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Warehouse improvement with Lean 5S - A case study of Ulstein Verft AS

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Preface

Just as living organisms, organizations are subjected to continuous changes. This statement is equally valid for warehouses as part of organizations or as single entities. Material flow is coming in, shipped out, or simply moved around the warehouse premises on a daily basis. This makes it difficult to control the work setting in terms of order and orderliness, or to keep neat facade, and may lead to disruption of processes, which on the other hand affect the overall performance. Contribution to the changes of the work environment have also the employees, and the fact that just as every individual has unique character, he also has unique work-habits, and it is these habits that define the work culture of the organization.

Practical example of the statement above is the case of Ulstein Verft AS. The shipyard is implementing 5S in the warehouse department in order to improve the visibility, material flow, work organization and standardization of processes. According to the problem areas and counteraction of the company, this research turns to the problems of improvement of efficiency and value adding through the implementation of 5S in the warehouse of the shipyard.

The research presents theory of organizational culture and management, looking at it in a warehouse setting and from Lean perspective and will discuss manners to sustain, and possibilities of tracking changes from the implementation of Lean 5S.

Acknowledgements

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Firstly, I would like to thank my supervisor Associated Professor Bjørn Guvåg for his joining in as my supervisor, for his criticism and guidance for improvement of this research work, and for his patience throughout the process.

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I would like to thank also Reidun Hagen, Management Trainee at Ulstein Verft AS, and Rolf Heltne, Logistics Manager at Ulstein Verft AS for their readiness and willingness to support this research by placing available information to my disposal.

Last, but not least I would like to appreciate my family and my friends for their moral support throughout this process.

Part I. Chapter 1: Introduction and description of the problem

1.1. Background

Norwegian shipbuilding is a long-established industry, the rationale for which is due to geographical, social and political factors. The Norwegian maritime cluster consists of few large and a number of smaller shipyards, which have developed their businesses in the following main markets: offshore ships, small specialist ships, fishing boats and passenger ferries. The output at present is mostly for the offshore segment. In search for innovation and for the sake of development, strong relationship between Norwegian maritime research and development institutions, the ship owners and shipbuilding companies has been established (*Norway's Shipbuilding Indutry* 2009).

Part of the Ulstein Group, Ulstein Verft AS (hereafter referred to as Ulstein Verft) has grown up to a worldwide, leading company in design and building of special-purpose ships. Construction processes are organized in projects, which requires high degree of management, technical knowledge and utilization of sophisticated equipment (Ulstein Group). The shipyard participates in MAROFF (Maritime business and offshore operations) Lean Shipbuilding research and development program, which is part of the Research Council of Norway. With the collaboration of Fafo (from Norwegian: Forskningsstiftelsen Fafo) and Møreforsking (Møre Research Center) on research of implementation of Lean Shipbuilding, a unique production system called Ulstein Production System has been developed, which focuses on planning methodology. Thus, production-guiding method The Last Planner has been implemented for yard number 277 in November 2006 and utilized then on (Longva 2009; Fafo) .

Subsequently, the scope of implementation of Lean has extended to other departments and in search for performance improvement and value creation to the processes, the shipyard has started the deployment of Lean 5S in the warehouse. Initially, a research work-group has been formed at Ulstein Verft, which has its focus on the functions of the warehouse.

With the objective for innovation and development, the shipyard also cooperates with institutions for higher education in Norway and thus several Master's thesis projects have been executed with Ulstein Verft. This thesis is a form of continuation of the 2009's Master thesis of Kjersti Kjos

Longva - Warehouse Management in a Lean Shipbuilding Perspective – An Exploratory Case Study of Ulstein Verft, which focuses on management for improvement of the warehouse functions and the material flow at Ulstein Verft. Thus, Lean 5S being chosen as an adequate tool for improvement of the warehouse processes, this thesis aims at giving insight into the practical implications connected to the deployment of Lean 5S.

1.2. Setting, research purpose and guiding questions

The initial purpose of the study was to form a deeper understanding of the practical implications, the follow up, and possibly the result of the implementation of the 5S tool in the warehouse of Ulstein Verft. The study was initiated in the winter of 2009, during which time Ulstein Verft had started the pilot project of the deployment of 5S in the Maintenance department. The pilot project was completed during the time of this research and the experience, and results are valuable source of information. However, due to the fact that the implementation of 5S in the warehouse is still in process, no complete description of the process was possible, and the scope of this thesis moved to a description of the problem areas in the warehouse which led to the need of the implementation of 5S. At the same time, the thesis discusses the managerial implications connected with the changing processes and describes the driving forces in the processes.

Focal point of this research is the warehouse of Ulstein Verft and the implementation of 5S tool in it. Factors that need to be taken into consideration, which play essential role in the function and performance of the warehouse are that it serves and is tied to the shipbuilding processes, which are known as complex, time, labor and resource consuming. Due to the fore-mentioned factors and in order to improve its performance and outmatch its competitors, Ulstein Verfit is occupied with active learning and development, part of which included deployment of Lean. This sets the frame of the research (Figure 1-1) of the thesis and carry general weight over it

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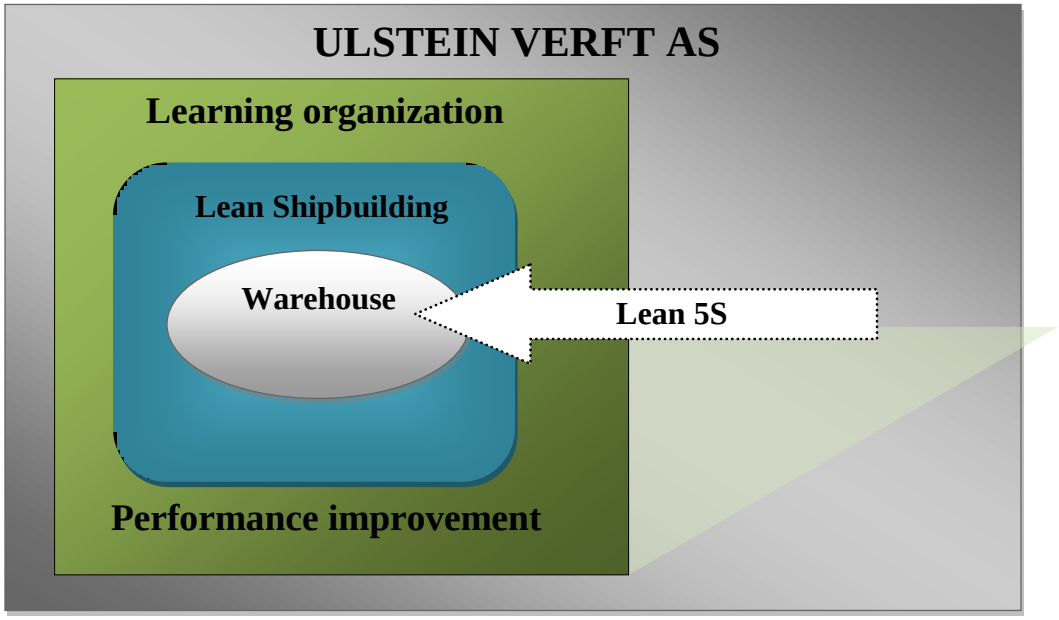


Figure 1 Research frame

Thus, research problem underpinning this Master's thesis is how the implementation of Lean 5S can contribute to the improvement of the warehouse of Ulstein Verft and how the changes of the deployment of 5S can be sustained.

The research objectives were defined as follows:

- To contribute to the understanding of implications related to the implementation of Lean 5S in the warehouse of Ulstein Verft.
- To present enabling factors for success and milestones of the implementation of 5S and its sustainability.
- To give ideas on measurement of the change effect.

The research questions, which were the rationale for this case study are:

- What are the problems the warehouse is faced with and how those problems reflect the overall performance?
- How can the implementation of Lean 5S contribute to the warehouse performance?
- How can 5S contribute to the improvement of information flow?

- How can the change processes be evaluated?

In order to answer the above questions, archival documents will be used, relevant theory will lead into the topic and analysis of the contemporary events at the warehouse of Ulstein Verft will be conducted. The elements of analysis supporting the case study include direct observations (2 visits at the company) in order to obtain knowledge about the events being studied, as well as interviews with the personnel involved in the events. Furthermore, documents and artifacts are also useful source of information for this case study. The theory presented will support deeper investigation and presentation of some facts about the problem and will try to develop a better insightfulness about the topic.

1.3. Overview and structure of the thesis

The principal structure of the thesis is divided into four main parts, which are subdivided into 5 chapters. *Chapter 1* leads to roots and the formulation of the problem. It aims at getting into the essence of the problem and how it emerged. *Chapter 2* elaborates the ground theory, which presents ideas for research and practice. The theoretical background is chosen based on the main concepts knitted into the problem i.e. Lean, Shipbuilding, Warehousing and Organizational changes. *Chapter 3* discusses the methods used for collecting the data further articulated in the case study chapter. *Chapter 4* articulates the need for the investigation of the phenomenon, which makes the bridge between the research done on the problem so far and the particular phenomenon, through the methodological approach used for the case. Chapter 5 is devoted to a discussion of the results of this research, conclusion, limitations and implications for further research.

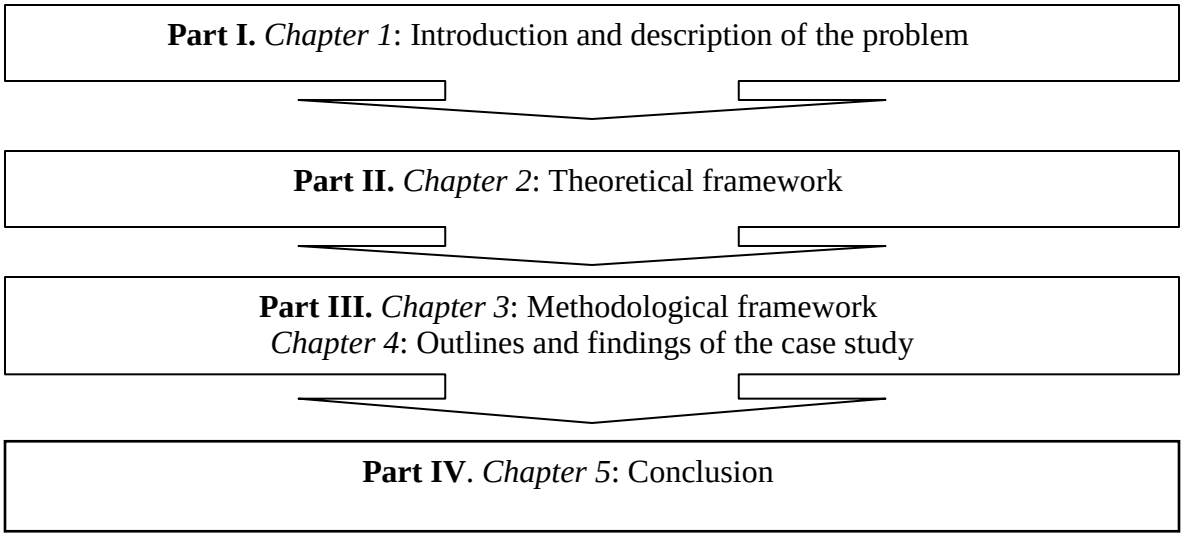


Figure 2 Structure of the thesis

Part II. Chapter 2: Theoretical Framework

The chapter resumes the literature surveys done on the relevant areas of interest for this case study – Lean, warehousing and organizational management.

2.1. Lean Thinking and Lean Shipbuilding

2.1.1 Lean Thinking

The term 'Lean' goes back to the 1990s when a book called '*'The Machine That Changed the World: The Story of Lean Production*''[1] introduced the term 'lean production' (Holweg 2007). The book follows up transfer of manufacturing ideas from craft production to mass production to Lean production (Poppendieck 2002). It origins come from the automotive industry and the Toyota Production System (TPS) in particular but nowadays it has been applied in other lines of businesses such as Lean Design and Lean Construction. The objective of Lean is to eliminate waste, to increase productivity and efficiency, to add value, to reduce costs, as well as to increase the competitive performance. All that aim at bringing customer satisfaction (customers, being the center of Lean).

Leanness can be achieved through follow-up of the following key principles (see Figure 2-1):

[1] The Machine That Changed the World: The Story of Lean Production, by Womack, James P., Jones, Daniel T., Roos, D, Harper Perennial; 1991

Figure 3 Principles of Lean

(Source: www.lean.org)

1. *Identify the value* – investigate the processes from customers perspective i.e. define the needs of the customers out of the processes. It can be done with tools as value management, function deployment and simulation.[2]

2. *Map the value stream* – the consequence of processes required to make a product is defined as value stream, and mapping of those processes will help understanding how the value for the customers is build through the processes.

3. *Create flow of the processes* – the aim is to create a value stream and one-piece flow, as well as to avoid or reduce the batch and queue, if possible.

4. *Establish Pull* – adjustment of the production to the customers' needs and requirements, i.e. produce when and what the customers want. The production processes should be supported by JIT and standardization.

[2] http://www.1000ventures.com/business_guide/lean_production_main.html (11.03.2009)

5. *Seek perfection* – once the above-listed actions are performed, they should be supported by continuous improvement, evaluation of the changing processes and waste elimination in a repetitive manner in order to consolidate the changing processes.

Furthermore, the following methods are sound supplement of the above-mentioned key Lean principles for Lean production (Ross&Associates Environmental Consulting 2004, p.2):

6. Implement a *plan-do-check-act (PDCA)* improvement framework to achieve results fast.

7. Use *metrics and performance feedba*ck to improve real-time decision-making and problem solving.

8. Approach improvement activities from the perspective of the *whole enterprise or system*.

Lean practices help organizations to improve fundamentally their competitiveness, by cost reduction, increased quality and response to customer needs. Rationale behind the implementation of Lean is typically strong business drivers, and successful implementation of Lean requires significant transformation of the organization's culture and practices. Lean practitioners assert that time of crisis is when changes are most successfully fostered and followed in (Ross&Associates Environmental Consulting 2004).

With the necessary adaptation, the principles of Lean have expanded its applicability from the production, to service industry, the military, and in construction processes, which speaks about the universality, and efficiency of the concept. Liker (2004) clams that every type of organization business can benefit from Lean not by imitating the tools used by Toyota in a particular manufacturing process but rather, by developing principles that are the right ones for the organization or businesses and by practicing them, to achieve high performance that continues to add value to the customers and society.

2.1.2 Toyota Production System

The idea of integration of production processes in a continuous flow came from Henry Ford in the beginning of the 20th Century. His practices were benchmarked by Kiichiro Toyoda, Taiichi Ohno and others at Toyota, and further developed the concept know as Toyota Production System (TPS).

Toyota Production System is based on the idea of optimization of production through complete elimination of waste, which leads to work efficiency and lower costs. Its name and origin come from the Japanese Toyota Motor Corporation and is also referred to as ‘’Lean Manufacturing system’’ or ‘’Just-In-Time (JIT) system’’. The term also became known as ‘’Lean Thinking’’ or ‘’Lean Philosophy’’, which is due to the wide-optional nature of applicability of the improvement concept. Examples of the implementation of the concept come from, but are not restricted to health care sector, service sector, sales, maintenance, government.

The fundamentals of TPS are visualized in the model developed by Toyota, known as Toyota Production System House (Figure 2-2).

