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PRODUCT CATEGORIZATION

Runner, Repeater, Stranger

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ABSTRACT:

The purpose of this paper is to define and create clear categories for the Wartsila Delivery Centre Vaasa engine manufacturing company's product portfolio and then use the created categorization system in order to determine how the delivery projects are assigned within the two delivery units in the DCV: s manufacturing area. Project includes the definition and assignment of the roles and responsibilities for communication and the systems upkeep.

Theoretical basis for this research is based on the Lean system and quality management and their role in the modern manufacturing industry. Their evolution and role are first generally examined and then it is investigated how the DCV has previously applied these methods in its operations and how they can be further utilized to enable better quality and lead-time reductions at the company.

The research presented in the paper was conducted by interviews and by utilizing data from previous and coming delivery projects in years 2011 - 2016. The results of the research are presented and analyzed to determine how the product categorization project can be utilized to benefit the DCV organization.

KEYWORDS: process management, Lean system, quality management, mass customization, process improvement

1. Introduction

1.1 Current situation at the DCV

Wartsila Delivery Centre Vaasa (DCV) lacks clearly differentiated categories in the product portfolio which results in a situation where tailored solutions are created for each delivery project. Uniqueness of every delivery project leads to an increasingly wide and complex product portfolio, which combined with the resulting lack of component standardization greatly complicates production planning within the organization and hampers the process flows.

Additionally the lack of product categories leads to difficulties in defining the lead times for products. A system exists for assigning demanding deliveries and the new products into the New Product Introduction (NPI) process where the production and validation of products and methods is done in Pilot Delivery Unit (PDU), but a framework for product assignment and lead-time definitions is lacking at the DCV.

Currently this assignment and lead-time definition is done in an ad-hoc basis which nevertheless functions quite well, but the absence of an agreed upon framework for definitions can result in customer dissatisfaction. Customer unhappiness results because the effects of the choices made in ordering a product cannot be accurately estimated in the sales phase. DCV aims to deliver everything on time, creating need for a framework with accurate lead-time definitions for ensuring customer satisfaction and establishing of a similar process as the NPI for all deliveries could resolve many issues.

These problems combined with deficiencies in communication create a situation which complicates all functions in the organization. Another major issue which is created by the amount of non-standard products in production is the result of the fact that only the engineering costs of special requests are billed to the customer leaving all the other potential costs such as changes, prototyping costs and validation required with suppliers to the DCV. Considering that about 50% of orders are non-standard, this incorrect pricing leads to massive costs that eat profit margins considerably.

1.2 Project goals

Current situation clearly wastes resources and leaves the DCV in more or less a continuous “firefighting” mode where problems are solved as they happen, but the problems keep repeating because underlying causes are not resolved. Product categorization project aims to create standardised categories for products. Clearly differentiated product categories would give a framework for the whole delivery process to all stakeholders in the organization. This would result in reduction of waste in resources, lesser amount of WIP and through these increased profit margins for the whole organization.

Rationalizing and standardizing the product portfolio will allow the company to concentrate on efficiency and reduction of lead-times. Fast responsiveness and rapid delivery times for standard options will allow the increase of sales, and combined with creation of a more accurate pricing system will result in increased profit margins for the DCV. Distinct definitions will also allow for faster lead-times for non-standard products because the whole organisation is aware of the requirements and challenges already in the sales phase of deliveries. Project is forecasted to create benefits in many ways:

- Increased standardization will improve quality and reduce throughput times which can allow for lower costs for standards products. In this context the standardization is not understood just as the standardization of products but also the standardization of processes and work.
- Increased customer satisfaction resulting from understanding that non-standard products will have much longer lead-times.
- Correct categorization and pricing for non-standard products will increase profit margins by creating a better understanding of potential costs.
- Additionally the product categories can be utilized to more accurately guide projects to the delivery units within the DCV.

Data for research and the propositions for the categorization project will be gathered by meetings and interviews with the representatives of different departments at DCV and from the data from previous delivery projects using both the qualitative and quantitative approaches. Research will cover the introduction of a unified model which is created based on the gathered data. This model will then be modified accordingly in further discussions and when it is agreed upon it will be implemented. Additionally there will be roles and responsibilities assigned for the further development and upkeep of this system. Theoretical base for this thesis will be modelled upon examining the Lean system and quality management and their role in the modern manufacturing industry.

1.3 Runner, Repeater, Stranger

Project aims to create a framework for DCV: s product portfolio by creating three categories based on different value propositions:

Runner

- Improved cost efficiency, fast delivery time
- Product design, DU capability and suppliers validated.

Repeater

- Customized with standard options including small changes non-standard requests (NSR: s), standard cost, standard delivery time.
- Evaluation of supplier & New Product Introduction (NPI) status.

Stranger

- High customization per customer request, also design change NSR: s. Prototyping costs, validation and lead / delivery times.
- New products or product variants.

Project will proceed in three phases:

In the first phase the data gathering is done by interviews and using the production data. Once the data has been gathered it will be used to create a preliminary categorization and operating models which will be refined in further discussions with the stakeholders. Finally when a system for the product categorization and system operation has been created and agreed upon, there will decisions on how to assign roles and responsibilities for the systems upkeep and how to implement the new system at DCV.

2. Literature Review: LEAN system and Quality Management

2.1 History of the LEAN system

Lean system (McCarthy & Rich 2009: 25-31) is a method for systematically eliminating waste within a manufacturing system, thus basically Lean creates improvement in essential functions of a company by reducing waste in everything else. Lean thinking has its origins in the variant of the flow production system developed by Toyota Motor Corporation that was to later become known as the *Toyota Production System* (TPS) (Ohno 1988: xvii). Toyota was forced to begin developing the production system in the 1930s and 40s because of the lack of natural resources, lack of large amounts of capital and later as the result of the wartime devastation in Japan.

These factors meant that the company couldn't use the same methods that were in use in the West, such as dedicated state-of-the-art machinery with very large production batch sizes. Instead, Toyota focused on making its processes as flow efficient as possible. This meant focusing on quality and the needs of the customers. Unlike in the West, the whole system would work as a whole and every department would view the others as their partners, and internal customers as important as external ones, rather than competitors. (McCarthy & Rich 2009: 25-31)

Production was arranged as a pull system where production is only initiated by customer orders in which way the system created was meant to deal with high-variety production in small batch sizes while minimizing WIP. This was achieved by a system called Kanban (Ohno 1988: 27–30), which allows holding small amounts of products in store for all phases of production system, and only the customer needs will trigger further production. Kanban was actually only a card that was used to relay internal orders but has become the name for the whole system of pull production.

Increased quality control became also a central point for this system. Every employee was allowed to stop production in case of problems and defects, which allowed instant recognition and correction, rather than only specialists involving themselves with quality.

The new system also sought to redesign the whole production system. Goal was to eliminate poor features of mass production which generated excessive production costs and slowed the flow of materials in the factories. These were identified as the seven key aspect of production management, “the seven wastes”. (Ohno 1988: 19–20)

Success of Japanese manufacturers and especially of the Toyota’s production system started creating interest regarding their methods amongst the Western manufacturers in the 1980’s. Studies and experimentation of TPS methods led to the introduction of the concept of Lean Manufacturing in 1990. (McCarthy & Rich 2009: 27-31)

2.1.1 Toyota Seven Wastes

The seven wastes in production industry as defined by TPS are: “overproduction, waiting, transportation, processing, inventory, movement and defects”. (Ohno 1988: 19–20, 54-56). Taiichi Ohno further elaborated these:

Overproduction

Production systems output is not driven by customer demand, but rather by set batches which tend to be very large. This results in large amounts of stock and WIP.

Waiting

Time that products and materials wait for transportation, processing etc. Usually much of the time in the process chain is spent waiting.

Transportation

Transportation deals with all the movement of materials and products within a manufacturing facility through the whole process chain. Unnecessary transportation not only wastes money and resources, it also risks damage to products.

Processing

Production system used is not optimal for products, because very expensive and sophisticated machinery is used to make products that a cheaper, simpler machines could

handle. Companies acquiring expensive machinery tend to also want fast “payback” for investments so this machinery is used at maximum rates regardless of actual customer needs leading to high inventories and unnecessarily large batch sizes; two forms of waste.

Movement

Poorly designed production processes and facilities force operators to work in unergonomic spaces and processes resulting in decreased efficiency and injuries. These can generate massive losses to an organization by through lesser productivity caused by slower processes, sick leaves and lower employee motivation.

Inventory

Correlates largely with overproduction. Usually this is also combined with system inefficiencies and constraints that necessitate very large safety stocks.

Defects

Production or receiving of materials that have to be reworked or scrapped, wasting both time and production capacity. Large batch sizes in orders and / or production exacerbates this problem. (Ohno 1988: 19–20, 54-56)

2.1.2 Focus on Flow Efficiency

Western manufacturers have historically focused on maximizing process resource efficiency which requires that these resources are being constantly utilized. Companies have invested in expensive state-of-the art production machinery that in turn has resulted in large production batches, because management has wanted maximal return on the investment. (McCarthy & Rich 2009: 27-31). Optimization of processes towards constant resource utilization creates large amounts of WIP, which in turn necessitates large stores of raw materials and semi-finished goods. These large stores then result in increased transportation costs which also increase the possibilities of goods getting lost, damaged or stolen. Focus on resource efficiency of processes also generally results in silo thinking where every department concentrates on its own processes without regard of the needs of

whole organization. Therefore silo thinking impedes the ability of the company to function as a whole that focuses in fulfilling the needs of the customers

Lean system on the other hand is focused on improving the flow efficiency of processes, which necessitates a whole different approach to the development of production processes. Smooth production flow requires that the product moving through system has constantly resources available to process it, but keeping production resources constantly ready to process the product flow naturally lessens their utilization. Maximizing process flow efficiency doesn't necessarily mean faster throughput times, because the flow efficiency is defined by the actions that produce value for the customer. Interaction with the customers is therefore of the paramount importance in finding their needs for being able to respond accordingly. (Modig & Åhlström 2013)

Transformation of company's processes into a Lean system necessitates pulling together best practices and concepts to achieve efficient operation. This includes concepts such as just in time (JIT) (Ohno 1988: 4), total quality management (TQM) (Oakland 2014), continuous improvement (CI) (Oakland 2014: 266-269), resource planning and total productive maintenance (TPM) (McCarthy, Rich 2009: 31-34). Not all of these are necessarily applicable and every company must choose which to implement to improve their core processes. Adopting a Lean system in a company will result in changes that initially can be seen as counterproductive such as lessening the workload of machines and personnel in some departments, and as such the change can encounter resistance. In many companies people have gotten used to the old system and training is required for adapting into the Lean system. Recognition that the company's' focus needs to be on assuring the efficiency of the process flow which adds value for the customer throughout the whole production system, rather than a part-optimization for process efficiency is essential. (Jadhav, Mantha & Rane 2014)

2.2 LEAN tools and Process Improvement

Lean system is often misunderstood to mean everything good, such as improvements, methods etc. that a company is aiming to achieve (Modig & Åhlström 2013). These things are either the methods or results of the system, and rather Lean must be seen as being a choice. Aforementioned view of a choice results from the fact that Lean promotes optimization of the company's process flows. Improvement within an organization starts from it looking at its production processes as a whole and then choosing to focus on improving the production flow, initially even at the expense of process efficiency.

