (Johansson, 2012; Lindström, 2012). Neither are there any tools or methods that are actively used to incorporate environmental requirements or issues (Arbin, 2012; Johansson, 2012; Karlsson & Möller, 2012; Lindström, 2012; Nilsson, 2012). A lot of decisions are made early in the design process. Consequently, it would be preferable to integrate environmental aspects at that point since it will be too costly to make changes later on. (Johansson, 2012)

Customer

Throughout the design process, the customer contact depends on the customer. Some customers want to be largely involved in the design work while other trusts that the agreed contract will be fulfilled. (Johansson, 2012) Spontaneous customer contact can occur during the design process. Nevertheless, most of the contact takes place when the ship is ready for testing or at the important gates in the design process, i.e., DRs. (Karlsson & Möller, 2012)

Feedback from customers, after ships are delivered, is not working well today. The acquired knowledge from projects is not used but there should and will be a change to this. (Johansson, 2012) Moreover, because of the limited control over the ship when sold to the customer, there are difficulties in maintaining a technical documentation up-to-date (Åkesson, 2012). Kockums AB has a concept called Through Life Support (TLS) that aims to facilitate better control of the product throughout its lifecycle. The TLS concept is currently reviewed and under further development. TLS is a service Kockums AB can offer to its customers where Kockums AB has the overall responsibility for the ship,

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8 The design checklist is a list of questions regarding for instance manufacturing drawings, mechanics, and environmental issues. The design checklist is useful during individual design work, when checking the design, design approval, and Design Reviews. (Kockums AB, 2012)
for instance, to manage planning of maintenance and performing maintenance, while the customer can focus on using the ship. In an optimal future TLS can be arranged as a rental agreement where the customer pays for access of the ship at certain given hours and Kockums AB ensures that the ship works. In that case, Kockums AB will be able to better manage administration, documentation, upgrading, spare parts, maintenance, and EoL management. (Kockums AB, 2012)

**Material**

Material selections are mainly made by customers. Nonetheless, it is often an open dialogue between Kockums AB and the customer in order to make the best decisions. When departments are making decisions themselves, they are selecting materials that will fulfill the performance requirements. Military products can be extreme; there need to be a very good argument for why a material with the best properties should not be chosen. As a consequence, exceptions are often made in military products which mean that potentially hazardous materials can be allowed. (Lindström, 2012) Military requirements have to be fulfilled hence material selections need to be based on those requirements. (Johansson, 2012; Lindström, 2012) Customers, sometimes, provide a list of forbidden materials that should not be used. However, designers have implicit knowledge and routine on what materials to select and which ones are hazardous or potentially hazardous. (Lindström, 2012)

### 5.1.7 Procurement

The Procurement department plays an active role in the "Offer" stage of the PDP, where the designers ask for an estimation of the price for the components, required to build the ship that the customer has requested. Later on in the development process, during the "Production" stage, the manufacturing is planned. When carrying out this planning, it is important to consider the delivery time since there are not that many standard products and the lead time can sometimes be long. Consequently, changes in the design during the PDP need to be communicated to the Procurement department in order for Procurement to be able to correct and update the orders. Unfortunately, the communication does not always work as desired, which in some cases lead to significant delays during the manufacturing and misunderstandings between Kockums AB and the suppliers. (Rodin, 2012)

The Procurement department acts as a link between the Design & Engineering departments and the suppliers. The purchase should be handled in a professional way, according to product requirement specification, in a cost efficient way, and the procurement strategy ought to be followed. The process for purchasing goods starts when the design departments send a request for purchase to the Procurement department, which then forwards it to predefined suppliers in a request for proposal. The request for purchase contains agreement, rules, customer requirements, military requirements, and in some cases environmental requirements. The supplier considers the request and responds with a confirmation, a proposal, and an estimated delivery time. If there is anything missing or if something is incorrect in the proposal, the process loops and starts from the beginning again. The requirements included in the request for purchase is the only information that is sent to the suppliers. The Procurement department does not question the choice of components and do not add any additional document of specification to the request for proposal that they send to their suppliers. (Rodin, 2012)

**Selection of Supplier**

The choice of supplier is primarily based on price but requirements such as if it is a known supplier, if the desired product is their core business, strategic purchases through contracts, and if the supplier has an EMS certification are also considered. That the suppliers have an EMS certification is more of an aspiration than a request from Kockums AB, since it otherwise can get too expensive for the customer. Quality and especially environmental aspects are not highly prioritized. (Rodin, 2012)

The supplier is selected when the requirements are specified. In some cases, there are predefined suppliers that ought to be selected if, for instance, Procurement department have long-term contracts...
with those suppliers. (Karlsson & Möller, 2012) The message on who selects the supplier is ambiguous. It is stated that Procurement always has the responsibility of choosing a supplier (Johansson, 2012). Whereas, it is also argued that the design department most of the times make the decisions on what supplier to use (Karlsson & Möller, 2012; Lindström, 2012), given that it is not specified by the customer (Lindström, 2012). In general, suppliers with certificates, such as ISO 14001, or ones that are approved by the Procurement department are chosen (Karlsson & Möller, 2012).

Rodin (2012) believes that the designers should have a more extensive dialog with suppliers to gain more knowledge of the material content of the products. Additionally, the designers should use standard products to a greater extent and use the supplier’s competence more by letting them come up with design suggestions in the early stages of the design process. (Rodin, 2012)

5.1.8 Product Requirements

Product requirements are derived from different sources such as external legal requirements, customer demands, and own company requirements. Requirements on the product that Kockums AB deals with are presented in following headings.

External Legal Requirements

In Sweden, there is an investigation in progress concerning whether or not Sweden will ratify the Hong Kong Convention that was presented in chapter 2. It was supposed to be completed by May 2, 2012, but due to EU negotiations regarding a Ship Recycling Regulation, the deadline for the investigation was extended. (Pousette, 2012) The European Commission adopted the Ship Recycling Regulation on 23 March 2012. This regulation builds on the Hong Kong Convention and the objective is to implement the Hong Kong Convention earlier, in EU, without having to wait for its ratification. (European Commission, 2012b) The new deadline for the investigation of the Hong Kong Convention to be completed is on August 31, 2012, and details will not be presented earlier. Some of the requirements in the Hong Kong Convention are already covered by Swedish constitutions. At the moment, it is looked into how the remaining requirements can be instated into current constitutions in best way possible, as well as be complemented by new constitutions. (Pousette, 2012)

Ships owned by the navy will not be affected by the Hong Kong Convention. Exceptions are always made for naval ships in the Swedish Transport Agency’s commercial standards. (Petrini, 2012) The Hong Kong Convention is believed to be enforced 2014-2015 at the earliest, if at all. For the maritime industry this will mainly mean two things. Firstly, the owner of existing ships in operation will need to investigate and possess a list of hazardous substances and materials on board and in the ship design. Secondly, for new ships, ship yards need to build their ships in a transparent way, meaning that all parts and systems that are included should be documented. Furthermore, hazardous substances and materials on board and in the ship’s structure should be declared in a list, which can be handed over to the customer, or ship owner, when the ship is completed. (Höfnell, 2012) If the Hong Kong Convention will be enforced, existing ships will be affected as well as new ship developments. It is hard to assess who has the obligation to constitute an IHM for a ship, the owner or the shipyard. It is believed that the owner of the ship will have to make sure that a material declaration is developed. However, the ship yard will surely be affected since it is stated in the resolution9 that an inventory should be made as far as practicable. (Petrini, 2012) The intention is that most of the ship recycling should be regulated by the Hong Kong Convention when it has entered into force. Consequently, the Hong Kong Convention can partly replace the Basel Convention, which was presented in chapter 2. However, it is hard to predict future development. Especially since it is not sure that the Hong Kong

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9 Referring to the IMO “Resolution A.962(23) IMO Guidelines on ship recycling”
Convention will be enforced which, in that case, will be in approximately five years. (Grundström, 2012)

**External Classification Requirements**

All ships that are developed and produced at Kockums AB should have a classification. The classification is a way to guarantee that the ship is built according to certain guidelines, necessary for the customer to be able to get insurance, and serves as a quality marking (Johansson, 2012; Lindström, 2012). There are mainly three certification bodies that Kockums AB work together with during the classification process; Det Norske Veritas (DNV), Germanischer Lloyd (GL), and Lloyd’s Register (Arbin, 2012). If no framework is specified by the customer, in the requirement specification, Kockums AB decides upon one from a reliable classification society (Johansson, 2012). DNV’s ‘Rules for ships’ is familiar and the first and foremost used framework in the PD at Kockums AB (Arbin, 2012; Johansson, 2012; Karlsson & Möller, 2012; Nilsson, 2012).

**Internal Requirements**

In addition to the requirement that all Kockums AB’s ships should have a classification, other internal requirements from Kockums AB are specified in "Kockums Verksamheter” (KV10), e.g., requirements on manufacturing, technical tolerances, work procedure, or welding (Nilsson, 2012).

There are no explicit internal requirements from Kockums AB in the product requirement specification. However, existing routines and processes should always be followed when developing ships. (Arbin, 2012; Lindström, 2012) These routines and processes are included in KV. This is done in order to ensure the customer, as well as the company itself, that the right competence exists and that "good workmanship” is provided. Hence, good quality of the product can be expected. (Arbin, 2012) However, "workmanship quality” is not stated explicitly in the requirement specification. Other internal requirements can be that certain suppliers or that certain standard components should be used. (Lindström, 2012)

**Customer Requirements**

‘The Swedish Armed Forces and the Swedish Defence Materiel Administration’ (FMV) shall take environmental consideration in all phases of the acquisition process of defense materiel. This was a decision made by the Swedish government in 1998. Consciousness regarding environmental issues has increased and it is the right time to put focus on these aspects. In connection with the decision taken by the Swedish government, the subject of environmental sustainability was discussed internally by one of Kockums AB’s main customer, FMV, and the subject is still of importance. FMV’s requirements derive from their policies as well as authorities’ requirements on suppliers to hold an EMS. Furthermore, FMV requires a criteria document11 to be followed, where prohibited and restricted chemical substances and products are listed. These criteria are in line with national environmental goals and policies within the defense sector. (Environmental Coordinator B at FMV, 2012) In addition to a criteria document, FMV sometimes requires a recycling manual12 to be completed. This recycling manual will be demanded for products where it is of importance to know how the future discarding will be done. Ships of different kinds are typical examples of products where it is suitable to demand such a manual. The recycling manual does not have any direct connection to IHM; it is used to collect desired information regarding content in the product. (Environmental Coordinator A at FMV, 2012)

All FMV’s environmental requirements are based on current legislation. In addition to the legislation, FMV request further environmental requirements when it is possible. It is possible that FMV’s

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10 Internal documents constituting the management system of Kockums AB.
11 FMV’s criteria document: http://www.fmv.se/sv/Verksamhet/Miljoarbete/Miljokrav-vid-upphandlingar/Forsvarsektorns-Kriteriedokument/
12 http://www.fmv.se/Global/Dokument/Verksamhet/Milj%C3%B6%28&%C3%85tervinningsmanual%20version%202.0%20sv%20eng%20slutf.pdf
requirements will be sharpened depending on tougher legislation or further development of what is technologically possible for products. (Environmental Coordinator A at FMV, 2012)

The environmental work at FMV should observe Agenda 21\(^\text{13}\) to the greatest extent possible. Agenda 21, and its environmental policy, has been adapted to be applicable for FMV, as well as other national defenses in the Nordic countries. It includes many aspects and guidelines of the overall targets, such as: (Försvarshögskolan, 2010)

- Set up environmental requirements when purchasing materiel
- Minimize the amount of waste, especially hazardous waste
- Foster the use of environmentally friendly technology, technical processes, and work methods

In addition, there are several guidelines on restricting or minimizing different kinds of environmental pollution. (Försvarshögskolan, 2010) Other guidelines that FMV has decided to use concern sustentation of defense materiel. A circular flow society is strived for in order to reach a long-term ecological sustainable development. However, requirements on performance and function are important aspects in defense matters that need to be fulfilled. This is the reference point for purchases, for FMV. Nonetheless, environmental aspects need to be regarded as well, which is why environmental protection principles, deriving from Agenda 21, are considered. (Försvarsmakten & Försvarets materielverk, 1998)

It is stated that environmental requirements shall be demanded, from FMV’s suppliers, in respect to the ambition level, which is reflected in the national environmental policies. This can be done through a lifecycle analysis, to compare and choose the alternative with the least environmental impact. Requirements shall be put on suppliers, e.g., Kockums AB, regarding environment to ensure that materiel is environmentally adapted; resource-economic, has long operating life, is recyclable, or contains a minimum of environmentally hazardous substances. Materiel shall be re-used or recycled as far as possible when it has reached the end of its operating life. Since the uptime of the materiel is an important part of its lifecycle, low energy consumption should be aimed for as well as low emissions.

Another guideline, that is also a legislation requirement, is to minimize the number of chemical products and systematically replace environmentally hazardous products with less hazardous alternatives. By requiring more environmentally friendly products and processes, FMV facilitate a possible competitive advantage for Swedish suppliers on the international market. (Försvarsmakten & Försvarets materielverk, 1998)

5.2 ENVIRONMENTAL WORK AT KOCKUMS AB

In 2010, Kockums AB was certified according to ISO 14001 by Bureau Veritas Certification Sweden AB. Complementary information and activities were added to the existing procedures, documented at the intranet Kabinet, to fulfill the requirements of ISO 14001. (Peterson, 2012) Kockums AB’s environmental policy can be found on the public homepage. However, it is not prominent. (Kockums AB, 2012) The documents are continuously updated and an increasing focus on the environmental performance of the products is noticed by the Environmental Manager, Rolf Peterson. The shift towards more product related environmental aspects has become especially explicit in a recent project, referred to as Project Schiff, where a recycling manual was demanded from the customer. (Peterson, 2012) Project Schiff will be further presented in heading 5.3 ‘Project Schiff and Lessons Learned’.

As a part of the EMS, an environmental handbook is available at Kabinet with links to all related documents concerning environmental and quality issues (Peterson, 2012). The environmental handbook is not used in the daily work at any of the Design & Engineering departments (Arbin, 2012; Johansson, 2012; Karlsson & Möller, 2012; Lindström, 2012; Nilsson, 2012; Rodin, 2012; Åkesson, 1992.)

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\(^{13}\) Action plan of the United Nations regarding sustainable environment and development, which was a result of a conference in Rio de Janeiro, Brazil, in 1992.
2012) but that is not something Peterson expects. His desire is rather that the environmental handbook is used as an encyclopedia when needed. Furthermore, the expectation is that the environmental handbook enables and makes employees consider environmental issues on a daily basis. To create interest and enthusiasm for questions regarding environment Peterson would like to introduce "environmental impact" as a permanent bullet point on the agenda of DRs and weekly department meetings. Another measure, to increase environmental awareness, is to create an Environmental Management Group (EMG) including personnel from Design & Engineering and Procurement departments. Peterson has set this formation in motion and was at the time of the interview waiting for a response from the head of the Design & Engineering department. The most important aspect to consider when putting together the EMG is to identify and choose employees who think "green". These people can then run the environmental related work at their departments and find possible improvement areas in processes and routines. The establishment of the EMG is meant to be a permanent action and not for one specific occasion or project. (Peterson, 2012)

5.2.1 Environmental Aspects in the Product Development

Environmental aspects that are integrated in the PDP are not apparent. Furthermore, there are hardly any requirements concerning environment included, see Figure 17.

The VS department, sometimes, design to make specific parts easy to access in order to facilitate updates, maintenance, or replacements. However, DfR, dismantling for EoL, or reuse are normally not considered to a great extent. (Johansson, 2012) Reuse, recycling, or "design for dismantling" are not considered at the P&A department either (Lindström, 2012). Recycled materials are only used if it is a customer requirement, Kockums AB does not have this as a regular requirement for their suppliers (Nilsson, 2012). There can be hazardous material or substances left in the hull of ships, when EoL is reached, and hence it is not easy to reuse parts from ships (Karlsson & Möller, 2012).

Environmental requirements that Kockums AB considers are the ones demanded by the customer. No external legal framework is taken into account if it is not specified in the requirement specification. (Karlsson & Möller, 2012; Lindström, 2012) The requirements that are demanded are always followed. Consequently, if there is no attached appendix regarding environmental requirements they will be neglected since performance is always the number one priority. (Lindström, 2012) Selection of material is where departments can influence and have an effect on environmental impact of the product. However, as mentioned, in most cases military aspects and requirements trump environmental aspects. (Karlsson & Möller, 2012)

Environmental aspects are mostly common in commercial projects (Arbin, 2012). The environmental aspects that are integrated, in commercial projects, are mainly requirements to fulfill legal
frameworks. Most commercial customers do not have additional environmental requirements since it will be too costly for them. (Nilsson, 2012)

Internal requirements regarding environment aspects are the ones originating from ISO 9001 and ISO 14001. In addition, there can be requirements from TKMS and their environmental vision. (Karlsson & Möller, 2012) The ISO 14001 certification is, however, not apparent in the daily work (Åkesson, 2012), there was no notable change after it was received (Arbin, 2012; Lindström, 2012). Nevertheless, ISO 14001 was integrated in the existing procedures at Kockums AB in order to make the implementation smooth (Peterson, 2012). Recycling bins and the way chemicals need to be sorted and handled are factors that employees notice more than the changes in the daily work procedures (Nyström, 2012).

5.2.2 Operational Management Perspective on Environmental Ambition

When considering the incentives for sustainable development, presented earlier in Figure 7, Kockums AB’s COO states that Kockums AB, at this point in time, is at the step "keep up with competitors". In a future perspective, the vision is to aim at higher steps. However, Kockums AB’s main customer has large influence on the potential level of ambition in their requirements. It is significant for Kockums AB to be a representative and attractive company in Sweden and internationally. Considering environmental aspects can contribute to an even better image. Efforts made in the area of environment can also decrease the risk of "bad-will". (Kallén, 2012) According to the head of the Design & Engineering departments, Kockums AB is at level 1, "follow law", or 2, "keep up with competitors", in the sustainability steps, depending on what discipline, naval or commercial ships, is regarded. Onward, a new product portfolio for naval ships should be aimed at level 3, "save costs" while commercial ships should aim one step higher, at level 4 "competitive advantage". (Edvardsson, 2012)

One step towards more environmentally friendly products is to start measure and review the products from an environmental perspective. However, the demands need to come from customers since they are the ones who need to be willing to pay for it. Nevertheless, being able to offer a recycling manual can be used as a sales argument. Though, one disadvantage is that different nations are at different level of maturity concerning environmental considerations. In conclusion, if Kockums AB has reached a point where a recycling manual can be delivered, it is important to not lower the level of ambition. Instead a higher level should be reached for, that at the same time correspond to customers’ demands, since they are of great importance. (Kallén, 2012)

5.3 Project Schiff and Lessons Learned

Project Schiff, which was previously mentioned, is carried out at Kockums AB, and it is a project for a midlife conversion of a ship, i.e., an update of the ship’s software and abilities. In Project Schiff, environmental requirements were highlighted, and of importance, for the first time at Kockums AB. Daniel Nyström is Project Manager for Project Schiff, and was recruited to this position from another company. Presently, there are 80 people involved in Project Schiff. During the process of the project, 30 additional consultants have been brought in to work on the design of the ship. These consultants made up approximately 40% of the design personnel. (Nyström, 2012)
The project organization for Project Schiff, see Figure 18, looks the same as when it started, with one exception. When the project started, ILS was included in the Design & Engineering project group, just as it is included in Design & Engineering department in the company organization chart. However, ILS’ work tasks are many and comprehensive. Therefore, ILS became an additional project group one year ago with their own ILS sub-project manager. (Nyström, 2012)

When the project started, all of the project members were spread out in different houses and at different departments. Starting this year, several of the project members were moved to a new house that now works as their base for the project. In this new project office, everyone is sitting, and working, close together which facilitates for the project to a great extent. Furthermore, the dynamic of the project team is better. (Nyström, 2012)

5.3.1 New Environmental Requirements

Environmental aspects are responsibilities of the quality project manager (Nyström, 2012). In project Schiff, requirements regarding environmental aspects were included in the requirement specification. (Ekvall, 2012; Nyström, 2012) The environmental requirements included that each supplier had to be environmentally approved and a recycling manual had to be delivered together with the ship. These types of requirements were new to Kockums AB, and who were to be responsible for the completion of the recycling manual was uncertain. (Ekvall, 2012) When it was clear that the required knowledge did not exist within Kockums AB, an environmental consultant was brought in and assigned the task of dealing with the environmental aspects. (Ekvall, 2012; Nyström, 2012) The environmental consultant gathered all the System Managers in the project and delegated environmental requirements and responsibilities. However, the delegation of environmental responsibilities has not worked as well as desired. This is probably due to the fact that there are neither routine nor experience regarding how to handle environmental requirements of this type. (Nyström, 2012)

During the compilation of the recycling manual there has been cooperation between the environmental consultant and other departments. Contact has been frequent with the Procurement department due to

![Figure 18. Project organization for Project Schiff (Kockums AB, 2012).](image-url)
its connection to the suppliers. In the beginning all contact with suppliers was done by the Procurement department. Later on, in attempt to make the work more efficient, the environmental consultant had direct contact with the suppliers when questions arose. Other departments that have been involved, but not as extensively, are the Design & Engineering departments. Moreover, the Environmental Manager has been contacted throughout the project for reports on the progress and to discuss questions. Overall, the cooperation has worked fine. However, difficulties emerged when trying to get everyone to understand the importance of fulfilling the demand for a recycling manual. Furthermore, Ekvall (2012) wants Kockums AB to understand that these requirements are not only specified in project Schiff but are a part of Swedish and European legislation. Kockums AB should place demand on their suppliers according to, for instance, the constitutions REACH and RoHS. (Ekvall, 2012)

Since the pre-study phases of Kockums AB’s projects are long, a lot of decisions are made early on. This was the case in Project Schiff, and hence it was difficult to make changes when environmental requirements were addressed. Therefore, products and projects have been adjusted afterwards as far as possible to fulfill environmental aspects. (Nyström, 2012)