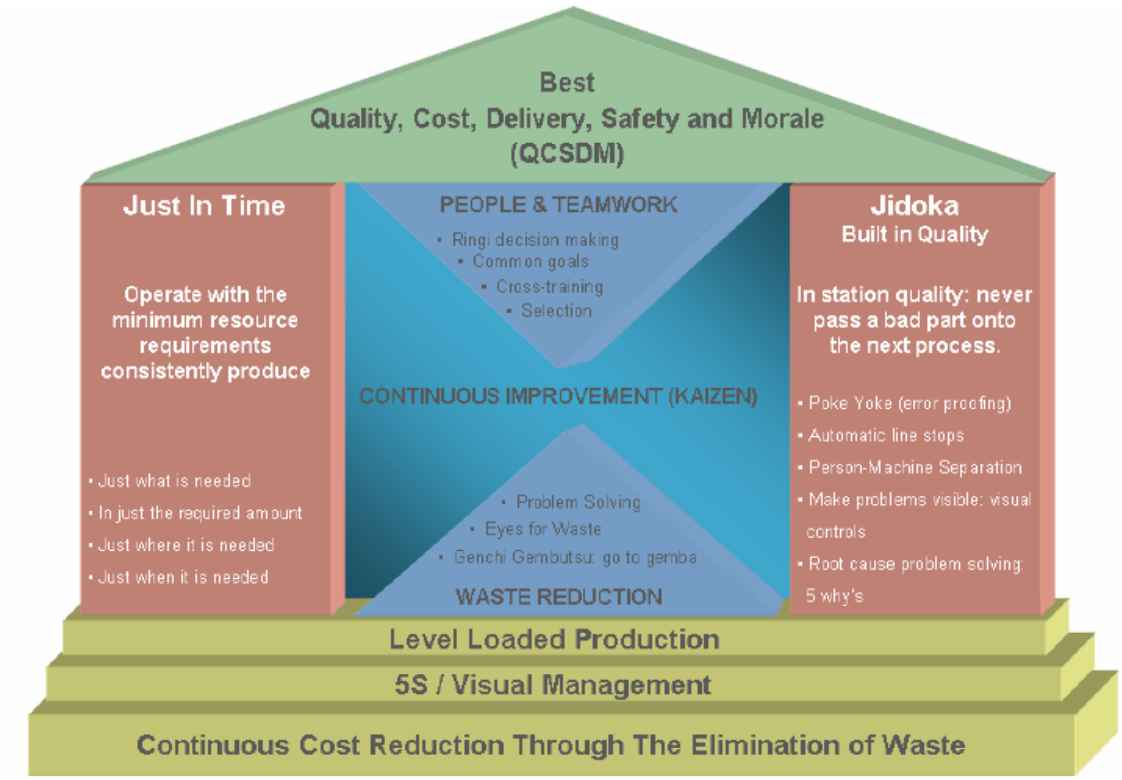


Figure 4 Toyota Production System House

(Source: http://www.gembutsu.com/system_files/library/15.pdf)

TPS is based on two concepts – ''Jidoka'' and ''Just –In-Time'', which are occupied with the elimination of the defective products and wasteful practices. The first concept is translated as ''automation with a human touch'' [3] and referrers to the visualization of the problems during production, i.e. the ability of the machine to recognize and stop the production in case defects occur, which ultimately leads to improved quality in the production. The concept of JIT refers to the consistency and reliability of production in a continuous flow with elimination of waste e.g. extra inventory, extra material handling et cetera.

TPS lays ground on *stability* - through work standardization and the tools of continuous improvement (Kaizen), and *waste reduction* - through production leveling (Heijunka). Toyota's business philosophy is based on motivation and training of the personnel, therefore central role in

[3] Toyota Production System, Source: http://www2.toyota.co.jp/en/vision/production_system/ (07.03.2010)

the success of the processes, the continuous improvement, and the system sustainability play the commitment and good training of the personnel. Continuous improvement and stability can be sustained through techniques such as 5S, Standardization, Visual control and management. Liker (2004) suggests that Lean has four dimensions and in order to create a Lean organization, all of them have to be applied. These four dimensions are captured in the Toyota model of successful management style and uniqueness known as the ‘’4P’’ model (Liker 2004).

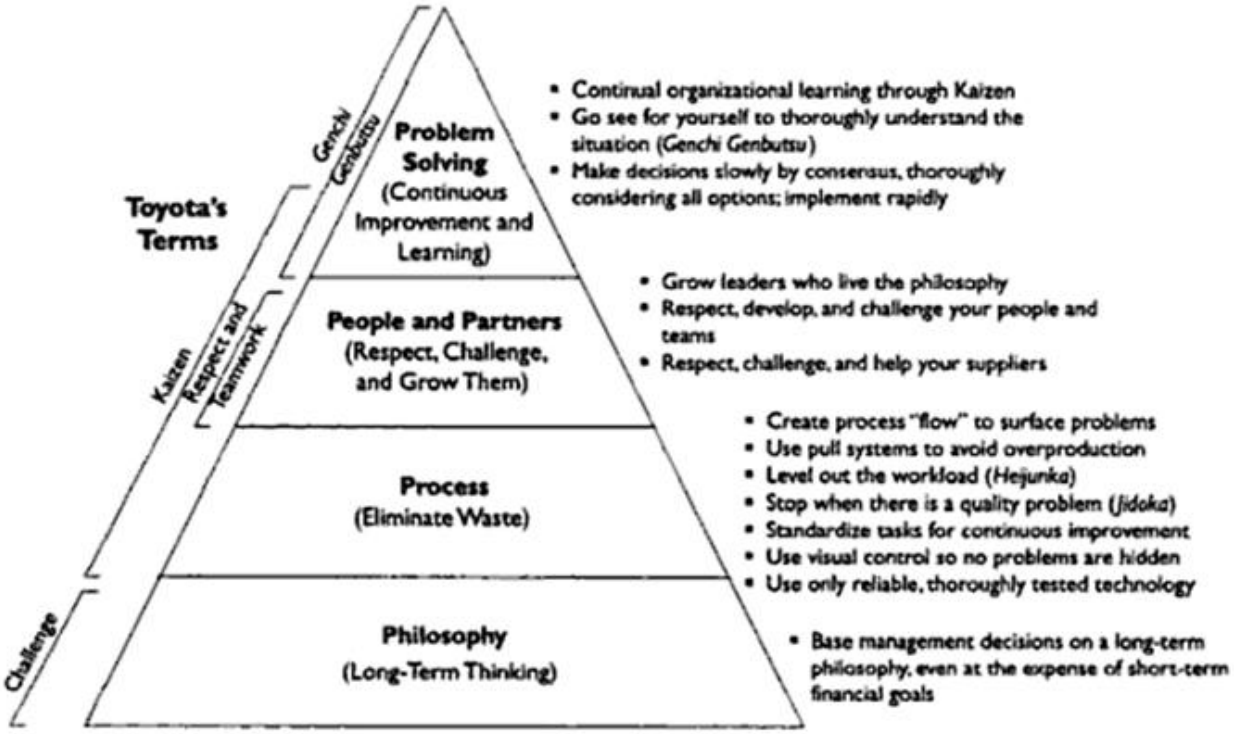


Figure 5 The Toyota Way - '4P Model'

(Liker 2004, p.6)

Liker (2004) asserts further, that despite employing variety of TPS tools, it is possible to follow only a select few of the Toyota Way principles, which will lead to short-term, non-stable jumps on performance measure, while truly practice of the full set of Toyota Way principles will be in accordance with TPS and will lead to sustainable competitive advantage.

TPS has become well known and studied worldwide. Toyota 4P model has been applied successfully in different types of organizations for the improvement not only of production but also of various business processes, and despite the fact that is a relatively new philosophy it has already been proven as efficient. The Toyota model and TPS have laid the foundation of a completely new paradigm - Lean Thinking and Lean Production.

2.1.3. Lean Production and Lean Techniques

The foundation of TPS tools and techniques laid ground of Lean Production. Just as in the original concept of Lean, the principles behind Lean Production aim at minimization of resources, and by this minimization of waste in the context of mass production, i.e. less human effort, less manufacturing space, less inventory, less defects (NSPR 2004). Accordingly, Lean production aims at meeting customers' expectations by delivering quality products and services at the right time and at the right cost (Ross&Associates Environmental Consulting 2004).

There is a common interchangeable usage between the terms Lean Thinking, Lean Production, Lean Manufacturing and TPS, which is due the a lack of a common agreed-upon definition but defying one is difficult since Lean is considered constantly evolving (Pettersen 2009; Demeter and Matyusz 2008).

While the traditional mass production involves predetermined production of large lots of products referred to as 'batch and queue', the production processes in Lean Manufacturing are organized in such a way that processing steps are adjoining each other in a continuous, one-piece flow (*Lean Thinking and Methods*). Such production processes need to be closely controlled in a well maintained, ordered and clean operational environment, which incorporates JIT production principles. Moreover, shift to Lean production requires system-wide, continual improvement with the participation of all employees. Differences between Lean approaches and traditional production paradigms are illustrated in Table 2-1: (Ross&Associates Environmental Consulting 2004).

	Craft Production	*Mass Production*	*Lean Production*
Focus	Task	Product	Customer
Operations	Single items	Batch and queue	Synchronized flow and pull
Overall Aim	Mastery of craft	Reduce cost and increase efficiency	Eliminate waste and add value
Quality	Integration (part of the craft)	Inspection (a second stage, after production)	Prevention (built in by design and methods)
Business Strategy	Customization	Economies of scale and automation	Flexibility and adaptability
Improvement	Master-driven continuous improvement	Expert-driven periodic improvement	Workforce-driven continuous improvement

Figure 6 Comparisons between Craft, Mass Production and Lean Thinking

(Source: (Ross&Associates Environmental Consulting 2004, p.2)

The extent to which Lean concepts in production systems have been adopted in various manufacturing industries brings in question the universality of the concepts of Lean in manufacturing. The doubt in the universality of Lean Production is supported by the fact that achieving production leveling and consequently the fundamental JIT for Lean manufacturing, dependent upon various factors such as business conditions or buyer-supplier relationship. When these conditions are not met, batch or mass flow may be a better manufacturing practice. However, the adaptation of some of the Lean production practices in batch and mass flows ‘’[…] does not imply that they are ‘in transition’ to Lean production.’’ (Cooney 2002, p.1145).

Lean production exists on both strategic and operational level. The strategic level refers to the customers value and identification of value stream, while the operational level deals with various tools and practices that lead to waste elimination and support continuous improvement (Demeter and Matyusz 2008). Accordingly, different opinions on which tools and practices are associated with Lean Production (see Appendix 1) have been expressed, however, some common concepts are recognized and in order to give insight into Lean Production some of them will be discussed below.

2.1.3.1. Waste Elimination

One of the main focuses of Lean production is on elimination of waste, i.e. activities that bring no value to the customers. Initially, the implementation of Lean should start by recognizing the types and the sources of waste in the system. The following forms of waste are recognized in a manufacturing environment:

1) *The waste of overproduction* – uncoordinated production - too early or just in case. That results in excess inventory;

2) *The waste of waiting* – prevention of the processes to move forward, or queuing. It can be due to lack of coordination in upstream and downstream activities;

3) *The waste of needless transportation* – movement of materials, which adds no value, extend the process-time and may lead to handling damages.

4) *The waste of extra processing* – the extra activities connected with overproduction, excess inventory or handling of defective parts, e.g. rework, reprocessing, storage.

5) *The waste of inventory* – this includes the raw materials, the material in process, and materials in store, which are not needed for the customers' orders.

6) *The waste of movement* – this refers to the motion of the personnel in vain, which occurs with processing of defects or from inefficient layout.

7) *The waste of defects* – finished goods that confront with the requirements of the customers, or parts or products which have defects and require correction.

8) *The waste of creativity* – the lack of utilization of creativity and ideas of the employees in the improvement of processes and practices. It is however arguable, whether this type of waste is inherent to the previous seven wastes (Hicks 2007).

2.1.3.2. Kaizen

Kaizen (from Japanese 'improvement') is considered a mindset for continuous improvement of processes within an organization via problem solving and creative thinking, with the participation of both the managerial and the shop floor staff. It is not associated with any specific technique, but is represented by quality circles, which provide opportunities for the workers to participate in the processes of *improvement* and *maintenance* through periodical team meetings, on which ideas for problem-solving are proposed. *Maintenance* requires the building of standard operating procedures (SOPs), rules, directives, et cetera, and is achieved through discipline and human resource development measures. *Improvement*, on the other hand is achieved through continuous revision of the settled standards and further establishment of higher standards. Essential for the implementation and the success of this strategy are step-by-step actions, the managers' commitment, the employees' mindset, and the training and education of the personnel (Salem 2006).[4]

2.1.3.3. 5S

Implementation of Lean in the production or in the various levels of an organization needs to be supported by establishment of Lean environment. This can be done through five processes for achievement of standardization, effective work place organization, and continuous improvement known as the 5S - short-stands from the Japanese words for **sort**, **set in order**, **shine**, **standardize**, and **sustain**.

Sort - organization and tidiness has to start from elimination of the unnecessary items at the work place. This will remove the excess, broken or obsolete materials, and will clear up floor space. Useful practice for sorting is the red tagging. The redundant items are tagged with a red paper note, and then taken out to a central holding area where they are further evaluated. The items

[4] http://www.1000ventures.com/business_guide/mgmt_kaizen_main.html

which are considered useful are kept in an organized storage, while the rest of the items are discarded.

Set in Order – all the materials has to be well organized, and an efficient and effective storage methods should be established. Strategies for effective storage of the items are painting of the floors, outlining working areas and locations, shadow boards, etc.[5]

Shine– after the clutter has been removed and the work environment organized, the working area has to be thoroughly cleaned and keeping it clean has to turn into a regular practice.

Standardize – having achieved the previous 3S's it is required to standardize the best practices in order to further sustain the processes.

Sustain – it is hard to change the ossified processed, so sustaining the changes is considered the most difficult ''S'' to implement and maintain. Resistance typically accompanies the changes, and the personnel easily turn back to the status quo, therefore understanding and promoting the changing processes is essential.

The implementation steps of 5S, the activities that follow them and the consequent results are presented in summary in the table below:

Step	Name	Activity	Result	Catch Phrase
1	Sort	Remove unnecessary items from the workplace.	Free up space, eliminate obsolete or broken items, scrap and excess material.	''When in doubt, throw it out.''
2	Set in Order	Locate everything at the point of use.	Achieve visualization of the position of items, easy access, saves time	''A place for everything, and everything in place.''
3	Shine	Clean and Eliminate the source of filth.	Satisfaction of working in clean and tidy environment,	''The best cleaning is to not need cleaning.''

[5] http://www.tpmonline.com/articles_on_total_productive_maintenance/leanmfg/5sphilosophy.htm

			creation of ownership of the facilities and equipment.	
4	Standardize	Make routine and set standards for best practices.	Facilitates and supports the new practices.	''See and recognize what needs to be done.''
5	Sustain	Sustain, by making the 5S second nature.	Increases the morale, the productivity, the safety and the quality.	''The less self-discipline you need, the better.''

Figure 7 Outline of 5S

(after 5S Consulting: Workplace Organization[6]).

Even though not common in the literature, a sixth S has been recognized by some practitioners (DiBarra 2002). It stands for **Safety** and is positioned between Shine and Standardize. It refers to the safety of the work place and respectively of the employees.[7] It is arguable whether the 6th S can be regarded as supplementary pillar to the 5S tool, or rather as an aspect of each of the 5S pillars, since safety is considered inherent to the concept of 5S. Bicheno (2004), for example, claims that safety procedures and their standardization should be developed, maintained and audited as part of the 5S program (Figure 2-4) (Bicheno 2004).

[6] http://www.gemba.com/tool-kit.cfm?id=145

[7] http://epa.gov/lean/toolkit/ch5.htm#definition

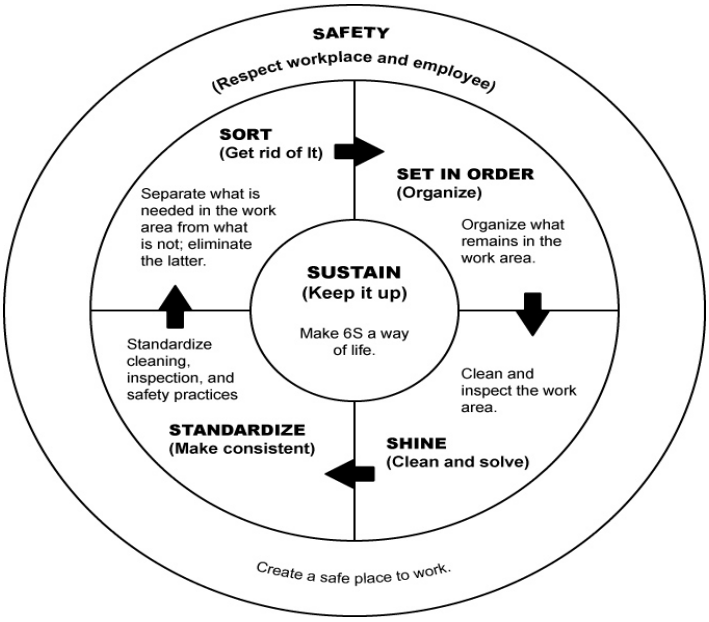


Figure 8 Relationship of the 6S pillars [8]

The idea behind the 5S tool is that well-organized environment contributes to the optimization and productivity by[9]:

- Creating and maintaining organization and orderliness;
- Using visual cues to achieve more consistent operational result;
- Reducing defects and making accidents more less likely;

The 5S principles refer to Manufacturing Management but are more popular in Lean Manufacturing Processes.[10] However, this standard approach for housekeeping appeared to be applicable in various activities, such as data organization, office housekeeping, measurements and management systems within the supply chain and factory (Sheldon 2008).