Focus of the Lean system is on increasing business value through the elimination of all forms of waste in the company's production system with continuous improvement (CI) (Jingshan 2013), and because of this the Lean system has become one of the most popular improvement approaches in modern businesses. Reduction of waste and business improvement are goals which naturally requires several tools and techniques, but this "hard" side of Lean receives usually more attention both in literature and real life practices than the "soft" side that deals with respect, teamwork and challenging work environment (Martínez-Jurado, Moyano-Fuentes & Jerez-Gómez 2014). Both the "soft" and "hard" sides are nevertheless necessary for a successful Lean implementation, because no tool is efficient if the operators are untrained and demotivated.

Process improvement in Lean system focuses in the needs of the customer, and the wastes are defined by activities that don't support the generation of value to customers. It is necessary for the organization to view its internal and external customers as equally important in every step of processes to maximize the efficiency and flow of the process chain (McCarthy & Rich 2009: 110-115). This will help avoiding the usual process industry problem of falling into the trap of part-optimization, where every department tries to maximize its own efficiency without looking at the big picture (Modig & Åhlström 2013). Part-optimization and silo thinking within an organization generally leads to inefficient resource usage, and high levels of WIP, preventing the company from transitioning into a world class leader in its field.

Adopting a continuous improvement philosophy throughout the organization will aid the company in avoiding the trap of part-optimization because it views the company's processes as parts of the greater whole. CI implementation seeks to generate better product quality, smaller buffer sizes and reduced machine downtime through process improvements rather than focusing on costly product improvements. (Jingshan 2013). To achieve this the CI philosophy requires the company to empower its workers on all levels, by allowing everyone to make suggestions and improvements in their work in a bottom-up approach. (Angelis & Fernandes 2012)

The first priority in starting any improvement program is to make sure that the production processes in question are brought to a stable state. Process stability is essential because it will allow measurements and improvements to be done, broken processes cannot be improved, and first task is fixing them (Smalley 2005). It is equally important to ensure that the responsibilities are clear and the project has the backing of the senior management along with proper resourcing.

Adopting a new way of working can be difficult and can only succeed by the support of the senior management. Management needs to involve itself by firstly assigning responsibilities, and then supporting, resourcing and monitoring the improvement processes. Receiving continuous support from the management in any improvement and implementation program is crucial for its success and this is also true for CI programs. Even though employee involvement in programs is crucial, it cannot make lasting impact on its own. (Talib & Rahman 2015)

2.2.1 Lean tools

2.2.1.1 *Benchmarking*

Improvements in company's processes can only take place in relation to general standards or to other companies. Comparisons with others are therefore necessary for achieving, maintaining and improving performance (Oakland 2014: 178-180). Benchmarking is a necessary tool towards this, because it allows the organizations processes to be compared to industry leaders enabling company to see possible avenues for improvement. Benchmarking can be used to challenge existing practises and structures within a company to get an understanding of which processes are in need of most improvement. Company can then focus on improving those processes that indicators show performing poorly and / or those that are deemed most critical towards answering to customer needs.

Most effectively benchmarking can be used when a company has already achieved stable processes, and when good practises have been implemented throughout the organization (Smalley 2005). Good initial position allows the company to effectively benchmark themselves against best practices of industry leaders, thus finding not only how own processes against others, but more importantly finding out *how* industry leaders achieve their results. Successful benchmarking doesn't need to be done in an immediately related industry for it to be effective. Examining wildly different industries can sometimes bring great benefits if their best practises can be adapted into your company's processes.

American Productivity and Quality Center provides a database powered service that is dedicated towards process measurement, and this service has identified that the average return of benchmarking is five times the cost of the study. Benefits include reduced costs, increased sales, greater customer retention and enhanced market share. (Oakland 2014: 179)

2.2.1.2 Just in Time

Just-in-time is a philosophy of lot size reduction that is an integral part of the TPS and Lean system. The aim of JIT is to speed up process flow by removal of excess stocks and work which don't create value to the customer. From the JIT perspective everything should be done in lot sizes of one item with zero inventory. Nevertheless real life constraints such as setup times, transport costs, supplier and machinery variabilities and other uncertainties necessitate larger batch sizes and safety stocks to ensure maximum efficiency and a smooth process flow. (Ohno 1988: 4)

Research has showed that reduction of batch sizes results in improved quality performance through reduction in process variance and by the more timely feedback created. Main requirement towards using smaller batch sizes is the ability to reduce setup times in processes. Lead time reduction also requires that production facilities and processes are also be designed towards allowing minimum time to be used in to moving products around. Quality improvement through batch size reduction leads to another of the TPS components, the Quality at the source (QatS) - principle which focuses on process quality and stability. (Yang & Deane 2002, Ringen, Aschehoug, Holtskog & Ingvaldsen 2014)

Importance of safety stocks has often been underrated when Western companies strive to adopt JIT system. Even Toyota utilizes these in their processes because the system is not intended just to generate cost savings by totally eliminating stocks, but rather as a part of a greater whole where customer needs are put as the priority in all processes. If JIT is understood as just the elimination of all stocks, then inevitably any disruption in processes will affect the customer, and in real life the uncertainties cannot ever be wholly removed. (Ohno 1988: 4, 95-97)

Modern businesses all over the world strive to achieve a JIT system believing it to be a way of easily cutting costs related to stocks. These programs have often failed because companies have not understood that successful implementation of a JIT system requires the overhaul of the entire production system. (Ohno 1988: 4, 95-97)

2.2.1.3 5S

5S can be described as a system that creates a disciplined, clean and well-ordered work environment. Term originates from five methods described in Japanese which translated to English mean: (Oakland 2014: 317-318)

- Sort
- Straighten
- Shine
- Standardize
- Sustain

These terms describe the methods that a working place should take in order to organize itself for improved efficiency. 5S processes are meant to be gradual, which transform the working methods and processes by eliminating waste and useless items, increase employee participation, maintain everything in order and sustain these new practices. In this way the company can engage everyone in the organization in Lean activities utilizing a continuous improvement approach through personal responsibility of their work spaces. (Oakland 2014: 317-318)

5S was developed for process industry, but its use has expanded in all kinds of companies regardless of their field. Some companies also use additional terms that are not directly part of 5S, but rather are more descriptive and clarify the goals of 5S. As an example Wartsila has added Safety as their own focus in applying 5S. Additionally for the last step of 5S, a Kaizen system (Oakland 2014: 319-320) is often utilized.

Kaizen utilizes small cross-functional teams of 6-12 members, which are tasked for solving specific work problems. Purpose of this is to utilize the actual operators of the work process for creating a new, improved process in a limited time period. By empowering the employees in finding solutions company can get great benefits and also keep the actual costs low. (Oakland 2014: 319-320)

2.2.1.4 Kanban

Kanban is a method for Lean and JIT operations for controlling the logistical chain in production processes. It can also be described as an inventory controlling system that creates its benefits by limiting the amount of WIP in the production system (Ohno 1988: 27-29). Kanban system derives its name from cards that use the rate of demand to regulate the amount of production in a pull-system. These Kanban cards are used as signals for material movement and orders, and the material demand by internal and external customers is used as the trigger for the production and order cycle for products in all levels of the process chain.

Kanban used to be organized as actual cards, but nowadays this process has mostly been automated by computer programs to help reduce human errors such as lost cards. Kanban signals are tracked throughout the entire process from the supplier to the end customers to monitor throughput times at all steps which helps to identify process bottlenecks. Controlling and monitoring the amount of Kanban signals in the production system allows for additional benefits, because the reduction of the amount of Kanban will result in finding the process bottlenecks through smaller allowed material stocks. It can also be used to increase stocks if some part of the process is vulnerable to demand fluctuations potentially resulting in disruptions to customer delivery. (Ohno 1988: 27-29)

Operating a Kanban system allows employees and managers to be constantly aware of the activities needed creating improvement in processes through elimination of confusion and unnecessary work. Achieving effectiveness with Kanban requires following and close monitoring of its rules, and Toyota for example has six rules in regards to Kanban use: (Ohno 1988: 30)

- Later process picks up the number of items indicated by Kanban at the earlier process
- Earlier process produces the items in quantity and sequence indicated by the Kanban
- No items are made or transported without a Kanban
- Always attach a Kanban to goods

- Defective products are not sent to the subsequent process. The result is 100% defect free goods.
- Reducing the number of Kanban increases sensitivity. (Ohno 1988: 30)

Kanban system has many features that are contrary to previous models applied in process industry, such as the elimination of production schedule in favour of a Kanban driven pull-system. Therefore it is not feasible for a company to adopt a JIT system without a complete overhaul of its processes, and Kanban is essential component towards achieving a JIT environment in a production system. It can initially be seen as counterproductive, and as such the management must take a role in the implementation process to lessen the resistance to change. (Ohno 1988: 27-29)

2.2.1.5 Theory of Constraints

Every system has at least one constraint that prevents it from making more profit and therefore this constraining process offers opportunities for improvement. These two statements are at the core of the theory of constraints (ToC). (Rahman 1998) ToC focuses on continuous improvement of processes through identifying constraints, and subordinating every decision to maximizing the usage of these constraints. In practise it means that lesser utilization / excess WIP in other parts of the production system are accepted to enable the maximum utilization of the constraining process.