Nyström finds it surprising that the standards of ISO 9001 and ISO 14001 are just recently implemented at Kockums AB. Kockums AB has a long journey to make now before the processes and mindsets of the ISO standards have permeated the organization. This is a sign that environmental issues have not been prioritized at Kockums AB. Another sign that environmental aspects not are infiltrated in the company is that the environmental department merely consists of Rolf Peterson. He is placed very separately, both location wise and in the organizational structure of the company. There are no environmental champions at Kockums AB, but there are consultants that are very driven and ambitious regarding these issues, for example the first environmental consultant in the Project Schiff. A person, like that, needs to be integrated in Kockums AB to be able to accomplish a change in attitude at the employees of Kockums AB. In general, there are no motivated employees at Kockums AB that strive for change that Nyström know of or no one that are trying to pursue environmental issues. Most of the environmental aspects are included thanks to customer requirements. Some of Kockums AB’s customers, for example in Project Schiff, are demanding more environmental requirements to be fulfilled than legislation or Kockums AB require. Kockums AB does have its own environmental requirements, however these are not evident. They should be incorporated in early procedures, for example when substances for the ship design are to be chosen. However, designers want to draw lines and design ships instead of filling out a lot of documents that often are required for environmental purposes. (Nyström, 2012)

5.3.2 Tools and Supporting Means
At the initiation of Project Schiff, no communication plan was implemented. It came in one year after the project start, due to the fact that a lot of things have been done on routine. Things are done in ways they always have been done. When a communication plan was established it was very dynamic and meetings changed when needed. When a new chief of information was appointed, more information started reaching out to the employees of Kockums AB via the intranet. For example, each project has their own project area where they can present progresses in the projects. (Nyström, 2012)

FMEA is a well-recognized tool that can be useful in projects, even at Kockums AB. Nyström is not sure if anyone at the Design & Engineering departments is using FMEA even though it is not in the normal routine of projects and has not been used in Project Schiff. If FMEA was to be implemented, Nyström thinks that it should be conducted in an early stage of the project, preferably in the first phase of the design process. It should be the Project Manager of the Design & Engineering project group that is responsible for performing it or delegate it to each design department to perform it. Furthermore, it would be useful to conduct a production-FMEA in addition to a normal product-FMEA. For this production-FMEA, the Project Manager for the Project group should be responsible for performing it.
Environmental issues should be incorporated in these FMEA. Or else, if an environmental FMEA should be performed it should be done at the same time as the product-FMEA. Otherwise the design process would proceed too far and chances of making steps toward a more environmentally sustainable product are diminished. (Nyström, 2012)

5.3.3 Obstacles and Problems
Since it was the first time that a project which included comprehensive environmental requirements was carried out some difficulties aroused along the way. The major problem was that the recycling manual was not of high priority. Another problem was that the request for recycling manuals was not sent to the suppliers at the time as the request for proposal. Therefore, some suppliers were not pleased when that requirement was added afterwards. The work could have been smoother if the environmental approval and the request for recycling manuals had been done at the same time throughout the whole process. Furthermore, it would have been desirable that the work with the recycling manual had started earlier, preferably in the first stages of the design process. During the early design phases, it is possible to choose a product or component that has a lower adverse environmental impact. (Ekvall, 2012)

The fact that a lot of consultants were needed for Project Schiff was a downside. This implies that the gained experience in this project will be lost. Another disadvantage was that Project Schiff worked as a “guinea pig”. New systems, processes, and tools were to be tried out in Project Schiff. It was believed that if it worked in this big project, it would work at any project at Kockums AB. This has shifted the focus from the product to the tools and processes instead. As a consequence, the project took longer time than expected and was delayed. (Nyström, 2012)

5.3.4 Positive Factors
A factor that has worked well in Project Schiff is the contract with the customer. It included payment per hour with a fixed highest cost for the project. This meant that every extra hour that was required was an additional cost for the customer. Consequently, for every new requirement that appeared Kockums AB would get more paid, this lead to a very good dialogue with the customer and more openness. Furthermore, the customer and Kockums AB had another common goal, which was to get the ship ready on time. Normally, when Kockums AB has had projects with this particular customer, there has not been a fixed deadline that would have to be met. (Nyström, 2012)

Nevertheless, the most important positive factor in Project Schiff was the new project office, which however should have been established earlier. The fact that it was placed within the walls of the ship yard was very positive, both product and production could be cared for by the project team in a better way. Employees from the production could stop by the office on their way to the ship and communication was much easier. In addition to the facilitated communication due to the new office, direct contacts were established. Employees from design departments were set up with their corresponding match from the production department, an arrangement that is not normally established. This made communication better as well. Moreover, better solutions for ship design could be worked out thanks to this. (Nyström, 2012)

5.3.5 Knowledge Transference in-between Projects
In general, Kockums AB is bad at retaining knowledge from previous experiences. There is a routine of conducting "lessons learned” and analysis in projects and after projects. However, gathered information is easily forgotten and not cared for. This information is kept in "history books” that never are used again. This is probably a result of the fact that there are many competent employees at Kockums AB with a lot of knowledge from earlier projects and shipbuilding. Unfortunately, it is difficult for consultants and newer employees to take part of their implicit experience. (Nyström, 2012)
In project Schiff, the lessons learned concept was conducted throughout the project. However, previously encountered problems have still existed. This is a proof that acquired experience need to be better taken care of. (Nyström, 2012) When experience is taken care of by doing lessons learned, the Quality Manager appoints a coordinator who is responsible for carrying out the lessons learned activities. Lessons learned are conducted separately with the different design departments and with the project management. This is done in order to make sure that the project is perceived in a similar way from different aspects. The difficulty is to transfer the gained knowledge to future projects. Presentations of the lessons learned are done throughout projects. Nyström is responsible for writing a final report on the outcome of the project when it is finished. The risk is that the presentations of the lessons learned will disappear and focus will be merely on the final report. All lessons learned should be kept in an electronic library on Kabinet in order to make them easy accessible to anyone who needs them. As it is now, the lessons learned are kept in a folder along with requirement documents for different purposes. It is not easy to access documents in that folder, you have to know exactly what you are searching for. (Nyström, 2012)

5.4 **SHIP RECYCLING AT STENA RECYCLING**

Stena Recycling (Stena) has previous experience in recycling vessels produced by Kockums AB and is used to manage disposal of military equipment. The most common technique used when recycling ships at Stena is gas cutting. However, gas cutting can cause a risk of fire. Consequently, cutting by using a pair of large scissors is another method. Dismantle parts by unscrewing is unusual because of economical and time related limitations but can be done if a component is valuable and can be reused. Before the cutting starts hazardous parts and components are identified, then a facility for decomposition of the material is used. Next, the waste is separated into smaller fractions, in what works as a huge mill, and sorted according to different qualifications and qualities by using, for instance, floating. Of a ship’s total weight, more than 90% of the material is recovered. In perspective, the amount of recovered material is less when looking at the total volume of the ship. (Jonasson & Petersson, 2012)

Naval vessels are well documented and therefore easier to recycle compared to commercial ships. In some cases, the documentation has not been updated in connection with modernization of the ship, e.g., ship maintenance and midlife conversions. Documented location of hazardous materials is desirable. Stena has good competence in handling hazardous materials, and customers choose therefore Stena even if there are cheaper alternatives. Having an agreement that allows Stena to sell parts and components that can be reused is also something that Stena would like. The business idea is to sell the recovered material. The customer pays for the disposal of waste and if Stena can sell the recovered material and earn money then the customer can get money in return, which gives an incentive for designing for easier recycling. (Jonasson & Petersson, 2012)

Metals are easy to identify but plastics are more difficult. Therefore, markings and codes on plastic parts would ease the recycling process. Moreover, decreasing the number of different plastics used would also lead to a simplified recovery. Another desirable design quality is the possibility of separating materials from each other to get as ’clean’ fractions as possible. For instance, separating insulation material from the hull structure is often complicated today. The most important aspects, in order to have as good waste management as possible, are to not mix or assemble non-compatible materials together and have a comprehensive documentation. (Jonasson & Petersson, 2012)

Today, carbon fiber is put to landfill. The carbon fiber cannot be reused as a component with the same function but it can be used as for example concrete reinforcement. At Stena, a department is researching the possibilities for future techniques for recycling of carbon fiber. (Jonasson & Petersson, 2012)
### 5.5 External Examples of Implementing Environmental Considerations in PD

Johansson and Magnusson (2006) conducted empirical studies on a case company where environmental requirements were taken into concern in a project in the telecom industry. This case is presented in Appendix J, and is summarized from the article ‘Organising for environmental considerations in complex product development projects: implications from introducing a ”Green” sub-project’.

Possible implications, highlighted in the article, due to the implementation of the green environment sub-project are listed in Table 8.

**Table 8. Possible implications due to the green environmental sub-project highlighted by Johansson & Magnusson (2006)**

<table>
<thead>
<tr>
<th>Implication</th>
<th>A Green sub-project can...</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>... serve as a means to put environmental considerations on the agenda within a product development project</td>
</tr>
<tr>
<td>#2</td>
<td>... introduce a risk for confusion within a product development project regarding who is responsible for fulfilling the environmental performance requirements</td>
</tr>
<tr>
<td>#3</td>
<td>... act as an arena for communication about the environmental performance requirements within a product development project</td>
</tr>
<tr>
<td>#4</td>
<td>... serve as a platform for environmental champions to be active within a product development project</td>
</tr>
<tr>
<td>#5</td>
<td>... serve as a means for environmental specialists to become part of established contact networks in the product development organization</td>
</tr>
</tbody>
</table>

The telecom company wanted to incorporate environmental considerations in a substantial way and chose therefore to introduce an operative group in a project. However, difficulties regarding responsibility and how to handle environmental versus customer requirements emerged. An interview with one of the investigators of the telecom case study showed that, today, the environmental requirements are managed by the use of a staff function instead of an operational team. (Magnusson, 2012)

Magnusson (2012) believes that the first step for introducing environmental issues in the product development process is establishing environment as a priority for the top management and making it a part of the daily work. Since it is the designers who are to realize the environmental work it is vital to have a clear purpose, which ought to be included in the strategy, in order for the designers to understand reasons for carrying out environmental work.

If an environmental group that should deal with environmental aspects is to be formed, employees who have the ability to mediate the information to the rest of the organization should be chosen. It is desirable that this group gets mandate from the top management to indicate their support. The concept can then be tested during a pilot project where it is important that the project management enhance and run environmental matters. (Magnusson, 2012)

Making the environmental work visible is essential. This can be done through in-house communication, strategic product planning, and articles in company magazines, which will affect the employees and make them feel that they can make a difference. (Magnusson, 2012)

Examples of ecodesign best practices, that Magnusson (2012) mentions are Volvo Powertrain, Toyota Prius, and Siemens Industrial Turbomachinery. Volvo Powertrain wanted to become a front runner on hybrid engines for heavy vehicles. In the beginning of the 21st century, the company understood the peak oil complexity and therefore started investigating the options for alternative fuel. At this point in time there was no market pull for alternative fuel. Instead, there had to be an explicit statement from the top management. A similar scenario took place when the Toyota Prius was developed. If a company wants to be a front runner the top management support is fundamental. Siemens’s gas turbines have a long operating life and there are only a few providers of equivalent turbines, two...
characteristics that are comparable to Kockums AB. During the development of a specific gas turbine Siemens were able to decrease the nitrogen oxide levels and accomplish a combustion that was way better than the competitors. Siemens aimed higher than the customers required and thereby made profit. In all mentioned examples, the environmental aspects were well rooted throughout the whole organization and a part of the business. (Magnusson, 2012)
RESULTS

Chapter six contains the results from the empirical study and highlights the factors which are affecting environmental aspects at Kockums AB. Moreover, it encloses the final result of the research; the Long-term Environmental Action Plan (LEAP).

6.1 EXISTING FACTORS POSITIVELY AFFECTING ENVIRONMENTAL ASPECTS
Following positive factors, affecting environmental aspects, already exists at Kockums AB:

- Ships are designed to be light-weighted and a state-of-the-art carbon fiber solution exists at Kockums AB; e.g., lighter ships consume less fuel.
- Expert competence within ship design exists at Kockums AB; there are big possibilities of being able to realize environmentally conscious design and still have the same qualities in terms of performance.
- Improvement work, KRAFT, is currently carried out at Kockums AB; there are large possibilities of including changes in environmental attitude and implement changes in processes.

There are most likely more success factors that can be identified. However, focus in this research has been on identifying problems and means to solve them.

6.2 IDENTIFIED DIFFICULTIES
Following problems, affecting environmental aspects, have been identified at Kockums AB:

- Customer requires recycling manuals for ships; Kockums AB does not have a routine to document materials in components of the ship design or how to handle other product related environmental issues.
- Performance and function are the most important parameters when developing ships; Environmental aspects are not intentionally considered.
- There are communication problems in projects, e.g., regarding environmental responsibilities; it is unclear who should be responsible for environmental requirements.
- A motivated person is needed to pursue environmental related issues; environmental champions do not exist at Kockums AB and/or no room is given for environmental champions to exist.
- Expert knowledge in ship design exists; Decisions in the design process are taken on routine which means that innovation is not benefited.
- No general knowledge regarding environmental matters exists; Education and training of employees in ecodesign is needed.
- Environmental Management System, certified according to ISO 14001, was implemented in 2010; no significant change in employees’ mindsets followed.
- The concept of “lessons learned” is carried out at Kockums AB; nonetheless it is not used in an optimal way in order to keep and transfer gained knowledge to future projects.
- When problems regarding environment are brought up, there are a lot of miscommunications because of the ambiguous term; environment can refer to the work environment, the environment the product is effective in, e.g., weather conditions, or the product’s affect on ecological systems.
The operational time of a ship is long; the product’s “usage”-phase is of great importance.

Decisions that affect the ship’s whole lifecycle are taken in early design stages; ship design is
done on routine with implicit knowledge without making environmentally conscious choices.

General Arrangements for ships are made in a collaborate way were project members try to ”pick
and choose” where they want to place their parts; no attention is paid to if parts containing
hazardous materials are placed nearby each other in order to facilitate recycling aspects.

It is unclear who is responsible for the ultimate choice of materials in components and suppliers;
the best decision regarding environmental aspects is not purposely taken.

6.3 STEPS TO MANAGE THE DIFFICULTIES
To solve the problems at Kockums AB and enhance the positive factors, it is important to create
awareness about ecodesign. This can be done through implementing tools and integrating them in the
existing PD and PDP. Moreover, the factors for successful implementation of ecodesign, presented in
4.2.4 ‘Successful Integration of Ecodesign’, should be considered and taken into account. All
environmental aspects cannot be integrated at once, in the PD and PDP. Instead there should be
continual improvements, which are also the signature of the ”Plan, Do, Check, Act” methodology used
at Kockums AB. A few steps that are important, in order to be able to implement environmental
aspects and deal with the identified difficulties, are;

- Clarify responsibilities and communication
- Provide education in ecodesign
- Carry out a pilot project where environmental aspects are included
- Evaluate the outcome of the pilot project and revise the implementation plan

6.4 LONG-TERM ENVIRONMENTAL ACTION PLAN (LEAP)
The solution, which is suggested to fulfill the objective of this research and to solve or facilitate
solving the identified problems, is a Long-term Environmental Action Plan (LEAP) that is enclosed
in Appendix A. The LEAP contains eighteen Actions, which serve as means to facilitate and support
employees of Kockums AB in being more environmentally conscious in their work. In addition, these
Actions will help integrate and interweave environmental aspects in Kockums AB’s PDP. The Actions
of the LEAP, their prioritization, who is responsible and where in the PD they should be implemented
are presented in Table 9. Several Actions include worksheets for the person, who is responsible, to use
in his or her work. References to worksheets and documents, which are included in the LEAP in
Appendix A, are presented in Table 9. The different worksheets and documents are named as LEAP-
14XX, from LEAP-1401 to LEAP-1410.

The LEAP is the ultimate result of this M.Sc. thesis, and hence what is handed over to Kockums AB.
The intention is that the environmental work should be continued by Kockums AB in order to fully
implement it, incrementally, over a longer period of time. Moreover, the suggestion is that the LEAP
should be included in the KRAFT project in order to emphasize the importance of ecodesign and show
that top management support is provided.
<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Responsible</th>
<th>When</th>
<th>Reference</th>
<th>Prioritization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Environmental Management Group (EMG)</td>
<td>Environmental Manager</td>
<td>-</td>
<td>LEAP-1401</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Revised Environmental Policy</td>
<td>Top management</td>
<td>Annual revision</td>
<td>LEAP-1402</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Revised Environmental Objectives and Targets</td>
<td>Top management</td>
<td>Annually before new financial years</td>
<td>LEAP-1403</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Communication Plan</td>
<td>Project Manager</td>
<td>Start-up of new projects</td>
<td>LEAP-1404</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Color list of forbidden and restricted substances</td>
<td>Employees from Design &amp; Engineering departments that are members of the EMG</td>
<td>Continuously in the PDP</td>
<td>LEAP-1405, Hong Kong Convention’s Appendix 1 &amp; 2</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Ecodesign Guidelines</td>
<td>Designers</td>
<td>First phase after ”Offer” and continuously in the PDP</td>
<td>LEAP-1406</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Education and Training</td>
<td>Top management together with EMG</td>
<td>Continuously and before start-up of new projects</td>
<td>LEAP-1406</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Recycling Manual</td>
<td>ILS</td>
<td>Should be completed in the Product Development’s final phase</td>
<td>FMV:s recycling manual</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Procurement department’s contribution to ecodesign</td>
<td>Employees from Procurement department that are members of the EMG</td>
<td>Annual revision</td>
<td>LEAP-1407</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>Employment of an environmental champion to ILS</td>
<td>ILS’s Head of Department</td>
<td>-</td>
<td>LeAP-1407</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Prestudy-EEA</td>
<td>Design departments</td>
<td>Phase A, Design Process</td>
<td>LEAP-1408</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>Fast Five</td>
<td>Top management</td>
<td>At strategic product planning, checkpoints of product concepts</td>
<td>LEAP-1409</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>Ecodesign Checklist</td>
<td>Sub-project Manager for Design &amp; Engineering and System Manager (Systemansvarig)</td>
<td>Design Reviews (DR), especially DR in Phase B1 in the Design Process</td>
<td>LEAP-1410</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>Eco-toolbox</td>
<td>EMG</td>
<td>Continuously in the PDP</td>
<td>LEAP-1409</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>Further Education and Training</td>
<td>Top management together with EMG</td>
<td>Continuously and before start-up of new projects</td>
<td>LEAP-1409</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>Product-FMEA</td>
<td>Project Manager together with System Manager for each system</td>
<td>Early design and as support during development of products</td>
<td>LEAP-1410</td>
<td>4</td>
</tr>
<tr>
<td>17</td>
<td>EEA</td>
<td>Same as for Action 16</td>
<td>In connection with Product-FMEA</td>
<td>LEAP-1410</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>LCA</td>
<td>Environmental Champion at ILS</td>
<td>Before the Design Process starts and at halftime conversions</td>
<td>LEAP-1411</td>
<td>5</td>
</tr>
</tbody>
</table>

### 6.5 RESULT DISCUSSION

The LEAP was developed in order to suit the existing procedures at Kockums AB. On the one hand, since the LEAP was not experimentally tested, it is not fully verified and the LEAP may have to be adjusted to suit Kockums AB even better before it can be entirely integrated and implemented. On the other hand, two verification sessions were used to verify that the LEAP was relevant and realizable at Kockums AB. Feedback from both of the sessions was positive, and especially regarding the
suggestion that the LEAP and the EMG should be a part of KRAFT. However, a potential disadvantage that could occur is that other projects in KRAFT, which also are of high importance, will receive less attention if too much focus is put on the integration of environmental aspects. Moreover, the LEAP contains several Actions which need to be prioritized and implemented incrementally in order to be successful and have an impact. It is especially important to do this incrementally because Kockums AB is not used to handle environmental work. If all Actions were to be implemented at once it would be too much to take in and deal with, even though the Actions are developed to suit the existing processes. Additionally, it is important to make sure that employees are motivated to fully implement this environmental work, and that they believe in the LEAP as well as understand why it is important to carry out the environmental work. If the LEAP would be supported by top management, for instance if the LEAP is a part of KRAFT, the employees motivation is expected to be high. All in all, the LEAP is a step in environmental direction, and little by little it is believed that environmental interest and motivation will increase.
ANALYSIS AND DISCUSSION

In chapter seven, the theoretical frame of reference is compared with empirical findings. The sub-questions are answered in order to provide an answer to the overall RQs, which will be presented in the concluding chapter eight. Moreover, the result is analyzed and discussed in this chapter.

7.1 ENVIRONMENTAL PRODUCT REQUIREMENTS FOR KOCKUMS AB TO FULFILL

Companies are often demanded to fulfill complex requirement specifications for their products. This is especially true for Kockums AB since the products are complex and there are a lot of military requirements. Following two sub-questions will provide answers to the first research question; What environmental product requirements are Kockums AB demanded to fulfill?

7.1.1 Where do the Requirements Derive from (external, internal, customers)?
External requirements mostly derive from classification societies. DNV, Lloyds Register, and Germanischer Lloyd are particularly used at Kockums AB according to Arbin (2012), where the most frequently used framework is DNV’s (Arbin, 2012; Johansson, 2012; Karlsson & Möller, 2012). DNV has the optional class notation "Recyclable" (Det Norske Veritas, 2010a) which means that the developed ship is in compliance with the Hong Kong Convention’s requirements, where an IHM is the basic requirement.

Kockums AB’s top owner TKAG recently published a Group Policy statement (ThyssenKrupp AG, 2011), regarding environmental and climate management, which all Group Companies are compelled to comply. This requirement makes it more significant for Kockums AB to pursue environmentally conscious ship development since it was made clear that environmental sustainability is important for TKAG and consequently for all Group Companies. The statement is general and basically implies that environmental concern should be taken at all levels of the organization as well as in all activities at TKAG’s Group Companies. However, there are no specific requirements that can be applied directly into ship development. The Group Policy statement is an incentive for top management to show their support in environmental issues.

There are currently more implicit internal requirements, such as "good workmanship" (Lindström, 2012), than explicitly stated ones, other than requirements from KV (Nilsson, 2012) and that a classification society’s framework should be followed (Arbin, 2012; Lindström, 2012).

Kockums AB’s main customer FMV includes legal requirements in their own demands on customers according to Environmental Coordinator B (2012). FMV’s environmental requirements are based on the environmental policy deriving from Agenda 21 (Försvarshögskolan, 2010) along with other national and legal responsibilities (Environmental Coordinator A at FMV, 2012).