[8] https://www.greensuppliers.gov/gsn/html/users/gsn/docs/module5_6S.pdf

[9] https://www.greensuppliers.gov/gsn/html/users/gsn/docs/module5_6S.pdf

[10] http://it.toolbox.com/wiki/index.php/5S_Principles_in_Manufacturing_Management

Though Lean practices appear to be easy to grasp, they can be difficult to execute in consistency. Many companies have reached a superficial implementation of Lean and that is due to the fact that they are concentrated on some of the Lean tools like 5S or JIT, rather than grasp the concept and apply it as a cultural change throughout the whole organization (Liker 2004). Often companies implement only the first 3S but fail to standardize the processes and in this way doom the sustainability of the results of the project to failure, therefore the completeness of the 5S tool is essential.

2.1.4. Applicability of Lean. Lean Shipbuilding

The available literature on the implementation of Lean principles in shipbuilding environment is quite restricted due to the novelty and the restriction of the concept. Lean Shipbuilding is a very specialized, limited division of application of Lean and is considered to be ‘’one of the extensions beyond Lean Construction’’(Dugnas and Uthaug 2007, p.60). The sources of information and examples for this thesis come from the U.S., the Japanese, and the Norwegian shipyards. The interest in the matter set the foundation of The National Shipbuilding Research Program (NSRP) in U.S., and the Lean Shipbuilding Project under the Norwegian Research Council MAROFF-program and the Norwegian shipyards.

2.1.4.1. Specificity of the Shipbuilding industry

Taken out of the original context - the automotive industry - but still following the main principles of Lean manufacturing, and sharing the same principles as Lean Construction, Lean Shipbuilding refers to cost reduction through elimination of waste, non-value adding processes and inventories, for the improvement of customers satisfaction. It is anticipated that by implementing Lean manufacturing principles in shipbuilding, the productivity could improve by at least 50% and the built time by 100% (Lamb 2001). Statistics show that for the period from 1965 to 1995 Japanese shipbuilding industry improved its productivity by 150%, which is due to the development of some of the Lean principles at the same time as Toyota, and probably learned from each other (Liker and Lamb 2000).

In accordance with the ‘’TPS House’’ diagram, Liker and Lamb (2000) have created the Lean shipbuilding model (Figure 2-5). However, despite the fact that all the elements of the TPS House

diagram could be successfully translated into the Lean shipbuilding model, the authors stress upon the fact that unlike TPS house, the ship-model does not clearly depict a system in which the elements are interdependent, and the lack of any of the elements will lead to misperformance.

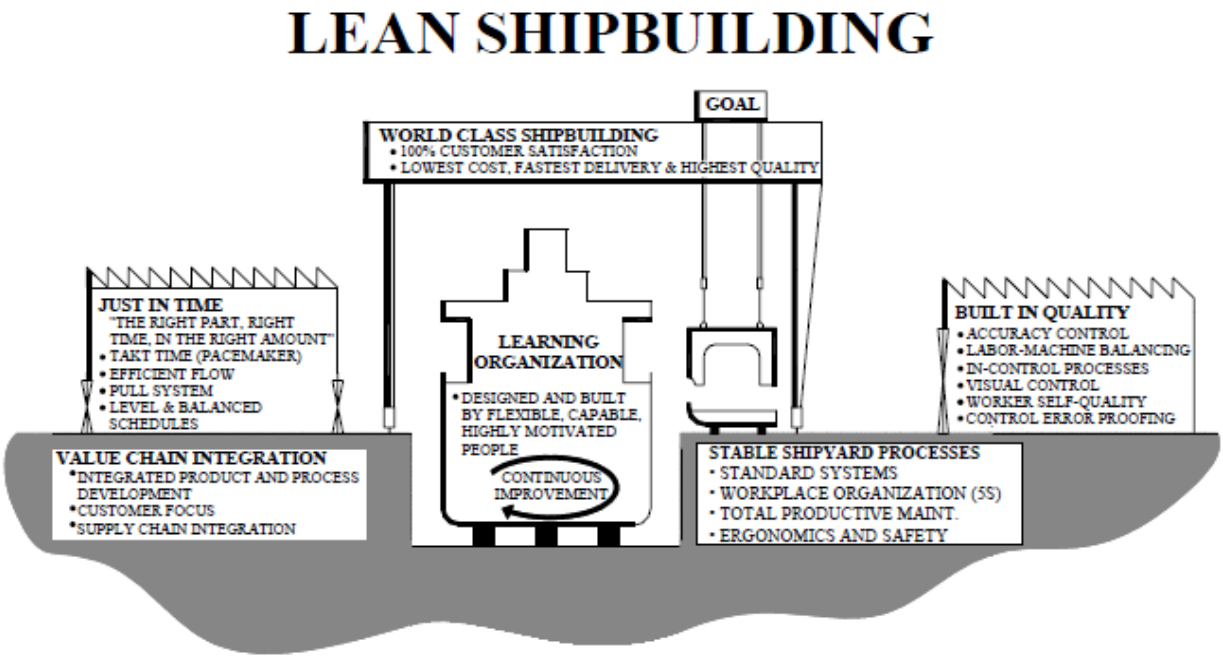


Figure 9 The Lean shipbuilding model

(Liker and Lamb 2000, p.16)

Lean shipbuilding model is inspired by the successful practices of the Japanese shipyards and includes the practices from TPS and Lean Manufacturing - adding value to the product, elimination of waste, JIT deliveries, integration of processes, built-in quality through visual control, error-proofing and employees empowerment, focus on the customers, and continuous improvement.

One of the major pillars of TPS, which is also present in the Lean shipbuilding model is JIT. According to Liker and Lamb (2000), creation of JIT flow will lead to improved quality and can be achieved through one-piece flow. That on the other hand, can be achieved through a dedicated production line for product family where families of parts go through the same set of processes.

Delivering products with coordinated cost/value relationship (value commensurate with cost) is a tedious task for mass-production manufacturers, such as car manufacturers. Example of this is the difficulties that the Japanese automakers (including Toyota) experienced in the late 1980s to early 1990s due to excessive product variety, unnecessary options, over-specification, and 'overquality'. On the contrary, this is rarely a problem for the international commercial shipbuilding industry. One reason is that the owners can determine the value they require based on business criteria. Another reason is that the merchant ships are built-to-order and the shipbuilding company and the owners communicate the requirements of the owners through the order contract (Koenig, Hitoshi, and Baba 2002).

Being suitable for large volume production, this approach has also been adopted by word-class shipyards. Applicable in Japanese and some European shipyards, (e.g. Damen shipyard in Gorinchem, The Netherlands), this model is not in accordance with the shipbuilding approach of the Norwegian maritime cluster, as the vessels produced are advanced and highly customized. However, it is applicable in the construction of vessels with standard modular design, low complexity and little customization where building is organized on moving lines (Longva 2009; Liker and Lamb 2000).

Common features of the shipbuilding industry is that it is labor-intensive, since the production automation format is limited (Kang). The products of the shipbuilding industry are high in volume and weight and each product contains numerous of different components, which makes the production processes and their command highly sophisticated. The concept of 'teamwork' is essential in shipbuilding, since the design, planning and manufacturing process overlap and at the same time the production processes are extremely complicated (Lyu and Gunasekaran 1993). However, shipyards across the world have specific mechanism in their production practices and thus their approach to the implementation of Lean varies, examples of which are presented below.

Shipbuilding in Japan

Successful application of lean principles puts Japanese manufacturing companies, including the Japanese shipyards, in the position of 'role-model', in terms of productivity, product quality and the utilization of human resources. Thus, the Japanese shipyards are considered best-examples of

Lean thinking in shipbuilding (Sanidas 2001; Koenig, Hitoshi, and Baba 2002). Research of some Japanese world-class shipyards shows that the shipyards haven't applied all of the Lean manufacturing principles due to specifications such as process time (months-long) and product delivery (very low) (Lamb 2001).

It is not possible to say to what extend the application of lean principles helped the shipyards in Japan in achieving the high productivity, since Lean manufacturing blurs with Total Quality Management and other Japanese development. However, they have used some applicable principles, such as one-piece flow, JIT, and 5S to some level. Accordingly, quality is built in at the source, rather than inspected in, processes are highly standardized and timed, raw materials are brought in on a JIT basis, and all the employees are engaged in work initiatives and carry responsibilities to follow up the processes (Liker and Lamb 2000; Lamb 2001).

In contrast to the automobile industry and Lean theory, the production in the Japanese shipyards is driven by pull at the top, and fixed schedules at the lower level, i.e. the construction processes cannot start until the customer pulls the order. The production process can start only after the previous ship launches, or moves to the next position. Thus, the pull-style prevents from overproduction. However, ship production from the erection schedule on down is based on schedule development and conformity. Thus, in cases of drops in the downstream stage, upstream schedule is not allowed to slip in. Moreover, in case of production problems that interfere the schedule, the workers does not have the authority to halt the upstream production (Koenig, Hitoshi, and Baba 2002).

Shipbuilding in Norway

Norwegian shipbuilding is a complex production, the performance of which is organized in projects. The industry is characterized by high degree of outfitting, and at the same time low degree of standardization. The ships are built to order and are often highly customized. Different suppliers and work force are involved in the execution of the projects (Aslesen 2007)

Due to the nature of the shipbuilding industry, Norwegian shipyards have adopted a completely new production concept of lean shipbuilding, which is blended between Lean manufacturing and Lean construction (Bertelsen 2007). The features that characterize the Norwegian shipbuilding industry are one-of-a-kind product, consistent production facilities, and fixed position layout (Longva 2009; Salem 2006). In search of process improvement and achievement of competitive advantage, Norwegian shipbuilding companies are developing Lean Shipbuilding based on cooperation with Lean construction forums (Longva 2009).

Lack of information on any particular case of implementation of Lean or 5S in any of the Norwegian shipbuilding companies prevents from presentation of such in this research. However, it is known that 5S has been implemented in Brunvoll AS (Molde, Norway), which is manufacturer and supplier of thruster systems and is part of the Norwegian Maritime Cluster. The production of the company is tailor-made, highly specialized and with the deployment of Lean practices (which includes 5S) in the production and the warehouse department, the company aims at improvement of the processes through efficient value stream. However, no data on the evaluation and efficiency of the project has been performed so far.[11]

Shipbuilding in U.S.

Driven by the mission to establish international shipbuilding competitiveness, and cost reduction, The National Shipbuilding Research Program (NSRP) has launched a Lean Shipbuilding Initiative, in order to facilitate transformation to Lean practices throughout the U.S. shipbuilding and ship repair industries (NSPR 2004).

Research conducted by Liker and Lamb (2000) for the NSPR shows that despite the improvements of facilities and process in the U.S. shipyards, the results are still marginal compared to those in Japan and Korea. Moreover, at that time the productivity of the U.S. shipyards has been half that of Europe and third of the Japanese shipbuilding. Thus, Liker and

[11] Source: Interview with Dag Brunvoll, Manager of Logistics and Planning at Brunvoll AS

Lamb (2000) suggest that significant improvement can be achieved through the adoption of lean manufacturing principles.

As part of NSPR – Advanced Shipbuilding Enterprise, Todd Pacific Shipyard has implemented the Lean 5S program in 12 areas of the shipyard, as well as onboard ships. The practical experience of the implementation of 5S shows that it is a powerful tool for cultural change, which is easily applicable to the realities of the environments. It is of low cost and could have a substantial payback for the investment involved. Benefit of 5S is that it involves analytical thinking and by that support successful outcome of the improvement efforts. However, applied in isolation from other Lean practices, it may lose inertia, that is why 5S should be used as a ground tool for further change efforts such as Lean (DiBarra 2002).

2.2. Warehousing. Lean Warehousing

2.2.1. Warehouse Management

Warehouses play key role in the supply chains by defining to a great extend the success of businesses (the company's competitiveness) in terms of cost levels and customer service. Despite the high expenses, which come by carrying inventories, warehouses function as a buffer between the variability of supply and demand, which makes them necessary element in the contemporary supply chains. The high expenses provoke the challenge for achieving low cost warehousing with a high level of customer satisfaction at the same time. However, under the influence of factors like e-commerce, supply-chain collaboration, globalization, and new management techniques such as JIT and Lean production, successful warehousing is heading towards tighter inventory control, shorter response time and a greater variety (Frazelle 2002; Gu, Goetschalckx, and McGinnis 2007).

3.1.1.1. Objectives of warehousing

Warehouses are storage systems whose functions support the efficiency and smoothness of the logistics operations by providing materials and supplies a in a timely and cost effective manners. Objectives for warehousing include the following (Warehousing and Distribution Operating Instructions 2009; Tostar and Karlsson 2008):

- Maximize the warehouse storage utilization, warehouse equipment and warehouse staff.
- Determine and maintain an inventory of Stock Keeping Units (SKUs) so that it can provide the requested quantities of stocked commodities needed by users.
- Maintain an inventory of critical SKUs so that zero levels of the latter do not occur.
- Reduce SKUs handling, maintain SKUs accessibility, and assure the designed SKU rotation or turns.
- Minimize the company's operating expenses.

Logistic costs take good part of the production cost. Being nods of the distribution activities, this is also valid for warehouses, therefore optimization of their performance is essential element in the cost structure of each company.

3.1.1.2. Typology and definition of warehouses

According to different characteristics various types of warehouse are recognized: (Rushton, Croucher, and Baker 2006, p.256):

- By the stage in the supply chain: materials, work-in-process or finished goods.
- By geographic area: national, local or regional, or such that may serve more than one country.
- By product type: for example small parts, large assemblies, frozen food, perishables, security items or hazardous goods.
- By ownership: owned by the user or owned by a third-party logistics company.
- By company usage: for example a dedicated warehouse for one company, or a shared-user warehouse.
- By area: classification according to the storage dimension in square meters.

- By height: classification according the height – e.g. from 3 meters high to 'high-bay' warehouses that may be over 45 meters in height.
- By equipment: from largely manual operations to highly automated.

Another classifications of warehouses presents the following three types: (Berg and Zijm 1999):

1. **Distribution warehouses** – products are collected (sometimes also assembled) from different suppliers and further redirected to the customers.
2. **Production warehouses** – storage of raw, semi-finished and finished products in a production facility.
3. **Contract warehouses** – warehouse facility used on behalf of one or more customers.

Frazelle (2002) on the other hand, presents another classification by distinguishing three types of warehouses according to their value-adding operations:

1. **Raw material and component warehouses** – hold raw materials at or near the pint of induction into a manufacturing or assembling process.
2. **Work-in process warehouses** – hold partly completed assemblies and products at various points along an assembly or production line.
3. **Finished goods warehouses** – hold inventories used to balance and buffer the variation between production schedules and demand.

Despite the various classifications based on different criteria, the essential difference between warehouses is confined to the perspectives of the sources, management and users of the warehouse. On the other hand, what brings them together is set of common operations: receiving, storing, picking and shipping (Tompkins 1998).

3.1.1.3. General warehouse operations

Market forces and the development of technologies within the material handling have brought influence on the warehouse operations (Van der Berg and Zijm 1999). However, the fundamental warehouse activities consist of:

Receiving

According to the standard procedures of receiving goods at warehouses, the goods are delivered and unloaded at the receiving docks, and before their allocation, the products are identified, the quantities verified against the orders and random quality checks are performed. The process is completed by entering the data for the delivery in the inventory system. Before transportation and allocation, the SKUs are labeled (e.g. a barcode label or an RFID tag are attached), and/or repacked in the right storage modules (pallets, cartons, etc.) if necessary.

Storing

The SKUs have to be allocated away to their designated storage location, which is defined by the warehouse management system. Identification of the right location of the SKUs is important because ‘’proper storage allocation rules optimize the space utilization as well as the efficiency of the warehouse processes (Van der Berg 2007, p.64)’’.

In connection with the putaway organization of the SKUs, several *storage policies* exist (Rouwenhorst et al. 1999):

- *Dedicated storage* – each product is assigned to a particular location.
- *Random storage* – the operator takes the decision where to place the SKUs.
- *Class based storage (ABC zoning)* – the products are classified in groups according to their turnover ratio and zones are allocated to those groups.
- *Correlated storage/family grouping* – nearby storage of SKUs if they are often required simultaneously.
- *Forward/reserve and replenishment* – which articles and in what quantity are stored in a separate reserve area (forward area), if such exists.