In longer term it might be reasonable to invest in improving the capacity of the constraint, but this will usually just cause the constraining process to move to somewhere else. Therefore the company must make detailed studies of the effects of increased capacity. Investment has to respond to true need, be cost effective and actually improve throughput (very important if many processes are close to each in capacity). (Rahman 1998)

Application of ToC can become very difficult if the constraints in the processes are not the same in different projects, or if the constraints within the system are constantly moving because of the nature of products or services being produced. Processes can be

improved in such cases to enable greater efficiency, but investment can also just create costly excess capacity if utilization of the new resources stays low. (Rahman 1998)

2.2.1.6 Poka-yoke

Poka-yoke (McKellen 2004), or mistake proofing is a design philosophy that can be broadly interpreted as any constraint designed into any system that prevents its incorrect operation. Term originates from the 1960: s when Shigeo Shingo adopted the philosophy as a part of the Toyota Production System. Philosophy differentiates between *mistakes* and *defects*, mistakes are inevitable, but become defects when they are allowed to reach the customer.

Cost of mistakes and defects increases as the products move through the production process chain and the sooner they are caught and corrected the better. Altogether missed problems will result in the costliest option where defective products manage to reach the customer resulting in warranty costs, reputation losses and possibly the reduction of company's market share. This makes mistake proofing a vital part in designing any product or process and eliminating potential mistakes goes a long way into realising the Lean system goal of zero waste. (McKellen 2004)

Poka-yoke devices can be divided into three types, "Contact, Fixed-value and Motion-step" which are defined as: (McKellen 2004)

- *Contact*: identifies product defects by testing the product's shape, size, color, or other physical attributes.
- *Fixed-value* (or *constant number*) alerts the operator if a certain number of movements are not made.
- *Motion-step* (or *sequence*) ensures that the prescribed steps of the process have been followed. (McKellen 2004)

Although poka-yoke is applicable to all areas of business its most commonly used in manufacturing industry. Many solutions towards mistake proofing are made from the common sense perspective, where parts will only fit when they are inserted the right way, parts are colour coded, production machines cannot be opened when in operation etc. Overly complicated instructions must also be avoided to ensure they are not ignored. (McKellen 2004)

In most cases mistake-proofing is only made when errors and mistakes become systematic and start to noticeably disrupt the process flow. Ideally every process and product should be designed in a way that minimizes potential mistakes. However care must be taken to design the mistake proofing in such a way that it's not overly complicated and to ensure it cannot be overridden. (McKellen 2004),

2.2.2 Total Quality Management

Total Quality Management is an increasingly popular philosophy how to manage quality throughout an organisation. Early TQM gurus such as Deming and Ishikawa emphasized the need to understand and control variation in processes to improve the management of quality (Oakland 2014: 3-18). TQM takes the view that organization must focus on the customer needs on all levels of the process chain. Quality can be seen as products or services ability to meet or exceed customers' requirements and expectations. Reliability can also be seen as being part of quality because it is the ability of the product or service to continue to meet the customer expectations over time.

Managing quality has become extremely important because excellent quality in products and services is increasingly a requirement just for the company to stay competitive in world market, and can't be seen as something extra, but a basic feature that is expected by the customers. Increasing expectations towards quality mean that in a company everyone must be responsible for quality, not just specialized "quality managers", and that improvement of quality must come through improvement of the processes. This means that organizational culture should be changed towards the view that quality should

be achieved by regular work and processes and that it cannot be “inspected in” by specialized staff. (Oakland 2014)

TQM: s objective of changing organisational culture means that it is very reliant on same continuous improvement techniques as other process improvement programs. Objective is to make everything done right the first time, and every time to meet customer needs. Achieving this will require a continuous program of managing and improving quality which involves the whole organisation. (Oakland 2014)

Senior management must set the goals for a quality policy, allocate resources and ensure that set goals are understood and met throughout the whole organization. Management must also ensure that the policy: (Talib & Rahman 2015)

- Is suitable for the needs of the customers and the purpose of the organization
- Includes commitment to meeting requirements and a continual improvement for all levels of the organization
- Provides a framework for establishing and reviewing quality objectives
- Is regularly reviewed for its suitability and objectives

Many companies still erroneously view quality management as a cost, but rather it should be seen as a way of reducing costs. Bad quality is much more expensive than investing into good quality, because defects necessitate rework and scrapping, not to mention of the effects on customer satisfaction and company reputation that delays and bad quality of products have. (Talib & Rahman 2015)

2.2.2.1 Quality Management System

Quality management system can be defined as an assembly of components, such as the management, responsibilities, principles, processes and resources for implementing total quality management. An isolated view of its component parts doesn't necessarily produce a clear understanding of the quality system because they should work together as a greater whole. In many cases companies fail to understand this and quality, Lean etc. are managed as separate entities with overlapping goals. (Oakland 2014: 243-251)

Quality systems began to be implemented in the 1990: s, when government regulations started to demand quality certificates. Because these regulations only mandated companies to comply with the standards of ISO9000 family, quality certification was viewed as mostly a marketing problem. (Oakland 2014: 243-251)

Therefore management usually handled the situation by outsourcing the function to quality consultants that set up top-down ISO9000 based quality systems that seemingly satisfied the need for certifications, but didn't take company needs into account. (Oakland 2014: 243-251). This kind of start for quality management systems led into the still existing view that quality management systems are not essential in realising the corporate strategy. Contrary to this view the quality management systems should be constructed within a company to be fully effective. Only by customizing the system according to the organizations needs rather than attempting to copy solutions can the quality management bring true value to a company. (Sramcik 2005)

Keystone of quality management is the concept of customer and supplier working together for mutual advantage. Management of quality becomes "total" in an organization when these customer/supplier interactions extend into the whole supply chain (Oakland 2014: 16). Achieving a TQM system requires that the human, administrative and technical factors affecting quality are under control. International standards are great tools, but the quality management systems are required to apply them into a company's processes in such a way that meets the specific organisational and product or service requirements of the organisation. Quality Management system must assure that two goals are simultaneously met: (Oakland 2014: 245)

- *Customers' requirements.* Organization must be able to deliver the product or service consistently in the expected quality to the customers.
- *Organizations' requirements.* Processes and products must be able to meet the internal and external regulatory requirements. This must be done at the ideal cost, with efficient usage of company's resources, –material, human, technological and information. (Oakland 2014: 245)

Requirements can only be met if the organisation is able to have good communication and coordination with all the internal and external parties that are involved in the process

chain. TQM should apply to and interact with all processes in the organization to achieve excellence in quality. Additionally there should be a joint management for disparate initiatives such as Lean, JIT, TQM etc. because they usually overlap and support each other. (Ringen et al. 2014, Oakland 2014: 245)

2.2.2.2 Design and development

Quality in a product starts with its design, and as such the production industry has to be able to have excellent control of design and development processes. Design process is the place where most of the products quality and reliability is decided. Customer interaction in the design phase is in many cases necessary (such as concerning custom designs) and helps to manage the expectations regarding costs and lead-times resulting from the choices made. Good design must take into account multiple factors that can be conflicting such as: (Franceschini & Rossetto 1999)

- Ability to meet or exceed customer requirements
- Costs & pricing
- Assembly times

Managing these conflicting needs (Franceschini & Rossetto 1999) requires that clear goals for designs are set and monitored by the stakeholders and managers. By setting clear goals necessary constraints are created to design-process which will help to prevent problems such as the project dragging on forever and massive cost overruns. Nevertheless it's essential that sufficient time is allocated into the design-process, because it is much easier to correct issues at the drawing board rather than releasing non-validated designs into production as a result of management pressure and then painstakingly correcting the mistakes later. (Oakland 2014: 90-93) Design processes should conform to the principle of made first-time-right-every time just like all the other processes.

Developing new features to existing products is an activity where design quality is also extremely important, because design process need to take into account also how the new feature interacts with the pre-existing product. Compatibility issues can create massive

problems even if design of the old product and the new feature are of good quality. Especially in the manufacturing industry the need for design processes is not limited to new product / feature introduction, but the design department also needs to handle the inevitable faults and breakdowns. These can become apparent already in testing and quality control, but in many cases they are only found about in customer surveys and reclamations. Problems and reasons for breakdowns need to be handled rapidly by the design process if their origins are found to be in the design, or if new design can remove the causes of these issues. Damage control in such a way is also an extremely important part of business processes and if handled well can actually increase customer satisfaction. (Oakland 2014: 255-258)

2.2.2.3 Quality Awards

Quality awards are prizes awarded for some aspect of quality performance which has been demonstrated to an organization which normally has no responsibility for the recipient's performance. Most of these are awarded in some kind of competition among companies, but a few are not competitive - being assessments of an organization's performance with no limit to the number of winners. There exists many different quality awards around the world, from which some are national such as: (Oakland 2014: 23-27, Chartered Quality Institute 2015)

- The UK Excellence Award, established in 1994 and run by the British Quality Foundation.
- The Malcolm Baldrige Award, established in 1987 and offered by the National Institute of Standards and Technology in the USA.
- Singapore's National Quality Award, established in 1994 and offered by the Singapore Productivity Board.

Others are international such as:

- The EFQM Excellence Award, established in 1992 and offered by the EFQM.
- Asia-Pacific Area Golden Quality Award.