Overall, most of the requirements derive from customers, who often are in control of the product design, and according to Lindström (2012) military requirements trumps most other. Furthermore, he states that customers are not willing to pay extra in order to make the product environmentally sound. As a consequence, environmental issues are often neglected. However, recently one of Kockums AB’s main customers started demanding a recycling manual, which required extensive knowledge of all parts in the ship design. This is also the most important implication if the Hong Kong Convention...
enters into force since an IHM is required to be provided by the ship builder, e.g., Kockums AB (Hirabara, 2008).

7.1.2 What Requirements might be Demanded in the Future?
In an e-mail correspondence with Environmental Coordinator B at FMV (2012) it was clearly stated that FMV follow national requirements and legislations. Since national legislation makes exceptions for military products, these requirements are not enforced in the naval ship design at Kockums AB. However, it is important to be proactive and include requirements that may become enforced for naval ships in the future. Therefore, it is vital to have knowledge on the components in the products and make careful and conscious decisions on where to place them.

Future requirements that may be enforced can be the Hong Kong Convention, which is an initiative from IMO (IMO, 2009). IMO is a pertinent external stakeholder to take into account since a lot of national requirements that are enforced derive from guidelines that IMO proposes. In order to be ahead of what legislation might enter into force, IMO is of significant importance.

The Hong Kong Convention excepts naval ships but also clearly states that naval ships should be consistent with the convention as far as it is reasonable and practicable (IMO, 2009). This is also an incentive for Kockums AB to start developing ships in accordance with the Hong Kong Convention.

Presently, there is ongoing work to see what countries will ratify the convention and the decision for Sweden’s ratification will be presented on 31 August, 2012 (Pousette, 2012). If the conditions for ratification of the Hong Kong Convention (IMO, 2009) are fulfilled, it will, according to Grundström (2012), enter into force in approximately five years. Lloyd’s Register (2011) and Höfnell (2012) states that the Hong Kong Convention will enter into force, at the earliest, in 2013-2014 and 2014-2015 respectively. The fact that a Ship Recycling Regulation recently has been proposed by European Commission (2012b), in order to speed up the process of enforcing the Hong Kong Convention, is a sign of how important the Hong Kong Convention is considered to be.

7.2 Suitable Environmental Ambition Level for Kockums AB
Companies should have a clear vision regarding what level of environmental ambition they are aiming for. Moreover, this should be communicated well to the company’s employees as well as to the public. Following two sub-questions will provide a perspective on where environmental issues are integrated in strategies of Kockums AB. Hence, answer to the second research question; What level regarding environmental issues is suitable to aim for at Kockums AB?

7.2.1 Where are Environmental and Recycling Aspects Integrated on a Strategic Level at Kockums AB?
As Jönbrink et al. (2011) state, companies should decide how they want to be positioned strategically regarding ecodesign. This can be done with help of Figure 7, incentives for sustainable development. Head of Design & Engineering, Edvardsson (2012), state that Kockums currently is on step 1 in their development of naval ships, which is "follow the law", while COO, Kallén (2012), believes Kockums AB is at level 2, "keep up with competitors". However, both agree that higher visions should be aimed for in the future. Edvardsson (2012) believes that step 3 "save costs" should be aimed for and Kallén (2012) believes higher steps, than step 2 which he considers Kockums AB to be at currently, should be aimed for. Since the Hong Kong Convention will potentially enter into force, according to Grundström and Höfnell (2012), it is beneficial if Kockums AB adopts the requirements of the convention. Although the convention does not include naval ships it would be strategically advantageous if the requirements could be integrated in the PD at Kockums AB. The convention encourages ship builders to follow the requirements of the Hong Kong Convention as far as possible. It is not certain that the regulation will not be enforced for naval ships in the future. Furthermore, since Kockums AB
sometimes develops commercial ships it is favorable if the PDP for commercial and naval ships is the
same in order to make processes smooth and easy to follow.

The concept of ecodesign covers various practices, which McAloone (2000) highlights, as was shown
in Figure 6, where DfE is one of those. According to Environmental Coordinator B at FMV (2012),
recycling manuals along with other environmental product requirements, will continue to be
demanded from Kockums AB when applicable. Thus, it is vital to address ecodesign which deals with
these issues. As Kockums AB’s COO Kallén (2012) stated, it is important to not move backwards; if a
recycling manual can be provided for customers it should be, since it facilitates EoL treatment. If
thorough documentation exists it will be cheaper to recycle the ship at the end of operating life
according to Jonasson & Petersson (2012). Consequently, dealing with environmental aspects has
economic incentives as well as the benefit of reduced environmental impact. Performing ecodesign
contributes to a good image for the company, which makes Kockums AB an attractive company as
Kallén (2012) mentions as an important aspect.

Environmental Management System is included in the overall management system and Kockums AB
was ISO 14001 certified in 2010 (Peterson, 2012). Kockums AB needs to integrate environmental
aspects into their product development in order to successfully make a difference on the products' environmental impacts, which is also the ISO 14006 standard’s definition of ecodesign (International Organization for Standardization, 2011). Consequently, Kockums AB should follow ISO 14006 to reduce adverse environmental impact related to products. Since Kockums AB is certified according to ISO 14001 this is a natural step to take next.

7.2.2 Are there any Ongoing or Planned Environmental Projects?
There are currently no ongoing ship developing projects that can be considered as “environmental projects”. The environmental focus that occurred in Project Schiff was due to customer requirements and not an initiative from Kockums AB. However, the fact that the idea of an environmental management group has been established (Peterson, 2012) is a significant step for Kockums AB in environmental direction. The EMG has not yet been set into work, which is why tasks and commitments, for the group to carry out, have been a vital part of the suggestion in the LEAP.

A reason for the lack of environmental projects can be that there also is a lack of incentives for carrying out environmental work. Best practice companies, presented by Magnusson (2012) in one of the external interviews, have prerequisites for carrying out ecodesign that are not applicable to Kockums AB. The companies, which the best practice cases are taken from, have greater and more obvious economic benefits from handling ecodesign. This is because decreased energy consumption has a great impact on several aspects in those companies, for example decreased final cost for the customer. In the case of a turbine, which produces energy, low energy consumption is of significant importance. Kockums AB develops ships which are light weight and therefore consume less fuel, but that is not of highest priority. At Kockums AB, performance and function are instead of utmost importance. This implies that the competitive advantages, that took place at the companies of the best practice cases, cannot be translated in the exact same manner to Kockums AB.

7.3 Integrating Environmental and Recycling Issues in the Product Development and its Process
Environmental and recycling aspects should be integrated in companies’ product development and processes in order for it to be effective and have an impact. Following sub-questions, to RQ3, explain what Kockums AB’s product development processes look like and where these aspects currently are integrated. Moreover, where environmental aspects should be integrated is identified and suggested. Consequently, the third research question; How can environmental and recycling issues be integrated in the PDP?, will be answered.
7.3.1 What does Kockums AB’s Product Development Process (PDP) look like?
Kockums AB’s PDP consists of six phases, is sequential and comparable to the PDP presented by Ulrich & Eppinger (2003). One difference between the two PDP’s is that the PD at Kockums AB can start at either one of the phases Study, Project, or Design since their customer can be fairly detailed in their requirement specification. Moreover, even though the PDP at Kockums AB is sequential it can be considered as iterative as well. This is because PD, within every PDP phase, is performed in the design spiral and looped multiple times if necessary (Kembring, 2012).

Study, Project, and Design are the three phases of Kockums AB’s PDP that founds the PD. In the PDP model by Ulrich & Eppinger (2003) the actual PD is constituted by Concept Development, System-Level Design, Detail Design, Testing and Refinement. It may be argued that the Testing phase at Kockums AB also contributes to the PD since modifications may occur in this phase. Consequently, it contributes to making improvements to the product. However, since ships are costly to produce there are rarely any big changes but rather amendments according to empirical findings.

7.3.2 Where are Environmental and Recycling Aspects Integrated in the PDP at Kockums AB?
There are no environmental and recycling aspects integrated explicitly in the PDP at Kockums AB. The diagram in Figure 17, illustrated the importance of including environmental aspects in the project’s requirement specification at Kockums AB. This is since it is stated in interviews that environmental aspects only are integrated in product development if they are included in the requirement specification. In short, interviews at design departments showed that customer demands and enclosed appendices are requirements that are incorporated in product development and ship design, along with designers’ implicit knowledge. Hence, it is necessary to include internal requirements in existing data bases, which handles requirements at Kockums AB, and enclose them in project specific requirements. This means that environmental aspects will be interwoven with the existing process, which is how Jönbrink et al. (2011) suggest that ecodesign should be conducted.

As Arbin, Johansson, Karlsson & Möller and Lindström (2012) points out, there are no tools or methods that are actively used in order to incorporate environmental requirements or aspects in the PDP at Kockums AB. Consequently, the LEAP, and the included tools, is needed. Even though a design checklist exists at Kockums AB, it is not extensively used according to Arbin, Lindström and Nilsson (2012). The design checklist is a tool which can ensure that vital product requirements are met and includes a few product related environmental aspects.

There exist an environmental handbook at Kockums AB (Peterson, 2012) which can support employees in their daily work. It is, just as the design checklist, not used a lot. However, it is accessible when needed. Though, it includes many different aspects regarding environment and not only product related environmental aspects. Empirical findings clearly show that there is a need for tools, which can facilitate more environmentally conscious decisions for designers in the product development.

7.3.3 Where should Environmental and Recycling Aspects be Integrated at Kockums AB?
As Jönbrink et al. (2011), Lindahl (2006), Tischner et al. (2000), International Organization for Standardization (2011) and Luttropp & Lagerstedt (2006) all state, environmental aspects need to be included early on in the product development. Freedom of decision making is large in early stages (Jönbrink et al., 2011; Lindahl, 2006; Tischner et al., 2000). Lindahl (2005) illustrates in the design paradox how freedom of action decreases as product knowledge and modification cost increases by time. The same principle applies to DfR (Nilsson, 1998). This depicts how important it is to integrate supporting methods and tools in early PD. Ekvall (2012) states that environmental aspects were not handled early on in the design during Project Schiff, which would have been desirable. Hence, Project
Schiff is an example that shows how important it is to include environmental aspects, just as any other, in early product development.

As stated, Jönbrink et al. (2011) argue that environmental aspects should be interwoven with the existing process in order to be successful. International Organization for Standardization (2011) suggests that an analysis of environmental and legal requirements ought to be completed in the planning phase of PDP, and the organization also states that environmental aspects should be considered in design reviews. Hence, several of the suggested Actions are to be included in the existing PDP and DRs. Environmental requirements need to be included in requirement specifications according to Jönbrink et al. (2011), which also was expressed by Nilsson (2012), and discussed in early stages of conceptual design. Therefore, these two aspects are taken into account in the LEAP.

7.4 LEAP for Integration of Environmental Aspects

With the answers to the first three questions as a reference point, the fourth research question; *What kind of tool/document/method is suitable for Kockums AB in order to pursue environmental issues?*, is answered. Following sub-questions provide answers and arguments to what needs to be included in the LEAP in order to fulfill the objective of this research. Moreover, it is illustrated how this result should be set up so that it can go well with Kockums AB’s existing processes.

7.4.1 What needs to be Included in the Tool/Document/Method?

According to the study conducted by Ammenberg & Sundin (2005a) companies feel that they have little influence on their products since customers micromanage requirement specifications. This may apply to Kockums AB, since interviews at Design & Engineering departments showed that there is a large focus on the provided requirement specifications, which are very complex and comprehensive already at the start of PD. Consequently, it is important to include simple tools, which are easy to use and understand. In this way, ecodesign is facilitated instead of changing focus from the product to how to use the ecodesign tools. Risks with too complex tools are that they are not used or that they become more important than the goal itself according to Lindahl (2006). The LEAP was, for that reason, developed to include several Actions, and worksheets or documents, for an easier implementation and use of ecodesign. The tools and methods, which are included in the LEAP, are hence meant to facilitate product development and should not be obstacles but instead help designers and employees to make environmentally conscious decisions.

**Action 1: Environmental Management Group (EMG)**

In the green sub-project case studied by Johansson & Magnusson (2006), the main issue, summarized in implication 2, was the difficulty of knowing who was responsible for the fulfillment of the environmental requirements. Since unclear responsibilities and mistakes due to communication failures exist at Kockums AB according to empirical findings, a green sub-project is not to recommend. On the contrary, the suggested EMG should work as a support group rather than an operative group. The other four implications, highlighted by Johansson & Magnusson (2006), when implementing a green sub-project are more advantageous; puts environmental considerations on the agenda, acts as a communication area, serve as a platform for environmental champions, and serves as means for environmental specialists to be integrated in the PD organization. These positive implications can take place if an EMG would be fully established and realized. When following-up on the case of the green sub-project, Magnusson (2012) explained that the operative green sub-project was changed into a group managed by the use of a staff function instead. This way of managing the group is comparable to the suggested EMG in the LEAP’s Action 1. Peterson (2012) also believes the EMG to be a permanent means and not a part of one project.

The EMG is suggested to be a part of the KRAFT project and Magnusson (2012) have various arguments that support this proposal. Magnusson (2012) states that members of an environmental group, such as EMG, should have the ability to effectively mediate information within company.
Further, he argues that the group should be legitimated by top management hence their support will permeate and shine through to the rest of the company. Besides being prioritized by top management, Magnusson (2012) argues that environment should be a part of the daily work. Additionally, a clear strategy, as to why an EMG is formed, should be presented. As a result, designers can understand why they are to realize environmental work that might seem unnecessary and time-consuming to them. Furthermore, making the environmental work visible is essential (Magnusson, 2012) and KRAFT is an excellent platform for making that a realization. Employees should feel that they can make a difference (Magnusson, 2012), and this is an aspect that already is integrated in the KRAFT-project, since the intention is that everyone can effect and will be affected by it, in a positive way.

Goals for products’ environmental performance should be set according to ISO 14001 (Furuhielm, 2000). However, that is not the case at Kockums AB since there is a distinction between the product design and EMS, which is not an unusual situation according to Eagan & Pferdehirt (1998, referred to in Furuhielm 2000). Therefore, ISO 14006 should be adapted in order to put more focus on the products. Furthermore, right people should be involved (Ammenberg & Sundin, 2005a), which is why an EMG is needed in order to pursue the LEAP in accordance with ISO 14006. As the empirical study showed, the cooperation between different disciplines at Kockums AB can be improved. For instance, Åkesson (2012) mentioned that ILS receives more attention now than previously but the communication still needs to be improved. Furthermore, the communication between the Procurement and Design & Engineering departments is currently not satisfying (Rodin, 2012), which leads to ambiguous opinions (Johansson, 2012; Karlsson & Möller, 2012; Lindström, 2012; Rodin, 2012). Hence, the establishment of a cross-functional EMG could not only facilitate ecodesign implementation but also strengthen the connection between different departments at Kockums AB, resulting in a more effective and efficient PDP.

Action 2: Revised Environmental Policy
According to the International Organization for Standardization (2004) the environmental policy should be a public document. Today, Kockums AB’s environmental policy can be found on the public website but it is not as easy accessible as desired. Furthermore, the empirical study implied that the current environmental policy was vague hence it was revised and extended in accordance with the ISO 14001 and ISO 14006 standards. The new and revised environmental policy was developed as a separate document to facilitate easy publication on the website. The document contains the policy in Swedish and also in English to make it available for international stakeholders.

Action 3: Revised Environmental Objectives and Targets
Furuhielm (2000) stresses that goals should be set for products’ environmental performance. This was not established in the existing environmental objectives at Kockums AB. Environmental targets are of great importance if ecodesign is to be implemented. When formulating the environmental objectives and targets related to the product, they were set up in consistency with the requirements in ISO 14001, which means that they have to be measureable, feasible, and in line with the suggested environmental policy (International Organization for Standardization, 2004).

Action 4: Communication Plan
International Organization for Standardization (2002) highlights the importance of having a communication strategy, both an external and an internal. Clarifying the environmental policy and have it easy accessible to the public is a way to communicate Kockums AB’s environmental strives externally. The policy should also be placed visibly at the intranet Kabinet. Moreover, Kockums AB should work out clear internal and external communication strategies. Currently, there are no communication plans established when new projects commence. After analyzing the interviews it could be concluded that the communication needs to be improved. For instance, Rodin (2012) pointed out that design changes was not always mediated to the personnel at the Procurement department leading to misunderstandings with suppliers and delays in production. It is important that
communication works well, for instance between Design & Engineering departments and Procurement department, if good quality products shall be developed in right time to the agreed price, which is Kockums AB’s aim according to their public website (Kockums AB, 2010). For this reason a communication plan is suggested as one of the Actions to facilitate communication during projects and serves to clarify responsibilities. Clarified responsibilities were showed to be a critical aspect, in Johansson & Magnusson's (2006) case study, when including environmental issues in a company’s procedures.

Action 5: Color List of Forbidden and Restricted Substances

In most cases materials, or rather components, are predefined by Kockums AB’s customer, or there is an open dialogue about material selection, according to Lindström (2012). If not, materials that fulfill military and performance requirements are selected by designers. This shows that designers’ perspective, when making material selections, need to be broaden in terms of environmental consciousness. Lutropp & Lagerstedt (2006) states that a starting step for integrating ecodesign aspects in product development is to use colored checklist for forbidden and restricted substances as support when making material selections. Interviews with Design & Engineering departments showed that there is no such internal list. However, there is a list of forbidden and restricted substances provided by the customer FMV, defence sector’s criteria document, which needs to be followed according to Environmental Coordinator A at FMV (2012). Since FMV is Kockums AB’s main customer their list is suitable to use as foundation when establishing a “Kockums AB specific” color list. Furthermore, the Hong Kong Convention’s Appendix 1 and 2 should also be considered in order to have a proactive approach towards possible future legislation when developing the color list. In this way, the color list can be further adapted to the maritime industry.

Performing ecodesign can stimulate innovation (International Organization for Standardization, 2011). By having designers thinking in new ways the possibility of finding new solutions, that only Kockums AB offer, is enhanced. A positive effect of this is an increased competitive advantage. Hence, having to choose materials that are not banned or restricted can boost research in the area of ship design.

The study by Ammenberg & Sundin (2005b) shows that it can be problematic to involve and motivate designers in environmental issues. It is argued by Allione et al. (2011) that designers play an important role for the environmental performance of products, especially when making material selections. It is also argued that, due to a lack of knowledge on environmental matters, decisions are based on technical or economical performance. This corresponds to the reality at Kockums AB. Lindström (2012) makes it clear that the performance of the product is prioritized. A color list can facilitate making decisions, regarding material selection, environmentally conscious. Hence, designers’ environmental knowledge can increase, which, otherwise, is a hurdle to overcome according to Ammenberg & Sundin (2005b) and Lindahl (2006).

Action 6: Ecodesign Guidelines

Another tool that can be used as support during product development is ecodesign guidelines. The ecodesign guidelines, presented in Appendix I, that were compiled from different authors have been narrowed down and prioritized according to how well they suit ship industry, Kockums AB, and Kockums AB’s needs. The guidelines have been verified by Jonasson & Petersson (2012) at Stena Recycling to ensure that there are no guidelines that are not applicable for the ship industry from a recycling point of view. This was an important input since the design otherwise might get optimized for a waste management method that is not used (Nilsson, 1998; Rose et al., 2002). For instance, dismantling of ships is most often done with large scissors and not by disassembly (Jonasson & Petersson, 2012), thus some Design for Disassembly guidelines are not important to consider. However, placing materials in right areas depending on the material content (Jönbrink et al., 2011; UNEP & TU Delft, 2006) and not mixing non-compatible materials are important (Jonasson & Petersson, 2012). Since FMV required a recycling manual to be established in Project Schiff (Ekvall,
2012; Nyström, 2012), and will keep require this according to Environmental Coordinator A and B at FMV (2012), the aspect of DfR in ecodesign has especially been be addressed.

**Action 7: Education and Training**

According to Ammenberg & Sundin (2005b), a company that has little knowledge in the area of ecodesign might run into problem when trying to introduce environmental work related to products. Empirical findings show that employees of Kockums AB do not have implicit knowledge regarding ecodesign in the same way they have implicit expert knowledge regarding ship design, as Lindström and Nilsson (2012) highlights. Ekvall (2012) also points out the fact that Kockums AB is not used to handle environmental requirements, such as the ones demanded in Project Schiff. Therefore, education and training is necessary and is, according to Johansson (2002), a success factor for implementation of ecodesign. Moreover, theoretical findings clearly show that knowledge in ecodesign is very important for designers in order for them to make well thought-through ecodesign decisions.

**Action 8: Recycling manual**

Jonasson & Petersson (2012) emphasize the importance of a comprehensive documentation of the material content in the ship and that this documentation is kept updated throughout the ship’s operating life. This is also a requirement of the Hong Kong Convention, as well as for DNV’s class notification ”Recyclable”. Documentation that enables an easier recycling should be aimed for at Kockums AB, especially since FMV requires a recycling manual. At first, Kockums AB should set up a procedure to follow in order to complete FMV’s recycling manual. The Hong Kong Convention’s requirements for establishing an IHM should also be considered in that procedure, so that possible future legislation is met. As a second step, EMG should further develop the recycling manual with the intention of creating a ‘Kockums AB standard’ that can be provided to all customers.

When looking at EoL aspects, Furuhjelm (2000) states that it is difficult to predict how recycling techniques will look like in the future since there is a large time gap between design of a product and EoL. This is especially true for ship design since ships have a life span of 25-30 according to Mikelis (2007). Since most of Kockums AB’s ships are made out of carbon fiber they are more robust and will probably have even longer life span. The recycling manual is therefore more of an inventory of materials than a description of what techniques to use when recycling.

By offering a recycling manual to customers, similar to, or the same as, the one developed by FMV, Kockums AB will have a competitive advantage since they are then able to offer something that is unique. Increased competitiveness is known to be an advantage deriving from ecodesign (International Organization for Standardization, 2011).

Since Kockums AB’s ships often contains hazardous or residues of hazardous substances in hull, according to Karlsson & Möller (2012), it is difficult to reuse the product entirely. However, in a future perspective a higher level of the European Commission's (2012) waste management hierarchy should be considered, since recycling is not the most preferable waste management option. The concept of TLS (Through Life Support) that is under further development at Kockums AB, should take the hierarchy into account. Moreover, if TLS is fully implemented it will be easier to keep IHM’s of ships updated.