While stored, the SKUs have to be counted on a periodic base. Cycle counts aim at smoothing the inventory discrepancies by determining the imbalances between the actual product amount in stock and the amount registered in the warehouse management system.

Order picking

Order picking is the process of retrieving products according to a specific request. The process of picking an order is performed manually or automatically and is guided by an order, which specifies the required products and the quantities. Orders can be picked individually (single order picking) or in batches. Two policies for picking exist – *pick and sort* (sequential), and *sort while pick* (simultaneous). A way to organize the order picking is through a *routing policy*, which defines the sequence and the route of the retrievals (Rouwenhorst et al. 1999). In cases when the order consists of multiple SKUs, the latter are accumulated and stored until shipping.

Order picking is identified as the most costly and labor-intensive operation in most of the warehouses, i.e. 65% of the total cost and 50% of the workforce of a warehouse (Figure 3-1) (Strack and Pochet 2009; Berg and Zijm 1999) . Bad performance of this operation may affect the whole supply chain through high operational costs and unsatisfactory service (Koster, Le-Duc, and Rootbergen 2007).

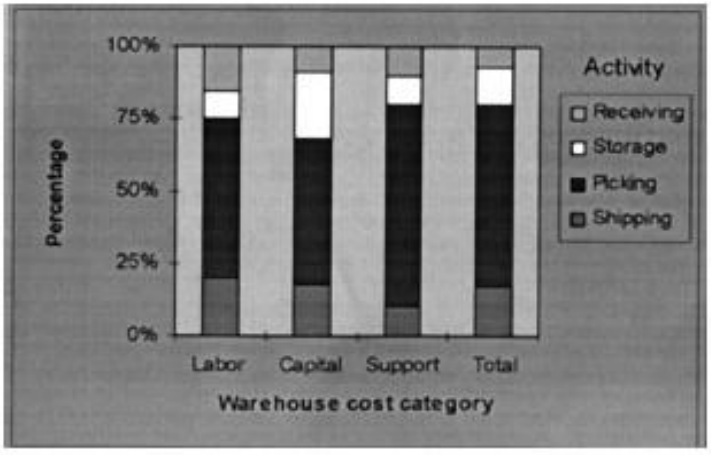


Figure 10 Warehouse costs by activity

(Berg and Zijm 1999, p.521)

Shipping

Many of the universal receiving principles apply for the shipping process but in reverse order (Fazelle 2001). Accordingly, shipping includes the picking up and delivery of the orders to the shipping dock where the SKUs are prepared to be shipped. Finally, the data for the SKUs, which left the warehouse is updated in the inventory system. For both shipping and receiving processes, scheduling of the incoming and outgoing loads would contribute for a better management of the resources (personnel, staging space, dock doors etc.) and could promote creation of timetables for the warehouse operations (Longva 2009). This would contribute to standardization of the processes in the warehouse and thus for its improvement.

2.2.2. Warehouse performance assessment

With the upgrade of the production came the need to look at better performance of the warehouses. The urge for measuring warehouse performance is provoked by internal issues (e.g. space utilization, inventory accuracy, safety and housekeeping), external issues (order accuracy, stock-outs, complaints) and performance issues (e.g. goals, feedback, competence) (Tompkins 1998). Some of the challenges the warehouses are faced with are material handling, data collection, increased labor to support the warehousing requirements (Garcia). The areas of interest to measure the performance are productivity, inventory and order fulfillment. Some organizations tend to measure their progress against financial measures such as return on investment, cash flow, sales growth, but those measures are irrelevant and do not truly refer to the issues of quality, service, and continuous improvement.

Warehouse benchmarking

A way to measure non-financial performance of warehouses is benchmarking, which identifies warehouse inefficiencies of the critical resources such as labor, space, storage and handling equipment. Benchmarking is defined as ‘’[…] continuous measurement and improvement of an organization’s performance against the best in the industry to obtain information about new

working methods or practices (Kozak, p.1).'' Benchmarking does not mean to adopt the methods of the benchmarkee (the organization being benchmarked), but rather to compare the performance, to look at the way the other companies are more efficient, to learn valuable lessons, improve quality and customer satisfaction and by this, to gain superior performance (Kozak ; Watson 1993; Johnson, Chen, and McGinns 2009).

Effective benchmarking requires a frame of reference from a wide group of best-practice warehouses for the measurement of performance. The primary hindrance for the implementation of this method is gathering sufficient data for characterizing the best performance since companies are sensitive for data-sharing, especially for proprietary information about a firm's operations or financials. However, due to the development of Internet technology the problem of collecting data can be solved by Internet performance measurement tools. An ongoing collaboration between academia and the warehousing industry has laid the foundation of the iDEAs-W tool for Internet benchmarking by which through online collection and maintenance of data, firms could get both individual firm evaluation, and industry-level trends. This benchmarking tool can provide efficiency estimates, gap analysis (pie charts describing the connection between partial productivity analysis and the efficiency estimates), and practice and attribute information for the efficient production processes identified as benchmarks (Johnson, Chen, and McGinns 2009).

Before introducing benchmarking, the organization should conduct a research to identify which Key Performance Indicators (KPIs) and Key Performance Measurement (KPMs) to apply. This will lead to the identification of performance gaps between the companies as well as to the identification of the enablers of better performance of the leading companies. The results should be applied for the sake of adaptation and improvement. (Anonymous, www.best-information.eu; Watson 1993).

Despite appealing, this approach carries drawbacks. Firms may lack the analytical personnel or tools to identify the best/worst performance, or proprietary firms might not be willing to share information and by this, data collection or limitation problems may appear. Furthermore, in order to ensure confidence that the industry-level benchmarking has identified the best/worst

performance, a large enough data for a peer group is necessary, and the collection of this data might be difficult (Johnson, Chen, and McGinns 2009).

KPI dashboard

Dashboard is a measurement system that utilizes integrated operational data to present measurement of business processes through performance indicators, which draw attention to the milestones in operations. The data is presented in graphs, grids and various visualization techniques. [12]

Measurement of performance through KPI dashboard requires careful choice of performance indicators according to the goal and objectives of the warehouse. Moreover, numerical values of target range of the chosen KPIs has to be set according to the objective measured, and according to time period. For example, warehouse KPI could be *service rate*, measured as No. of order lines shipped on time / total No. of orders lines shipped.[13] Despite the variety of performance indicators available, a close consideration for the choice and the number of indicators utilized in the dashboard should be made.

2.2.3. Lean Warehousing

Warehouse improvement refers to improvement of the material flow, order picking, replenishment, and dock operations. Improvement techniques such as material flow analyses, quality improvement and application of 5S can be applied. Successful application of Lean techniques would lead to reduced lead-time (the unnecessary time part of the order-to-delivery processes), order picking time, and the time for material handling. This can be achieved through

[12] Anonymous, www.businessintelligencecentre.co

[13] http://www.humanresources.hrvinet.com/warehouse-kpi/

reduction of the non-value adding activities, and improvement of velocity and flow in the warehouse (Garcia).

Lean thinking has become popular in the last 20 years and its techniques have been applied to different service industries. Examples are the replacement of the telephone operators by dialing systems, the implementation of self-check or home-print boarding pass option introduced by some airline companies, the implementation of ATM machines by the banks, and the implementation of the automatic payment devices implemented on the gasoline tanks on some gas stations (Ackerman 2007). These examples prove the versatility and adaptability of the concept of Lean and support the statement that the implementation of Lean in warehousing can doubtlessly be successful.

Warehouse optimization includes optimization of the functions and the material flow. Despite the common perception that Lean thinking is typically subscribed to the production processes (the origins of Lean come from the mass production of highly standardized products, in contrast, warehousing belongs to service industry), where the elimination of waste and the non-value added processes are most visible, and the fact that ‘’many practitioners consider the term warehouse and Lean mutually exclusive.’’ (Garcia)(p.1), the application of Lean in the warehouse activities can lead to significant improvement, such as elimination of waste, improvement of the lead-times and better value creation.

The types of waste recognized in manufacturing are also transferrable to warehouse environment (Ackerman 2007):

1. *The waste of overprod*uction - overproduction in manufacturing results in waste of materials. In *warehousing, an excess of inventory has the same significance.*
2. *The* waste of waiting - waiting is a waste of time. This is as true in warehouse operations, as it is in production.
3. *The waste of needless transportation* - unnecessary movement of cargo is a major source of waste in material handling processes.
4. *The waste of inventory* - poor inventory control represents waste, particularly when stock-outs are frequent.

5. *The waste of extra proc*essing – in warehousing context, this waste is transferred as over checking.
6. *The waste of movement* - movement is a waste when it involves seeking after for tools, or stored items, which cannot be located.
7. *The waste of defects* - defective parts waste production; in warehousing, errors result in waste.
8. *The waste of creativity* - unused employees' creativity represents a waste of human resources.

Despite no concrete example for Lean warehousing and 5S is available, according to the practical experience of STL Warehousing with the implementation of 5S in warehousing activities shows that ''[…] Lean philosophy alone, is not enough to resolve (or pre-empt) all warehousing problems. But when combined with traditional project management skills, it is amazingly effective at transforming a warehouse into a clean and organized system that performs like a production line, delivering predictable and reproducible results with significantly less labor.''[14]

2.3. Organizational management and development

According to Adcroft (2008) ''organizations are collections of specifies like products, functions, processes and finance but they are also defined through intangibles such as culture, knowledge and learning'' (Adcroft 2008, p. 40). Organizations are considered continuous changing institutions, and the changes are driven by the velocity of the complex business environment. Triggers for change are: *political factors* (wars, universal rights, taxations etc.), *economic factors* (wage rates, employment rates, government economic changes etc), *technological factors* (computerization of processes, information technology, etc.) and *socio-cultural factors* (skills availability, attitude to work and employment, etc.) (Senior and Swailes 2010).

[14] From www.stlwarehousing.com.au – Lean Warehousing – Fact or Fiction?

2.3.1. Organizational change and Change management

Organizations are entities of people, interacting with each other in a structured way. Furthermore, the interaction of the people is managed so that their activities are directed to achievement of set organizational purposes or goals. Change in organizations is successfully directed through setting clear goals and measurement of the processes. Change involves learning processes that require time, physical, social and mental space (Oxtoby, MGuiness, and Morgan 2002). Implementation of changes without developing a plan for the organization's continuous adaptation and improvement is an effort in vain. Creating change, however, is not synonymous with creating adaptation and despite the fact that many organizations have tried to implement changes - few of them have managed to create organizational capacity for continuous and adaptive change (Malone 2007).

Successful implementation of changes depends on the employees' involvement and their commitment to the processes. Their individual and collective attitude towards the change will reflect on their behavior and that is critical for the success or failure of the change program. According to the social information theory, people within an organization form their opinion about the organization and the appropriate behavior through the evaluation and acceptance of their co-workers. Furthermore, ''[…] an individual's attitudes and believes are partially formed as a result of the attitudes and believes of surrounding others through mechanisms of social comparison and social information processing''(Jones 2007, p.7). Therefore, the collective participation or the formation of team work in which a dedicated leader is appointed is essential, because ''[…] in times of uncertainty at work, people look to others for standards and guidance on how to think and behave'' (Jones 2007, p.8). Moreover, according to Jones (2007), what is being evaluated in the attitude and behavior of the others are the different *reasons* for and against the changes. Adopting the reasons of an individual, determines that particular persons are the most powerful and influential in the context of the change. It is those reasons that define the type of commitment to change and the implementation behavior (Jones 2007). The steps of the influence process could be seen in Figure 9.

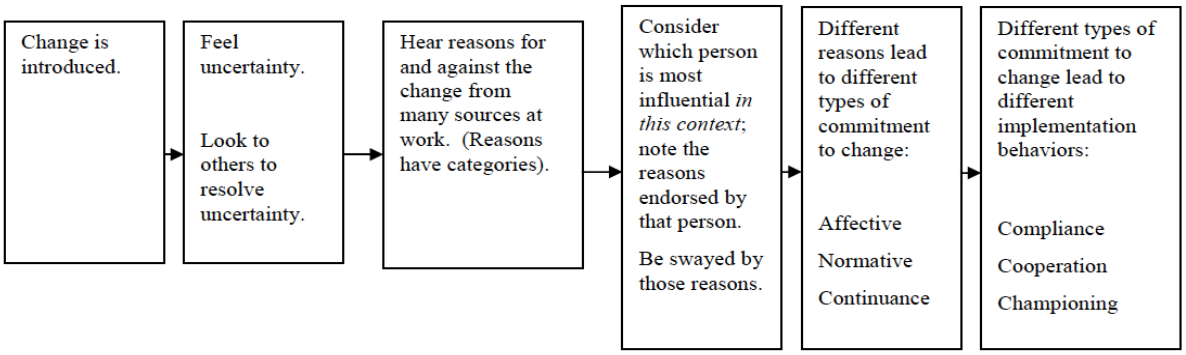


Figure 11 Process model of dynamic influence, commitment to change, and change implementation

Source: (Jones 2007, p.9)

2.3.1.1. Resistance to changes

It is natural feature of human beings to involve emotions in times of change. Usually these emotions refer to fear or anxiety of the unknown. In order to perform best in a situation of uncertainty such as changing environment and practices, adequate managerial approach is important for the successful performance of the staff during the changing processes.

Based on Edgar Stein's concepts for understanding and managing change, Cameron et al. (2004), assert that there are two forces that every individual undergoing change is faced with. The first force is *learning anxiety*, which is associated with the process of learning something new and the fear of failure connected with it. The second force is *survival anxiety* and it is referred to the pressure to change. Examples of survival anxiety include fear of temporary incompetence, fear of punishment for incompetence, fear of loss of personal identity, and fear of loss of group membership. Survival anxiety is considered a driving force, while learning anxiety is a restraining force. Among some of the interventions that an organization or managers could apply in order to support the changing processes are visioning, skills training, counseling people through change, and addressing emotions.

Part of the reasons for resistance to change is the fact that workers persist to past familiar and comfortable practices and behavior. Another reason for failure is that ‘’ […] changes introduced fail to alter the fundamental psychology or ’feel’ of the organization to its members’’ and ‘’[…] it is this ’feel’ that directs and motivates employees efforts. Without changing the psychology, there can be no sustained change.’’ (Schneider 1996, p.1) Moreover, personality plays essential role in the initiation and adaptability to changes. Other key factors in an individual’s response to change are the history of the organization, the history of the individual, they type and the consequence of change (Cameron and Green 2004).

Communicating the changes would give rationale and security to the employees for what is actually happening. Lack of information and communication will provoke frustration and alienation. It is in the human nature to feel anxiety towards changes and this might cause resistance to change. A way to support the organizational changes is to articulate the necessities for this change. Furthermore, according to Peter de Jager (2009) if the communication strategy is focused on answering the question ‘’Why is this change necessary?’’, then it can never go astray (De Jager 2009).

Referring particularly to resistance of the deployment of 5S as a changing process, Sarkar (2006) recognizes two types of resistance: *passive* and *active*. *Passive* resistance is silence opposition to the implementation of 5S, such as indifference and lack of participation in the implementation processes or meetings, missing such meetings or deliberately making mistakes, not carrying out assigned 5S work etc. *Active* resistance towards 5S deployment is recognized by obvious outcry against the implementation of 5S, such as complaining in meetings and labeling 5S as a burden, disruption of 5S meetings with irrelevant questions, lack of involvement in the deployment of 5S etc. (Sarkar 2006).

2.3.2. Communication and organizational change

Referring to Pitman (2004), Huf outlines the following factors as critical for the success of organizational change: (1) proper preparation, (2) user/client participation, (3) a strong business-related need for change, (4) reward system that supports the change, (4) high degree of

communication (Huf III). The factor of communication is a prerequisite for organizational functioning and success not only in knowledge-intensive organizations, but also in the present work environment consisted of teamwork and collaboration between workers from different functional groups.

A reason for communication barrier could be due to language. This refers to language barrier for companies with multi-cultural employees, cross-cultural communication styles, values, manners of expression. This may lead to misunderstandings and confusion, which on the other hand will influence the work-relationship and the performance of the employees. Moreover, in external, inter-cultural organizational communication, such implications may dissolve business relations.

Furthermore, determinant for effective communication is information sharing and ‘’effective communication can be described as a combination of how well information is delivered, accessed, shared, and used (Yazici 2001, p.542).’’