- The Deming Prize, established 1951 (International from 1984) and offered by the Japanese Union of Scientists and Engineers. (Oakland 2014: 23-27, Chartered Quality Institute 2015)

These are one time presentations and not indicators of previous or continuing quality. Nevertheless many companies strive to achieve the results necessary for these awards, even though there is no immediate reward except the popular acclaim these bring. Reason for this is that the improvement project for a company's processes for achieving these rewards will necessitate so much scrutiny, preparation and experience with quality tools that the whole reward becomes almost meaningless compared to the improvement that company achieves during the process. Application process can be costly and will require a good deal of investment in time and resources. As such the company must consider carefully if they truly have good commercial reasons for entering the process for receiving quality awards. : (Oakland 2014: 23-27, Chartered Quality Institute 2015)

2.2.3 Total Productive Maintenance

Total productive maintenance (TPM) can be seen as an integral part of Lean system, being a system for introducing preventive maintenance of the machines, equipment and for training the workers in self-maintenance of tools and machinery. Its origins are in preventive maintenance system introduced to Japan from the US in the 1950: s, and in Japan the system was further developed by Seiichi Nakajima in the Japan Institute of Plant Maintenance (JIPM). (McCarthy, Rich 2009: 31)

TPM tools improve the effectiveness of a company's improvement process when adopting a Lean system by giving frameworks for releasing capacity, increasing control and repeatability. TPM goals align well with Lean precisely because they also create results by adopting a continuous improvement approach to eliminating waste towards the optimization of the whole supply chain. (McCarthy, Rich 2009: 31)

Focus on empowering employees for equipment maintenance may seem narrow and not necessarily worth the effort of a major improvement process. Nevertheless when the benefits of TPM are examined carefully the reality is very different, because when the equipment fails to perform at its potential it causes massive losses for a company. JIPM identified six categories of equipment loss: (McCarthy, Rich 2009: 33)

- Breakdowns due to equipment failure
- Set up and unnecessary adjustments
- Idling and minor stops
- Running at reduced speed
- Start-up losses
- Rework and scrap (McCarthy, Rich 2009: 33)

Three main reasons for these losses were also identified:

- Equipment condition is poor
- Human error/lack of motivation
- Lack of understanding how to achieve optimum conditions (McCarthy, Rich 2009: 33)

Research showed that addressing these three reasons through training and employee motivation can actually be quite simple. In most cases there are observable quality defects before the breakdown, and if employees are trained to recognize and report these the breakdowns can be avoided by preventive maintenance, which results in notable savings of both in time and money. Many breakdowns can also be avoided with simple procedures such as proper training for tool use, and maintaining the equipment by doing lubrication and cleaning regularly. (McCarthy, Rich 2009: 33)

These tasks allow the processes to be stabilized which is a key towards allowing improvement projects to succeed. Basic rule is that an unstable process cannot be improved without first bringing it to a stable state and thus allowing an unimpeded process flow. Time released from tackling problems caused by breakdowns can be used by management / specialists for process improvement and for developing new ways of working. (Modig & Åhlström 2013)

Responsibility for successful adoption a TPM approach lays with the management, because the maintenance department cannot succeed in bringing a lasting change alone. As in any process the management must make resources available, show dedication towards a new way of working, empower employees in a bottom-up approach and then monitor the progress of the improvement program. TPM compliments the Lean system by allowing practical ways to begin continuous improvement and by helping everyone understand how these enable better business results through creating competitive advantage. Combined approach of Lean and TPM improves both operational efficiency and organizational effectiveness. (Modig & Åhlström 2013, McCarthy, Rich 2009)

2.2.4 Human Resource Management

Phrase “employees are the most valued resource of our company” is nowadays used so much in businesses that it has become a cliché, and in many cases the never-ending cycle of hiring and downsizing creates ridicule towards it amongst the employees. Nevertheless research done by the European Centre for Business Excellence (Oakland 2014: 331) that focused on world-class award winning organizations, showed an overwhelming amount of evidence that it’s counter-productive for any company to actually ignore employee empowerment and development, and having the view that employees are just an expendable resource.

Human resource management (HRM) factors are especially important in the adoption of the Lean system, because HRM enables the company to cultivate the new way of operating by enabling recruitment, training and management of personnel towards supporting the goals set by the senior management in the whole organization. (Talib & Zillur 2015). Successful management of employees creates the conditions for the company to succeed in a Lean environment by developing the competencies of its work force. Employee competence and participation is becoming increasingly more important in sustaining and improving organisational performance. (Martínez-Jurado et al. 2014)

2.2.4.1 Employee participation, training and rewarding

Managing a successful enterprise in today's rapidly evolving situations at the world markets will require a highly motivated and trained work-force. Need for training and development amongst the employees has been highlighted with comparing the benchmarking and self-assessment against quality frameworks such as the EFQM Excellence Model (Oakland 2014: 340). Successful training and development programmes within a company requires an on-going commitment in the organisation to focus on creating long-term competitive advantage through personnel training rather than a short-sighted view of cost cutting through constant cycle of hiring and firing.

Getting the desired results from training programmes requires a continuous effort to keeping the training material databases up-to-date and readily available to employees seeking to improve their skills. Evidence points out that organizations that utilize training and development programmes in a systematic way are more likely to be able to succeed in today's competitive markets. Successful training programmes can be combined with the use of incentives such as promotions and other rewards to increase motivation amongst the employees. Employees willing to improve their skills and participate in improvement programs are usually the most motivated and resourceful, and company can also identify potential candidates for promotions or job rotations amongst them. (Oakland 2014: 331-343, Talib & Zillur 2015, Martínez-Jurado et al. 2014)

Continuous improvement programs and 5S are good ways for a company to begin involving their work force in process improvement at all levels of its organization. These initiatives give employees more control over their work, which generally results in increased satisfaction and motivation among them. Employees are also the most knowledgeable about the challenges in their daily work, so empowering them to make suggestions and initiatives for improvements can bring great results towards improved quality and faster process flows. (Gardner 2002)

Research toward rewarding methods of highly successful companies has made it possible to highlight activities that were common among them: (Oakland 2014: 335)

- Rewards are based on consistent, quality-based performance

- Awards are given to employees and also to customers, suppliers, universities, colleges, students etc.
- Financial incentives are offered for company-wide suggestions and new idea schemes
- Internal promotion, for example, from non-supervisory roles to divisional managing directors encourage a highly motivated workforce and enhance job security
- Commendations include ad hoc recognition for length of service, outstanding contributions, etc.
- Recognition is given through performance feedback mechanisms, development opportunities, pay progressions and bonuses
- Recognition systems operate at all levels of the organization but with particular emphasis on informal recognition ranging from a personal “thank you” to recognition at team meeting and events (Oakland 2014: 335)

Companies offering a wide range of options for rewarding and advancement can more easily create a bond with their employees. People have differing needs and desires and a wide range of options allows the company to cater to these needs. (Oakland 2014: 335)

Company that manages its workforce successfully and is capable to develop their competencies is also often able to foster loyalty by having employees identify with their organization and with the people they work with. Employee satisfaction, loyalty and commitment towards the company is something that is difficult to achieve with just financial incentives. Even companies that are just interested about the “bottom-line” should therefore strive to manage, develop and train their employees to maximize their success. (Oakland 2014: 335, Gardner 2002)

2.2.4.2 Communication

Successful management of human resources requires the organization to commit resources towards fostering a good communication environment. No training or rewarding scheme can be successful if the management doesn't know their employees desires and competencies, and it's difficult for the company to foster trust and commitment amongst the employees if they feel that they are never listened to. (Martínez-Jurado et al. 2014)

Communication must therefore be two-way, company and management must offer honest information to employees about general situation and opportunities, and employees must have channels to express their ideas and desires. A good way for addressing employee concerns and for taking their desires into account in the Lean system implementation is to include representation from the employee unions into the process. (Martínez-Jurado et al. 2014)

Presenting the process in accordance with employee representation allows company to lessen the effect of unavoidable initial resistance. Good communication and co-operation of parties is the foundation to success in any project, because without sufficient knowledge about factors impacting on the starting point and the desired outcome no amount of resources is enough. (Martínez-Jurado et al. 2014)

Communication is essential for efficient management of human resources because humans aren't alike, they have different desires, needs and they respond differently to challenges and changes. Without good communication company cannot get the best results from its workforce. Additionally the trust created by good and honest communication helps not only company to maintain standards and to increase efficiency, but additionally it serves to lessen the impact of unpopular events such as outsourcings and downsizing of the work-force. (Martínez-Jurado et al. 2014)

2.3 Continuous Improvement

Philosophy of continuous improvement (CI) differs from regular top-down initiatives by its approach. It aims to involve everyone in a company regardless of their position to a continuous cycle of process improvement. It can be viewed as a bottom-up approach where the companywide accumulation of continuous small improvements leads to major process improvements over time. (Jingshan 2013).

Pioneered by Toyota, CI (also called Kaizen) projects have been applied throughout manufacturing-, engineering- and business processes. Continuous improvement philosophy is in the core of, and the most important part of the TPS and Lean system (Jingshan 2013). Studies about effects of CI systems have proven that the amount of employee suggestions being made and executed in companies has significant positive correlation between them and the success in implementing the Lean system (Angelis & Fernandes 2012). These studies have also shown that a large amount of employee suggestions has significant positive impact towards improved quality and increased delivery speed.

These facts make CI programs very attractive to companies in basically every field of business that are seeking to excel in local and world markets. Innovativeness is the key source for competitiveness, which allows the company to find solutions for the problems and challenges it faces. Without innovations a company cannot even maintain its position, much less improve it and therefore CI aims to harness the innovativeness of its whole staff into creating the conditions for the company's success. (Angelis & Fernandes 2012, Jingshan 2013).

Adopting CI can lead to massive improvement in process efficiency without costly investments into major programs or equipment acquisitions, because it is designed to utilize and develop resources that the company already has. CI system especially focuses on developing human resources, which are in many cases left underutilized even in major companies that boast that their primary resource is the employees. (Angelis & Fernandes 2012, Jingshan 2013)

2.3.1 Five Pillars of Continuous Improvement

Continuous improvement programs are essential tools for a company to succeed in transforming their business into a Lean environment. The programs also have the advantage of requiring the involvement of employees' right from the start, which gives them motivation for the program and dissuades the view that Lean system is "just another fad from management" (Oakland 2014: 305-307). CI can be seen as having five main points: (Prado 1997)

- Involve all company personnel at all levels
- Search for savings without making an investment
- Quantify data and information
- Use common sense as an essential tool
- Implement or practise ideas (Prado 1997)

First two points are closely related, involvement of everyone allows the organization to harness the knowledge of those that see the bottlenecks and problems in their work. Most likely they have ideas how to resolve these issues and in many cases fixes can be made by rearrangements etc. with minor or no investments required. Third point illustrated the need for data to be gathered from the suggestions and improvement activities. Data gathered will allow the management to evaluate the costs and benefits of different initiatives that have been executed or designed. Stored data from experiences and improvements must also be distributed to ensure that lessons are not lost and that the efforts are not duplicated within the organization. (Prado 1997, Gardner 2002, Angelis & Fernandes 2012)

Usage of common sense can be seen as a tool in the way that CI essentially enables the persons most aware of the issues and problems processes, –the actual operators, to present their views on the problems and offer solutions (Prado 1997). Common sense can be used in accordance of the poka-yoke design methodology meaning that designs are made to be mistake-proof to eliminate (or at least lessen) the possibilities of human error. Finally the implementation phase must be well designed. No idea or initiative can be useful if it gets

mired in bureaucracy, nor can they make a difference if these new methods aren't systematically practised to make them the new way of working in a company.