As stated, the main consequence of enforced Hong Kong Convention, for Kockums AB, would be that material inventories (IHM), of hazardous and potentially hazardous substances, for ships will be legally required for the ship developer to provide (Höfnell, 2012). However, since naval ships are excluded from the convention, Kockums AB is not troubled by it. Nevertheless, it is possible that they will be affected in the future, which is why it is of importance to focus on acquiring extensive data from suppliers regarding purchased components. Furthermore, having access to material inventories will facilitate calculations in LCA, if such a tool is desired to be used in the future.
**Action 9: Procurement Department’s Contribution to Ecodesign**

Large parts of the ships developed and produced at Kockums AB are made of parts and systems that are directly bought from supplier, according to empirical findings. Consequently, it is of importance that the suppliers are developing environmentally sound components in order for Kockums AB to deliver environmentally conscious products. For instance, Kockums AB needs to put demands on their suppliers in accordance with constitutions such as REACH and RoHS, according to Ekvall (2012). Moreover, the revised environmental policy needs to be communicated to the suppliers in order for them to be aware of the environmental work at Kockums AB and the requirements that will be demanded as a consequence.

At the procurement department, one aim is to decrease the number of suppliers (Rodin, 2012) and in that process it is vital to have environmental aspects as a part of the evaluation. Ekvall (2012) pointed out that one of the requirements in Project Schiff was that suppliers needed to be environmentally approved, for instance have an EMS, and the Procurement department should continue with that work started. The environmental strategy of the Procurement department has been revised and improved in this research. Environmental targets in line with the company’s overall environmental objective and targets, which are specific and measurable, have been added. Since these targets are measurable, and hence tangible, it will be easy to measure the progress, which will increase motivation among employees. Personnel’s motivation is stated as an important aspect for ecodesign by Luttropp & Lagerstedt (2006).

**Action 10: Employ an Environmental Champion at ILS**

Because of the lack of knowledge in environmental work a new employment is recommended. An environmental consultant was assigned the recycling manual in Project Schiff (Ekvall, 2012; Nyström, 2012). When the project is completed the experience and knowledge will not be kept within the company and, according to Nyström (2012), difficulties with retaining lessons learned is an acknowledged problem at Kockums AB. Moreover, since no feedback is attained from customers after ships have been delivered, no knowledge of the outcome of the ship design can be transferred to future projects (Johansson, 2012).

Johansson (2002) emphasizes the argument of motivation connected to the presence of an environmental champion as a success factor for implementation of ecodesign. The environmental champion should not only be an employee at ILS, responsible for the recycling manual, but also a member of the EMG. Since the work with the compilation of the recycling manual will only be carried out in certain phases of the PDP the environmental champion should be the head of the EMG.

**Action 11: Pre-study EEA**

The suggested Pre-study EEA is meant to act as an incremental implementation of EEA. The Pre-study EEA consists of the first two phases of EEA (Lindahl & Tingström, 2001), but with minor modifications of the original worksheet used in the inventory phase. The intention of the Pre-study EEA is that it should work as a platform for discussions about products’ environmental performance in the early stages of PD. Paying attention to environmental aspects early on in PD highlights the importance of the issues and can contribute to more conscious decisions made by the designers.

**Action 12: Fast Five**

Philips Fast Five-Checklist gives a quick and qualitative assessment of the environmental performance of a product (Tischner et al., 2000). According to Tischner et al. (2000), the method can be used at strategic management level. A success factor for ecodesign is having the management support and commitment (Johansson, 2002; Magnusson, 2012). If management is involved, by including a Fast Five, derived from Philips’ method, at early design reviews, ecodesign is more likely to succeed. Improved environmental awareness regarding products at top management also facilitates establishment of appropriate environmental objectives and targets.
Action 13: Ecodesign Checklist

The suggested ecodesign checklist incorporates the environmental checkpoints of the existing design checklist. In addition, it is expanded with further important environmental requirements deriving from literature studies, future legislations, and external interviews. In order for the ecodesign checklist to be used, it has to be incorporated in the existing processes at Kockums AB and/or be enclosed as an appendix in the requirement specification, which Nilsson (2012) suggests. Therefore, the ecodesign checklist should be used at the Design Reviews to explicitly pay attention to ecodesign aspects and their fulfillment.

Checklists are an example of a support tool (International Organization for Standardization, 2002) and the suggested ecodesign checklist is modified to match the Fast Five checklist. The ecodesign checklist should be used for each system in the ship design and the results are then to be used as support for top management when answering the Fast Five checklist for the whole product. In this way, a well supported result can be achieved thanks to the solid foundation from the ecodesign checklist.

Action 14: Eco-toolbox

Ecodesign tools should be easy accessible for all employees of Kockums AB. An eco-toolbox, set up according to the one presented by Tischner et al. (2000), should be introduced. The eco-toolbox should contain Kockums AB-specific ecodesign tools, which can be accessed through the toolbox that ought to be placed, visible, at Kabinet. By presenting the available tools in categories, in the same way as Tischner et al. (2000), designers can easily navigate and find a tool suitable to support the work task they are to perform.

Action 15: Further Education and Training

In Action 7 above, the reasons for education and training were stressed. Hence it is of importance to have further education and training. As Lindahl (2006) states, tools that are not used will easily be forgotten about. Therefore, continuous training is vital in order to keep up the environmental work and motivation. To provide employees with further education can also be considered a sign of support from top management.

Action 16: Product-FMEA (Failure Mode and Effect Analysis)

According to theory it is easier to implement EEA if FMEA is already used at a company since there is no need of learning a new tool (Lindahl & Tingström, 2001). Although, that is not applicable in Kockums AB’s case since FMEA is not carried out. However, Nyström (2012) believes that conducting a FMEA at the early stages of PD can be beneficial for Kockums AB. Even though FMEA is not established at Kockums AB it can be argued that implementation of both FMEA and EEA should be done at the same time because of the similarities.

Action 17: EEA

The implementation of a full-scale EEA will offer a qualitative way of finding out the largest environmental impacts of a product (Lindahl & Tingström, 2001). By studying the whole lifecycle of the product the right ecodesign efforts can be made, not only with focus on recycling aspects.

Action 18: LCA (Life Cycle Assessment)

This research has only covered the recycling aspects of the product’s lifecycle, because of recent requirements from customers. To fully implement ecodesign, the whole lifecycle should be considered (International Organization for Standardization, 2011). The total environmental impact of a product should be assessed to ensure that ecodesign efforts are focused correctly. Nonetheless, by starting the implementation of ecodesign by establishing a recycling manual for the ship that inventory conducted, for the manual, can facilitate for an easier introduction of a tool like LCA. Since ships have a long operating life (Mikelis, 2007), carrying out a LCA could be very useful when it is time for midlife
conversion. The quantitative nature of the LCA, compared to EEA, is also an advantage if the result is desired to be used for marketing purposes.

The LEAP

As Ammenberg (2003) and Gibson (2005) points out, it is not certain that better environmental results will be accomplished if an EMS is implemented. This applies to the LEAP as well, merely to follow the LEAP as a roadmap will simply not be enough. The Actions presented in the LEAP are developed according to ISO 14006 with the success factors presented in Johansson’s (2002) literature review as support. Table 10 below shows how the suggested Actions link to the different success factors and areas of concern and in Appendix K further explanations are provided. According to the literature review the three most frequently mentioned success factors are; ‘Commitment and support are provided’, ‘Education and training are provided to the product development personnel’ and ‘An environmental champion exists’. Support from top management is a significant success factor according to International Organization for Standardization (2002) as well. Best practice cases in ecodesign, presented by Magnusson (2012), further emphasize the importance of top management support and that it is beneficial to be proactive. Additionally, the same best practice examples imply that it is possible to succeed with ecodesign in industries that are not mass-producing, e.g., at Kockums AB. International Organization for Standardization (2002) further states that the two most important tasks for top management are strategic planning and manage internal process in order to ensure that ecodesign is well integrated into processes. Therefore, it is vital that top management addresses these issues as well as give their full support to the EMG in order for them to be legitimated when pursuing the LEAP. Moreover, it is important to integrate ecodesign in management reporting, practice, and thinking, which is why Fast Five ought to be followed through. The bottom line is that it is significant that ecodesign permeates both at management level and design level. Hence the LEAP aims to ensure that actions are taken from top-down, as well as from bottom-up.

Table 10. Summary of how success factors are connected to suggested Actions in the LEAP.

<table>
<thead>
<tr>
<th>Success factor</th>
<th>Action/LEAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commitment and support are provided</td>
<td>Action 1/LEAP-1401</td>
</tr>
<tr>
<td>Clear environmental goals are established</td>
<td>Action 3/LEAP-1403</td>
</tr>
<tr>
<td>Ecodesign are not only treated on an operational level, but also on a strategic level</td>
<td>Action 12/LEAP-1409</td>
</tr>
<tr>
<td>Close supplier relationships are established</td>
<td>Action 18</td>
</tr>
<tr>
<td>Environmental issues are considered at the very beginning of the product development process</td>
<td>Action 11/LEAP-1408 and later Action 17</td>
</tr>
<tr>
<td>Environmental issues are integrated into the existing product development process</td>
<td>LEAP</td>
</tr>
<tr>
<td>Environmental checkpoints, reviews and environmental milestone questions are introduced into the product development process</td>
<td>Action 11/LEAP-1408, Action 13/LEAP-1410 and later Action 17</td>
</tr>
<tr>
<td>Company-specific environmental design principles, rules and standards are used</td>
<td>Action 6/LEAP-1406</td>
</tr>
<tr>
<td>Support tools are applied</td>
<td>Action 14 including LEAP-1404, LEAP-1405, LEAP-1406, LEAP-1408, LEAP-1409, and LEAP-1410</td>
</tr>
<tr>
<td>Education and training are provided to the product development personnel</td>
<td>Action 7 and later Action 15</td>
</tr>
<tr>
<td>An environmental expert supports the development activities</td>
<td>Action 1/LEAP-1401 and Action 10</td>
</tr>
<tr>
<td>An environmental champion exists</td>
<td>Action 10</td>
</tr>
</tbody>
</table>

The other two, of the three, most frequently mentioned success factors have shown to be of importance in the empirical findings. Currently, there are no employee at Kockums AB that has a strive for
environmental issues and can be considered as an environmental champion, according to Nyström (2012). However, this is vital in order for employees to motivate each other in ecodesign. A new employee, an environmental champion, will contribute to an increased knowledge since employees learn a lot from each other. Education showed to be an important factor, especially when first handling ecodesign (Ammenberg & Sundin, 2005b). Hence education and training will also increase the employees’ knowledge in product related environmental areas. As a result, an increased motivation and environmental awareness is aspired.

All in all, the three most frequently mentioned success factors in Johansson’s (2002) literature review showed to be important in the case study of Kockums AB. Consequently, all three success factors are well included in the suggested LEAP.

One incentive for integrating ecodesign into EMS is that, as studies by Ammenberg & Sundin (2005a) shows, it can be profitable. Moreover, if environmental aspects are included in a structured way from start, unnecessary expenses can be avoided. Companies with EMS should have these aspects integrated in their processes. Nevertheless, product development are often excluded in the management systems, according to Ammenberg & Sundin (2005b). In order to strengthen the connection between ecodesign and EMS, Ammenberg & Sundin (2005b) highlights three factors; emphasizing customer demands, tougher legislation, and simpler tools and better databases. These factors give grounds for the suggested LEAP. Kockums AB is already good at fulfilling customer demands, according to the empirical findings from the conducted internal interviews. Tougher legislation may enter into force in terms of the Hong Kong Convention. However, it excludes naval ships. Nevertheless, it is of importance for Kockums AB to take these requirements into account which is why the LEAP includes actions and tools as recycling manual, ecodesign checklist, and ecodesign guidelines. Lastly, the LEAP already consists of simple tools as mentioned. A suggestion for Kockums AB is to purchase established tools and databases to facilitate carrying out the LEAP. In conclusion, the result will be a strengthened connection between ecodesign and EMS.

7.4.2 How can the Tool/Document/Method be Designed to go well with Kockums AB’s Existing Processes and how should the Implementation Process be set up?

As mentioned, the EMG is suggested to be a part of the KRAFT project. Revision of and making processes more efficient is a part of KRAFT (Källén, 2012). By making the EMG a part of the same adaptation program, the changes regarding environment would automatically be carried out in accordance with the existing processes. Moreover, the KRAFT project is all about changes and improvements which also reflect the nature of environmental work and therefore the EMG would be a natural part of KRAFT.

Vezzoli & Sciama (2006) highlight the importance of customizing tools and methods to suit the company and the company’s procedures. Furthermore, they state that in order to successfully accomplish this, extensive knowledge about the company, its procedures, and the company environment is needed. An extensive empirical study was carried out to ensure that the researchers had a sufficient level of knowledge about the company when developing the LEAP. The LEAP was also verified in a focus group with employees of Kockums AB. However, it is vital that an employee with extensive knowledge within the above mentioned areas about Kockums AB continues with the LEAP and revises it. This person should be a member of the EMG and work together with the group to ensure that the LEAP and its included tools and methods are well customized to suit Kockums AB.

The suggestions of tools, in the LEAP, were done with an aspiration for them to not be too time consuming since tools which are too complex are less used, according to Lindahl (2006). The tools, documents, and methods that are suggested to be implemented first hand, higher priorities in the LEAP, are therefore easy to use and support the daily work. As the employees at Kockums AB gain more knowledge and the processes are settled, more complex tools can be introduced. The
tools/documents/methods are also developed with the existing PDP in mind and are therefore designed to be used at DPs and as support when needed during the process.

Johansson (2012) stresses that most decisions are made in early stages of design process and environmental aspects need to be integrated at that point, since it will be too expensive to make changes otherwise. Further theory, as stressed earlier, confirms the argument that ecodesign need to be integrated early on in PD (International Organization for Standardization, 2011; Jönbrink et al., 2011; Lindahl, 2006; Luttropp & Lagerstedt, 2006; Tischner et al., 2000). Thus, tools in the LEAP, such as ecodesign guidelines, are suggested with the aim to facilitate decision-making in, and be helpful in, early stages of PD in order to make environmentally conscious decisions.

As stated by Gibson (2005), an EMS can facilitate integration of environmental issues at companies. Kockums AB introduced ISO 14001 as a part of the existing processes and the intention, and suggestion, is to introduce LEAP in the same manners. The implementation should be done according to the methodology for introducing POEMS; integrating ecodesign aspects into the EMS. The methodology is based on the plan-do-check-act principle (Ammenberg & Sundin, 2005a), which is the basis of the continual improvement philosophy which impregnates ISO 14001 (Comoglio & Botta, 2011). Since Kockums AB has an established EMS (Peterson, 2012) the implementation of product related environmental work can, according to Charter and Clark (1999 referred to in Furuhjem, 2000), run smoother. Furthermore, the already implemented EMS brings experience in working in line with the plan-do-check-act methodology, which makes the POEMS methodology familiar to Kockums AB. In step 2 of POEMS it is of importance to ensure that conducting ecodesign is in line with the company’s visions and strategies, as well as have top management support. Top management support is highlighted as one frequently mentioned success factor in Johansson’s (2002) literature review, as stated earlier. The literature review and interview regarding best practice examples conducted in this research also shows that top management is one of the most important aspects for successful implementation of ecodesign.

7.4.3 How could the Tool/Document/Method help Increase the Awareness of the Employees on a Daily Basis?

The KRAFT project has many information channels (Kockums AB, 2012) and Magnusson (2012) emphasizes mediation of information to employees as a key factor for successful implementation of ecodesign. The integration of the EMG as a workstream in KRAFT would therefore make it easier to inform employees about ongoing environmental work and consequently obtain an increased awareness.

Karlsson & Luttropp (2006) present the obstacle of changing the environmental interest from external to internal. As assessed earlier, environmentally driven aspects derive mostly from customers hence the interest is external. The LEAP will facilitate employees’ environmental work since it contains tools and support. As a consequence, the expectation is that employees will have greater understanding and knowledge about ecodesign and the environmental interest will become internal. Education, as suggested in Action 7, is another aspect that will increase the knowledge and interest of ecodesign.

If environmental aspects are integrated in the existing product development process, the expectation is that the implementation will be smooth. This was the idea when requirements for ISO 14001 were implemented, according to Peterson (2012). Interviews at the Design & Engineering departments (Arbin, 2012; Johansson, 2012; Karlsson & Möller, 2012; Lindström, 2012; Nilsson, 2012; Åkesson, 2012) showed that the ISO 14001 was successfully implemented since it was not disturbing their normal working procedure. However, it can be argued that the reason for the implementation not disturbing the daily work was because of the limited knowledge of what an EMS is and how it affects the daily work. Education in not only ecodesign but also in EMS would facilitate an increased awareness related to the daily work tasks.
Having a cyclic implementation process, as the POEMS methodology described above, helps increase the environmental awareness gradually. In this way, the level ”save costs”, which was an expressed wish of Edvardsson and Kallén (2012), can be aimed for at first and in following cycles the environmental ambition can be aimed higher.
The concluding chapter summarizes the research’s result and answers the RQs, stated in chapter one, with help of the comparison and analysis that was presented in chapter 7. In the end, a final conclusion that satisfies the objective of this M.Sc. thesis will be provided.

8.1 RQ1: WHAT ENVIRONMENTAL PRODUCT REQUIREMENTS ARE KOCKUMS AB DEMANDED TO FULFILL?

Kockums AB is demanded to fulfill various environmental product requirements, which are mostly customer requirements and external requirements from classification societies’ frameworks. Customer requirements are based on legislations and regulations, which mean that those external requirements are automatically taken into account in the process of designing ships at Kockums AB. Requirements from the classification societies’ frameworks are external, but they can also be considered as customer requirements as well as internal requirements. Most times, customers demand a specific framework to be followed. If that is not the case, a framework is still followed since it is a guarantee that the ship has been developed according to a good standard hence the quality of the ships is good, which also is one of Kockums AB’s objectives.

A pressing environmental requirement, that might be of interest in the near future for Kockums AB, is deriving from the Hong Kong Convention. The requirement will mean that an Inventory of Hazardous Materials (IHM) needs to be developed and maintained for ships. This requirement is similar to the recycling manual, which is demanded from Kockums AB’s main customer, where knowledge about material content in the ship design is of utmost importance. Moreover, an IHM is demanded if the environmental class notation from the classification body DNV is desirable.

In conclusion, the environmental requirements that Kockums AB are demanded to fulfill, which are considered to be most important, are the customer demand of completion of a recycling manual and fulfilling of a classification societies’ framework. Consequently, knowledge about material content and the ability of setting up an IHM are important aspects for Kockums AB to consider.

8.2 RQ2: WHAT LEVEL REGARDING ENVIRONMENTAL ISSUES IS SUITABLE TO AIM FOR AT KOCKUMS AB?

Operational management’s opinion and interviews with Design & Engineering employees show that a suitable environmental ambition, in the future, for Kockums AB would be to “save costs”. At the moment, Kockums AB does not have the competence or knowledge in ecodesign that is needed to aim higher. First and foremost, empirical findings showed that the Environmental Management System of ISO 14001 needs to be mediated to the employees in a better way. Employees need to be informed of the implications of ISO 14001 in order to understand ecodesign and ISO 14006. Moreover, there is a lack of understanding regarding the ambiguous term “environment”. This needs to be clarified; product related environmental issues are not the same as having a good work environment for the employees.

8.3 RQ3: HOW CAN ENVIRONMENTAL AND RECYCLING ISSUES BE INTEGRATED IN THE PRODUCT DEVELOPMENT PROCESS?

In order for environmental and recycling issues to be considered and integrated in the work at Kockums AB, they need to be well implemented in the existing processes. Environmental
requirements need to be added, permanently, to project specific requirements. This means that environmental requirements should be treated in the same manner as any other requirement. Supporting tools and methods should be implemented in early stages of product development to facilitate fulfillment of the environmental requirements. Moreover, theoretical and empirical findings show clearly that there is a need for support from top management in order to successfully implement environmental aspects in a product development process.

8.4 RQ4: WHAT KIND OF TOOL/DOCUMENT/METHOD IS SUITABLE FOR KOCKUMS AB IN ORDER TO PURSUE ENVIRONMENTAL ISSUES?

A Long-term Environmental Action Plan (LEAP) is suitable for Kockums AB since it contains tools, documents, and methods that will support Kockums AB in order to pursue environmental issues. By using ISO 14006 as a guide and setting up the LEAP with the ISO 14006 standard as a foundation, environmental and recycling issues can be introduced at Kockums AB. Especially recycling aspects will be considered since the LEAP supports designers when making decisions that can affect the End-of-Life of ships.

8.5 CLOSURE

The proposed Long-term Environmental Action Plan is a leap for Kockums AB to take in the direction of environmentally conscious design. It includes tools, documents, and methods that are to be used in daily work as well as in product development. Consequently, environmental and recycling aspects will be included in the product development process at Kockums AB. As a result the expectation is that employees’ environmental awareness and interest will increase, along with their knowledge in ecodesign.

8.6 FUTURE STUDIES

One of the delimitations in this M.Sc. research concerned the disregarding of the product’s usage and production phases. However, these phases should be addressed when dealing with ecodesign since the whole lifecycle of a product should be considered. Consequently, a suggestion for further studies or M.Sc. proposals is to investigate these phases further. Moreover, other customers’ requirements, than FMV’s, should be examined and taken into account when striving to be proactive and suggest solutions in order to integrate environmental aspects.

Another suggestion, to study further, is to look into how product development and processes are conducted at BUS and BUMS to modify the result of this M.Sc. research to suit all business units of Kockums AB. This way, this result can be further assessed, verified, and developed. As a consequence, ecodesign can be applied to the entire organization of Kockums AB.

Since ships are made out of large amounts of material that have a high value at the end of the operating life there is a possibility to earn money on controlling the EoL treatment. By establishing a Product Service-System, similar to the TLS which is in place at Kockums AB, ships can be sold on leases. Consequently, better control during the usage-phase of ships will be gained. Moreover, ships will be brought back to the company and money can be earned on taking care of the ships. As a result, feedback from customer, as well as closer customer connections, will be attained. This would also be a motivation to design ships with regards to how they will be recycled or reused, since the own company is responsible for it and makes money off of it. Therefore, it is recommended that Kockums AB sets up a new M.Sc. research which looks into how Product-Service Systems can be applied at Kockums AB.