Another factor that may influence the communication processes between employees in a changing organization is the emotions of the employees, which are involved in the changing processes. Such emotions could be, for example frustration, anger, anxiety, uncertainty and fear and they can be managed through monitoring change program implementation, and in particular through better communication with change recipients (Liu and Perrewe 2005).

2.3.3. Organizational sustainability and adaptability

Sustainability is concomitant with the implementation processes of a program and is supported by routinization. Programs consist of activities, required to achieve a set of objectives that direct the behavior of the actors involved. These activities on the other hand consist of tasks, the performance of which draw on financial, human, and material resources. Studying the processes is performed through events, which are divided into three types: (1) events specific to sustainability, (2) events, specific to implementation, and (3) events that belong to both sustainability and implementation (Pluye et al. 2005).

Pluye et al. (2005) suggest the following routinization and implementation events:

- Resource stabilization – the stabilization of financial, human and material resources encourages routinization.
- Risk-taking – by taking risks, organizations encourage exploration of new activities and by that employees learn new activities or products and have a broad range of opportunities to be routinized. Exploration leads to presence of organizational routines (exploration).
- Incentives – incentives encourage permanence in human resources and routinization. Promotion of personnel, for example, would encourage the routinization of innovations (by offering greater responsibility and power).
- Adaptation of activities – adaptation of activities (for example, adaptation to local circumstances or environmental variation) according to their context or environment has an influence on the routinization processes.
- Objectives fit – fit of the organization's objectives with its goals and values is likely to bring into routinization.
- Transparent communication – open communication increases the trust and sharing of resources. It also helps the actors to focus on a common purpose and set of goals, which will lead to congruence and will support routinization.
- Integration of rules - integration of program rules into the rest of the organization's rules will encourage routinization.

Schneider et el. (1996) assert that sustainability of organizational change will be achieved when both the climate (what the organization's members experience) and the culture (what members believe that organization values) change. Sustainability of organizational changes depends to a great extend also on the commitment of the employees to change.

2.3.4. Organizational improvement - learning and development

Organizations develop with experience and by learning. Knowledge or competence is also achieved by learning. Organizational learning, is much more than individual learning of persons but it is rather a matter of '' […] a dynamic process based on knowledge, which implies moving along the different levels of action, going from the individual to the group level, and then to the

organizational level and back again''(Jerez-Gomez, Cespedes-Lorente, and Valle-Cabrera 2003, p.716). Some researchers of the problem imply that there is a correlation between organizational learning and effectiveness and assert that organizational learning occurs only when organizational effectiveness is enhanced (Huber 1991, p.89)

Learning organization is an experimenting organization. ''Organizational experiments and self-appraisals are generally directed toward enhancing adaptation, while maintaining organizational experiments is generally directed towards adaptability'' (Huber 1991, p.93)

Huber (1991) asserts that organization subjected to experiments or changes would become more adaptable because such an organization will remain flexible and will cope easier with adaptation of unfamiliar environments or engagement in unfamiliar environments.

Continuous improvement

Continuous improvement (CI) is related to transformation of organizations, so that they will become more 'fit and agile'. Managers promote CI (mainly through worker-involvement programs) also in cases when their competitors are getting leaner (e.g. reduced inventory, reduced lead time etc.). The latter triggering condition will lead to reduced wasteful practices, which on the other hand will move the organization to adopt lean strategies (Choi 1995). This makes the bridge between Lean and continuous improvement and gives reasons for a Lean organization being a learning organization

Improvement can be achieved through improvement methods (e.g. PCDS, STARS, IDEAL, TRIZ) or by forming teams to work on the problems. Team building or team forming is important for the accomplishment of larger or complex tasks and for the improvement of organizational performance (Cameron and Green 2004; Wesner 2010).

Part III. Chapter 3: Methodological Framework

This chapter presents the methodological approach applied in this thesis and will give insight into the data collection methods and the main sources of information.

3.1. Selection of method of analysis

The rationale behind this research was to investigate the implementation of Lean 5S in the warehouse of Ulstein Verft, and the expected outcome is to get an overview over *how* the processes are/were rolled out and *what* are/were the possible implications connected to the deployment of this tool. Accordingly, the case study was recognized as a valid methodological approach. It is considered appropriate method because ‘’ case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. (Soy 1997)’’, which is considered the very purpose of this thesis.

3.2. Data collection

The analysis of the project is based on empirical data from previous researches conducted at the shipyard, by Master’s students and researchers from Møreforskning and FAFO who work in collaboration with Ulstein Verft. In this respect, the Master’s Thesis of Kjersti Lonva – ‘Warehouse Management in a Lean Shipbuilding Perspective – An Exploratory Case Study of Ulstein Verft AS’ was a valuable source of information concerning the warehouse management and processes at the shipyard, by outlining the problem areas in the warehouse management and functions, as well as by setting the ground for further research and managerial implication.

Sources for formulation of the theoretical part include scientific articles from ScienceDirect and ProQuest, books on Toyota production system, Lean and the implementation of 5S in particular. However, it is worth drawing attention to the fact that considerable amount of non-academic sources have been quoted throughout the thesis and the author reasons the latter with the fact that the problems of interest have been widely applied in practice and thus, it is the practitioners that are involved in the further investigation and development of the phenomenon.

Further data collection was performed through interviews, which were used to acquire understanding about the changing processes and how the individuals feel about them. Several warehouse employees considered key figures in the changing events at the warehouse were interviewed, as well as two employees from the Maintenance department, where the project of implementation of 5S has already been performed. The interview guide presented in Appendix II

comprised of open-ended questions, separated in four categories according to the position of the employees interviewed – i.e. warehouse managerial, warehouse operational, maintenance managerial and maintenance operational. In this way the point of view from both strategic (managers) and operational (shop-floor employees) point of view were considered in gathering the data for the analysis.

The interviews were hold behind closed door and took approximately 30 minutes per respondent. They were held in a manner of natural conversation in order to conduct cooperation from behalf of the respondents. The interviews were valuable source of information in the sense that they gave insight into the experience and thoughts of the personnel about the processes, which is in relevance for the outcome of the project.

Part III. Chapter 4: Outlines and findings of the case study

This chapter will present elaboration of the case findings. It discusses the shipbuilding and warehouse practices at Ulstein Verft, as well as gives information about the implementation of 5S of the pilot project in the maintenance department and in the warehouse of the shipyard.

4.1. Background - shipbuilding at Ulstein Verft

Established in 1917 as a mechanical workshop and turned into Ulstein Group ASA - a maritime group of companies operating within ship design and solutions, shipbuilding, shipping, power and control systems, and global sales and services, Ulstein Verft is part of Ulstein Group and is a shipyard, specialized in building advanced vessels, such as offshore support, offshore construction, seismic and research vessels, with a strong focus on innovative technological solution and methods more than 300 employees from different countries (UlsteinGroup).

The following disciplines are part of the shipbuilding processes at Ulstein Verft: design, engineering, planning, procurement, warehousing and production, as well as on-going customization and innovation during the construction phase. Additionally, trades as carpentry,

piping, and electrical installation are part of the construction processes. The material flow of equipment delivered into the shipyard depends upon a wide range of suppliers and the choice of suppliers involved is made by the ship-owners (for strategic components) or after maker's list (for other components) (Longva 2009). The afore-mentioned present a sophisticated network of external and internal processes, the management of which requires a high degree of coordination.

In order to improve the coordination in production planning, and the overall performance, The Last Planer method was implemented for yard no.277. The same method for organization of the production processes has been utilized in all the consequent construction projects at the shipyard.

The Last Planner at Ulstein Verft consists of three plan-levels:

Process plan - coordinates the processes of the whole project and consists of mapping of those processes.
Periodic plan – includes a discipline plan with time span of 4-8 weeks ahead and aims at improvement of the activities.
Weekly work plan – defines the assignment for the upcoming 1-2 weeks.

The process and periodic plans are managed by the project leaders. The weekly work plans (WWPs) are accomplished through meetings on weekly basis, where workers agree upon the organization of work (e.g. sharing of space, tools and equipment during the week) for the coming week. The fulfillment of the weekly plan is measured at the end of the week by percent of plan complete (PPC).

The shipyard has also utilized Project Logistics, which together with the Last Planner set the foundation of a unique working culture and environment – 'Ulstein Production system', which is based on principles of Lean Shipbuilding, adjusted for the problem areas and the facilities of Ulstein Verft.

In search for system efficiency, Ulstein Verft has started using the Brix Project Manager in Nauticus Yard Package, which allows access to information in various ways, for example by timeline, by zone of the ship, by discipline or SFI Group System. This software also supports the Process, Periodic and Weekly work plan (DNV 2009).

Presently, the shipyard is occupied with the building of yard no. 287 (due date 15 Oct. 2010) and yard no. 288 (due date 11 Feb. 2011). Despite the global recession from 2008 and the anticipated slowdown of the industry, the management of the shipyard expect to have even more contracts signed in 2010 and 2011, than the year before (Skipsrevyen 2010).

4.2. Warehousing at Ulstein Verft

Led by the principle of adding value for its customers in the development, design and processes of work, the company has also turned to the principles of Lean for its warehouse operations.

The warehouse plays essential role as a link of the logistics system of the shipyard for the storing and forwarding of units necessary for the production. The complex nature of the vessels built at Ulstein Verft defines the variety of units stored in the warehouse. Presently, it is not possible to estimate the level of inventory at the warehouse due to the withdraw practices of components, however, a rough estimate points toward circa 20 000 different SKUs being stored at present. A great number of them are obsolete material of great value (e.g. specific outfitting components for a particular project, which cannot be utilized in another project).

The warehouse comprises of several storage facilities (see Appendix III). The central warehouse is situated in the middle of the shipyard and stores the three groups of SKUs: i) *tools* – various tools necessary in the production processes. Despite moved by the employees on some occasions, the tools have relatively fixed position and are stored in boxes; ii) accessories – small in volume standard units; iii) *outfitting components* – large in volume components, suited for particular projects, and engineer to order components. Large components are stored not only in the central warehouse but also in some of the other warehouse facilities or outside.

Components arrive and are shipped from one and the same area (U-flow design) in the central warehouse. After the items arrive, they are registered in the system and are stored in one of the warehouse departments (equipment/accessories/tools department) or sent directly to the production department where they are further utilized in the production at the shipyard, in outsourced production, or by sales to aftermarket (Figure 10)

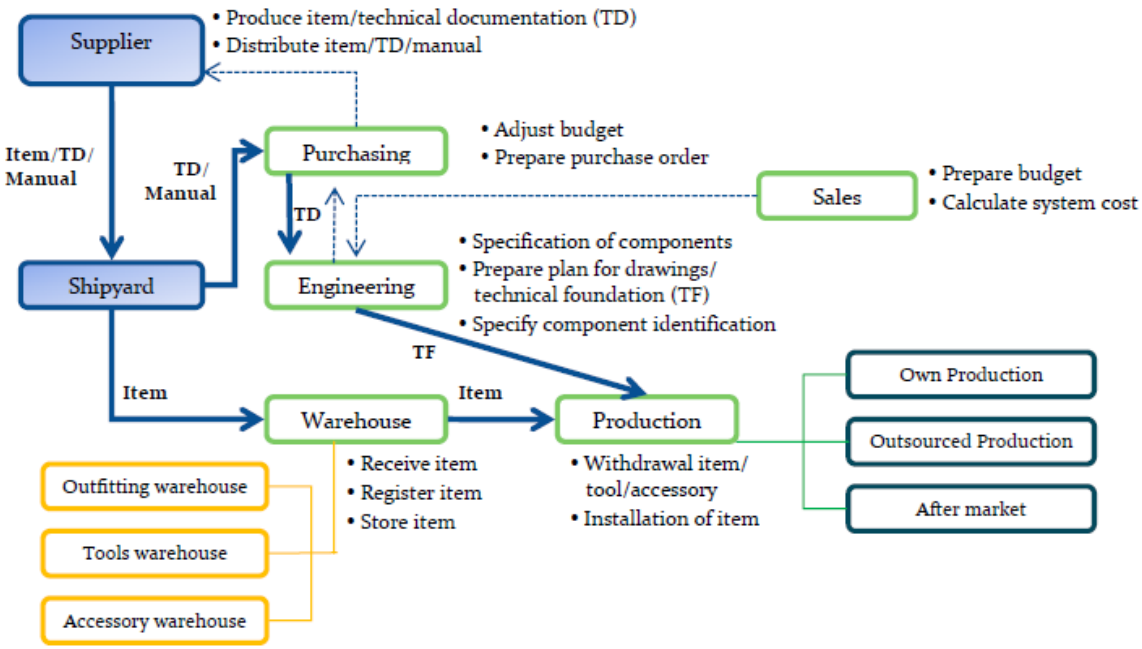


Figure 12 Material flow at Ulstein Verft

Source: (Longva 2009, p.64; Aslesen and Dugnas 2009)

The tailor-made ERP system for maritime that the shipyard is using is Multiplus Solution, and is fully integrated with the Nauticus Yard Package. It is a software that coordinates not only the warehouse but also the logistics and the shipbuilding processes. It is specifically suited to handle project-based production and distinguishes between project-based and ordinary warehouses. Thus, the registration of the SKUs is as *stock goods* available upon request, which are registered in the ordinary warehouse, or as *project specific components*, which are dedicated to particular yard numbers and are accordingly registered in the project warehouse solutions. The software supports information about reservation and withdrawal of stock, article numbers and RFID technology, which the shipyard has not utilized at present (Longva 2009; DNV 2009).

The shipyard has utilized SFI Group System (SFI, from the Norwegian: Skipsteknisk Forskningsinstitute - Ship Research Institute) for control of operations by presenting classified information on purchasing, accounting, technical records, designation, et cetera according to projects. Figure 11 visualizes the parts and components of SFI Group system 874 for yard no. 279. According to the SFI System the information about the vessel is divided into eight groups, which include information such as the status of the parts and components, the name of the supplier, the quantity, the designation, the project and order number et cetera.

Søk på bestillingslinjer

Prosjekt	Aktivitet	Best.nr.	Linje	Status	Leverandør	Antall	Enhet	Betegnelse	Verdi	Lev.dato	Innkjøper
10279	874005	78331	10	Sluttlevert	NATIONAL OILWELL	1	PC	SOFT STARTER OFFSHORE CRANE	0	25.02.2008	I3
10279	874005	78662	35	Sluttlevert	ROLLS-ROYCE ULSTEINV	1	PC	STARTER 1 LO PUMP MAIN AZIMUTH	0	14.12.2007	I3
10279	874005	78662	36	Sluttlevert	ROLLS-ROYCE ULSTEINV	1	PC	STARTER 2 LO PUMP MAIN AZIMUTH	0	14.12.2007	I3
10279	874005	78662	37	Sluttlevert	ROLLS-ROYCE ULSTEINV	1	PC	STARTER 1 LO PUMP MAIN AZIMUTH	0	14.12.2007	I3
10279	874005	78662	38	Sluttlevert	ROLLS-ROYCE ULSTEINV	1	PC	STARTER 2 LO PUMP MAIN AZIMUTH	0	14.12.2007	I3
10279	874005	78662	39	Sluttlevert	ROLLS-ROYCE ULSTEINV	1	PC	STARTER 1 SERVO PUMP MAIN	0	14.12.2007	I3
10279	874005	78662	40	Sluttlevert	ROLLS-ROYCE ULSTEINV	1	PC	STARTER 2 SERVO PUMP MAIN	0	14.12.2007	I3

Figure 13 Extract from SFI Group 874 for yard no. 279

Source: (Longva 2009, p.97)

4.3. Problem areas in the warehouse operations at Ulstein Verft

The basic characteristics of warehouse operations of receiving, storing, picking and shipping are also assigned to the warehouse of Ulstein Verft. However, there are several problem areas, which will be discussed below. These problem areas are due to internal and external factors and affect the flow of materials and the flow of information of the warehouse, which consequently reflect on the performance of other departments such as purchasing, and production.

Receiving

One of the factors that affect the receiving processes is delivery of components out of the official working time of the warehouse. The deliveries are accepted by occasional personnel of the shipyard, who do not perform the required check according to packing list or for defects, nor the deliveries are registered in Multipluss. This causes problems with the registration of incoming items and thus affects the follow up of components in stock, and creates slacks of the processes. Accordingly, it could also affect purchasing, invoicing and production. The lack of check up of the incoming components affects the production processes by allowing possible defect components to get into the system in the cases when check has not been performed.