2.3.2 Bottom-up approach

Manufacturing industry is generally aided in the implementation of CI system by the fact that many commonly used initiatives such as Six Sigma, Lean, TQM etc. have lots of similarities. All programs are interested in promoting employee participation and cross-functional teams with the goal of increasing process efficiency and quality. Nevertheless the improvement programs by themselves are useless if the situation immediately regresses into the old ways after the programmes end. Truly effective improvement program requires that its result are codified into new ways of working and maintained to achieve lasting changes. (Gardner 2002, Oakland 2014: 305-326)

Creating visible changes and improvements into work places combined with rewards for outstanding performance will serve to motivate employees to continue with further improvements leading to a self-reinforcing cycle of improvement which leads to a true CI environment. Attitude change that comes from employees themselves is the most effective tool towards achieving a continuous improvement environment. (Gardner 2002, Oakland 2014: 305-326)

Reaching these improvement goals and maintaining them means that the CI projects will need the support of all levels of organization and management to succeed. Support from senior management makes it clear to whole company that change in methods of working is needed and gives the organization the necessary resources for the process. Middle management involvement is also essential even though the CI is a bottom-up process, because if the ideas and changes proposed by the employees don't get properly examined and implemented the whole project collapses. (Angelis & Fernandes 2012)

Besides the obvious measurable results of process efficiency, CI system creates also motivation and commitment in employees towards the company. Committed and skilled employees also lead indirectly into increased flow efficiency in production processes by reducing employee turnover, allowing company to better harness their talents which helps

company to develop further towards to a Lean production system. Research shows that CI combined with clear programs of sustained training can make the employees a source of competitive advantage to the organization. Motivated, multi-skilled and innovative employees will be a great asset to any company. (Oakland 2014: 352)

Key of maximizing the effect of the continuous improvement system is that it must grow “organically” into being a part of company’s processes, which itself requires involving all employees at all levels. Even though managerial input and supervision cannot be entirely eliminated, the bottom-up way of implementing the program means that it will also be able to sustain itself without constant managerial input, and employee involvement and commitment towards the system will be greater. (Angelis & Fernandes 2012)

2.4 Process Management

Importance of creating excellent processes in any organization can be seen in the quote made in 1999 by Fujio Cho, President of the Toyota Motor Company to the market place: “We get brilliant results from average people managing brilliant processes – while our competitors get average or worse results from brilliant people managing broken processes”. (Oakland 2014: 199) Comparison is now as true as it was then, developing excellence in company’s processes is key to success in world markets. Essentially the focus of every improvement approach, methodology and tool is ultimately on creating excellence in organizations processes.

Process management is therefore essential because every process in company requires guidance to achieve good results for ultimately serving the customer needs. Inevitably problems will be encountered in company’s daily operations that hamper the process flows, and management is required to detect such issues and take actions towards resolving them. High quality process management is therefore required for not only achieving and sustaining excellent results, but also for perceiving the need and possibilities for improvement. (Gardner 2002)

Communication between every level of the organization is required and needs to include all the process stakeholders. Roles and responsibilities must be clearly defined and regular meetings arranged. These meetings between departments are essential for the every process, including the improvement projects, to advance goals on the level of whole organization rather than ending up making choices that result in part-optimization of processes. (Modig & Åhlström 2013)

2.4.1 Senior Management role

Top management role is critical in any company because strategic level decisions affecting process management can only be made by senior management. This includes establishing companywide performance measurements for the improvement programs and determining the goals which the organization strives for. Established goals must be communicated to everyone making the commitment of the management clear, if this is not done the project will fail, because no-one will view it as important. (Gardner 2002)

Active participation by the top management is needed for every part of the organization to have constantly the necessary support and resources it needs to succeed. By setting clear goals and involving themselves continuously in the improvement processes, the senior management will not just keep themselves informed on the progress of these programs, but this attention will also allow them to perceive further possibilities of improvement. Close engagement by the management will also enable a speedy decision-making process and prevent confusion caused by unclear communication. (Jadhav et al. 2014)

True Lean environment depends upon that every stakeholder in the company and its supply chain is working towards the same goal. This requires that outsourced functions, customers, suppliers, partners etc. are handled by the same process framework. Establishing these frameworks will help in creating mutually beneficent long-term partnerships with supply chain members, which will be much more profitable for everyone than the blind chasing of the cheapest suppliers. (Jadhav et al. 2014)

Establishing these clear process frameworks is responsibility of the senior management. By enabling communication and making accountabilities clear throughout the organization and supply chain, they will help to create a common purpose for all stakeholders. This is especially useful in situations when the parent company implements changes and improvements in its operations, which will inevitably affect all partners and suppliers. (Jadhav et al. 2014)

Lean system is not just about setting up frameworks and goals, these must also be implemented. This will require that first the management and then the rest of personnel

is trained towards the new ways of working. Establishing these training programmes is vital, and management must take care in evaluating the needs of different departments, because it is unlikely that the organization can successfully use a single approach in training for all employees. (Jadhav et al. 2014)

Far-reaching transformative programs such as adopting a Lean system will require even more senior management supervision and involvement to overcome resistance to change and to ensure that the whole organization is committed into the new ways of working. Need for senior management's support and active participation is thus evident in implementation of any project. (McCarthy & Rich 2009: 58-68). Even the bottom-up initiatives that are part of continuous improvement and Lean system need senior management's approval and backing to succeed. Monitoring the daily processes helps the senior management to focus on possible problem areas, and for the middle management and employees it serves as reminder of the senior management's commitment and helps in keeping the organizations goals in focus. (Jadhav et al. 2014, Gardner 2002)

2.4.2 Middle Management role

Middle management is the level of the organization where the goals set by senior management meet the reality of actual company processes (McCarthy & Rich 2009: 68-69). It makes the middle managements role especially vital for the success of the new initiatives, because this level is actually the deciding part in rate of change and improvement. Reason for this is the ability for middle management to hinder the movement of information and inputs in either from the top-down or bottom-up direction. Mostly this is not done maliciously, but rather the middle management can consider senior management initiatives as impractical, or the employee requests can be seen as unrealistic and thus not considered.

In some cases this is the result of internal power struggles between departments, these happen because departments view each other as hindrances to their processes. Result of these is that every department works on only maximizing their own efficiency at the expense of other departments and nobody is viewing the customers' needs and a smooth

process flow as whole company's priority. Monitoring by senior management is necessary to avoid these situations. Breaking down barriers between departments by good communication and co-operation results in all levels of an organization achieving mutual respect and understanding that everyone is needed to achieve world class process quality. (McCarthy & Rich 2009: 68-69)

Middle management is responsible for creating an environment within the organization that is conducive for the employee participation which will create enthusiasm and commitment among the work-force. This can be done by explaining the goals set by the senior management, rewarding participation and applying the suggestions made by employees, and also by showing their own commitment. Implementing the training programmes will go a long way in this regard, they will increase the knowledge and skills of the employees and allow them to better understand the Lean systems goals. (Angelis & Fernandes 2012, Jadhav et al. 2014, Oakland 2014: 33-34)

2.5 Integration of Process Improvements

Improvement programs such as Quality management and Lean should be managed under the same organizational system. Goals of the improvement programs generally align well and are complementing each other, and a unified management will avoid the problems with parallel systems regarding bureaucracy, inefficiency and needless costs. (Ringen et al. 2014) Integrating quality and Lean processes within an organization is dependent on the maturity of the production processes and on the support of experts and managers throughout the process chain. Process maturity is dependent on stable and standardized work processes, which must be the first things to develop in any improvement project.

Excellent processes will allow even mediocre management and employees to attain success. Some organizations are able to have good performance with poorly functioning processes (Marquardt et al. 2004), but this is the result of extremely skilled workers and good organizational culture and cannot be seen as examples of quality in these companies' processes. Role of the culture in effecting and sustaining systematic improvement within an organization is often misunderstood and neglected. Situation usually results from the fact that the benefits of process changes and improvements are easily calculable but the culture of organization and its effects are much less tangible.

Research into multiple companies revealed common features of organizations that can be defined as having an excellent organizational culture that supports peak performance: (Marquardt et al. 2004)

- High degree of trust towards employees, empowerment and a lack fear
- Successful teamwork
- Clear and attainable but challenging goals that have direct contribution to the organizations success (Marquardt et al. 2004)

Many other factors are of course involved, but they generally flow from the success of these facts. These are clearly prerequisites towards succeeding in adopting changes into organizational structure towards achieving improvement programs goals. If the organizational culture is not good or conducive to development, then successful change management must also integrate culture change within the process of adopting other

initiatives. This will require that the management is able to have a clear picture of the type of organizational culture that will support long-term success. Without culture change no improvement program will be able to deliver the desired results. (Marquardt et al. 2004)

Improvements to production processes need not just good initiatives, vision and management, but also time in order to mature. Diversity of many improvement plans such as initiatives for quality, batch reduction etc. requires their integration into a unified improvement system. Adoption and integration of the programs and assimilating the changes into the organizational culture is no easy feat making time an essential requirement. Integrating process improvement into unified management will be able not just implement the desired changes into organization, but will also make it possible to sustain the improvements and enable further development. (Marquardt et al. 2004)

2.5.1 Process Stabilization

Process stability can be defined as the ability of the processes to consistently meet their assigned goals. Lack of stability is often the reason for failure in implementing process improvement programs such as the Lean system. Processes cannot flow if the system is not working, which makes stability of existing processes is essential requirement for any improvement program. Statement “control before improve” applies very much, making reduction of fluctuation the key for getting the processes under control and achieving stability. (McCarthy & Rich 2009: 98-100)

In order to control and improve, the existing processes need to be defined, measured and evaluated to know what the process goals are and how the processes have achieved these at a defined time period (Ohno 1988). Goal of the stabilization is to ensure that the equipment and processes are capable of delivering these results and also to ensure that standard for best practise operation and asset care are in place. In basic terms the definition of process stability consist of finding out if the 4M: s are in place: (Smalley 2005).