8.6.1 Further Readings

It is of importance to be up to date in the progress of the Hong Kong Convention’s ratification. It is suggested that the investigation in Sweden at the Enterprise Ministry is contemplated. On 31 August,
2012, a document will be presented at their website\textsuperscript{14} regarding what standpoint Sweden has in the ratification of the Hong Kong Convention. Moreover, the EU’s regulation "Ship Recycling Regulation" is suggested as further readings since it is based upon the Hong Kong Convention with the purpose of a quicker implementation process in the European countries.

Swerea IVF regularly updates their book \textit{Ekodesign – praktisk vägledning}, which has been extensively used in this research. This book is suggested as a starting point for learning more about ecodesign, unfortunately it is only available in Swedish. An English book that is recommended, as further readings, is \textit{How to EcoDesign} by Ursula Tischner, Eva Schmincke, Frieder Rubik, and Martin Prösler.

\textsuperscript{14} \url{http://www.opengov.se/govtrack/utredning/N/2011:02/}
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APPENDIX A – LONG-TERM ENVIRONMENTAL ACTION PLAN (LEAP)

The Long-term Environmental Action Plan (LEAP), which is the ultimate result of this M.Sc. thesis, is enclosed on the following pages. Note that the LEAP is developed specifically for Kockums AB as a separate work document, and hence the LEAP has no page numbers.
Long-term Environmental Action Plan (LEAP)
### Definitions and Abbreviations

| **Action** | The step that should be taken in order to facilitate and create a more sustainable development of products. These Actions can be tools, methods, strategies, or similar. |
| **Change Management** | Approach where the organization is transitioning or shifting from a current state to a desired future state. |
| **Design** | When this term is used in connection with a department it refers to the design departments that are involved in the product development: Vessel Systems, Commercial Vessel, Composite & Technology, Propulsion & Auxiliary System, and Intelligence & Electrical Systems. |
| **Ecodesign** | Integration of environmental aspects into product design and development, with the aim of reducing adverse environmental impacts throughout a product’s life cycle. |
| **EEA** | Environmental Effect Analysis, previously named E-FMEA (Environmental Failure Mode and Effect Analysis). A tool, which works similar to FMEA, where risks and consequences are examined with the objective to identify hot-spot areas where environmental improvements can be done. |
| **Environment** | The term refers a product’s affect on ecological systems with the aim of sustainable development for future generations. In this research, the term does not refer to work environment or environment that the product is effective in, e.g., weather conditions. |
| **Environmental aspects** | Element of an organization’s activities, products, or services that can interact with the environment. |
| **FMEA** | Failure Mode and Effect Analysis is a tool used for identifying risks, causes, and effects with the aim of a final result of higher quality. |
| **Hong Kong Conventionen** | A convention which was accepted by International Maritime Organization (IMO) in 2009, containing rules that cover the entire lifecycle of ships and ship recycling facilities. The convention may enter into force within the next years depending on how many of the member states, of IMO, that ratify the Hong Kong Convention. The convention makes exceptions for naval ships. |
| **ISO 14001** | Standard for certification of Environmental Management Systems. |
| **ISO 14006** | This ISO standard works as support when ecodesign issues are to be implemented in an existing Environmental Management System. |
ThyssenKrupp Marine Systems
Kockums

Table of Contents

Definitions and Abbreviations.........................................................3
Table of Contents...........................................................................5
Introduction..................................................................................7
Prioritization 1 .............................................................................11
  Overview of Actions of Priority 1...............................................11
  Action 1: Environmental Management Group..........................11
  Action 2: Revised Environmental Policy....................................12
  Action 3: Revised Environmental Objectives and Targets............12
  Action 4: Communication plan...............................................13
  Action 5: Color list of forbidden and restricted substances........14
  Action 6: Ecodesign Guidelines...............................................15
Prioritization 2 .............................................................................17
  Overview of Actions of Priority 2...............................................17
  Action 7: Education and Training............................................17
  Action 8: Recycling Manual...................................................18
  Action 9: Procurement department’s contribution to ecodesign....19
  Action 10: Employment of an Environmental Champion to ILS...19
Prioritization 3 .............................................................................21
  Overview of Actions of Priority 3...............................................21
  Action 11: Prestudy-EEA..........................................................21
  Action 12: Fast Five...............................................................22
  Action 13: Ecodesign Checklist...............................................22
  Action 14: Eco-toolbox............................................................23
Prioritization 4 .............................................................................25
  Overview of Actions of Priority 4...............................................25
  Action 15: Further Education and Training...............................25
  Action 16: Product-FMEA (Failure Mode and Effect Analysis)...25
  Action 17: EEA........................................................................26
Prioritization 5 .............................................................................27
  Overview of Actions of Priority 5...............................................27
  Action 18: LCA (Life Cycle Assessment).................................27
Closure ........................................................................................29
Introduction

This document contains a description of a long-term plan of how to introduce product related environmental aspects in Kockums AB’s product development process, ecodesign, in accordance with ISO 140006. The introduction of the Long-term Environmental Action Plan (LEAP) should be incremental and it contains several Actions, which have been prioritized according to what order the implementation of the Actions should take place. These Actions are methods, tools, or aiding means that have the purpose of facilitate ecodesign in the daily work, product development, and mindsets’ of Kockums AB’s employees. The majority of the suggested Actions include worksheets or documents. These worksheets and documents are named as LEAP-14XX, where XX are the specific numbers for the Actions' worksheet or document: from LEAP-1401 to LEAP-1410. The responsibility for implementing the LEAP should be on an Environmental Management Group, which is suggested to be a part of the KRAFT-project. By implementing LEAP, Kockums AB will take a leap in the direction of more environmentally conscious products and hence gain an increased awareness, in the organization, about ecodesign.
Implementation

The process of how this LEAP should be implemented has been developed according to the method of how Product Oriented Environmental Management Systems (POEMS) should be introduced. The method of POEMS is based on the concept of Plan-Do-Check-Act, which is a natural part of ISO 14001, where the concept of Plan-Do-Check-Act often is described as continual improvement. The work is carried out in loops, within which four steps should be completed. By the means of the conducted M.Sc. thesis ‘Integration of Environmental Aspects in Product Development Process and Ship Design’, the first loop was commenced. The first step has been completed and the second step is nearly completed, where the result of the second step is this LEAP. The responsibility of carry on with the LEAP is handed over to Kockums AB, and the company should continue with the last part of the second step in the POEMS-method. This should be done in order to assess and determine what measures are needed to be introduced in a PILOT-project, which should commence in the subsequent step 3.

The Actions, which are suggested in this LEAP, are prioritized according to a scale for ranking from 1 to 5, where 1 is of highest priority. The prioritization has been done with regards to the Actions’ complexity as well as with regards to how easily Kockums AB can implement them and how important it is for Kockums AB to implement them within the nearest future. The prioritization provides guidance on what is suitable to implement initially but does not prevent that work regarding Actions of lower priority commence.

<table>
<thead>
<tr>
<th>1. Product-specific environmental review</th>
<th>2. Responsibilities and procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Identification of environmental impacts/aspects.</td>
<td>- Definition of roles, responsibilities, and authorities for product development.</td>
</tr>
<tr>
<td>- Review of eodesign organization and capabilities.</td>
<td>- Establishment of policies, objectives, and targets</td>
</tr>
<tr>
<td>- Review of the product development process.</td>
<td>- Revision of the product development process. Establishment of procedures for staff involved in product development and other product-related activities.</td>
</tr>
<tr>
<td>- Market investigation.</td>
<td></td>
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</tbody>
</table>

3. Ecodesign projects

- Development of environmentally compatible products with competitive price, performance, and quality standards.

4. Audit/Evaluation

- Revision of existing procedures and products aiming for continual improvement.
Prioritization 1

Overview of Actions of Priority 1

<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Responsible</th>
<th>When</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Environmental Management Group (EMG)</td>
<td>Environmental Manager</td>
<td>-</td>
<td>LEAP-1401</td>
</tr>
<tr>
<td>2</td>
<td>Revised Environmental Policy</td>
<td>Top management</td>
<td>Annual revision</td>
<td>LEAP-1402</td>
</tr>
<tr>
<td>3</td>
<td>Revised Environmental Objectives and Targets</td>
<td>Top management</td>
<td>Annually before new financial years</td>
<td>LEAP-1403</td>
</tr>
<tr>
<td>4</td>
<td>Communication Plan</td>
<td>Project Manager</td>
<td>Start-up of new projects</td>
<td>LEAP-1404</td>
</tr>
<tr>
<td>5</td>
<td>Color list of forbidden and restricted substances</td>
<td>Employees from Design &amp; Engineering departments that are members of the EMG</td>
<td>Continuously in the PDP</td>
<td>LEAP-1405, Hong Kong Convention’s Appendix 1&amp;2</td>
</tr>
<tr>
<td>6</td>
<td>Ecodesign Guidelines</td>
<td>Designers</td>
<td>First phase after &quot;Offer&quot; and continuously in the PDP</td>
<td>LEAP-1406</td>
</tr>
</tbody>
</table>

Action 1: Environmental Management Group

The Environmental Management Group (EMG) consists of representatives from different disciplines within Kockums AB and should pursue, and support, environmental issues in the daily work at the departments.

By establishing an Environmental Management Group, work regarding environmental issues can be extensively pursued and environmental aspects can easier infuse the entire organization.

The Environmental Management Group should consist of representatives from the departments of Environment, Design, Procurement, and ILS. Moreover, it should be considered if more group members should be added from the areas of quality, production, TLS, or the business unit BUMS. The EMG is currently being formed and consists of Rolf Petersson, Jonas Möller and Mikael Rodin, who all work in Karlskrona. However, the group should later be expanded with representatives from Malmö and Muskö. Since a great deal of environmental work is Change Management, EMG should be included as a workstream in the KRAFT-project. By being a part of KRAFT, a clear indication is given within the company that environmental issues are of importance and that change is needed. EMG will, in that case, also have authority to pursue the changes and Actions which are recommended in this LEAP. The EMG’s function and tasks are described in detail in LEAP-1401.

The EMG should continuously pursue environmental work in the daily operation and business. When the LEAP is fully pursued, the EMG will not cease to exist. Instead, EMG will
work as an active and permanent group to where employees can turn with questions and thoughts on environmental issues and ecodesign.

The Environmental Manager is responsible for establishing the Environmental Management Group and for directing the work initially. The intention is that an “Environmental Champion” will be employed to Design & Engineering, preferably to ILS, with the assignment of being responsible for this EMG group in order to unburden the Environmental Manager.

If an Environmental Management Group is instated in KRAFT, environmental issues can be brought up in a clear manner and the status of environmental work can more easily be communicated and mediated to the employees. A cross-functional group is a must in order to succeed with the work regarding environmental issues since it ranges over several disciplines.

**Action 2: Revised Environmental Policy**

A company’s environmental work, its range and direction, is summarized in an environmental policy. The environmental policy should be determined by top management and be known to all employees, as well as being accessible to the public.

The purpose of the environmental policy is to indicate and show, internally and externally, how Kockums AB is actively working with minimizing the adverse impact on the environment in the company’s operation and business.

The environmental policy should, according to ISO 14001, describe that laws and other requirements are observed. The policy should also focus on the environmental impact, specific for the company, and show how work with continual improvements and preventive work are carried out. The environmental policy should create a framework within which environmental targets and objectives can be established.

The existing environmental policy has been revised, to be clearer, as well as expanded, and it can be found in LEAP-1402. The environmental policy is in English and in Swedish, and in a separate document so that it easily can be published on Kockums AB’s public homepage.

The environmental policy should be reviewed annually and, at the same time, be assessed by the top management. The top management is responsible for making sure that the policy is mediated to the all employees who work at and for the company.

Through a well formulated and worked through environmental policy, Kockums AB can show their employees and the public that environmental issues are pursued and that environmental aspects are an important part of the business. This can give competitive advantages and it makes Kockums AB an even more attractive employer.

**Action 3: Revised Environmental Objectives and Targets**

In order to pursue the environmental work that is described in the environmental policy, measurable objectives and targets are established for relevant disciplines and on suitable levels in the company.

The purpose of establishing environmental objectives and targets is to reach an environmentally sustainable development in the long run.
The environmental objectives and targets should, according to ISO 14001, be measurable, feasible, and correspond to the environmental policy. For every environmental objective and target, there should be a plan of action, where it should be described who is responsible for fulfilling the established objective and target, how it should be accomplished, and within what timeframe the objective and target should be completed.

The environmental objectives and targets for 2011/2012 have been reviewed. Additional environmental objectives and targets have been added in accordance with ISO 14006, which relate to the product and the product development process. The environmental objectives and targets should be accessible via Kabinet, just as they are today. However, links to the plans of action should also be available for everyone within Kockums AB. It is important that all employees of Kockums AB are well aware of what objectives and targets exist so that they can be fulfilled with joint efforts. The environmental objectives and targets for 2011/2012 with the added product related environmental objectives and targets can be found in LEAP-1403.

Kockums AB should establish all-embracing and detailed environmental objectives and targets from the current situation in which the company is in with regards to what level of ambition that is believed to be suitable. The environmental objectives and targets should be revised and renewed before every new financial year. The employees of the company should contribute to the composing of the environmental objectives and targets. The top management is then responsible for legitimate and authorize the suggested objectives and targets.

With product related environmental objectives and targets, Kockums AB can be a part of and contribute to an environmentally sustainable development that reaches outside of the walls of the shipyard.

**Action 4: Communication plan**

A clear communication plan that is continuously updated makes it easier to avoid inadequate communication, which could otherwise lead to expensive mistakes. Moreover, clear channels of communication can support environmental work, which is dependent on collaboration in order to accomplish a successful result.

Several decisions within projects are affecting numerous people and as a consequence of this, changes in, for instance, procurement processes or design, need to be made. It is therefore important to inform and communicate, which is what the communication plan intends to facilitate.

A clear communication plan should be established in every project, and it should be visible and accessible for all affected parties. A communication plan for each project should be available at Kabinet. There should be distinct instructions of how communication should take place and there should also be instructions on who is responsible for what. In this way, it is clarified who should be contacted if questions arise. In LEAP-1404, there is a template that should be used when forming a communication plan for a project.

In the beginning of every new project, a clear communication plan should be established, in accordance with the template, and it should be enclosed in the project plan.
The project manager is responsible for forming, maintaining, and distributing the communication plan throughout the entire project.

By clarifying communication channels within projects, insufficient communication can be avoided, ecodesign can be supported, and an efficient project with good quality can be carried out.

**Action 5: Color list of forbidden and restricted substances**

A color list of forbidden and restricted substances, in accordance with FMV’s criteria document and the Hong Kong Convention’s Appendix 1 and 2, makes it easier for designers to make environmentally conscious decisions in ship design.

The purpose of categorizing substances according to colors is that it makes it easier to make environmentally conscious decisions.

Companies, such as Volvo, ABB, and Scania, have color lists of forbidden and restricted substances. To have a color list, similar to theirs, makes it easier for designers, as well as for suppliers, to see what substances that should not be used and hence should be avoided. By making the color list public, Kockums AB can mediate a part of the environmental work that is carried out, thus demonstrate the company’s commitment to environmental issues. A color list work as support when making material selections and, for Kockums AB, the list should be developed in line with FMV’s criteria document. The list should also be expanded with substances in the Hong Kong Convention’s Appendix 1 & 2, especially if it is desirable to receive the class notation “Recyclable” from DNV.

- A ‘black list’ should be established for substances that can absolutely not be used, on any condition, in ship design. (forbidden)
- A ‘grey list’ should be established for substances that should not be used, but can be used if exceptions are given. (restricted)
- A ‘yellow list’ should be established for substances that should not be used, but are exceptional cases in naval design and can therefore be used. (exceptional cases)

Categories that should be included in tables for the color list can be found in the example in the table below.

<table>
<thead>
<tr>
<th>Group</th>
<th>Substance</th>
<th>CAS no.</th>
<th>Regulation</th>
<th>Risk</th>
<th>Example of application; type or area of use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Lead chromate</td>
<td>7758-97-6</td>
<td>RoHS directive 2002/95/EC</td>
<td>C, A, E, N</td>
<td>Pigment</td>
<td></td>
</tr>
</tbody>
</table>

The color list should be established as soon as possible since this is an important first step to take in ecodesign. In LEAP-1405 there is a template that should be used when the color list is to be established. All employees that are making material selections are responsible for

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1 FMV’s criteria document can be found at following website: http://fmv.se/sv/Verksamhet/Miljoarbete/Miljokrav-vid-upphandlingar/Forsvarssektorns-Kriteriedokument/
updating the color list. However, the person who is ultimate responsible for the color list is the
appointed member from Design in the Environmental Management Group.

The color list should be used continuously by designers during the entire product
development process when material selections are being made.

By having color a list, Kockums AB clearly indicate that the company, just as other large
companies, are well aware of the fact that the world is going in the direction of
environmentally sustainable development and that environmentally conscious material
selections are important even when it concerns naval design and performance.

**Action 6: Ecodesign Guidelines**

*The Ecodesign Guidelines is a tool aimed for use throughout the product development
process. The guidelines work as guidance so that environmentally conscious choices can be
taken when making design decisions.*

The purpose of using the Ecodesign Guidelines is to support decisions that are taken when
designing ships so that the decisions can be environmentally well though-through. This
results in a more sustainable design, from an ecodesign point of view.

The guidelines, which are presented in LEAP-1406, should be contemplated when making
selections of, developing, and/or designing parts, components, systems, or similar during the
product development process. The intention is that the guidelines should be used as a
compass, or guidance, and it is not necessary that they are fully followed through to the last
detail. The guidelines are ranked according to how well they are applicable to ship design and
to Kockums AB. The ranking is scaled from 1 to 3, where 1 is of highest priority.

In the first phase in the product development process after the “Offer” phase, for example in
the “Study”-phase, the Ecodesign Guidelines should be contemplated by all affected
employees. This should be done in order to question decisions from an ecodesign point of
view at an early stage. The Ecodesign Guidelines should also be applied and contemplated
continuously throughout the product development process.

The Ecodesign Guidelines should be contemplated by every single one of the designers as
well as other affected employees, so that the employees can argue for how ecodesign has
been considered when developing a component, or similar, for the ship.

By applying the mindset and inspiration that can take place thanks to the Ecodesign
Guidelines, an environmentally conscious ship design will be achieved. This is a big
advantage for Kockums AB since the success of the environmentally conscious decisions
should be assessed by the 'Ecodesign Checklist' (Action 13).
## Prioritization 2

### Overview of Actions of Priority 2

<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Responsible</th>
<th>When</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Education and Training</td>
<td>Top management together with EMG</td>
<td>Continuously and before start-up of new projects</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Recycling Manual</td>
<td>ILS</td>
<td>Should be completed in the Product Development's final phase</td>
<td>FMV:s recycling manual</td>
</tr>
<tr>
<td>9</td>
<td>Procurement department's contribution to ecodesign</td>
<td>Employees from Procurement department that are members of the EMG</td>
<td>Annual revision</td>
<td>LEAP-1407</td>
</tr>
<tr>
<td>10</td>
<td>Employment of an environmental champion to ILS</td>
<td>ILS's Head of Department</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Action 7: Education and Training

*Education for and training of employees is of great importance in order to gain new knowledge and inspiration, which is beneficial for company’s development.*

The purpose of educating employees on the subject of Environmental Management Systems and ecodesign issues is to ensure that a sustainable perspective on products exist so that development of products can be environmentally sustainable.

To start off, all employees should get a basic education regarding environmental work and how this is pursued at Kockums AB, both regarding Environmental Management Systems and ecodesign. As a suggestion, this can be done by a computer based test, where the aim is that the employee receives a diploma when the test is completed in order to prove that the employee has sufficient knowledge in the area in question. Moreover, key personnel that can have a big influence and impact on the product should especially be educated in ecodesign. Next, managers on higher levels should be educated in order to transfer the gained knowledge down in the organization. The intention is to create an interest further down in the organization chain so that education and training in product related environmental issues are requested. The expectation is that interest and knowledge will be created both top-down and bottom-up in the organization, which will eventually permeate the entire company.

Before start up of new projects, education in ecodesign should be provided to the project members so that inspiration and knowledge can be brought in to the project. Education should also be provided continuously, in the daily work, to build on the already existing knowledge in order to keep the interest and knowledge growing as well as apply it.

The top management is responsible for creating an interest in education and to provide opportunities of participating in education and training, and should delegate the responsibility of inviting employees to participate in this.
An increased knowledge level in Environmental Management Systems and ecodesign will take Kockums AB forward, which ensures that proactive and environmentally adapted design can be developed.

**Action 8: Recycling Manual**

*Recycling manual is already a familiar concept to Kockums AB. To not continue the work with a recycling manual and provide one to customers would be a step backwards in environmental work.*

The purpose of the recycling manual is to ensure that the ship will be taken care of in a safe and efficient way when the ship has reached the end of its operating life.

Information about what materials components/products/systems contain and how the waste management should be carried out should be collected and then compiled in a recycling manual. This information should then be integrated with other information that ILS compiles and be included in the technical documentation that is delivered together with the ship. The information that is requested from suppliers, today, should be synchronized within the departments so that doing the work twice can be avoided. As a suggestion, the departments can develop and compile a joint requirement specification that always should be enclosed in the information sent to the supplier. What information that should be collected should be based on the latest version of FMV’s template for the recycling manual, since this recycling manual has been carried out in a project already. Moreover, requirements for an Inventory of Hazardous Materials (IHM) should be followed. This is to assure that rules, from regulations such as Hong Kong Convention that may enter into force, are fulfilled. An additional motive, as to why these rules should be fulfilled, is that it provides an opportunity to receive an additional class notation from DNV; “Recyclable”. When this work procedure has been instated, a Kockums AB specific standard can be developed, which then also can be used for marketing purposes.

Documentation that suppliers enclose with the component/product/system should be compiled to a complete recycling manual together with all other technical documentation.

Information from suppliers should be gathered when the request for proposal is made. It is the designer’s responsibility to make sure that the recycling manual template is enclosed with order specifications, when the request for proposal is sent to the Procurement department. In the final phases of the product development process, when the technical documentation is compiled, the recycling manual should also be compiled as well as included in the technical documentation, which should be delivered together with the ship. The responsibility for the compilation of the recycling manual should be on ILS.

To provide a recycling manual can give competitive advantages for Kockums AB, and it is a proactive step in order to fulfill the Hong Kong Convention’s rules which may enter into force. The inventory of the material content in the ships, which will be made thanks to the recycling manual, will provide positive conditions if a LCA (Action 18) is to be introduced.