Typically, outfitting components arrive labeled with the information about the name of the supplier, the SFI- number, yard number, and designation of the system the components belong to. However, on some occasions components may, arrive without that information, and in such cases, it is up to the warehouse employees to label them which might be a difficult task for the warehouse employees due to lack of technical knowledge. When this appear to be the case, in order to identify the unlabeled components, the warehouse employees require help from the employees of the production department. This creates hinders in the receiving operations and thus bottlenecks in the system.

Storage

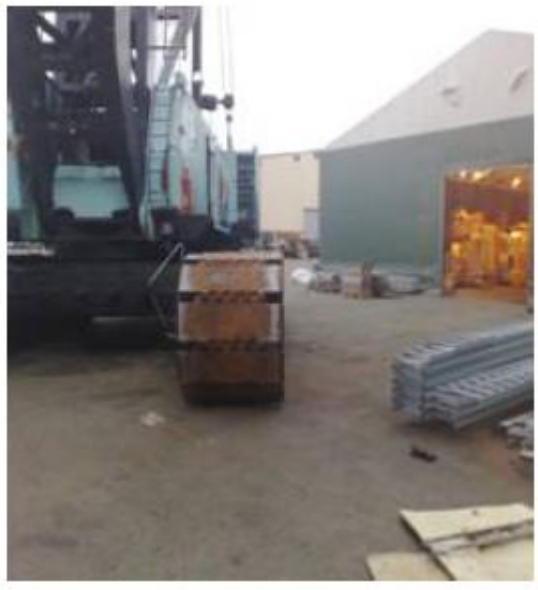
The outfitting components are stored in one of the warehouse facilities or outside. If they arrive tagged by the supplier, they are registered in the system and stored at the dedicated places. In this case Multipluss gives information in which storage hall the component is but not other information is available. Thus, further location of components is performed manually, which may be a difficult and time consuming task in cases when components have been moved around after their initially placement in the storage.

Picking

Access to the warehouse premises is free, so apart from the warehouse personnel, it is also the case that workers from the production department pick up necessary components. This is due to the fact that sometimes, need for technical competence is required in picking up those components, which the warehouse employees do not have. On other occasions, components are withdrawn out of the official working time of the warehouse employees. Accordingly, no record is kept for the withdrawal, which leads to inventory discrepancies. Thus, it is difficult to know which components are withdrawn and which are in storage, and sometimes time for manual location of components has to be used. This time can be compensated in cases when the warehouse employees have kept memory track of the withdrawn components. The same is valid for the re-location of components.

Shipping

The warehouse consists of several premises and the distance between the shipping dock in the central warehouse, together with obstacles of different sort scattered on the area of the shipyard create hindrances and increase the picking up time. All that adds up time for shipping of the components to the production facilities and contributes to delays of production processes. The latter is also exalted by the fact that there is no route marking of the shipyard's area for the internal transportation vehicles (Picture 4-1).



Picture 4-1 Truck obstacles at the shipyard. (Longva 2009, p.73)

4.4. Implementation of Lean 5S in the maintenance department of Ulstein Verft.

The problem areas discussed above create a challenging work environment and put in doubt the optimization of performance of the warehouse. In search for improvement of the work environment, the shipyard has started the implementation of 5S in the warehouse. Despite the simplicity of the implementation steps of this Lean tool, visible and long-lasting results can be achieved only through consistency and motivation during, and sustainability after the changing processes.

A model for successful practices and result is the pilot project of the implementation of 5S in the Maintenance department. The project spanned from the autumn of 2009 to the spring of 2010 and the experience could be taken as a valuable example for the warehouse department. Despite the two departments being essentially different, what brings them together in this cause is that success depends on the employees' involvement and positive attitude towards the goal.

The interviews with the employees of the Maintenance department show that the roadmap of implementation of 5S started with a couple of meetings on which the employees were introduced to the concept and methods of Lean 5S and the particular performance practices were agreed upon (e.g. criteria according to which materials will be cast away or kept). The first one month of the implementation has been used for preparation and affiliation of the employees for the upcoming changes. It has been crucial to incorporate everyone in the processes, especially since some of the employees have expressed skepticism towards the success of the final results. One of the crucial problem that appeared through the implementation processes has been the extension of the deadlines initially settled. The reason for that has been the lack of time, which is due to the fact that the nature of work of the employees makes it difficult to schedule the workday in advance. Thus, difficulties to meet the planned deadlines of the 5S appeared. However, the 5 steps for achievement of order and orderliness were performed in the following manner:

Sort - No tagging has been used, instead, the materials defined as unnecessary have been discarded, while those the status of which have not been decided on, have been placed in boxes for further sorting out.

Set in order – The materials placed in boxes for further check are sorted out and set to the dedicated places. New working desks, and storage shelves have been created and all the materials have been organized and set in their fixed places. Notes have been placed on the shelves to help keeping organized storage and locations have been outlined with floor tape.

Shine – Having finished the sorting of unnecessary materials, and setting those in use on their dedicated places, the workers of the department have painted the floor (Picture 4-2 and 4-3).

Picture 4-2 Maintenance department before and after

Picture 4-3 Maintenance department before and after

Standardize – In order to standardize the achieved, the workers from the department have agreed upon that everyone should contribute to daily clean up of the working place. Moreover, in the end of the working week a more detailed clean up is performed, the performance of which is controlled by a dedicated employee on a week-cleanup duty.

Sustain – According to the information obtained from the interviews, the department is still struggling to find solution for sustaining the changes. However, the attempts such as the week-cleanup duties are good initiatives, yet hindered by lack of time due to daily tasks connected with the duties of the employees.

The interviews with the workers form the maintenance department show that the implementation of 5S was pursued by several hindrances such as skepticism for the outcome or small conflicts between the employees caused by misunderstandings in what needs to be cast away and what to be kept. Due to lack of pre-arrangement of the working days of the employees, no objective planning of the implementation processes could have been settled and this caused delay in the scheduled implementation period. However, despite prolonging the deadlines of the initial time-plan, the implementation of 5S in the Maintenance department has been successful and both the final result for the department and the experience of the employees have been positive.

Hindrances	Benefits
1.Scepticism towards the outcome, which leads to demotivation.	1. Better work environment.
2. Not possible to schedule the workdays of the employees, thus problems scheduling the steps of 5S.	2. Better awareness of the inventory.
3. Extended implementation period due to lack of time of the employees involved, which is due to unscheduled workdays and changes in the daily tasks.	3. More focused and motivated employees.
4. Small conflicts between the employees arose due to disagreements on what has be discarded and what to be kept.	4. Visual control.
5. Still working on finding routines.	5. More space acquired.
	6. Socialization and motivation of the employees through reward dinner.

Figure 14 Summary of hindrances and benefits connected with the implementation of 5S at the Maintenance department of Ulstein Verft

4.5. Implementation of Lean 5S in the warehouse of Ulstein Verft

At the time of writing of the thesis the implementation of Lean 5S in the warehouse department was still in process with a deadline for completition 01.01.2011, however, the deadlines tend to fluctuate. Since the project is still ongoing, the case study could not include a thorough follow up of the implementation of 5S and the consequent results of it. However, it will present the background behind the implementation of Lean 5S and possible improvements of it, and will go one step ahead, focusing on the sustainability of the changing processes, which is considered the ultimate goal and issue related to the problem. Thus, in order to articulate the need of implementation of Lean 5S in the warehouse and to present the expected outcomes the problem that the warehouse is faced with are discusses below.

In pursuit of clean, safe and well organized work environment, which will improve the process and by this add value, the warehouse of Ulstein Verft has initiated the implementation of Lean 5S. According to the action plan, and in practice, the warehouse is divided into three sections – tools, equipment and accessories store, and the implementation of 5S follows this division.

During the visits at the shipyard and after the observation of the warehouse premises, as well as from the information obtained from the interviews, it became known that the first two S - *sorting* and *setting in order* have already been initiated both in the central warehouse and in the external storage halls. The employees involved in the process are eleven, five of them are from the outfitting department, which according to the employees of the warehouse is facing the greatest difficulties. The interviews show concern of the employees that the amount of people working on the project is too little, which together with the lack of time to perform the 5S due to prioritized daily activities leads to slacks in the performance of the project.

Picture 4-4 Central warehouse – before and after

The approach for implementation of 5S is performed according to the specificity of the department. Thus, instead of following strictly implementation guidelines on 5S, freedom to take decisions in the processes has been given to the employees with the goal to fully involve them and to stimulate their creativity, as well to help establish the new way of thinking towards the processes.

Even though application of the 5S tool is necessary for all the three warehouse departments, it is the outfitting department where most effort needs to be concentrated. As already mentioned, that is where the greatest discrepancies arise. This is due to lack of item numbers of the incoming components, which complicates the warehouse processes and creates condition of chaotic and inconsistent practices for storage and location. Accordingly, the warehouse employees seek to compensate the lack of item numbers and the lack of relevant information from the software, by organizing the storage according to projects. Project-dedicated zones are created for the storage

of components, thus during sorting, the components which will not be discarded are redirected to the dedicated project zones.

A 5S map has been created for maintaining the first 3S. For this purpose the warehouse premises, as well as the areas outside are divided to cleaning-zones for the maintenance of which dedicated employees are assigned. The participation is stimulated by rewards, such as time-off for the one who performs best in maintaining his area clean and organized.

The overall impression of the employees in connection with the implementation of 5S is positive. However, skepticism in some of them has been perceived, which could be due to the fact that attempts for implementing 5S have been done before but the sustainability if it has not been successful.

Analysis of the setting for the implementation of 5S according to the present situation identified the following advantages and pitfalls for the implementation of 5S in the warehouse of Ulstein Verft:

Advantages	**Pitfalls**
Relatively small warehouse (small target scope).	Restriction of capacity of personal - few employees, therefore slower changes.
Few employees are easier to manage and thus to create a Lean mindset.	Changes require overtime and not everyone is willing to, or has the possibility to work overtime.
Flexibility of the work-force who could be involved in the warehousing activities (i.e. employees from other departments can work in the warehouse if necessary.	Involvement on personal level, e.g. some warehouse employees find it difficult to let go of unnecessary or obsolete components.
	The mindset of the employees i.e. misconception of what is necessary and what not; tendency to hoard.

Figure 15 Advantages vs. pitfalls connected with the implementation of 5S at the warehouse of Ulstein Verft

During the analysis of data obtained from interviews about the experience and thoughts of the employees from both the warehouse, and the maintenance department, the following pattern

became apparent: despite the positive attitude towards the process, there exists *skepticism towards the sustainability of changes*, which is mixed with problems such as difficulties to let go and tendency to hoard. By implication, this promotes the idea that the employees are willing to cooperate, but the final result depend however on strong managerial back up. By the same token, the implications of creation of lean culture, as well as measurement and improvement of performance will be further referred to in this thesis.

4.6. Sum up of problem areas it the warehouse of Ulstein Verft

A changing environment such as the warehouse, where not only the fact that the flow of material incessantly circulates in the warehouse, but also its management by human forces, who apply different work-approaches, provoke the warehouse performance in terms of organization, which depends on discipline and routinization of best- practices.

A major problem of the warehouse presently is to establish and organize practices connected with the storage of the components. As already mentioned, internal and external practices are identified as reasons for these problems. External practices refer to the collaboration with the suppliers in terms of planned deliveries during work time, so that technical and material check can be performed, as well as labeling of all the shipped components to the shipyard. This will eliminate time and effort of the warehouse employees and of the personnel from the production department who sometime participate in identifying the arrived unlabelled components, which leads to waste of time both for the warehouse employees and those from the production department. Internal practices include for example the use of visual organization. This includes zone division of the warehouse according to the time the components are required for the production. This would say, the components used in the near future to be stored closer to the entrance, while those with a longer timeframe before utilization could be stored inwards and moved forward as needed. This strategy has already been applied, but rather inconsistently. Another valid strategy is to organize the storage of the components in zones, according to project numbers which will save time searching for them. This has also already been initiated at the warehouse, however, the fact that all the employees have access to the storage facilities and in attempts to locate certain components move others have to be considered as a drawback. Another drawback that affects the performance of these two strategies is the lack of closer information

exchange with the production department on the WWP, which would guide the warehouse activities such as order picking and help planning the work-day schedule.

Another problem the warehouse is facing is the amount of inventory compared to the storage area available, which hinders the proper utilization of space, contributes to the lack of order and adds up inventory carrying costs. Reasons for the lack of space in the central warehouse is low ceilings which prevents from volume/height utilization (see Picture 4-5) or due to materials, randomly scattered on the floor of the warehouse premises, which contributes to the lack of storage space as well as to lack of accessibility (see Picture 4-6).

Picture 4-5

Height utilization through four storage high singe-deep pallet racks in the central warehouse.

Picture 4-6

Lack of storage space and high accessibility in one of the halls.

However, the common cause for lack of space in the warehouse premises can be related to the high level of material stored. A reasons for this is to ensure inventory buffers and in this way to prevent delays in production, which speaks about the lack of JIT deliveries at present. Moreover, lack of steady JIT deliveries due to lack of precision of suppliers contributes to the extra

inventory the warehouse is carrying. Furthermore, good part of stored material is obsolete, which is presented for example by components of great value, dedicated to a special project, and which were not utilized and thus they cannot be used in any further project. However, due to lack of control over the obsolete inventory or 'just in case', the components are being stored. Alternatives for managing the problem is for the obsolete components to be returned to the suppliers if possible, to be sold, or to be discarded.

A manner of improvement of the storage space is through utilization of the floor space and cubic volume by building more racks in the storage halls, few of which could be seen at present. The warehouse has recently expanded with a new hall which is used for the incoming goods. Moreover, further space expansion may be achieved, through possible building up of warehouse premises in the coming two to five years. However, it is the matter of achieving the best of the present situation what Ulstein Verft is through the deployment of 5S resources on extension of the warehouse, extra technical equipment and employees can be achieved at present.

The following table presents the correlation between the wasteful practices in the warehouse and the seven wastes recognized in the literature.

The 7 Lean Warehousing wastes		**Warehousing waste recognized in Ulstein Verft**
1. The waste of excess inventory.	✓	High level of inventories and high levels of obsolete material, lack of control what is in stock.
2. The waste of waiting.	✓	Waiting associated with delays in production while waiting for components that need to be located after being moved, or ordered after being loaned without registration in the system.
3. The waist of needles transportation.	✓	Moving around of misplaced components in search for the right/needed one. Occasional movement of items between storage locations. The warehouse consists of several buildings, so a lot of time is wasted in transportation between them.

4. The waste of poor inventory.	✓	Lack of follow up of inventory for components, no withdrawal practices, this lack of information what is in stock and by this situations of stock outs may occur.
5. The waste of extra processing (over checking).	✓	Registration mistakes take up of the time of the warehouse employees.
6. The waste of movement.	✓	Movement of the warehouse employees through the storage facilities in order to locate items; movement of items between different storage halls;
7. The waste of errors.	✓	Registration mistakes – e.g. some items are not registered properly, or not registered at all, which affects also other departments such as purchasing and production.
8. The waste of creativity	✓	According to Lean theory, creativity is lost when the employees are preoccupied with wasteful activities.

Figure 16 The warehousing wastes at Ulstein Verft

Supporting the eight waste is the fact that the warehouse employees are valuable in locating SKUs in the cases when there are discrepancies between the information given from Multipluss and the actual inventory, which burdens them with extra responsibilities.

Part IV Chapter 5: Conclusion

5.1. Reflection and discussion of miscellaneous case findings

The following chapter aims at binding together the points form the case findings with the theory on the problem. Since the basis of this thesis is the implementation of 5S, a natural inference would be that a systematic description of an approach dedicated to the warehouse of Ulstein Verft for the implementation steps of 5S would be presented. However, due to the fact that the shipyard has already appointed a warehouse work group, which looks into possibilities and practicalities for the improvement of the warehouse, and since the deployment of 5S has already been initialized, no systematic approach for the deployment will be included, but it will rather present discussion and inferences about the problem areas recognized. Thus, the scope of this chapter will be focused on the potential improvement for the warehouse from the implementation of 5S, as well as manners to cope with problem areas connected with sustainability of the changes.

Having started the most time- and effort consuming steps of the implementation of 5S and with the elimination of excess inventory, better visibility, possibility for locating of material will be improved. Discarding of the unnecessary or obsolete inventory and setting in order the rest will also ensure easier access and will reduce wasteful activities such as movement of components or warehouse equipment, or time spent to physically locate items will be spared. This will shift the efforts of the employees in a creative direction and will add value to the process.