- *Manpower*: does the company have enough trained manpower to handle the processes?
- *Machines*: is there enough machine uptime for customer demand?
- *Materials*: is there enough materials on hand to meet the daily demand?
- *Methods*: does the company have defined working methods such as working instructions and standards implemented? (Smalley 2005)

The 4M: s must be in order for the organization to have the ability to meet the defined goals which is the basic requirement for success in any operation and must be taken into consideration in improvement projects. If there is problems in any of these, the problem needs to be fixed before proceeding with further attempts at implementing process improvements. It’s imperative to create understanding of this fact not only among the management, but also throughout the organization. (Smalley 2005)

Defining process goals and applying measurements to process performance will find out which processes are the most critical / needing improvements the most. Problems in the

processes that are found to be the most serious must be addressed first (Smalley 2005). Evaluation process must also take into account the existing company development / product introduction plans to find out if these projects have goals that have specific needing to be taken into account and integrated into the improvement programs.

Findings from the review and analysis of existing systems and goals can then be categorized accordingly into high/low benefit and high/low cost improvement priorities. Beginning the improvement by adopting activities that are high benefit and low cost can alter the whole situation within a company by itself, which will require modification of process goals. In such a way minor activities and improvements can add up into massive improvements in process efficiency and quality at almost no cost. (McCarthy & Rich 2009: 97-100)

If actual output is consistently at lower levels than what the system is thought to be capable, larger changes of methods might be in order or the situation will require long term investments into equipment / work force. It might be feasible for a company to temporarily lower expectations in ways such as making safety stocks larger, building production programs around the bottleneck operation or assigning extra workers into monitoring / helping the part of the process that is causing delays. (Smalley 2005)

Accepting such a temporary lower level of utilization in exchange of system stability can make addressing problems easier by releasing employees and managers from constant firefighting mode. Focus can then be shifted into addressing the problems that resulted from higher utilization. It will also result in increased morale when production goals are not viewed as constantly unrealistic by the production departments. Care must be taken so that this doesn't become a new way of working, it must be strictly viewed as a part of the correction process. (Smalley 2005)

Process stability will also enable adopting the previously mentioned method of small incremental improvements in a continuous improvement cycle. Low cost of implementing these will complement any major investments made by company and enable employees to feel that they're a vital part of improvement processes. (Smalley 2005)

2.5.2 Mass Customization

Demands of world market have been continuously shifting towards increased differentiation of products, which has led to the massive growth in required product portfolios and individual product customization (MacCarthy 2013). Previous ways of mass production which are geared towards being very efficient in producing standardized models in great quantities cannot answer to this changing demand environment (Stump & Badurdeen 2009). This need for individualized products combined with the continuing and increasing requirements for low prices, fast delivery times and excellent product quality are creating a very challenging competitive environment to companies.

Mass customization philosophy has the potential to create an answer to this problem. It aims to combine the benefits of mass production and individual customization in order to offer the customers the advantages of low cost and high efficiency combined with the ability to customize the ordered product. These goals have been previously seen as contradictory and unrealistic, but can be achieved by through merging the Lean system with standardization of products and a flexible manufacturing systems. There are many approaches towards Mass Customization but they all have defining characteristics: (MacCarthy 2013)

- Significant number of product attributes can be customized
 - Customization can be offered to without sacrificing response time or quality and company is able to offer the products without serious added costs
 - Mass Customization offers a range of options, not unrestricted customisation
 - Range of options must focus on those attributes on which customers most wish to differentiate.
 - Standardization of options allows for postponement of the differentiation
- (MacCarthy 2013)

Integrating customers and their desires as input at every stage is the main element that a company desiring to move towards offering mass customized solutions needs to adopt (Theilman & Hukau 2014). Involvement must start at the design process, where the customer is able to choose options from a premade list according to their needs and

desires. Limiting the options with such lists is essential, because the delivery times and price must remain competitive in mass customization system.

It is possible to also offer limitless custom-designed options, but care must be taken with these because custom products will have higher prices and lead times. Company that desires to include such options must take into account that custom designs can disrupt the whole production system and be able to reflect these risks in the final price of the product. Customer needs are nevertheless paramount for the company, it is not enough to sell a custom product, but rather the whole development process must answer to the customer needs in the mass customization environment. Organization must design its whole approach to mass customization around its products and processes and because of this fact there is no easy way to copy the necessary processes (Theilman & Hukau 2014).

Achieving a successful mass customization production requires that the production system and supply chain are flexible and highly responsive. Modularization is also a necessary part, because it creates some commonality between products allowing the company to take advantage of efficiencies in mass production while retaining the ability to customize (Stump & Badurdeen 2009). Modularization creates also the ability for company to move the product differentiation point until later in the process chain, which allows for common base frames to be produced and only later to differentiate according to customer wishes. Postponing the differentiation of product like this is a tool commonly used to achieve MC capabilities.

All Lean tools won't be viable in a highly variable production system, such as the Theory of Constraints (ToC), because of the inherent movement of the constraints in this system. Some methods such as using CONWIP (Stump & Badurdeen 2009) system to control WIP can on the other hand be very successful because they allow for cost savings by limiting WIP in production system.

2.6 Challenges in adopting a Lean system

Lean system has become a byword to success in Western companies since Toyota's success with its TPS became world famous in the 1980: s and popularized the methods. As such the Lean system has been the target of countless of studies and implementation programs for companies around the world seeking to improve results of their businesses. (Jadhav et al. 2014)

In addition to Lean system there has been an explosion of different improvement philosophies offered to companies. Examples include TQM, Six Sigma, TPM etc., the list is very expansive and is getting larger every year. Nevertheless and maybe not surprisingly this clutter of programs has not in all cases produced the desired results, rather many companies have failed all together in implementation or the programs have failed to produce the expected results (Jadhav et al. 2014).

Actually most of companies outside of Japan have been incapable of adopting a Lean system. Only 10 per cent or less of the companies have succeeded at implementing TPM and Lean manufacturing practices (Jadhav et al. 2014). Analysis points that the problems have centred on cultural, human and geographic factors. This supports the conclusion that there is no intrinsic fault with the programs, but that the improvement programs have failed because of the companies' lack of understanding what these programs are and what they are not.

2.6.1 Lack of program focus

Many improvement programs have focused just on applying some of the Lean tools without understanding that the whole production system needs to adopt a new way of thinking and working for the programs to be really successful. Example of these mistakes can be seen in the belief that Lean system is just a manufacturing concept, and not a system that needs to be applied throughout the whole organization to be successful. (Modig & Åhlström 88-97)

This approach is common in top-down driven initiatives. Point of the Lean system is not understood by not involving employees, thus missing out the potential improvement that could be generated by 90% of company's work-force (Jadhav et al. 2014). Worsening the situation is the fact that bottom-up initiatives can be done with practically zero budget and they have the added bonus of increasing employee motivation. All of these issues could be solved by having sufficient training for implementing Lean system to personnel at all levels. Trained workers will more easily understand the programs goals, how to focus on and to work towards achieving them.

2.6.2 Leadership problems

Senior management role is the key to success with integrating and sustaining a Lean system. Research and experience points that most of problems adapting a Lean system result from poor managerial commitment and resource allocation (Jadhav et al. 2014). Lack of commitment is the result from the fact that many manufacturing businesses have not truly transitioned into the mind-set and operating principles that are required in the modern economy. Old operating models dominate in many cases because of their success in the past.

Changing the processes within a company is never cheap nor easy. Overcoming resistance to change requires addressing barriers on organizational and individual levels. Especially difficult to overcome is the resistance resulting from past success. Success with previous methods will have created pride and complacency amongst those very people which are essential for any improvement programs success –the senior management (Marquardt et al. 2004).

This becomes a trap, creating a lack of urgency even when the old methods are incapable of producing further success. Clinging to old ways is much easier than dealing with the lack of clarity and uncertainty of the change, pressure, interference with interests and the challenges to learn something, which will result when process improvement programs start to transform the old systems and methods. Complacency and pride among top

management can prevent any successful questioning and change of previous operating models as long as these don't completely fail. (Jadhav et al. 2014)

Process improvement is therefore never easy and proper resource allocation will be necessary for achieving success with the Lean system. Although there are many opportunities to “snatch low-hanging fruits” in process improvement, wholesale success will depend on expensive process of benchmarking, personnel training and supplier integration into new system and then monitoring the changes. Successful adoption of a new system will require investment of both time and money. (Gardner 2002)

2.6.3 Lack of commitment

Role of Lean system in the process to transforming company's processes into must understood as a tool to change the way to think. Lean system by itself will not give the company the ability to do things better, these ways must be developed within the organization to fit with the company's products and chosen strategy (Sramcik 2010). Developing these competencies will require the training of all personnel starting from the managers. (Jadhav et al. 2014)

Usual mistake is to see the Lean system as a method that requires or allows the downsizing of the workforce. Lean is concerned about eliminating non-value adding waste and successful applications of Lean should rather be interested about how to empower, motivate and train the existing work-force. Problems in adapting and committing to Lean system are not exclusively the domain of management. These kinds of projects which change old ways of working and the roles of employees will inevitably create uncertainty and resistance among at least some of the employees. (Jadhav et al. 2014, Sramcik 2010)

Existing rewarding schemes may also be counter-productive to adoption of a new system. These may reward actions that are no longer viewed as beneficial (such as production quotas only on departmental level) for the whole organization if they're not updated to reflect new goals. Very few people are willing to work towards lowering their own

benefits (Jadhav et al. 2014). Nature of Lean system requires the whole organizations commitment to process improvement process, and those who cannot accept new ways of working must be replaced with new people. Replacing workers will create initial disruptions and problems, but in the long run the company will benefit from this. New employees will be fully invested and committed to the Lean system provided they're properly trained towards it right from the start (Sramcik 2010).