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2 The template can be found on following website: http://fmv.se/sv/Verksamhet/Miljøarbete/Miljokrav-vid-upphandlingar/Krav-pa-produkten/
Action 9: Procurement department's contribution to ecodesign

A Procurement strategy that is expanded with clearer targets will lead to more environmentally conscious decisions and contribute to good ecodesign.

The purpose of including the Procurement department in the product development process is so that selections of suppliers with greater environmental awareness can be made, and hence a final product with lower adverse environmental impact can be achieved.

The environmental work that is currently carried out at the Procurement department should be expanded with the suggested tasks and targets in LEAP-1407. These include clearer department specific environmental targets and objectives, environmental status in the supplier system (MARS), and informing suppliers about Kockums AB’s environmental policy.

This environmental work should be carried out continuously and the employee, who represents Procurement in the EMG, is responsible for making sure that this is accomplished.

Product related environmental work is strongly connected to components'/systems' environmental performance and hence the suppliers which Kockums AB are doing business with. Procurement department plays therefore an important role in Kockums AB’s environmental work.

Action 10: Employment of an Environmental Champion to ILS

A person who is passionate about environmental issues and has experience in technical documentation should be employed to ILS, to firstly work with the recycling manual and be a part of the EMG.

The purpose of employing an environmental champion to ILS is to facilitate the work with the recycling manual and to bring in a person that can speak for ILS in the EMG.

The person who is to be recruited should have previous experience in environmental related work, as well as experience in technical documentation. It is beneficial if the environmental champion has experience in environmental tools such as LCA. Above all, it is important to employ a person who is passionate about environmental issues. Moreover, it is also important to have in mind when employing to all departments, especially within Design & Engineering, to see if the person that is under consideration for employment has previous experience in and/or a passion for pursuing environmental work.

The work of the environmental champion will reach over the daily work because of the work in the EMG. During the product development process, most of the work with the recycling manual will take place in the latter phases when the documentation is compiled. However, the environmental work should be carried out continuously to ensure that the information that is required, for the recycling manual, have been gathered. A big part of the environmental work will consist of making sure that the process for gathering information works well.

The responsibility of recruiting an environmental champion is on the head of department of ILS. The employed environmental champion is then the one who is responsible for establishing the recycling manual as well as pursuing continual improvement work together with the EMG.
With an environmental champion at ILS, Kockums AB will be able to deliver a well elaborated recycling manual which can give increased competitiveness. A person who is passionate about environmental issues can contribute with energy that is needed in order to pursue environmental related changes and improvements.
Prioritization 3

Overview of Actions of Priority 3

<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Responsible</th>
<th>When</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Prestudy-EEA</td>
<td>Design departments</td>
<td>Phase A, Design Process</td>
<td>LEAP-1408</td>
</tr>
<tr>
<td>12</td>
<td>Fast Five</td>
<td>Top management</td>
<td>At strategic product planning, checkpoints of product concepts</td>
<td>LEAP-1409</td>
</tr>
<tr>
<td>13</td>
<td>Ecodesign Checklist</td>
<td>Sub-project Manager for Design &amp; Engineering and System Manager (Systemansvarig)</td>
<td>Design Reviews (DR), especially DR in Phase B1 in the Design Process</td>
<td>LEAP-1410</td>
</tr>
<tr>
<td>14</td>
<td>Eco-toolbox</td>
<td>EMG</td>
<td>Continuously in the PDP</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

**Action 11: Prestudy-EEA**

*It is of great importance to discuss environmental parameters in order to make employees at Kockums AB aware of the parameters significance, especially since product related environmental aspects are becoming more common in requirement specifications from customers and authorities.*

The purpose of conducting a Prestudy-EEA is to establish a routine in examining what environmental effects different components have in various lifecycle phases. This will facilitate implementation of the tool EEA, which should be introduced at a later stage (Action 17).

A Prestudy-EEA should be completed for different components, parts, and systems. First, it should be assessed what component, part, or system the Pre-study will be regarding. Next, the different environmental activities and effects are discussed depending on what lifecycle phase is regarded. LEAP-1408 consists of a worksheet that should be used when carrying out the Prestudy-EEA. An example of an “Activity”, under the heading “Environmental Characteristics”, can be propulsion of the ship and an “Environmental Effect/Aspect” can be the consumption of fuel and emission. A “Potential action for Kockums AB to take” can be, for instance, to make the combustion more efficient, change the fuel to a more environmentally friendly option, or to make the ship lighter in the design in order to decrease the consumption of fuel. Lastly, the activities should be ranked according to how important they are assessed to be, where importance 1 is least important and 3 is most important. This will provide a perspicuous overview of the different environmental parameters’ significance. It is important to try to discuss activities that are connected to LCC, a tool used by ILS, in order to be able to motivate product concepts from both an economical and environmental point of view.

The Prestudy-EEA should be carried out in Phase A in the design process in order to be able to observe important environmental parameters early and have the opportunity to include these in the requirement specification.

System Managers, for the different systems, are responsible for carrying out the Prestudy-EEA. Thereafter, it is their responsibility to report the result to project management and to the person at ILS who is conducting LCC. Moreover, it should be considered if Area Managers...
(områdesansvariga) should examine the result or if a Prestudy-EEA should be carried out per area, as well as for each system.

By using a Prestudy-EEA as a basis of discussion, important issues will be brought up that can result in more environmentally conscious decisions, and hence provide more environmental related sales arguments from an economical perspective.

**Action 12: Fast Five**

*Fast Five is a tool that works as a quick and qualitative check to see if a product concept is more sustainable than a reference concept, from an environmental perspective.*

The purpose of Fast Five is to assess and ensure that a developed product concept is not worse, regarding ecodesign, than a predefined reference concept.

By answering "yes" or "no" to five questions, within different categories, about the product concept, it can be compared with a chosen reference concept. It can thereby be assessed if the product concept is a good choice or if it needs to be revised. The number of "yes"-answers also indicates how environmentally good a product concept is. The more "yes" the concept gets, the more "green" it is considered to be. The categories, which the questions are asked within, are; ‘Energy’, ‘Recyclability’, ‘Hazardous waste content’, ‘Durability, reparability and preciousness’, and ‘Alternative ways to provide service’. The worksheet for Fast Five is presented in LEAP-1409.

Fast Five works well as a check when a new product concept is first evaluated at a strategic product planning in the top management group. The top management is responsible for using the tool and making sure that new product concepts are strategically correct and correspond to the expectations towards the chosen reference concept and ecodesign. Fast Five can also be used as support for designers, to quickly assess and check if the development of a product is carried out in the right direction in order to fulfill the objective of having an environmentally conscious product.

Fast Five also works well during the product development process, as a quick check to see if the product that is being developed is improved compared to the predefined reference concept. The employees of the design departments are responsible for using the tool in the product development of concepts and for reporting to System Managers about how they are motivating their choices with regards to the five categories.

Having Fast Five as a basis and inspiration in design can contribute to making sure that environmental requirements are considered in a natural way in the product development process. The top management will get more insight in how environmentally sound a developed product concept is hence they can establish relevant and strategic environmental objectives and targets. Moreover, the result from Fast Five is an assurance that product concepts are proactive and "green" which is good marketing for Kockums AB.

**Action 13: Ecodesign Checklist**

*The Ecodesign Checklist works as an assessment at design reviews to see if developed products are well reasoned regarding environmental aspects.*
The purpose of the Ecodesign Checklist is to check how environmentally conscious and sound a design of a product is.

The Ecodesign Checklist is used by studying the developed concept and discussing it with regards to the checkpoints in the Checklist. The Ecodesign Checklist is based on the five categories which the tool Fast Five is based on, and the Checklist also has one additional category about general principles concerning legislations, requirements, and regulations. By having the same categories in the two different methods, top management can have a basis for discussion from the result of the Ecodesign Checklist when they are using Fast Five. The field for comments in the Ecodesign Checklist should be used for specifying the reasons for why an ecodesign aspect not fulfilled. For example, it can be that there is an exceptional case for a normally forbidden substance that is allowed since it is a naval ship that is developed. The Ecodesign Checklist is presented in LEAP-1410.

The Ecodesign Checklist should be used in Design Reviews, internally at Kockums AB. It is of great importance that the Checklist is used in the Design Review in Phase A in the design process so that the ship design can be checked to see if it is environmentally good, before changes in the design will be too costly to make. In later Design Reviews together with customers, the Checklist can be used to show Kockums AB’s dedication to ecodesign and environmental issues.

The sub-project managers at Design are responsible for completing the Ecodesign Checklist at Design Reviews, while System Managers are responsible for making sure that designers are striving for fulfilling the Ecodesign Checklist during the entire design process.

To have many checked points in the Ecodesign Checklist is a sales argument that can be used to show that Kockums AB is handling product related environmental issues proactively.

**Action 14: Eco-toolbox**

*The suggested tools, which can be used for ecodesign, are compiled in the Eco-toolbox in different categories to show what tool to use for what purpose.*

The Eco-toolbox, see figure below, has the purpose of presenting what ecodesign tools exist and are accessible for employees at Kockums AB.

An eco-toolbox should be accessible and visible at Kabinet. It illustrates which ecodesign tools there are to use and what purpose the different tools have. It should be possible to quickly be able to compare alternatives in order to choose the tool according to the purpose and application field. The four ‘Purpose of the Tools’ fields are ‘Analysis of environmental strengths and weaknesses’, Setting priorities, Selecting most important potential improvements’, Support for idea generation, design and specifying drafts’, and ‘Coordination with other criteria; Cost/Benefit-Assessment, Profitability-Check’. The Eco-toolbox is modeled as a diagram where ‘Purpose of the Tools’ is the longitudinal axis (x-axis) and ‘Complexity/Time requirements’ is the vertical axis (y-axis). As a result, it will be easy to overview the different types of tools and how complex it is to use them.
This Eco-toolbox should be used whenever it is needed during the entire product development process, or at any given time. Initially, it should contain the suggested tools according to the LEAP as well as the existing ones at Kockums AB, e.g., LCC. Later, more ecodesign tools should be added.

It is the responsibility of the EMG to revise and update the Eco-toolbox and its tools. All employees of Kockums AB should be aware of the Eco-toolbox and use it in order to facilitate ecodesign and hence product related environmental issues.

Thanks to the Eco-toolbox it is easy to overview what ecodesign tools are available. This will make it easier for employees at Kockums AB to make use of these resources, which also result in well-reasoned ecodesign.
Prioritization 4

Overview of Actions of Priority 4

<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Responsible</th>
<th>When</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Further Education and Training</td>
<td>Top management together with EMG</td>
<td>Continuously and before start-up of new projects</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>Product-FMEA</td>
<td>Project Manager together with System Manager for each system</td>
<td>Early design and as support during development of products</td>
<td>-</td>
</tr>
<tr>
<td>17</td>
<td>EEA</td>
<td>Same as for Action 16</td>
<td>In connection with Product-FMEA</td>
<td>-</td>
</tr>
</tbody>
</table>

Action 15: Further Education and Training
Continuous and expanded education and training of personnel should be carried out in accordance with the education that is suggested in Action 7.

Action 16: Product-FMEA (Failure Mode and Effect Analysis)
To systematically determine what risks there are in a design or process a FMEA can be carried out as a means to take preventive action.

The purpose of performing a FMEA is to identify potential failures, causes, and effects in a design or process.

The design is systematically examined, by a cross functional team, to identify failures, causes, and effects. A product-FMEA should be carried out for each system design (systemkonstruktion). When the procedure for performing a product-FMEA is established at Kockums AB, a production-FMEA should be considered. However, an EEA (Action 17) is suggested to be the next step to take. Then, a combined session for carrying out product-FMEA and EEA should take place.

Product-FMEA should be carried out at different stages of the product development process and for design of different systems of the ship. Most importantly, the product-FMEA should be performed thoroughly in early design process to avoid expensive mistakes, since making design changes in early stages are less costly.

The Project Manager together with System Managers should be responsible for carrying out the product-FMEA.

Product-FMEA will result in a more carefully thought-through design, where risks are considered and a high quality consequently is attained.
**Action 17: EEA**

*Performing an EEA can assess a product concept’s largest adverse environmental impacts and thereby provide an opportunity to improve the concept.*

An EEA is carried out with the purpose of identifying and determine the potential environmental impact of a product throughout its lifecycle by identifying so-called environmental “hot-spots”.

EEA is performed in a similar way as a product-FMEA. Action 11, Prestudy-EEA, includes the first two phases of EEA which now should be extended with the three remaining phases; analysis, implementation, and follow-up.

EEA should be carried out in early stages of product development, consequently in Phase A of the design process, in connection with the product-FMEA. Performing EEA early creates an opportunity to make changes in the design to minimize environmental impact.

The person responsible for carrying out the product-FMEA should also be responsible for EEA.

A well performed EEA indicates that environmental aspects and the product’s whole lifecycle is considered, which can be used as motivating arguments towards customers and the market.
Prioritization 5

Overview of Actions of Priority 5

<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Responsible</th>
<th>When</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>LCA</td>
<td>Environmental Champion at ILS</td>
<td>Before the Design Process starts and at halftime conversions</td>
<td>-</td>
</tr>
</tbody>
</table>

Action 18: LCA (Life Cycle Assessment)

To assess the environmental impact of Kockums AB's products, a Life Cycle Assessment (LCA) should be carried out. The result can then also be used as a sales argument towards customers.

The purpose of carrying out a LCA is to get an interpretation of environmental impact and flow of resources to be able to choose a more environmentally conscious concept, find possibilities for environmental improvements, and enable mediation of products' environmental impacts to customers.

A LCA covers the whole lifecycle of the product, from cradle to grave. One argument for carrying out a LCA is to illustrate the environmental impact of a product, e.g., ship. Another argument is that Kockums AB can compare different product concepts to be able to choose the most promising one, regarding environmental aspects. A LCA can also be used to find possibilities to improve an existing ship, for instance at midlife conversion.

To obtain a holistic perspective, and to complement LCC, a LCA should be performed when a sufficient knowledge base of ecodesign is established. The EMG should consider the situation at Kockums AB and decide when it is suitable to implement LCA. However, knowledge about the LCA tool should be established earlier. The LCA should be carried out before the design process starts to get an overview of previous products' environmental impacts and in this way determine what environmental aspects to prioritize when developing a new, or improving an existing, ship. LCA could also be used when comparing potential concepts.

The recruited environmental champion at ILS should be responsible for carrying out the LCA.

By carrying out a LCA, Kockums AB can receive a quantitative analysis of the company's products. Demonstrating a low environmental impact to customers can give an advantage towards competitors.
Closure

This LEAP should be followed-up and revised annually by the EMG. The figure below illustrates how the different Actions in the LEAP impregnate, and are used throughout, the entire organization and how some Actions are connected. If the LEAP is followed through, it shows that Kockums AB have taken action to be more proactive regarding ecodesign and sustainable development. It is a leap towards a more environmentally conscious product development.
Kockums AB’s Miljöledningsgrupp

Miljöledningsgruppen består av ett tvärfunktionellt team med representanter från konstruktion, inköp, miljö och ILS. Detta genererar ett helhetsperspektiv på, och ett ökat samarbete inom, miljöfrågor.

Miljöledningsgruppens uppdrag består i att

- Utarbeta långsiktiga strategier för miljöfrågor och driva det kontinuerliga miljöledningsarbetet, med andra ord fullfölja och revidera LEAP.
- Följa upp hur miljöarbetet genomförs samt se ifall avvikelser finns. Resultatet från uppföljningen ska sedan spridas till organisationen.
- Ge förslag på nya miljömål och handlingsplaner för att uppmuntra till ständig förbättring på Kockums AB.
- Inneha kunskaper om ekodesign och relaterade områden för att kunna erbjuda medarbetare stöd vid behov.
- Ha ett engagemang i att driva frågor inom hållbar utveckling samt öka intresset och medvetenheten hos medarbetare inom miljöfrågor.
- Skapa och underhålla en eco-toolbox så att verktyg och metoder finns tillgängliga för medarbetare samt undersöka behov och möjligheter till inköp av ytterligare verktyg.
- Tydliggöra skillnaden mellan olika begrepp så som arbetsmiljö och produktrelaterade miljöfrågor. Säkerställa att informationen om detta når ut till de anställda.
- Se till att konkreta krav gällande

Kockums AB’s Environmental Management Group

The Environmental Management Group consists of a cross-functional team with representatives from design, procurement, environment, and ILS. This will generate an overall perspective on, and an increased cooperation within, environmental issues.

The Environmental Management Group’s assignments consist of:

- Compose long-term strategies for environmental issues and pursue the continuous environmental management work, in other words fulfill and revise the LEAP.
- Follow up how well environmental work is observed and mediate the results to the organization.
- Propose new environmental goals and action plans in order to encourage continuous improvement at Kockums AB.
- Possess knowledge within ecodesign and adjacent areas in order to provide support to co-workers when needed.
- Be committed to address aspects relating to sustainable development and increase co-workers’ interest and awareness within environmental issues.
- Develop and maintain an eco-toolbox to ensure that tools and methods are available to the employees. Additionally, the need and possibilities for getting supplementary tools should be explored.
- Clarify the difference between concepts such as work environment and product-related environmental issues. Ensure
• Make sure that concrete requirements regarding product-related environmental issues are developed specifically for Kockums AB. These should be established as internal requirements, for example in DDB, in order to be applied directly in projects.

that the information is mediated to all employees.

produktrelaterade miljöfrågor tas fram specifikt för Kockums AB. Dessa ska etableras som interna krav i exempelvis DDB för att direkt kunna appliceras på projekt.
Miljöpolicy

Vi på Kockums AB avser att minimera negativ miljöpåverkan orsakad av våra produkter och processer. Miljöarbetet utförs i enlighet med nuvarande lagstiftningar och vi arbetar proaktivt med att möta framtida lagstiftningar, bestämmelser och krav. För att uppnå minimal miljöpåverkan ska vi:

- Ta hänsyn till miljöaspekter under utvecklingen av våra produkter för att säkerställa att negativ miljöpåverkan under produktens hela livscykel minimeras.
- Reducera antalet farliga ämnen och substanser i utveckling, konstruktion och produktion av fartyg.
- Inkludera miljöaspekter som en del av produktframställningsprocessen.
- Reducera användningen av energi och andra resurser i den dagliga verksamheten.
- Uppmuntra anställda att aktivt delta i en ständig förbättring av miljöarbetet.
- Förmedla budskapet i denna policy till leverantörer och andra affärspartners i vårdekedjan.

Environmental Policy

We at Kockums AB intend to minimize environmental impact caused by our products and processes. Environmental work will be carried out in compliance with current legislations and we work proactively towards future legislations, regulations, and requirements. In order to achieve minimum environmental impact we will:

- Consider environmental aspects during development of our products to ensure a minimized adverse environmental impact of the product throughout its entire life cycle.
- Reduce number of hazardous materials and substances in development, design, and production of ships.
- Include environmental aspects as a part of the product development process.
- Reduce use of energy and other resources in daily operation.
- Encourage employees to actively support continuous improvement related to environmental work.
- Mediate the principles of this policy to suppliers and other business partners along the value chain.
Miljömål

Övergripande mål
Ständigt minimal miljöpåverkan genom kontinuerlig inventering av de prioriterade miljöaspekterna ur vilka de årsvis fastställda miljömålen identifieras. Tillagda miljömål är markerade i gult.

Miljömål för budgetåret 201x/201x

- **Kockums AB:s andel av energi från fjärrvärme utökas genom fortsatt utbyggnad av fjärrvärmennätet på varvsområdet i Karlskrona enligt 'Infrastruktur's planering.**
- **Fortsätta genomföra identifierade åtgärder enligt 'Infrastrukturs' förteckning för att minska energiförförbrukning.**
- **Andelen sorterat avfall skall öka från ca 60 % till 70 % av avfallsmängden**
- **Minska elförbrukningen med 10 % i förhållande till år 2011.**
- **Förbrukningen av kopieringspapper per anställd skall minskas med minst 20 % enligt separat uppföljning.**
- **Säkerställa att miljöaspekter beaktas i processer och rutiner.**
  - 60 % av de leverantörer som använts i nästkommande projekt ska vara certifierade i enlighet med ISO14001 eller motsvarande standard.
  - 95 % av de leverantörer som tillhandahåller icke produktrelaterat materiel (t.ex. stolar, kontorsmateriel) ska vara certifierade i enlighet med ISO14001 eller motsvarande.
  - 90 % av de beställda komponenterna till nästkommande projekt ska ha en medföljande återvinningsmanual.

Objective
Constantly minimize environmental impact through continuous inventory of prioritized environmental aspects from which the yearly established environmental targets are identified. *Added environmental objectives and targets are highlighted in yellow.*

Environmental targets 201x/201x

- **Kockums AB’s amount of energy from district heating should increase by means of further development of the district heating system according to ‘Infrastruktur’s planning at the ship yard in Karlskrona.**
- **Reduce the energy consumption by continuing to realize the identified measurements according to ‘Infrastruktur’s list.**
- **The amount of sorted waste shall increase from approximately 60 % to 70 % of total waste.**
- **Reduce the energy consumption by 10 % compared to year 2011.**
- **Consumption of copy paper per employee shall decrease by 20 %.**
- **Ensure that environmental consideration is an integrated part of processes and routines.**
  - 60 % of the suppliers for the next project should have an environmental management system in accordance with ISO14001 or similar standard.
  - 95 % of the suppliers providing non-product related materiel (e.g., chairs, office supplies) should have an environmental management system in accordance with ISO14001 or similar standard.
  - 90 % of the ordered components for the next project should be delivered together with a recycling manual.
COMMUNICATION PLAN
for project XXX

Revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Comment</th>
<th>Revised by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Responsible author/Project Manager

Signature
Table of content

1. **Introduction** ........................................................................................................... 3  
   1.1. Current situation .................................................................................................. 3  
1.2. **Definitions** ............................................................................................................. 3  
2. **Objective, targets and strategy** ............................................................................ 3  
   2.1. Objective ............................................................................................................. 3  
   2.2. Targets ................................................................................................................ 3  
   2.3. Strategy ............................................................................................................... 4  
3. **Message, roles and channels** ............................................................................... 4  
   3.1. Message .............................................................................................................. 4  
   3.2. Actors .................................................................................................................. 5  
   3.3. Channels ............................................................................................................. 5  
4. **Follow-up** ............................................................................................................... 5  
5. **Distribution of responsibilities** ............................................................................. 5  
6. **Time and activity plan** .......................................................................................... 6
1. Introduction

A communication plan aims towards ensuring that a thorough foundation exists for effective communication as a result of good planning. Outcomes of this can be that more messages can be successfully mediated since there is a structure and plan for how communication should be done. The plan facilitates cooperation within the company and benefits the communication of information about the project.