Successful implementation of 5S can be used as a bridge to other improvement-related tools such as visual management. By implication, the deployment of 5S could be extended to and sustained by visually managing the results of the performance towards the goal, and by that, focus on what is important for the goal of this project will be achieved. This can be done through the arrangement of visual boards set in the premises of the warehouse, on which photographs of before and after state could be exposed, road map on 5S, rules implemented on work processes, process improvement matrixes and any other systematized information that refers to 5S. Furthermore, signboard strategy can be useful with the division of the warehouse in zones according to projects (or yard number). This refers to visual orderliness by exposing signboards with information about where and what is stored in which particular zone. Since the warehouse employees have already been assigned individual zones to maintain, the signboards may also

include the name of the person in charge for keeping the order in each particular zone. This would however, require correlation with the ERP system in cases when the system tells where the components are (to be) situated. This strategy is applicable after the first two S's have been deployed.

Consequently, the deployment of 5S and visual management can be stretched to enabling one-piece-flow and JIT deliveries from the warehouse to the production, by ensuring quick turnaround of the material within the system. Achievement of the latter depends on strong dedication and discipline of the personnel towards the improvement activities since the link between the support of these activities and JIT practices is very weak and a deviation of established best-practices can easily lead to collapse of the system. However, the most important link in supporting JIT delivers are the suppliers and their reliability.

Another approach for enabling velocity of the flow, and management and scheduling of the workday, is to incorporate the suppliers in the changing processes. Physical organization of the incoming materials could be the division of the receiving area of the warehouse to zones dedicated to different suppliers or groups of suppliers. Despite the lack of space that is experienced, with the acquisition of the new building for incoming materials it should be possible.

Communication as an enabler for success

Due to the complexity of internal and external practices, the management of which requires high level of coordination and development of network of communication, sharing of information has been identified as essential for the improvement of performance and sustainability of changes.

Information exchange is considered on both levels – external and internal. On internal level communication between departments is denoted as inconsistent. Indication for that is the lack of information exchange between the production department and the warehouse. Instead of incorporating the information about the weekly work plan between the production and the warehouse departments, and by this enabling work task scheduling, the warehouse employees receive material orders from the production department on a short notice, as the case often is, which causes delays of shipment, and by this delays in production occur. However, efficient

communication between these two departments would not only improve the flow of material but will also contribute to level the workday of the warehouse employees, which would respectively give way for more precise scheduling of the activities connected with 5S.

Moreover, an efficient manner of communicating the above-mentioned problem is through the utilization of the ERP system for placement of orders. Presently, production addresses orders for the needed materials mostly in person and in a short notice. Placement of orders in advance and according to the weekly work plan would give the opportunity for the orders to be picked in advance by the warehouse employees, which would prevent or reduce the practices of random withdrawal of components by personnel form the production department. Accordingly, this would be favorable for keeping order and orderliness.

On external level, lack of JIT deliveries and synchronization of deliveries within the official working hours of the warehouse contributes for disorganization of the work of the warehouse employees and creates obstacles for both the information and the material flow. Thus, communication between the purchasing department, the warehouse and the suppliers on scheduling of the shipments would facilitate the practices of receiving and organization of the incoming materials. A way to incorporate the supplies in the practices towards improvement is through awards for better management of labeling of the shipped components or on-time deliveries.

Employees as driving force of changes

Achievement of success towards the implementation of 5S depends to a great extend on the employees involved in it. Trainings, development and educational activities such as seminars and courses, is one way of incorporation of the personnel. Critical success factor is also for the management to bond the warehouse employees towards the common goal. Despite the strong managerial back up needed, the freedom that the warehouse manager of Ulstein Verft has given to the warehouse operators gives them the freedom of mastering the processes-time, and in this way the feeling of control over the situation is developed, which stimulates positive attitude towards the 5S processes.

Sustainability and standardization of processes

Critical success factors for achievement of the favorable outcome of 5S are the standardization and sustainability of processes. The later is inferred both from the literature review, as well as from the elaboration of the interviews with the key personnel.

Physical changes of the environment through the implementation of 5S do not change the conventional thinking, habits and practices. Being used to the existing practices and habits, a reason for failure of 5S could be the resistance from the warehouse employees to change. Thus in order to prevent rejection against the new manners of work, management should be alerted and ready to cope with it. One way of doing that is for the management to make sure that the employees have thoroughly understood the rationale behind the implementation of 5S. It is useful to give the freedom in decision-making processes to the warehouse employees because in this way they will be part of designing the changing process and after all it is them who are the driving force of changes and performance of the 5S's. The latter will also make the warehouse employees comfortable in taking decisions, and being used to it will make easier the further deployment and sustenance of 5S. However, a manner to move forward the deployment of 5S and to prevent lingering around the processes is to enforce the changes with firmness and certitude.

In order to create Lean culture, working habits of the employees have to change. One of the obstacles in that is the fact that often employees tend to have difficulties grasping the new methods and instead of utilizing the new approaches, they may easily fall again into the velocity of their habits. Moreover, what is seen as rationale for some, could be regarded to as a mistake for others. Example of the latter is the different attitude towards the materials in the sorting processes and the decision of what need to be kept and what discarded experienced by the employees in the maintenance department, which could ultimately lead to conflicts. Thus, a managerial approach towards creation and maintenance of Lean culture is essential and a way to support the deployment of the 5S practices is for the management to ensure written procedures for those tasks that require guidance. This will support development and establishment of habits for the tasks and will stabilize the work pace and quality. The latter could be arranged by descriptions of the assignments to the employees. In accordance with Lean (use the creativity of

the employees), rules that refer to the organization of the workplace which support the 5S could also be elaborated through brainstorming with the warehouse personnel. In this way, activities that benefit to the organization of the workplace will be settled and by this, their follow-up will be more consistent.

A way for sustaining the result of 5S mentioned during the interviews was for the warehouse to be closed, and only the warehouse operators to manage it. Ambitious as it is, this option would require not only good discipline of the production employees, but also collaboration and sharing of information between the production department and the warehouse on the weekly work plan, so that the necessary components could be obtained during the opening hours of the warehouse. However, that not being the case, after order and orderliness has be achieved in the warehouse, and with the access of the production personnel to the warehouse, it will be useful to include some of the employees from the production department into 5S-warehousing trainings or seminars.

One of the ways to sustain the deployment of 5S is by analysis of the reasons that lead to disorganization of the workplace, because without understanding and working against them, no institutionalization of the 5S practices will be possible. A way to manage this is by performing root cause analysis through why-why tool.

Measurement of performance

Measurement of performance enables organizational change by reporting and validating the impact and benefits of the changing processes. One way of doing that is through follow-up of performance indicators, which would reflect the goal of the shipyard towards improvement of its warehouse. Ulstein Verft has already utilized this way of measurement, however not for the warehouse. Thus, some performance indicators are proposed in Appendix IV, the choice of which is based on the following two criteria - general research area of this thesis, i.e. Lean, and the particular problem areas of research i.e. the warehouse of Ulstein Verft. Due to lack of data, the role of the chosen indicators is restricted to only a recommendation for possible KPIs of interest

for the shipyard. However, if Ulstein Verft utilizes performance indicators for the warehouse, they can be followed up on a regular basis through a KPI dashboard.

After the 5S has been deployed, a proactive approach for recognition whether the 5S enablers are being followed is through audits. In this way, the problem areas could be recognized and corrected and by that sustainability of the changes would be achieved.

A way for improvement of performance is for the warehouse to examine its own practices through internal benchmarking, or compare them to 'best practices'. Specificity of the warehouse, which supports project-based production, as well as information protection restrict the options towards competitive benchmarking. However, with adaptation to the context of shipbuilding, generic benchmarking could also contribute with valuable lessons.

5.2. Elaboration of sum up of case findings and recommendations

The results achieved from the pilot project in the maintenance department of Ulstein Verft come down to improved ergonomics and safety, pride of the employees towards the work environment and their achievement, improved work environment and visibility over the work space and what is in house, which leads to less time spent for searching and by this adding value to the processes. According to the common experience of successful deployment of Lean 5S, it is expected that the warehouse could be favored in the same manner. Apart from the expected improvements such as efficiency, productivity, quality, etc. the marginal result from the implementation of 5S for the employees would be psychological safety and support.

Positive outcome of the implementation of 5S could be encouraging for extension of 5S to other areas in the shipyards, such as dry dock or the common areas of the shipyard. Besides, such success of implementation of 5S in other areas has been proven by the U.S. shipbuilding and repair industry in the case of Todd Pacific Shipyard.

The success of 5S depends to a great extend on the in-house education. Ideas for performing in-house education are different posters and slogan, videos, launching of newsletters on 5S among

the employees. However, the education of 5S should be continuous in order to build up discipline towards the changes.

Success factor for the results achieved from Lean 5S is for it to be part of a greater Lean transformation and thus to support it. In this respects, Lean 5S should be knitted with the Last Planner method that Ulstein Verft has implemented and the warehouse should be aware of the necessary materials needed for the week ahead.

In order to sustain achieved, it is recommended that Ulstein Verft use the implementation of 5S as a transition to larger changes, which also address the systematic issues. Otherwise, the project will loose inertia, which will lead to frustration, just as the case is from pervious attempts to implement 5S at the shipyard.

It would be hard to measure the financial impact from the deployment of 5S because the costs connected are hidden (for example the costs of the production employees waiting for locating the right material by the warehouse employees could be difficult to calculate). However, instead of capturing precise monetary number, a way to have an overview of the effect of 5S is to utilize measurements like performance indicators, which would show the operational performance towards the objective of having clean and well-organized warehouse all of the time and by that to add value.

5.3. Limitations and further research

Since the project is on-going, limitation of this research is that it could not grasp and present the process in the mass. By the same token, the case study part includes review of the problem, rough conclusions, and recommendations. Moreover, due to the incompleteness of the implementation of the project it has not been possible to state thoroughly the implications of the implementation of 5S and possible quantitative evaluation of the results of deployment of 5S.

By implication, a suggestion on measurement of performance of the warehouse is derived. On the way to performance improvement through the implementation of Lean 5S tool, in order to detect changes, follow up of performance indicators could be carried out through utilization of KPI

dashboard. Due to time and resources limitations, measurement of the sorted out indicators was not possible as initially planned.

One of the areas identified as problematic is in the field of inventory management and is connected with inventory tracking of the components. Since the ERP system utilized by the shipyard allows registration of components withdrawal, transfer to and return form project, utilization of this option is a plausible solution for better control over the inventory. However, lack of item numbers at present makes it impossible to utilize these functions. In order to possibly omit expenses for implementation of high-cost technology such as RFID, an idea for research is for the shipyard to carry out a project in which stock keep units identifiers of the sub- parts of the components could be applied for a particular yard number. An idea is that to be carried out only for one project in order to initially identify the impact of this method. This should be carried out with tight collaboration with the suppliers and with strict discipline of the warehouse employees on gathering information and keeping track of all the parts of the test yard number.

Furthermore, despite not discussed in this thesis due to the direction of the scope of the research, investigation on the incorporation of Agile in the processes could be performed. This is prompted by the fact that the shipbuilding processes at Ulstein Verft are followed by ‘’[…] continuous customization and innovation, with high amount of change orders during the construction period. (Longva 2009, p. 36)’’,which correspond with the essence of the concept of Agile to manage change, complexity and uncertainties.

REFERENCES

Ackerman, Ken, ed. 2007. *Lean Warehousing*: Ackerman Publications.

Adcroft, Aandy, Williams, Robert, Hurst, Feff. 2008. A new model for managing change: the holistic view. *Journal of Business Strategy* 29 (1):40-45.

Anonymous. *Chapter 7 Methodology of Research* [cited 19.09.2010. Available from www-best-information.eu/international-marketing-strategies/C7-Benchmarking.html.

Aslesen, Sigmund. 2007. Lean Shipbuilding. Lean Construction Beyond Lean? In *EGLC-5*. Oslo, Norway: FAFO Institute for Applied Social Sciences.

Aslesen, Sigmund, and Karolis Dugnas. 2009. Lageret - et nav i systemet.

Berg, Jerone.P. van den, and W.H.M. Zijm. 1999. Models for Warehouse Management: Classification and Examples. *International Journal of Production Economics* 59 (1999):519-528.

Bertelsen, Sven. 2007. Lean Shipbuilding. A Norwegian Research Project. EGLC 6.

Bicheno, John. 2004. *The New Lean Toolbox Towards Fast, Flexible Flow*: PICSIE Books.

Cameron, Esther, and Mike Green. 2004. Making sense of change management: a complete guide to the models, tools and techniques of organizational change., ed E. C. a. M. Green.

Choi, Ty. 1995. Conceptualizing continuous improvement: Implications for Organizational Change. *Omega, Int. J. Mgmt Sci.* 23 (6):607-624.

Cooney, Richard. 2002. Is ''Lean'' a Universal Production System? - Batch Production in the Automotive Industry. *International Journal of Operations and Production Management* 22 (9/10):1130 - 1147.

De Jager, Peter. 2009. 7 ways to communicate change. *ProQuest Health Management* 119 (2):31.

Demeter, K., and Z. Matyusz. 2008. The impact of lean practices on inventory turnover. *International Journal of Production Economics* 2010.

DiBarra, Camilla. 2002. 5S - A tool for culture change in shipyards. *Journal of Ship Production* 18 (3):143-151.

DNV. *Ulstein gives Nauticus Yard Package thumbs up* 2009 [cited 17.10.2010. Available from http://www.dnv.com/services/software/news/2009/ulsteingivesnauticusyardpackagethumbsup.asp.

Dugnas, K., and I. Uthaug. 2007. Can Lean Philosophy Strengthen and Develop Cluster Advantages? - An Exploratory Research towards Lean Shipbuilding, Høgskolen i Molde, Molde.

Fafo. *Lean Construction NO. Nettverk for prosjektbasert produksjon.* [cited 15.11.2010. Available from http://develop.fafo.no/lean/lean/article/1182.html.

Fazelle, E., ed. 2001. *Supply chain strategy. The logistics of Supply chain managment.* Edited by McGraw-Hill.

Frazelle, Edward. 2002. World-Class Warehousing and Material Handling, ed McGraw-Hill. New York.

Garcia, Frank C., P.E. Applying Lean Concepts in a Warehouse Operation.

Gu, Jinxiang, Goetschalckx, and Leon F. McGinnis. 2007. Reasearch on Warehouse Operations: A Comprehensive Review. *European Journal of Operational Research* 177 (2007):1-21.

Hicks, B.L. 2007. Lean Information Management: Uderstanding and Eliminating Waste. *International Journal of Information Management* 27 (2007):233-249.

Holweg, Matthias. 2007. The Genealogy of Lean Production. *Journal of Operational Management* 25 (2007):420-437.

Huber, G. P. 1991. Organizational Learning: the contributing proceses and the literatures. *Organization Science* 2, No.1 (February 1991).

Huf III, Alfred W. Organizational development and change - communication. Argosy University - Twin Cities.

Jerez-Gomez, P., J. Cespedes-Lorente, and R. Valle-Cabrera. 2003. Organizational learning capability: a proposal of measurement. *Journal of Business Research* 58 (2005):715-725.

Johnson, A., Wen-Chen Chen, and Leon F. McGinns. 2009. Large-Scale Internet Benchmarking: Technology and application in warehouse operations. *Computers in Industry* 61 (2010):280-286.

Jones, Lisa M. 2007. An Examination of Social Influence Effect on Commitment to Change and Implementation Behaviours. dissertation, Department of Management, Kenan-Flagler Business School, University of Noth Carolina, Chapel Hill.

Kang, Hyun Jung. Shipbuilding Industry.

Koenig, P. &, N. Hitoshi, and K. Baba. 2002. Lean production in the Japanese Shipbuilding Industry? *Journal of Ship Production* 18 (3):2002.

Koster, R. de, T. Le-Duc, and K.J. Rootbergen. 2007. Design and Control of Order Picking: A Literature Review. *European Journal of Operational Research* 182 (2007):481-501.

Kozak, Metin. What is benchmarking? Understanding its Philosophy. edited by M. U. Turkey.

KPI Library. Available from www.kpilibrary.com.

Lamb, Thomas. 2001. World-class Shipbuilders: Thier Productivity and Useof Lean Manufacturing Principles. *SNAME Transactions*.

Lean Thinking and Methods. Available from www.epa.gov/lean/thinking.

Liker, J., and T. Lamb. 2000. Lean Manufacturing Principles Guide. A Guide to Lean Shipbuilding. (University of Michigan, Ann Arbor, Michigan).