Lack of commitment is not solely the problem of implementation phase. New system must be continuously monitored and upheld to prevent the sliding back to old methods. Especially companies that have used Lean system as a way to downsize work-force suffer from this, as naturally employees will be hostile to a system which they view as causing the loss of employment for their co-workers. (Oakland 2014: 306-308, Jadhav et al. 2014).

2.6.4 Lack of understanding

Many organisations view Lean system as a “one size fits all” solution that can directly be transplanted to replace existing processes, rather than viewing Lean system as something that must be adapted and “grown” to fit the company’s needs (Sramcik 2010). Lean system is not something you can directly transplant because of the fact that Lean is a never-ending process. It starts by analysing company’s processes and ways of working, then moves to implementing changes towards achieving better results and then starts again to think new process improvements.

The fact that Lean doesn't have an endpoint can be a difficult concept for employees to accept, especially when company begins to move towards a Lean system. Especially in process industry people can become frustrated because they need solutions to problems immediately which the Lean system cannot instantly give. Lack of understanding the nature and goals of Lean system among the managers and employees will result in resistance to change. Increased monitoring and personnel reshuffles can also be viewed as intrusive and counterproductive. (Jadhav et al. 2014).

Understanding of the goals will create acceptance of Lean systems nature among the personnel which is required for it to be of use to the organization. Lean system's nature of being continuously self-assessing and improving means that its tools and concepts will continue evolving and transforming over time. Process will continuously lead into whole new ways of working in organizations. (Gardner 2002)

2.6.5 Communication issues

Every issue presented is solvable by training, education and development of personnel and processes, provided that there are ways for the people to communicate. Roles and responsibilities must therefore be assigned clearly to manage communication between parties that are involved company's internal and external activities. Working communication throughout the organization will enable the goals set by top management to be understood by the employees. Information flows must also work in the other way allowing potential problems to be brought into the top management's attention. Communication between all departments will enable everyone to feel working towards a common goal in the transition to a Lean system and also generally to see everyone being "in the same boat" viewing the customer needs as the most important thing. (Jadhav et al. 2014).

2.6.6 Successful transitions

Organizations that have been able to avoid these problems and successfully implemented the Lean system have had a clear view of their customer needs. These organizations have then identified the activities that don't support these needs and taken steps to eliminate unnecessary waste in their processes. (Marquardt et al. 2004)

Improvement programs in any organization seeking to adopt a Lean system and improve quality of its processes should seek to measure, and then control and reduce the amount of variation these processes have. Reducing variation allows the processes to be stabilized

which has the effect of directly improving quality and achieving better process flows. Stabilization will also allow for better process control and implementation of further improvement processes. (Smalley 2005)

Successful transition to a Lean manufacturing organization will require that everything, communication, rewarding schemes, management, training etc. in the company is arranged to support the new system. Lean system is not an instant cure for all, like Abraham Maslow's famous quote says: "He that is good with hammer thinks everything as a nail" (Gardner 2002), also the Lean cannot be applied to every problem. Methodologies addressing a problem in an organization should be based on the specific needs of the problem.

3. Process Improvement at DCV

3.1 Company profile

Wartsila is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wartsila maximizes the environmental and economic performance of the vessels and power plants of its customers. In 2014, Wartsila's net sales totalled EUR 4,779 million with approximately 17,700 employees. The company has operations in more than 200 locations in nearly 70 countries around the world. Wartsila is listed on Nasdaq Helsinki, Finland. (Wartsila 2015) Wartsila has divided its business into three units:

Energy Solutions – supplier for baseload power plants

Marine Solutions – supplier for marine and oil & gas industry customers

Services – supports the customers throughout the lifecycle of the products

3.2 Requirements for success at the world markets

Wartsila is facing a customer environment that demands high customization and product variety combined with need for low costs and fast delivery times which creates a range of challenges and constraints to its operations. Successful corporate strategy must find a balance to the requirements of the demand and supply side. (Stump & Badurdeen 2009, Theilman & Hukau 2014)

Typical demand side considerations facing companies:

- Different customers for a product group don't necessarily have the same needs and thus their desires for product details differ. Some customers are satisfied with

a pre-configured variant, and some have needs which need specific customization. Some customers can be prepared to compromise on exact specs in return of a lower price or faster delivery time, but some may prefer longer lead-times and higher prices to get exactly what they need.

- Customer needs change over time, the features that customers wish to specify are dependent on constantly evolving market conditions and demands. (Stump & Badurdeen 2009, Theilman & Hukau 2014)

Typical supply side considerations:

- Need of production planning for all production resources to ensure they are available when required. Even in a pull-system there is need for decisions based on forecasts, previous data and/or speculation.
- Communication and planning with partners in company's supply chain is needed to ensure in advance that the partners can plan and commit to supply and co-operation as required.
- Production planning also needs to maintain a maximum amount of stability in production processes in order to keep the efficiency, cost and quality factors controllable. (Stump & Badurdeen 2009, Theilman & Hukau 2014)

Taking into account and balancing these considerations depends on the demands of the customers and abilities of the company's products and supply chains. Manufacturers often need to adopt or combine a range of different order fulfilment strategies depending on the nature of customer requirements across product ranges and how new needs emerge on markets over time. The combination of ever-changing market trends, different customer needs within the customer base, as well as production and supply chain constraints, requires flexible fulfilment strategies that attempt to balance the demand-side and supply-side requirements. This is the environment that the DCV's organization needs to be able to operate in, and the product categorization project aims to offers tools and solutions for this task.

3.3 Quality and Lean System

3.3.1 Lean System

Wartsila has been very keen in its desire to implement a Lean production system to improve the company's processes at all levels. Different Lean initiatives such as JIT and 5S have been adopted by the DCV organization. Customers expect that products are delivered in time and in the quality that answers their expectations, which has made product quality the main priority of Wartsila. Aim is to every step of the process to be able to deliver their product reliably and in "done right the first time" - quality.

Focus of the Lean system on removing non-value adding processes and on smooth process flows are seen to be conforming to DCV: s goals (Modig & Åhlström 2013). These initiatives combined to the focus on quality and the view that every process must serve the customer's needs are seen to be the key to continuing as the global leader in complete lifecycle power solutions. Continuing to involve all personnel in a continuous improvement environment is increasingly seen as the key to success also at the DCV.

True transformation into a Lean system has still eluded DCV, partly this is because of problems created by nature of the product portfolio and partly because of the lack in understanding and commitment within the organization. Continuing to focus on these problem areas by initiatives in training and process improvement will nevertheless allow the organization to overcome these difficulties in order to move the focus of the operations into achieving a frictionless process flow.

3.3.2 Lean initiatives at DCV

3.3.2.1 Just in Time

DCV has put a lot of effort in to a JIT system because of the large high value items it produces. This makes stock keeping and WIP very expensive, and JIT principles have been seen as a good way to greatly reduce costs. Nevertheless the Lean system focus on process flow efficiency makes relying solely on JIT deliveries dangerous. High value items and focus on customer needs makes possible disruptions in deliveries / production very costly both financially and also by effects concerning the company reputation.

Production reshuffles can also result from the activities of the customers, it is quite normal that a delivery is postponed until later or cancelled which requires rescheduling. This naturally involves all the suppliers and some components can be project specific leading to need for excellent communication and delivery timing in which the JIT is invaluable. This is compounded by the fact that storage space at DCV premises is very limited and many of the components can be difficult to store because of their weight / dimensions.

Nevertheless the (quite high) possibility of different situations arising that affect production requires that some kind of safety stocks are retained to ensure the ability to serve customer needs even in the event of disruptions. These stocks can also be utilized for very fast deliveries of single items to demanding and well-paying customers. Care and discretion must nevertheless be taken so that such activities don't become normal or endanger the actual purpose of these stocks.

3.3.2.2 Continuous Improvement and 5S

Continuous improvement system was implemented alongside with 5S several years ago in DCV. Employees are allowed and instructed to make suggestions and improvements to their work and surroundings. System has worked quite well in creating better organized and cleaner workspaces. Nevertheless effective employee empowerment has been lacking in some issues, major changes such as layout changes are only superficially consulted in departments that are required to make them. Major initiatives made by employees also in many cases just get stuck in bureaucracy because of the lack of interest in the parties handling these.

Continuing to apply a Lean approach to employee empowerment in a continuous improvement fashion by including better consultation amongst employees when designing and implementing changes to workplace would help in achieving the goals of 5S. Faster handling of initiatives and adding representation from all parties that changes will concern should be standard practice in every program. Even if the changes or resulting conditions cannot please everyone or solve all problems, the participation and getting honest responses would increase morale by granting the feeling that employee concerns aren't just hand waved away.

More participation from all concerned parties might also result in findings that would allow a better process flow to be achieved. Changes are always easier to make in design phases of plans and therefore mapping and design of layouts and process changes should have input from as many sources as possible. Better monitoring of 5S practices should also be implemented. Especially in production areas the cleaning and organizing is generally only done randomly and it's not standard practise to continuously keep the areas clean and in order. Further efforts to keeping the standards high can only result in cleaner and more efficient work-spaces.

3.3.2.3 Employee training

DCV has everything in place for a successful employee training program. The organization has opportunities for work rotation for employees, courses about company guidelines and products and a system for implementing continuous improvement and employee initiatives. Rather the issues and problems at the DCV lie in the application of these programs that often results from the lack of understanding about the principles of the Lean system. In some cases managers view additional training as unnecessary and prefer people to do same jobs in an effort to increase efficiency. This combines with the lack of incentives regarding training which creates indifference towards training amongst the employees.