1.1. Current situation

Describe what project is regarded and which other projects can be affected or have an affect. Emphasize if there is anything in particular that needs to be communicated or be focused on.

1.2. Definitions

Describe specific concepts, definitions, names, abbreviations or contexts. Make sure to carefully define concepts that can have different meaning depending on the context, for example environment.

2. Objective, targets and strategy

2.1. Objective

The communication plan aims to informing project members and affected parties about important messages in the project in order to avoid mistakes.

This project aims especially at ...describe what should be achieved thanks to this particular communication plan.

2.2. Targets

The tangible targets and results, connected to project objectives/company objectives, that the communication plan aims to achieve is listed in the table below.

<table>
<thead>
<tr>
<th>Target</th>
<th>(number) Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>We want to achieve...</td>
<td>By...</td>
</tr>
<tr>
<td>We want to achieve ...</td>
<td>By...</td>
</tr>
<tr>
<td>Example: All project members should be aware of who is responsible for the different requirements.</td>
<td>(1) There should exist documentation which should continuously be updated, where with contact persons for each requirement are stated.</td>
</tr>
</tbody>
</table>

For example: Target: Pass down gained knowledge from this project to the next one.
2.3. Strategy

Presented strategies above are well thought through, see table below for a compilation of success factors, risks and measures.

<table>
<thead>
<tr>
<th>Strategy number</th>
<th>Success factors</th>
<th>Risks</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Have clear instructions from the start regarding who is responsible for what requirement, accessible placement of the documentation, continuous updates.</td>
<td>Project members have not access to or do not look at the document with requirements and responsible person.</td>
<td>Place the document easy accessible and clear, for example in a project map or at the project's site at Kabinet in order to make sure that all affected parties can access vital information.</td>
</tr>
</tbody>
</table>

Additional success factors for the project in general are:
- Make a bullet list
- ...

Other risks that exist for the project in general are:
- Make a bullet list
- ...

Measures in order to prevent these risks are:
- Make a bullet list
- ...

Make sure to consider needs and prerequisites that exist, what prevents the objectives, what hurdles that can occur, competitors, which risks should be emphasized for the project members before problems occur, what can be used in order to succeed with the communication, which persons are especially important for the project in order to make sure that communication happens in best way possible.

3. Message, roles and channels

3.1. Messages

Present what messages should be communicated and when it should occur. For example, it can be stated that project meetings should be held every other week and what to bring up at these, e.g. every project member should report their status. Also include here if documentation should be in English or in Swedish and make clear which type of documentation should be in what language.
3.2. **Actors**

The persons that are participating in the project are presented in the figure below, which shows the entire project organization.

*Insert a picture of the project organization*

**Define what actors and parties are important for the project and where they are located, how the communication happens today and how it should happen. Emphasize what actors that should be prioritized. Examples of actors are suppliers, press, customer, classification bodies…**

3.3. **Channels**

Existing channels are:

- Kabinet
- Set department meetings
- News letters
- Homepage
- Personnel e-mail
- etc…

*Emphasize which channels that will be used in this project and how/for what messages. Consider following when selecting channel: Range, Selectivity, Speed, Awareness, Efficiency and Cost. Are the existing channels enough or do additional channels need to be formed.*

4. **Follow-up**

Follow-up of the project will be conducted where the questions below will be examined:

- Have the information been distributed and received correctly?
- Have the information been clear, relevant and correct?
- Was the information understood and did it cover all needs?
- Have established targets been achieved?
- What changes are important to do?

*Add on more questions relevant for this specific project…*

These questions will be answered and included in the final report for the project.

5. **Distribution of responsibilities**

*Describe who is responsible for the communication plan’s different aspects and include contact information. Managers should have notable responsibility.*
6. Time and activity plan

Following table presents, in chronologic order, the planned messages that are to be mediated along with actors, channels, and person responsible for the message. *Include activities such as project deliveries.*

<table>
<thead>
<tr>
<th>Date</th>
<th>Message</th>
<th>Actor(s)</th>
<th>Channel(s)</th>
<th>Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-04-25</td>
<td>A product concept has been chosen for the project</td>
<td>Project members, employees of Kockums AB, FMV</td>
<td>Project meetings, Project site at Kabinet, Design Reviews</td>
<td>Project Manager</td>
</tr>
</tbody>
</table>

...
Color list

The color list tool is provided in an external Excel-document (LEAP-1405_Color list.xsl). Below is an illustration of how the excel worksheet is set up.

The yellow highlighted text provides an example of a forbidden substance.

## Forbidden substances

<table>
<thead>
<tr>
<th>Group</th>
<th>Substance</th>
<th>CAS no.</th>
<th>Regulation</th>
<th>Risk(s)*</th>
<th>Example of application; type or area of use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Lead chromate</td>
<td>7758-97-6</td>
<td>RoHS directive 2002/95/EC</td>
<td>C, A, E, N</td>
<td>Pigment</td>
<td></td>
</tr>
</tbody>
</table>

## Restricted substances

<table>
<thead>
<tr>
<th>Group</th>
<th>Substance</th>
<th>CAS no.</th>
<th>Regulation</th>
<th>Risk(s)*</th>
<th>Example of application; type or area of use</th>
<th>Comments</th>
</tr>
</thead>
</table>

## Exceptions

<table>
<thead>
<tr>
<th>Group</th>
<th>Substance</th>
<th>CAS no.</th>
<th>Regulation</th>
<th>Risk(s)*</th>
<th>Example of application; type or area of use</th>
<th>Comments</th>
</tr>
</thead>
</table>

## Risks*

- **A** Allergy
- **AT** Aquatic toxic (high)
- **BA** Bio accumulating
- **C** Cancer
- **E** Environmentally hazardous
- **GW** Global warming
- **M** Mutagenic
- **N** Neurotoxic
- **O** Ozone depletion
- **R** Reproductive hazards
- **T** Toxic
# APPENDIX 1

## CONTROLS OF HAZARDOUS MATERIALS

<table>
<thead>
<tr>
<th>Hazardous Material</th>
<th>Definitions</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>Materials containing asbestos</td>
<td>For all ships, new installation of materials which contain asbestos shall be prohibited.</td>
</tr>
<tr>
<td><strong>Ozone-depleting substances</strong></td>
<td>Ozone-depleting substances means controlled substances defined in paragraph 4 of article 1 of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987, listed in Annexes A,B,C or E to the said Protocol in force at the time of application or interpretation of this Annex.</td>
<td>New installations which contain ozone-depleting substances shall be prohibited on all ships, except that new installations containing hydrochlorofluorocarbons (HCFCs) are permitted until 1 January 2020.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ozone-depleting substances that may be found on board ship include, but are not limited to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Halon 1211</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bromochlorodifluoromethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Halon 1301 Bromotrifluoromethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Halon 2402 1,2-Dibromo-1,1,2,2-tetrafluoroethane (also known as Halon 114B2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFC-11 Trichlorofluoromethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFC-12 Dichlorodifluoromethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFC-113 1,1,2-Trichloro-1,2,2-trifluoroethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFC-114 1,2-Dichloro-1,1,2,2-tetrafluoroethane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFC-115 Chloropentafluoroethane</td>
</tr>
<tr>
<td><strong>Polychlorinated biphenyls (PCB)</strong></td>
<td>“Polychlorinated biphenyls” means aromatic compounds formed in such a manner that the hydrogen atoms on the biphenyl molecule (two benzene rings bonded together by a single carbon-carbon bond) may be replaced by up to ten chlorine atoms</td>
<td>For all ships, new installation of materials which contain Polychlorinated biphenyls shall be prohibited.</td>
</tr>
<tr>
<td><strong>Anti-fouling compounds and systems</strong></td>
<td>Anti-fouling compounds and systems regulated under Annex I to the International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001 (AFS Convention) in force at the time of application or interpretation of this Annex.</td>
<td>1. No ship may apply anti-fouling systems containing organotin compounds as a biocide or any other anti-fouling system whose application or use is prohibited by the AFS Convention.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. No new ships or new installations on ships shall apply or employ anti-fouling compounds or systems in a manner inconsistent with the AFS Convention.</td>
</tr>
</tbody>
</table>
APPENDIX 2

MINIMUM LIST OF ITEMS FOR THE INVENTORY OF HAZARDOUS MATERIALS

<table>
<thead>
<tr>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Hazardous Materials listed in Appendix 1</td>
</tr>
<tr>
<td>Cadmium and Cadmium Compounds</td>
</tr>
<tr>
<td>Hexavalent Chromium and Hexavalent Chromium Compounds</td>
</tr>
<tr>
<td>Lead and Lead Compounds</td>
</tr>
<tr>
<td>Mercury and Mercury Compounds</td>
</tr>
<tr>
<td>Polybrominated Biphenyl (PBBs)</td>
</tr>
<tr>
<td>Polybrominated Diphenyl Ethers (PBDEs)</td>
</tr>
<tr>
<td>Polychlorinated Naphthalenes (more than 3 chlorine atoms)</td>
</tr>
<tr>
<td>Radioactive Substances</td>
</tr>
<tr>
<td>Certain Shortchain Chlorinated Paraffins (Alkanes, C10-C13, chloro)</td>
</tr>
</tbody>
</table>

I:\CONF\SR\45.doc
Kockums AB’s Ecodesign Guidelines

Following ecodesign guidelines have been developed to suit Kockums AB and are based on the latest research within the ecodesign area and existing technologies on how to recycle a ship.

<table>
<thead>
<tr>
<th>Material Selection</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce the weight of the product by choosing lightweight materials.</td>
<td>1</td>
</tr>
<tr>
<td>Avoid hazardous and potentially hazardous materials. Use colour list in LEAP-1405 as support.</td>
<td>1</td>
</tr>
<tr>
<td>Choose materials that can be recycled.</td>
<td>1</td>
</tr>
<tr>
<td>Choose a surface treatment that minimizes the total environmental load.</td>
<td>1</td>
</tr>
<tr>
<td>Avoid using materials that need extra surface treatment.</td>
<td>1</td>
</tr>
<tr>
<td>Minimize the number of different materials.</td>
<td>1</td>
</tr>
<tr>
<td>Choose materials that are durable in order to reduce need of maintenance and prolong the ship’s lifetime.</td>
<td>1</td>
</tr>
<tr>
<td>Minimize the amount of material that produces a lot of emissions in manufacturing phase.</td>
<td>3</td>
</tr>
<tr>
<td>Use recycled materials and components.</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Design</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce the weight of the product by a well thought-through design, e.g., minimize thickness.</td>
<td>1</td>
</tr>
<tr>
<td>Choose standard components.</td>
<td>1</td>
</tr>
<tr>
<td>Develop a sound design and avoid weak links, e.g., by using Failure Mode and Effect Analysis.</td>
<td>1</td>
</tr>
<tr>
<td>Choose a classic and timeless aesthetic design.</td>
<td>1</td>
</tr>
<tr>
<td>Locate unrecyclable parts in one area that can be quickly removed and discarded.</td>
<td>1</td>
</tr>
<tr>
<td>Make it clear if and where the product contains hazardous materials.</td>
<td>1</td>
</tr>
<tr>
<td>Place hazardous materials together in order to facilitate simultaneously detaching of the materials.</td>
<td>1</td>
</tr>
<tr>
<td>Make assemblies of materials that are mutually compatible, in order to avoid the need of disassembly when recycling the product.</td>
<td>1</td>
</tr>
<tr>
<td>Avoid using surface treatment that is incompatible with the material, i.e., that is preventing recycling.</td>
<td>1</td>
</tr>
<tr>
<td>Make sure not to over-dimension components’ performance in correspondence to required need, in order to avoid unnecessary excessive consumption, e.g. of diesel, oil, or refrigerant.</td>
<td>1</td>
</tr>
<tr>
<td>Integrate and combine functions.</td>
<td>2</td>
</tr>
<tr>
<td>Make components and systems easy accessible in order to facilitate maintenance, repair, and upgradeability.</td>
<td>2</td>
</tr>
<tr>
<td>Design the product so that it meets legal requirements, including those that may enter into force. Take into account requirements from conventions, and similar regulations, e.g., Hong Kong Convention.</td>
<td>2</td>
</tr>
<tr>
<td>Design the product as a series of blocks or modules.</td>
<td>2</td>
</tr>
<tr>
<td>Reuse parts of the product (product should be demountable).</td>
<td>2</td>
</tr>
<tr>
<td>Sell a function instead of a product.</td>
<td>3</td>
</tr>
<tr>
<td>Make fasteners from a material compatible with the parts which are connected, in order to avoid the need of separating the parts when, for instance, recycling the product. Example: If a</td>
<td>3</td>
</tr>
</tbody>
</table>
component made of plastic are to be attached, the fastener should not be made out of metal since the two materials cannot be recycled together without having to be separated.

| Ensure easy accessibility of the product for inspection, cleaning, repair and replacement of vulnerable or innovation-sensitive sub-assemblies or parts. | 3 |
| Reuse material and components. | 3 |
| Locate parts that are relatively quickly worn out in adjacent areas so they can easily be replaced. | 3 |
Procurement department’s contribution to Ecodesign

In the existing environmental strategy for the Procurement department, environmental actions are described. The input is Kockums AB Environmental Policy (KV 9442), which currently generates an output where suppliers’ environmental status is registered. Furthermore, Kockums AB should demand that environmental certified suppliers should be the primary choice. The action plan for the Procurement department is well composed. However it needs to be complemented by measurable targets. As a suggestion, these targets can be:

- 90 % of the amount of existing suppliers, that Kockums AB are doing business with, should be checked and registered whether or not they have an environmental management system, similar to ISO14001.
- 50 % of the amount of existing suppliers, that Kockums AB are doing business with, should have an environmental management system, similar to ISO14001.
- 95 % of the suppliers that provide Kockums AB with non-ship related supplies should have an environmental management system according to ISO14001 or equivalent.

Since Procurement have an outspoken strategy to register the environmental status of suppliers it is beneficial if this can be done in a clear way. It should be communicated among the company’s departments whether or not a supplier is environmentally certified. A discussion should be held regarding the possibility of making changes in the existing system (MARS). As a suggestion, there should...
Föreslagna komponenten (från konstruktörens sida) är ifrån en miljömässigt bra leverantör. Ett samarbete mellan konstruktörer och Inköpsavdelningen är viktigt för att underlätta detta samt även för att göra övrigt arbete smidigt.

En av de ingående principerna i den föreslagna miljöpolicyn (LEAP-1402) är att förmedla policyns innehåll till leverantörer. Miljöpolicyn ska sändas ut till leverantörer för att göra dem medvetna om det miljöarbete som bedrivs på Kockums AB. Detta bör göras årligen då miljöpolicyn revideras och fastställts. Inköp ansvarar för att samtliga leverantörer har tagit del av och förstått miljöpolicyns principer. För att lyckas med miljöarbeitet är det viktigt att de leverantörer som förser Kockums AB med produkter/komponenter/system även de följer den uppsatta miljöpolicyn då leverantörernas produkter har stor verkan på slutproduktens totala miljöpåverkan.

Cooperation between designers and procurement department is vital to facilitate this as well as other work tasks.

One of the principles in the suggested environmental policy (LEAP-1402) is to mediate the policy to Kockums AB’s suppliers. The environmental policy should be sent to the suppliers in order to make them aware of the environmental work that is conducted at Kockums AB. This should be done yearly when the environmental policy have been revised and affirmed. Procurement is responsible for making sure that all suppliers have taken part of and understood the policy and its principles. In order to succeed with the environmental work, it is important that the suppliers that provide Kockums AB with products/components/systems also follows the affirmed environmental policy since the suppliers’ products have a large affect on the final products’ environmental impact.
<table>
<thead>
<tr>
<th>Lifecycle</th>
<th>Environmental Characteristics</th>
<th>Possible area of improvement</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>Propulsion</td>
<td>More efficient combustion, change of fuel, lighter ship design</td>
<td>1-3</td>
</tr>
</tbody>
</table>

Example highlighted in yellow:
# LEAP-1409. Worksheet: Fast Five Checklist

**Product/Project**  
**Person in charge**

## Categories of questions

<table>
<thead>
<tr>
<th>Category 1 – Energy</th>
<th>Yes or No?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the proposed design require less energy than the reference counterpart?</td>
<td></td>
</tr>
<tr>
<td>Consider manufacturing, transportation, product use (both in normal operation as well as in stand-by mode)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 2 – Recyclability</th>
<th>Yes or No?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the proposed product more recyclable than the reference product?</td>
<td></td>
</tr>
<tr>
<td>Consider whether the larger components can be easily separated into mono-material sub-assemblies. Special care should be given to the separation possibilities of non-compatible metal or plastics. What is the amount of actually recycled material in the product?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 3 – Hazardous waste content</th>
<th>Yes or No?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the product design contain and/or produce less chemical waste than the reference alternative?</td>
<td></td>
</tr>
<tr>
<td>Consider whether any restricted materials are used, e.g. halogenated flame retardants, cadmium pigments, or ozone depleting chemicals (ODCS).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 4 – Durability, reparability and preciousness</th>
<th>Yes or No?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the proposed design have better durability, reparability or affection level than the reference product?</td>
<td></td>
</tr>
<tr>
<td>Consider whether the new design will last longer or be easier to upgrade than the reference. Also consider whether the precious qualities of the new design will make the owner/user keep the product longer than the reference.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 5 – Alternative ways to provide service</th>
<th>Yes or No?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there ways to provide the service that produces lower ecological load?</td>
<td></td>
</tr>
<tr>
<td>Consider whether there are techniques that require much less energy or material, but provide the service at the same level of quality.</td>
<td></td>
</tr>
</tbody>
</table>

The result of the checklist may be interpreted as follows

<table>
<thead>
<tr>
<th>5 times</th>
<th>“yes”</th>
<th>An excellent alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 times</td>
<td>“yes”</td>
<td>Probably a viable choice</td>
</tr>
<tr>
<td>3 times</td>
<td>“yes”</td>
<td>Interesting alternative, but where still to improve</td>
</tr>
<tr>
<td>2 times</td>
<td>“yes”</td>
<td>Please reconsider the reference concept</td>
</tr>
<tr>
<td>1 times</td>
<td>“yes”</td>
<td>Upgrade the reference</td>
</tr>
<tr>
<td>0 times</td>
<td>“yes”</td>
<td>Where is your “green” feeling?</td>
</tr>
</tbody>
</table>

**Completed by**

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
</table>

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### LEAP-1410. Ecodesign Checklist

<table>
<thead>
<tr>
<th>Category 0 – General principles</th>
<th>Fulfilled</th>
<th>Comment, if not fulfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the system/product fulfill current work environment and environment legislation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have consideration to KAB’s environmental policy and environmental requirements been taken?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are environmental requirements from the customer fulfilled?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have special regulations regarding refrigerants, batteries, and, electronic waste been regarded?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Category 1 – Energy

<table>
<thead>
<tr>
<th>Have the system’s energy consumption been optimized from an environmental point of view?</th>
<th></th>
</tr>
</thead>
</table>

### Category 2 – Recyclability

<table>
<thead>
<tr>
<th>Have consideration to the system’s/product’s future disposal been taken?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Can the material used in the product/system be recycled?</td>
<td></td>
</tr>
<tr>
<td>Have the number of different materials been minimized?</td>
<td></td>
</tr>
</tbody>
</table>

### Category 3 – Hazardous waste content

<table>
<thead>
<tr>
<th>Are any hazardous substances, harmful to human health, included in the design? If so, do user manuals exist?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Have materials been selected from an environmental point of view?</td>
<td></td>
</tr>
<tr>
<td>Have hazardous materials been placed within adjacent areas?</td>
<td></td>
</tr>
</tbody>
</table>
**LEAP-1410. Ecodesign Checklist**

<table>
<thead>
<tr>
<th>Product/Project</th>
<th>Person in charge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 4 – Durability, reparable and preciousness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fulfilled</strong></td>
</tr>
<tr>
<td><strong>Comment, if not fulfilled</strong></td>
</tr>
<tr>
<td>Have components/parts/systems that often are repaired, updated, or, exchanged been placed in an easy accessible position?</td>
</tr>
<tr>
<td>Have a timeless design been chosen?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 5 – Alternative ways to provide service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fulfilled</strong></td>
</tr>
<tr>
<td><strong>Comment, if not fulfilled</strong></td>
</tr>
<tr>
<td>Have more resource efficient alternatives for the same service or function been considered?</td>
</tr>
</tbody>
</table>

**Completed by**

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**APPENDIX B – SEARCH INDEX**

Key words that have been used when searching for relevant literature are presented below. These words have been used solely and/or in combination and are not presented in any prioritized order. However, the words in bold letters are the ones which have been vastly used.

<table>
<thead>
<tr>
<th>Green Passport</th>
<th>IHM (Inventory of Hazardous Material)</th>
<th>Ship Recycling Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMO (International Maritime Organization)</td>
<td>Ship recycling</td>
<td>Ship recycling facilities</td>
</tr>
<tr>
<td>Ship recycling best practice</td>
<td>Convention</td>
<td>Ship lifecycle</td>
</tr>
<tr>
<td>End-of-life</td>
<td>Prevent pollution</td>
<td>Dismantle</td>
</tr>
<tr>
<td>Ship breaking</td>
<td>Basel convention</td>
<td>DfR (Design for recycling)</td>
</tr>
<tr>
<td>European waste shipment regulation</td>
<td>International Ship Recycling Association</td>
<td>Green shipbuilding</td>
</tr>
<tr>
<td>Design for ship recycling</td>
<td>EMS (Environmental Management Systems)</td>
<td>Environmentally Conscious Design</td>
</tr>
<tr>
<td>DfE (Design for Environment)</td>
<td>Guidelines</td>
<td>Checklist</td>
</tr>
<tr>
<td>ISO 14006</td>
<td>Ecodesign</td>
<td>Lifecycle engineering</td>
</tr>
<tr>
<td>ISO 14062</td>
<td>Design for End-of-Life</td>
<td>Classification societies</td>
</tr>
<tr>
<td>Tools</td>
<td>Methods</td>
<td>Systems engineering</td>
</tr>
</tbody>
</table>
APPENDIX C – INTERVIEW QUESTIONS FOR DESIGN & ENGINEERING DEPARTMENTS

Following questions were used for interviewing key personnel at the Design & Engineering departments.