Liker, Jeffrey 2004. The Toyota Way - 14 Management Priniciples from the World's Greatest Manufacturer. (McGraw-Hill).

Liu, Yongmei, and Pamela L. Perrewe. 2005. Another look at the role of emotion in the organizational change: A process model. *Human Resource Management Review* 15 (2005):263-280.

Longva, Kjersti K. 2009. Warehouse Management in a Lean Shipbuilding Perspective - An Exploratory Case Study of Ulstein Verft AS Masters in Logistcs, Høgskolen i Molde, Molde.

Lyu, J., and A. Gunasekaran. 1993. Design for Quality in the Shipbuilding Industry. *International Journal of Quality&Reliability Management* 10 (4).

Malone, Sarah A. 2007. Creating organizational capacity for continuous and adaptive change, Benedictine University.

Norway's Shipbuilding Indutry. 2009 [cited 28.11.2009. Available from http://www.nmi2008.com/2009/02/19/norway%E2%80%99s-shipbuilding-industry/.

NSPR, ASE. 2004. The National Shipbuilding Research Program and the Lean Shipbuilding Initiative. *Reference Package developed for Students at the Defense Asquisition University*.

Oxtoby, B., T. MGuiness, and R. Morgan. 2002. Developing organizational change capability. *European Management Journal* 20 (3):310-320.

Pettersen, Jostein. 2009. Defining Lean Production: Some Conceptual and Practical Issues. *The TQM Journal* 21 (2):127-142.

Pluye, P., L. Potvin, J. Denis, J. Pelletier, and C. Monnoni. 2005. Program sustainability begins with the first evenets. *Evaluation and Program Planning* 28 (2005):123-137.

Poppendieck, Mary. 2002. Principles of Lean Thinking

(Poppendieck. LLC).

Ross&Associates Environmental Consulting, Ltd. 2004. Findings and Recommendations on Lean Production and Environmental Management Systems in the Shipbuilding and Reapir Sector.

Rouwenhorst, B., B. Reuter, V. Stockrahm, G.J. van Houtum, R.J. Mantel, and W.H.M. Zijm. 1999. Warehouse design and control:Framework and literature review. *European Journal of Operational Research* 122 (2000):513-533.

Rushton, A., P. Croucher, and P. Baker. 2006. *The handbook of logistics and distribution management*. Edited by K. P. Limited.

Salem, O., Solomon,J., Genaidy, A., Minkarah, I. 2006. Lean Construction: From Theory to Implementation. *Journal of Management in Engineering* 22 (4):168:175.

Sanidas, E. 2001. The successful imitation of the Japanese Lean Production System by American firms: Impact on American Economic Growth. http://ro.uow.au/commwkpapers/33.

Sarkar, Debashis 2006. 5S for Service Organizations and Offices. *A Lean Look at Improvements.* Milwakee: Quality Press

Schneider, B., Brief, A.P., Guzzo, R. 1996. Creating a climate and culture for sustainable organizational change. In *Organization change: a comprehensive reader*, edited by W. W. Burke, Lake, D.G., Paine, J.W.

Senior, B., and S. Swailes. 2010. Organizational Change.

Sheldon, Donald H. 2008. Lean Materials Planning and Execution: a Guide to Internal and External Supply Management Excellence: J. Ross Publishing.

Skipsrevyen. *Inspection of the ''Ulstein standard''* 2010 [cited 17.10.2010. Available from http://www.skipsrevyen.no/artikler/artikler-4-2010/inspection-of-the-%E2%80%9Culstein-standard%E2%80%9D.html.

Soy, Susan K. *The case study as a research method.* (Unpublished paper, University of Texas at Austin

) 1997. Available from www.ischool.edu.

Strack, Geraldine , and Yves Pochet. 2009. An Integrated Model for Warehousing and Inventory Planning. *European Journal of Operational Research* 204 (2010):35-50.

Tompkins, James A., Smith, Jerry D. 1998. The Warehouse Management Handbook: Tompkings Press.

Tostar, M, and P Karlsson. 2008. Lean Warehousing. Gaining from Lean thinking in Warehousing, Linkjøping Tekniska Høgskola.

Ulstein Group.

UlsteinGroup. [cited 15.10.2010. Available from www.ulsteingroup.com/kunder/ulstein/cms66.nsf/Shipbuilding_ny.html.

Van der Berg, J.P. 2007. Inegral Warehouse Management.*The next generation in transparency, collaboration and warehouse management systems*, ed M. Outlook.

Van der Berg, J.P., and W.H.M. Zijm. 1999. Models for Warehouse Management: Classification and Examples. *International Journal of Production Economics* 59 (1999):519-528.

Warehousing and Distribution Operating Instructions. 2009. In *Procedual documents*: Florida Department of Transportation.

Watson, Gregory H. *Strategic benchmarking: Learn from the best companies* 1993.

Wesner, Marilyn Sawyer. 2010. Organizational learning: The enduring influence of organization development. *Organization Development Journal* 23 (3):41-46.

Yazici, Hulya Julie. 2001. The role of communication in organizational change: an empirical investigation. *Information and Managment* 39 (2002):539-552.

APPENDIX I CHARACTERISTICS OF LEAN PRODUCTION SORTED BY AUTHOR/FREQUENCY

Extract from Pettersen, Jostein (2009), *Defining Lean Production: Some Conceptual and Practical Issues*, The TQM Journa, Vol.21, Iss.2, p.5

	Womack & Jones (& Roos)	Liker	Bicheno	Dennis	Feld	Ohno	Monden	Schonberger	Shingo
Kaizen/Continuous improvement	X	X	X	X	X	X	X	X	X
Setup time reduction	X	X	X	X	X	X	X	X	X
Just in time production	X	X		X	X	X	X	X	X
Kanban/Pull system	X	X	X	X	X	X	X	X	
Poka yoke		X	X	X	X	X	X	X	X
Production leveling (Heijunka)	X	X	X	X	X	X	X		X
Standardized work		X	X	X	X	X	X	X	X
Visual control and management		X	X	X	X	X	X	X	X
5S/Housekeeping	X	X	X	X	(X)	X	X	X	
Andon	X	X			X	X	X	X	X
Small lot production		X	X		X	X	X	X	X
Time/Work studies	X	X	X	X	X	X	X		
Waste elimination	X	X	X	X		X		X	X
Inventory reduction	X	X		X		X	X	X	X
Supplier involvement	X	X	X	X	X		X		
Takted Production		X	X	X	X		X		X
TPM/Preventive mainenance		X	X	X	X	X		X	
Autonomation (Jidoka)		X		X			X	X	X
Statistical quality control (SQC)	X		X	NO!	X		X	X	
Teamwork	X	X		X	X	X			
Work force reduction				X		X	X	X	X
100% inspection		X		X				X	X
Layout adjustments				X			X	X	X
Policy deployment (Hoshin kanri)	X	X	X	X					
Improvement circles		X		X			X	X	
Root cause analysis (5 why)	X	X	X			X			
Value stream mapping/flowcharting	X	X	X	X					
Education/Cross training (OJT)		X			X			X	
Employee involvement	X	X		X			(X)		
Lead time reduction		X		X			X		
Multi manning	(X)					X	X		X
Process synchronization		X						X	X
Cellular manufacturing			X		X		(X)		
Goal	*make products with fewer defects to precise customer desires*	*One-piece flow*	*Reduce waste and improve value*	*Customer focus (high quality, low cost, short time)*	*Robust production operation*	*Cost reduction*	*Eliminate waste and reduce costs*	*Improve quality and productivity*	*Cost reduction through waste elimination*

APPENDIX II INTERVIEW GUIDE

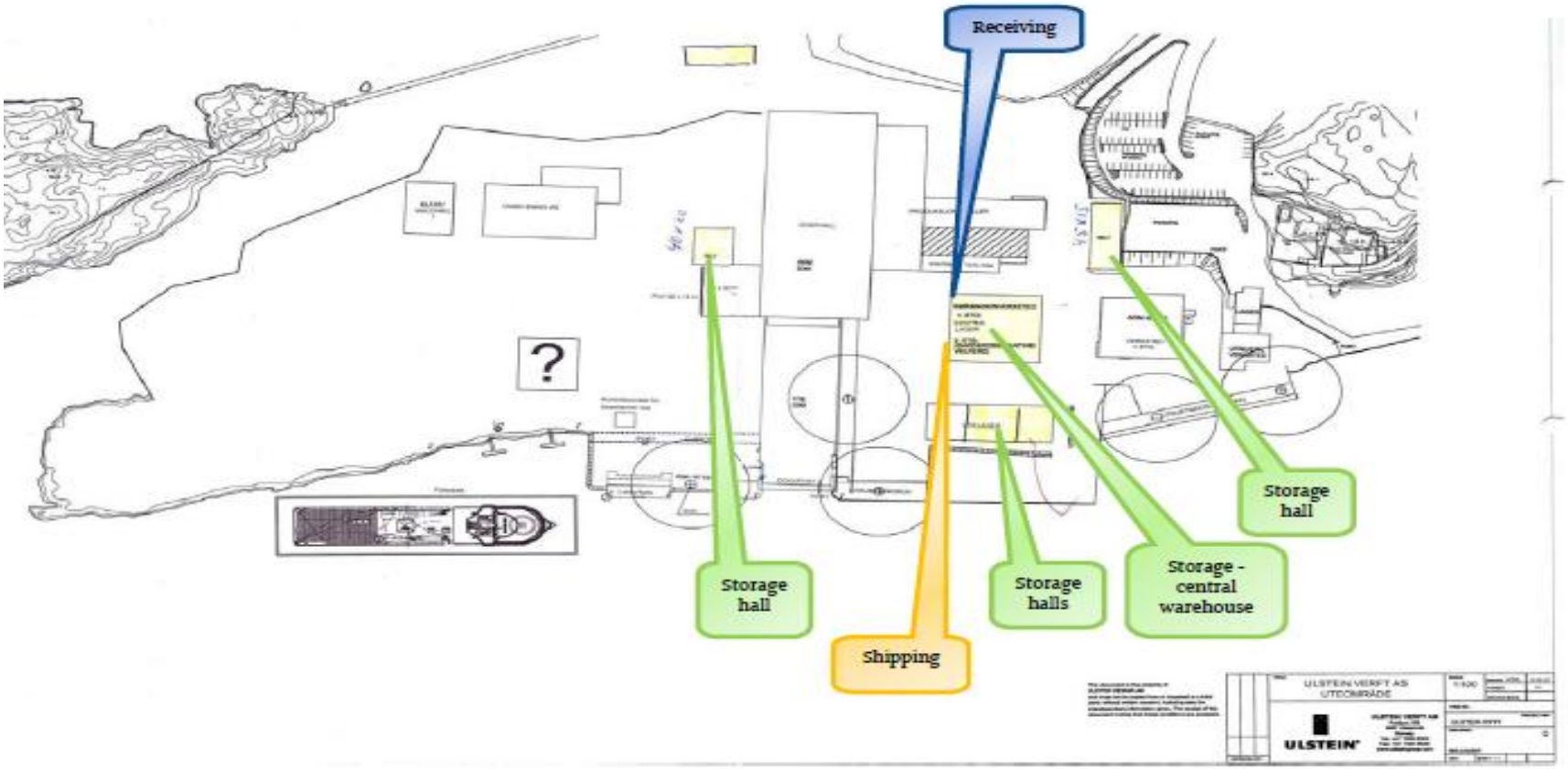
Warehouse Management	Name: Position: Contact info:	• **What is/are the company's goals/aims in connection with the ongoing changes in the warehouse?** (Comment: the goals will help in/will support the choice of the KPIs. *A KPI is a financial and non-financial measure used to help an organization measure progress towards a stated organizational goal or objective.*) • **How is the inventory of the warehouse tracked?** (Comment: match between the counted inventory v.s. the booked inventory?) • **Is there a set time-frame for the implementation of 5S in the warehouse? If the implementation of 5S is scheduled, describe the Promotion Plan (e.g. steps/month).** • **Who is/are the implementation agent(s) of 5S?** (Comment: apart form the warehouse employees is there an appointed leader?) • **How will/was the personnel prepared for the implementation of the 5S and the changes?** (Comments: materials created, in-house education etc.?) • **How will the innovation and continuous improvement be supported?** • **How is the staff motivated for the (future) changes?**

Warehouse Operators	Name: Position: Contact info:	• **What are the daily maintaining tasks of the warehouse personnel and is there a prearranged daily schedule of the workday?** (Comment: any responsibility for the technical equipment for e.g.?) • **Are there routines in registering and storing of the items?** (Comment: deciding upon the storage location, random storage, zoning) • **How is the inventory of the warehouse traced?** (Comment: match between the counted inventory v.s. the booked inventory?**)** • **Is there a set time-frame for the implementation of 5S in the warehouse?** • **Who is/are the implementation agent(s) of 5S?** • **How is the staff motivated for the (future) changes?** • **How was the personnel prepared for the implementation of the 5S and the changes?** (Comments: materials created, in-house education etc.?)
Maintenance Department Management	Name: Position: Contact info:	• **How was the process of the implementation of 5S performed ?**(the steps of the implementation of 5S) • **What obstacles appeared during the changing processes?** • **How was the staff prepared/motivated for the changes?** • **What are the benefits achieved by the changes?**

Maintenance Department Operators	Name: Position: Contact info:	• **How was the process of the implementation of 5S performed?**(the steps of the implementation of 5S). They were introduced to the project and they were told what the plan was and how the plan is supposed to work and how they should get to the result. There was a time-plan but it wasn't that easy to follow but they couldn't follow it because of other tasks on the way. Most of them had were sceptic about the result. Some of the people were very positive, the are very negative. The department is complex because they have a lot of parts. Sorted according to knowledge. Tried to use the tags but but it wasn't useful because of the specificity of the parts. The most important thing in the process was to find what they have and what to keep and what to throw away. They were not aware of the inventory. Still working on finding routines. • **What obstacles appeared during the changing processes?** Time issues, mindset of the people were a problem, small conflicts. They have no settled working days – the tasks might be unexpected. Difficult to schedule the working responisibilites • **How was the staff prepared/motivated for the changes?** Not prepared, but they had some meeting with Reidun. Rolf was the

		project leader. Reidun was following up the project, ‘’pushing Rolf’’. She started to push herself into the situation. • **What are the benefit achieved by the changes?** They found out a lot of spare parts that they actually use and they didn’t know they have them and they know where to find them. They have some routines to try and clean up every day with what they are working with, and last week day they make a basic work up. They got rid of approx. of 30-40% in the electrical part. Positive experience – cleaner workshop and people are more aware of how things should be and there is a system, people are more focused. They are willing to be dedicated but it is difficult due to the lack of space and time. Overall they learned a lot of the project and made a change in how they think.

APPENDIX III LAYOUT OF WAREHOUSE PREMISES AT ULSTEIN VERFT (Longva 2009, p.100; Aslesen and Dugnas 2009)



APPENDIX IV. KEY PERFORMANCE INDICATORS (Source for KPIs defined: (*KPI Library*))

Warehousing

- Title : **Inventory Accuracy**

Measure: (|book inventory – counted inventory|)/book inventory. Measured in %

Target: minimize (the inventory error)

- Title: **Perfect order measure/Fulfillment**

Defined: The error-free rate of each stage of an order. Error rates are captured at each stage (order entry, picking, delivery, shipped without damage, invoiced correctly) and multiplied together

Measure: percentage

Target: minimize

- Title: **Storage capacity utilization rate**

Measure: Loaded Storage Field/Storage capacity. Measured in %.

Target : maximize

- Title: **Floor space utilization**

  Defined: Warehouse space utilization percentage. This ratio measures how efficiently the storage or distribution facility is using floor space.

  Measure: The formula identifies floor space used to generate sales. Formula (?): the total number of pallets (or units stored) /

area of storage (warehouse) in sqm. Measured in %.
Target: minimize

- Title: **% of Inventory items incorrectly located**

Measure: in %

Target: minimize

Improvement and Innovation

- **Average number of training hours per employee**
  Defined: Total number of training hours divided by the number of employees (in full time equivalent or headcounts).
  Measure**:** (total number of training hours)/(total number of employees). Measured in numbers, time range: per year.
  Target: Range

- Title: **% of goals accomplished from most recent strategic plan**
  Measure: (Goals accomplished) as a percentage of (most recent strategic plan)
  Target: maximize

- Title: **% of HR budget spent on training**
  Measure**:** [HR budget for training] percentage of [total HR budget]
  Target: 20% from the HR budget (for a ‘’learning organization’’)