1. What are the department’s main tasks?
   Vilka är era främsta uppgifter?

2. Where are you involved in Kockums AB’s overall product development process?
   Var i produktframstagningsprocessen kommer ni in?

3. Where are you involved in the design process?
   Var i konstruktionsprocessen kommer ni in?

4. What does your specific process look like at the department?
   Hur går er process till på avdelningen?
   a. How much do you work in line function vs. project?
      Hur mycket jobbar ni i linje vs projekt?

5. How does your cooperation with/connection to other departments, in the process, look like?
   Hur kopplar ni till andra avdelningar i processen?

   Vad använder ni för verktyg/metoder? Brainstorming? Checklistor?

7. What kind of environmental aspects are integrated in the process?
   Vad för miljöaspekter är integrerade?

8. Are you using the Environmental Handbook?
   Tittar ni på miljöhandboken något?

9. How is the contact with customers throughout the process?
   Hur är kundkontakten genom processen?

10. Are you involved in setting up the requirement specification?
    Är ni involverade i kravspecifikationen på något sätt?
    a. When your work tasks begin, do any prior requirements exist?
       Existerar krav när arbetet startar för er del?
    b. Are you taking any external requirements such as regulations into consideration?
       Tar ni hänsyn till utomstående krav exempelvis regulationer?
    c. Do you have any internal requirements that are always demanded?
       Har ni några interna specifika krav som alltid ställs?
    d. What kind of requirements are there (if you were to categorize them, e.g., environment, technical, performance)?
       Vad för slags krav är det (om ni skulle kategorisera ex miljö, tekniska, prestanda)?

11. How are materials being selected? (Who? How?)
    Hur väljer man material? (Vem? Hur?)
    a. Do you have some kind of (color) list of hazardous substances?
       Har ni någon ”färglista” över förbjudna ämnen?
    b. Do you have any influence concerning the choice of suppliers?
       Har ni något att styra över när det gäller leverantörer?
    c. Do you reuse any of the materials in your design or do you use any recycled materials?
       Återanvänder ni några av era material/ använder ni återvunna material?
APPENDIX D – INTERVIEW QUESTIONS FOR CHIEF OPERATING OFFICER

Following questions were used for interviewing Pontus Källén, COO of Kockums AB.

1. What are your main tasks?
   Vilka är dina främsta uppgifter?

2. What is your responsibility concerning the KRAFT-project?
   Vad är ditt ansvar inom KRAFT-projektet?

3. Are you ultimately responsible for making sure that the product development process and the design process are used in practice?
   Ar det du som har ansvar för att se till att produktframtagningsprocessen och konstruktionsprocessen följs?

4. How do you see the development of ships in the future, commercial ships compared to military ships?
   Hur ser du på framtidens utvecklande av fartyg, civilt jämfört med militärt?

5. If you look at the steps of business incentives for sustainable development, what level of ambition would you say that Kockums AB
   Om du ser till ambitionstrappan (affärsmässiga incitament för hållbar utveckling), vilken ambitionsnivå skulle du säga att Kockums AB
      a. are working from today?
         jobbar utifrån i dagstiden?
      b. will be on in the future?
         ska ligga på i framtiden?

6. Do the executive committee want to put more focus on environmental issues?
   Vill ni från ledningens håll satsa mer på miljöfrågor?
      a. If yes, how do you think Kockums AB should proceed and what questions should be pursued?
         Om ja, hur anser du att man bör gå tillväga och vilka slags miljöfrågor bör drivas?
      b. At what level should this environmental work be at? (fulfill customer requirements or have own internal requirements that always should be applied)
         På vilken nivå bör detta arbete ligga? (uppfylla krav som kunden ställer eller ha egna krav som alltid ska tillämpas)
APPENDIX E – INTERVIEW QUESTIONS FOR PROCUREMENT DEPARTMENT

Following questions were used for interviewing Mikael Rodin, employee at the Procurement department.

1. What are the department’s main tasks?
   Vilka är era främsta uppgifter?

2. Where are you involved in Kockums AB’s overall product development process?
   Var i produktframtagningsprocessen kommer ni in?

3. What does your specific process look like at the department?
   Hur går er process till på avdelningen?
   a. How does your cooperation with/connection to other departments, in the process, look like?
      Hur kopplar ni till andra avdelningar i processen?
   b. What works well/bad with the way you work today?
      Vad är bra/dåligt med hur det fungerar idag?

4. What does the procurement process look like?
   Hur går inköpen till?
   a. Who sets the requirements? Designers?
      Vems krav utgår ni ifrån? (Konstruktion styrande?)

5. Do you have any influence regarding the choice of material in the products that is selected?
   Har ni någon påverkan på vilket material som väljs?
   a. Do you have some kind of (color) list of hazardous substances?
      Har ni någon ”färglista” över förbjudna ämnen?
   b. Have you got some kind of collaboration with other companies in the industry, e.g., a shared material database?
      Har ni något samarbete med andra företag i branschen t.ex. en gemensam materialdatabas?

6. Regarding suppliers
   När det gäller leverantörer
   a. How do you choose them?
      Hur väljer ni ut dem?
   b. How much influence does the price have?
      Hur stor roll spelar priset?
   c. What requirements are you considering? (whether the supplier has an Environmental Management System, environmental policy and environmental goals)
      Vad utgår ni ifrån för kriterier? (Har leverantörerna miljöledningssystem, miljöpolicy, sätter de miljömål)

7. Do the suppliers provide material declarations/recycling manuals?
   Lämnar leverantörer materialdeklarationer/återvinningsmanual?
   a. To what extent? Do all suppliers do that?
      I vilken utsträckning? Gör alla leverantörer det?
   b. Are you gathering that information somewhere?
      Samlar ni denna information någonstans?
   c. Is this a requirement?
      Är det ett krav?
8. What input do you need to be able to make environmental evaluations (e.g., proper material choices, choosing appropriate suppliers)?
   Vad behöver ni ha för input för att kunna göra miljöbedömningar (ex. bra materialval, bra leverantörsval)?
   a. From where/who should this input be provided?
      Vart kommer denna input ifrån?

9. Are you using the Environmental Handbook?
   Tittar ni på miljöhandboken något?
Following questions were used for interviewing Nils Jonasson and Rikard Peterson, managers at Stena Recycling.

1. What kind of products are you recycling at Stena?
   Vilka typer av produkter återvinns av Stena Recycling?
   a. Does it happen that you recycle ships at Stena?
      Händer det att ni på Stena får in fartyg som ska återvinnas?

2. What kind of ships are you recycling at Stena? (e.g., cargo liners, passenger ships, naval vessels)
   Vilka typer av fartyg får ni in till Stena? (t.ex. lastfartyg, passagerarfartyg, militära fartyg)
   a. What materials are most common in the ship construction?
      Vilka är de vanligaste materialen som fartygen består av?

3. What does the recycling process look like?
   Hur går återvinningsprocessen till?
   a. What disassembly methods are you using?
      Vilka demonteringsmetoder använder ni?
   b. What tools are you using?
      Vilka verktyg används?
   c. How much material are reused, recycled, energy recovered respectively goes to landfill?
      Hur stor del återanvänds, materialåtervinns, energiutvinns respektive deponeras?

4. Do you sell any material after processing it?
   Säljer ni material vidare?

5. Do you have any requirements on documentation, e.g., regarding the ship’s/product’s material content before processing them?
   Har ni några krav på att t.ex. materialinnehåll finns dokumenterat för de fartyg/produkter som ni tar hand om?
   a. If yes, what kind of documents?
      Om ja, vilka typer av dokument?
   b. If no, is this desirable?
      Om nej, är detta önskvärt?
   c. What would the optimal design of the ship look like for it to be as easy as possible for you to recycle?
      Hur skulle ett optimalt fartyg vara konstruerat för bästa möjliga återvinning hos er?

6. What does the recycling process look like for carbon fiber today?
   Hur tar ni hand om kompositer av kolfiber idag?
   a. What is the prognosis for future technology for recycling of carbon fiber?
      Hur ser framtidens teknik ut för kolfiberåtervinning?
   b. What potential areas of use are there for recycled/reused carbon fiber?
      Vilka potentiella användningsområden ser du för återvunnen/återanvänd kolfiber?
APPENDIX G – INTERVIEW QUESTIONS REGARDING GREEN SUB-PROJECT

Following questions were used for interviewing Thomas Magnusson, Assistant professor at Linköping University. Magnusson has conducted research in the field of innovative product development that is driven by demand on environmental compliance.

1. How did it turn out for the company that implemented a “green sub-project”?
   Hur gick det för företaget där ett ”green sub-project” implementerades?
   a. Does the company work in this way still today?
      Jobbar företaget på detta sätt även idag?
   b. Have the company expanded its environmental work? How?
      Har samma företag utökat sitt miljöarbete? Hur?

2. Do you have additional examples (best practice) of companies that have worked with environmental issues in a similar or alternative way?
   Vet du fler företag som arbetar på ett liknande eller alternativa sätt för att uppmärksamma miljöfrågor?

3. What, in your opinion, is the easiest way to implement environmental aspects in the product development process?
   På vilket sätt anser du att det är lättast att implementera miljöaspekter i produktutvecklingen?

4. Do you have any example of a best practice for a company that has no prior experience in working with environmental aspects?
   Har du något exempel på ett best practice för införandet av miljöaspekter i produktutveckling på ett företag som inte tidigare arbetat med miljöfrågor?
APPENDIX H – INTERVIEW QUESTIONS FOR THE PROJECT MANAGER IN PROJECT SCHIFF

Following questions were used for interviewing Daniel Nyström, Project Manager for project Schiff.

1. How did the start-up of project Schiff happen?
   *Hur skedde uppstartandet av Schiff-projektet?*
   a. What did you bring with you into the project? (e.g., experience)
      *Vad tog ni med in i projektet? (erfarenheter etc.)*
   b. What did the project organization look like?
      *Hur såg projektorganisationen ut?*
   c. Did you set up a communication plan?
      *Uppfördes någon kommunikationsplan?*

2. What tools have been used during project Schiff? (e.g., LCA, FMEA, QFD)
   *Vilka verktyg har använts under projektet? (t.ex. LCA, FMEA, QFD)*
   a. What tools are used normally?
      *Vilka verktyg används vanligen?*
   b. Are any additional methods, other than the product development process and the design process, used?
      *Används någon ytterligare metod än produktframställningsprocessen och konstruktionsprocessen?*

3. How was the environmental requirements dealt with at the start-up and during project Schiff?
   *Hur hanterades miljökrav vid uppstartandet och genom hela projekt?*
   a. Who was responsible for those requirements?
      *Vem var ansvarig för dessa krav?*
   b. When did the requirement for a recycling manual appear?
      *När kom kravet på en återvinningsmanual?*

4. Do you know anyone who strive for and motivate others to pursue environmental issues?
   *Vet du någon person som kämpar för och motiverar andra att driva miljöfrågor?*
   a. Do you know anyone who is dedicated and committed, in general?
      *Någon som är allmänt engagerad och driven?*

5. How will you retain the experience and knowledge gained in this project?
   *Hur kommer ni att ta till vara på de erfarenheter ni fått i detta projekt?*
   a. What have worked well/poor?
      *Vad har fungerat bra/mindre bra?*
   b. What is, of your opinion, the most important experience from this project?
      *Vilken anser du är den viktigaste erfarenheten?*
**APPENDIX I – GUIDELINES FOR ECODESIGN**

Following guidelines are divided into areas of concerns and are based on the conducted literature review, for example, manufacturing and energy aspects are not covered. All ecodesign guidelines are not presented, however most important areas of green design for this M.Sc. thesis are assumed to be covered.

### Material

<table>
<thead>
<tr>
<th>Reduce amount of material:</th>
<th>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce the weight of the product</td>
<td>(Jönbrink et al., 2011)</td>
</tr>
<tr>
<td>Maximize operating life</td>
<td>(Jönbrink et al., 2011)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Choose right material:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid hazardous and potentially hazardous materials</td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td>Minimize the amount of material that produce a lot of emissions in manufacturing phase</td>
<td>(Jönbrink et al., 2011)</td>
</tr>
<tr>
<td>Minimize the use of material from scarce resources</td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011)</td>
</tr>
<tr>
<td>Use recycled materials and components</td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td>Choose materials that can be recycled</td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; Nilsson, 1998; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td>Choose a surface treatment that minimize the total environmental load</td>
<td>(Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td>Avoid using materials that need extra surface treatment</td>
<td>(Jönbrink et al., 2011)</td>
</tr>
<tr>
<td>Use renewable resources</td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td>Minimize number of different materials</td>
<td>(Nilsson, 1998; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td>Choose materials that are durable</td>
<td>(Sundin, 2004)</td>
</tr>
</tbody>
</table>

### Function

<table>
<thead>
<tr>
<th>Sell a function instead of a product</th>
<th>(Jönbrink et al., 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrate and combine functions</td>
<td>(Jönbrink et al., 2011; Nilsson, 1998)</td>
</tr>
<tr>
<td><strong>Product Durability</strong></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Develop a sound design and avoid weak links, e.g., by using Failure Mode and Effect Analysis</strong></td>
<td>(UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Prolong the products technical operating life</strong></td>
<td>(Jönbrink et al., 2011; Sundin, 2004)</td>
</tr>
<tr>
<td><strong>Facilitate maintenance, repair and upgradeability</strong></td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Design the product so that it more than meets the (possibly hidden) requirements of the user for a long time</strong></td>
<td>(UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Choose a classic and timeless aesthetic design</strong></td>
<td>(Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Design for Disassembly:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Minimize number of separate components and materials</strong></td>
<td>(Centre for Design at RMIT University, 1997; Nilsson, 1998)</td>
</tr>
<tr>
<td><strong>Avoid glues, metal clamps and screws in favor of ‘push, hook and click’ assembly methods</strong></td>
<td>(Centre for Design at RMIT University, 1997; Johansson, 1997; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Make fasteners from a material compatible with the parts connected</strong></td>
<td>(Centre for Design at RMIT University, 1997)</td>
</tr>
<tr>
<td><strong>Design the product as a series of blocks or modules</strong></td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; Nilsson, 1998; Sundin, 2004; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Locate recyclable parts in one area that can be quickly removed and discarded</strong></td>
<td>(Centre for Design at RMIT University, 1997; Johansson, 1997)</td>
</tr>
<tr>
<td><strong>Design for Remanufacturing:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ensure easy accessibility of the product for inspection, cleaning, repair and replacement of vulnerable or innovation-sensitive sub-assemblies or parts</strong></td>
<td>(Centre for Design at RMIT University, 1997; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Waste Management</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Reuse the entire product</strong></td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Reuse parts of the product (product should be demountable)</strong></td>
<td>(Centre for Design at RMIT University, 1997; Jönbrink et al., 2011)</td>
</tr>
<tr>
<td><strong>Reuse material</strong></td>
<td>(Jönbrink et al., 2011)</td>
</tr>
<tr>
<td><strong>Make it clear if and where the product contain hazardous materials</strong></td>
<td>(Johansson, 1997; Jönbrink et al., 2011)</td>
</tr>
<tr>
<td><strong>Place hazardous materials together in order to facilitate simultaneously detaching of the materials</strong></td>
<td>(Jönbrink et al., 2011; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Make assemblies of materials that are mutually compatible</strong></td>
<td>(Nilsson, 1998; UNEP &amp; TU Delft, 2006)</td>
</tr>
<tr>
<td><strong>Avoid using surface treatment that is incompatible with the material</strong></td>
<td>(Nilsson, 1998)</td>
</tr>
<tr>
<td><strong>Locate the parts that are relatively quickly worn out close to one another so they can easily be replaced</strong></td>
<td>(UNEP &amp; TU Delft, 2006)</td>
</tr>
</tbody>
</table>
APPENDIX J – IMPLEMENTATION OF A GREEN SUB-PROJECT GROUP AT A TELECOM COMPANY

The following text is a summary of the article ‘Organising for environmental considerations in complex product development projects: implications from introducing a ”Green” sub-project’ written by Glenn Johansson and Thomas Magnusson.

The company that was studied had no prior experience in how to deal with environmental requirements. To manage the new situation a green environment sub-project was created within the project organization, at the same level as the other sub-projects. Consequently, it was made clear that the environmental requirements were just as important as any other. The green environment sub-project was given responsibility for carrying out tasks such as define the environmental requirements, evaluate suppliers, and develop an environmental declaration of the product. Additionally, the project group was supposed to work as an advisor on environmental issues to the other sub-projects.

The green environment sub-project group consisted of people with different competences. Most members of the sub-project had environmental experience. However, members from other sub-projects and functional departments with less environmental knowledge were also included. This was due to the multi-disciplinary character of the environmental requirements.

Possible implications, highlighted in the article, due to the implementation of the green environment sub-project are the following. A Green sub-project can

- serve as a means to put environmental considerations on the agenda within a product development project
- introduce a risk for confusion within a product development project regarding who is responsible for fulfilling the environmental performance requirements
- act as an arena for communication about the environmental performance requirements within a product development project
- serve as a platform for environmental champions to be active within a product development project
- serve as a means for environmental specialists to become part of established contact networks in the product development organization

The first implication stated that the establishment of the green environment sub-project mediated the importance of the environmental requirements hence the environmental awareness could increase overall. However, simply establishing the group does not necessarily mean that the awareness is increased. Problems still occurred since it was not clear to all project team members that environmental requirements were "must" requirements. Even though the sub-project did increase the environmental awareness it became more unclear who was responsible for fulfilling environmental requirements, as identified in the second implication. Because of the multi-disciplinary nature of the environmental requirements it was not suitable to put the responsibility only on the green sub-project. As a result, it was concluded that roles and authorities for decision making were needed to be clarified. An alternative solution, suggested in the article, were to include environmental specialists either in the project leadership support group, in comparison with a quality coordinator, or position them directly under the Project Manager in a separate group.

The case study also showed that communication problems occurred between people with different competences in the projects. The green sub-project became an arena for meetings and discussions between personnel with different knowledge background. However, they had difficulties in understanding each other because of different terminology. It is stated that product developers need to learn from environmental specialists. Nevertheless, it is pointed out that environmental specialists need to learn of the other members’ competencies as well.
The fourth implication concerned the possibility for environmental champions to be active during the development process. An environmental champion is a person that is enthusiastic and eager to inspire the organization in the area of environmental issues but does not necessarily have a widespread environmental knowledge. Consequently, the personal attributes of the environmental champion is as important as the skills the person possess.

In the studied case the environmental specialist had no previous experience in product development and lacked contacts within that part of the organization. The green sub-project did allow environmental specialists to not only work on a corporate level but actually in the product development. The cross-functional composition of the green sub-project group supported an increased contact network for the environmental specialists.
## APPENDIX K – SUGGESTED ACTIONS LINKED TO SUCCESS FACTORS FOR ECODESIGN

All factors for successful implementation of ecodesign that have been highlighted in the theoretical frame of reference have been taken into consideration when developing the LEAP. In following table, the connection between success factors and Actions will be showed. Further comments, regarding the fulfillment of the success factors are also provided.

<table>
<thead>
<tr>
<th>Area of concern</th>
<th>Success factors</th>
<th>Action/LEAP</th>
<th>Other comments or suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>• Commitment and support are provided</td>
<td>Action 1/LEAP-1401</td>
<td>If the EMG becomes a part of KRAFT it will be given support from top management by being authorized to introduce the changes suggested in the LEAP</td>
</tr>
<tr>
<td></td>
<td>• Clear environmental goals are established</td>
<td>Action 3/LEAP-1403</td>
<td>If environmental performance can be translated into a measurable economic parameter it will become easier to address environmental issues as business issues.</td>
</tr>
<tr>
<td></td>
<td>• The environmental issues are addressed as business issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ecodesign are not only treated on an operational level, but also on a strategic level</td>
<td>Action 12/LEAP-1409</td>
<td>Steps of Incentives for sustainable development can also be utilized as a strategic aid.</td>
</tr>
<tr>
<td></td>
<td>• Environmental issues are included when establishing a company’s technology strategy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer relationship</td>
<td>• A strong customer focus is adopted</td>
<td>Action 18</td>
<td>A strong customer focus already exists.</td>
</tr>
<tr>
<td></td>
<td>• Companies train their customers in environmental issues</td>
<td></td>
<td>As of right now, it is the other way around. Hopefully, this can be turned the other way.</td>
</tr>
<tr>
<td>Supplier relationship</td>
<td>• Close supplier relationships are established</td>
<td>Action 18</td>
<td></td>
</tr>
<tr>
<td>Development process</td>
<td>• Environmental issues are considered at the very beginning of the product development process</td>
<td>Action 11/LEAP-1408 and later Action 17 LEAP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Environmental issues are integrated into the existing product development process</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Environmental checkpoints, reviews and environmental milestone questions are introduced into the product development process</td>
<td>Action 11/LEAP-1408, Action 13/LEAP-1410 and later Action 17</td>
<td></td>
</tr>
</tbody>
</table>
- Company-specific environmental design principles, rules and standards are used
- Ecodesign is performed in cross-functional teams
- Support tools are applied

**Action 6**/LEAP-1406

EMG should help instate this way of working where various departments work closer together.

**Action 14 including LEAP-1404, LEAP-1405, LEAP-1406, LEAP-1408, LEAP-1409, and LEAP-1410**

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<table>
<thead>
<tr>
<th>Competence</th>
<th>Education and training are provided to the product development personnel</th>
<th><strong>Action 7 and later Action 15</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An environmental expert supports the development activities</td>
<td>Action 1/LEAP-1401 and Action 10</td>
</tr>
<tr>
<td></td>
<td>Examples of good design solutions are utilized</td>
<td>Best practices need to be established by EMG and the concept of &quot;Lessons learned&quot; needs to be further developed and utilized in the start-up of new projects.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivation</th>
<th>A new mindset emphasizing the importance of the environmental issues is established</th>
<th>As a consequence of the LEAP this is expected to happen.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An environmental champion exists</td>
<td>Action 10</td>
</tr>
<tr>
<td></td>
<td>Individuals are encouraged to take active part in the integration of Ecodesign</td>
<td>By providing education employees are encouraged to learn, later they should be encourage to apply what they have learned.</td>
</tr>
</tbody>
</table>

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Ecodesign

“In Business, as in Nature, All Wastes are Assets in Disguise”

Green design
Sustainable engineering
Environmental/Ecological Design
Environmentally Conscious Design, ECD
ISO 140006
Environmental Design
Sustainable design
Design for Environment, DfE