Promoting a more active approach towards training would be in the interest of everyone within Wartsila. Incentivizing personal development and learning by linking it to rewards and for defining pay scales would undoubtedly get better results. By focusing more on finding motivated personnel by aggressively offering training possibilities amongst the whole DCV staff, the company would be able to maximize its operational efficiency. Combined with financial incentives and possibilities for advancement for those that excel in the training programs the company could utilize the staff to its maximum potential. (Martínez-Jurado et al. 2014)

More focus into increasing employee participation and training should be made because a multi skilled and motivated work-force is a great asset for company and would potentially make further downsizing of the work-force unnecessary. Skilled employees could be utilized in other roles with minimal re-training if such situations arise. This would also conform to the Lean goals of creating long-term success by a motivated and committed staff, and avoid the problems of reduced efficiency that results from employee dissatisfaction and resistance to lay-offs and outsourcings.

3.3.3 Focus on Quality

Wartsila has made quality its priority in every function, and the company aims to remove waste resulting from defects and errors to achieve the principle of making everything done first-time-right. Focus on quality is a necessary for achieving customer satisfaction, and also for cutting unnecessary costs created by rework and scrap. This has created an effort to moving towards an organizational culture where everyone is responsible for meeting the customer's needs. Perfect results through zero defects is not possible if every employee and department is not viewing the others as partners.

Many of the quality problems in DCV stem from faults within the design-process, and in too many cases design changes are even made to engines already in production. By extending additional focus on quality towards the design-process by increasing communication between stakeholders and by making better design validation a priority, many of the problems in production would be solved. Part of the issues in design arise from nature of the product portfolio and from the customer demands for non-standard solutions, and the categorization project aims to be a part of the solution for this by rationalizing the portfolio and lessening the amount of non-standard requests.

Lean system and TPM on the other hand offer ways of internal quality improvement by allowing everyone to make corrections to faulty operations. In this way the company will not only create improved quality at marginal costs, it also fosters an environment where the whole staff is appreciated, leading to an improved culture within the DCV. Excellent organizational culture will create an environment where quality is viewed as a source of pride, and fulfilling the customer needs is seen as the focus of daily work.

Improving product and service quality will require assigning clearly defined roles and responsibilities within the organization. Inevitably something will go wrong and the main objective will be rapid recovery so that the process flow is minimally disturbed. With clear roles in the organization, it will avoid the unnecessary period of confusion and can immediately start working towards resolving the situation. Part of the focus in the categorization is the definition of these roles and responsibilities in order for the DCV to achieve frictionless flow in production processes.

3.4 DCV production system

3.4.1 Mass Customization (MC)

DCV: s efforts in process improvement such as the product categorization project and the ongoing projects like 5S and efforts towards a Lean production system are designed to answer to the increasing demands of the customers. Situation facing DCV can be quite accurately described as demanding a Mass Customization approach because the demand for custom solutions with competitive pricing. Organization encounters quite high variations with work content created by the nature of its make-to-order products. Situation results in moving constraints in the production system which is amplified by company's products being of low-volume and with high cycle times.

Nature of DCV product portfolio does require that many of the customer requests are designed "from the ground up", and the long order times and high costs and product specific nature of components quite effectively prevents the popular methods of achieving MC capabilities such as postponement of differentiation and production system decoupling. Customer needs regarding the DCV and the nature its products means that not all Lean tools and solution are necessarily viable in implementing changes towards an optimal production system.

Despite these difficulties especially the categorization and LT-50% projects both aim to create mass producible engine configurations that could be offered to customers. These would be incentivised by lower prices and faster delivery times, which would release resources towards taking care of the more demanding delivery projects. This conforms directly to Mass Customization approach and can be projected to bring great benefits to the DCV organization. Furthermore the new engine configurations being introduced are designed from the ground up towards enabling the company to offer this kind of mass customizable solutions.

3.4.2 Modularization

Product modularization offers a way to achieve cost and lead time reduction by dividing the work into subassemblies and outsourced producers that each can produce their products independently according to the needs of main assembly. Dividing processes like this requires increased resources in planning, quality control and communication. Common base frames for modules can also act as buffers against process disruption. Each subassembly creates a safety stock of finished or semi-finished products in a push system, from which products are then fed into the main process according to pull signals. Properly arranged process division and safety stocks like this are also the key to the TPS and Lean system and must not just be seen as a source costs, but rather as requirements to a frictionless process flow.

Production in DCV has been departmentalized into subassemblies and external suppliers that feed materials into SDU and PDU assemblies, but the lack of product commonality prevents the push production of components in most cases. Changing design requirements can create problems even within same projects in regards of the compatibility of modules in the assemblies. Regardless of the issues that have arisen, the division of production systems with internal and external suppliers has worked quite well and has allowed DCV to utilize the resources and space released by such arrangements towards process expansion and improvement.

New products that are being introduced have been designed right from the start towards modular assembly and for allowing later product differentiation, which is projected to reduce lead times considerably. Categorization of products and identifying the “Runner” products aims to achieve similar results in existing products by rationalizing the product portfolio and by concentrating demand as much as possible to proven, rapidly producible engine configurations.

3.5 Process Improvement

3.5.1 Process stabilization

Currently the production system in DCV is not in a stable state, because throughput times are varying even in standard products making the system inherently unstable. Overly large portfolio makes it very difficult to accurately plan production and delivery dates, which leads to missed deadlines creating unnecessary costs and customer dissatisfaction. Production system has been and is analysed continuously and extensively for its performance and for the levels of loss/waste, but a part of the problems in making process improvements are directly related to the fact that the products have different needs at different stages of the production system.

To resolve the situation a priority should be made to stabilize the processes, because the success of every improvement project requires that the production process is in a stable state. Nevertheless prioritising the improvements necessary for achieving stability is difficult, because improvements needed are often costly and an improvement for a process might be almost useless in improving the throughput time of the next project. Lean system approach of increasing employee involvement would allow the management to more effectively and correctly focus the efforts on correcting the problems.

For example the situation of variable throughput times in SDU could be helped by combining further efforts at employee participation with existing programs such as Operational Excellence. The approach of a management approved project with external advisors such as this would be more effective if its implementation group would include employees from the department the project is focusing on. Combining the intimate knowledge that the workers have about their daily work with external advice and sufficient managerial resourcing would bring greater rewards than any of the parties attempting to improve situation on its own. Additionally by involving the employees the company will be able to potentially lower costs of any stabilization effort. (Ohno 1988)

3.5.2 Roles, Responsibilities and Communication

Another vital improvement needed for further implementation of a Lean system is improving the communication internally between company's department's, and externally with the partners and suppliers. Departments must continue moving from viewing other departments and supply chain partners as adversaries into viewing them as customers and partners. Goal of the whole organization should be a system where every part of the supply chain is dedicated to a smooth flow of production processes with the aim of fulfilling the needs of the customers. (Modig & Åhlström 2013)

Departments have clearly made progress towards this goal, but still quite often the big picture is missed which leads in to the desire to optimize only their own areas of responsibility. Increased communication and shared responsibilities should increase the co-operation levels and lessen the still existing part optimization of processes. Senior management input and commitment is needed for continuous departmental communication and co-operation to be fully realized throughout the whole DCV organisation.

Communication between internal and external supply sources requires clearly marked roles and responsibilities within the whole organization. When everyone has clear view on who to contact and responsibilities are clearly defined it serves to reduce confusion and the time needed for finding out who is responsible for what. This has been recognized in implementation of projects such as the product categorization, where one of the main goals is to assign permanent responsibilities for communication and to the systems upkeep, and not just focusing on creating yet another unsupported and forgotten system.

Benefits of this are most visible in the case of problems, which will usually require a rapid response to make sure that meeting the customer needs is not endangered. Additional advantages are also gained by assigning people to permanent positions which handle communications, because it creates sense of co-operation and helps to maintain sense of common purpose within the organization which are pre-requisites for optimization of the process flow.

3.5.3 Management Role

Improvements programs that are supported at the managerial level are the only way to successfully implement the changes needed for eliminating the organisational and inter-organisational wastes. Improvements from the bottom-up are an integral part in processes but cannot make a lasting difference by themselves (McCarthy & Rich 2009: 85-90). Current situation of DCV regarding high process time variability and the attendant problems can be seen as arising from the lack of stability in processes resulting in that the time of middle management is spent in a “firefighting” mode preventing the proper application of improvement projects.

Senior management is monitoring of the situation constantly and several improvement projects are being planned and implemented to rectify the situation. These include initiatives such as LT-50% and the product categorization project both of which aim to rationalize the product portfolio, reduce lead-times and thus allow for better responding to customer needs. Still the lingering problems in communication between departments will require managerial attention to be fully resolved. Ongoing projects will help in this because many of these include assignments of areas of responsibility to individuals that will then be used as primary contacts in their departments.

Middle managements role is crucial in resolving these problems, but a lack of commitment and support to the goals of programs is creating problems in implementation of improvement projects. This can be seen as result of the previously mentioned need for “firefighting” that consumes much of their time and also from the lack of understanding of the goals of the improvement systems. Better communication and training on all levels of the organization will increase understanding of the necessary steps to improve situation. Nevertheless there is a desire for improving the processes in every department, it just needs to be harnessed through managerial commitment and resourcing.

4. Product categorization

4.1 Data gathering

Data was gathered by using free-form interviews with the people assigned by the chosen DCV departments. Additional data was received from other on-going improvement projects at DCV related to lead-time reduction and the results were combined with the production history and estimated orders between years 2011 - 2016 for the RRS categorization. Initially interviews were only held with those departments of DCV that hadn't participated previously in discussions about the product categorization:

- *Machining Delivery Unit (MDU)*
- *Serial Delivery Unit (SDU)*
- *Pilot Delivery Unit (PDU)*
- *Materials Management (MM)*
- *Delivery Management (DM)*

In these both the managerial and employee level was interviewed. A related project in lead-time reduction (LT-50% project) is underway at the DCV and the project owner from this initiative (at MM) was included in interviews. Additionally as the project proceeded it was decided to include the Sales point of view into the project, and representatives from both the Energy Solutions (ES) and Marine Solutions (MS) Sales departments were interviewed.

In the participating departments generally two persons were interviewed about the things that they viewed essential for their departments to achieve the fast throughput rates needed for Runner products, about the challenges faced in their operations and how the product categorization project could help in responding to these. The main findings and areas in need of attention which were found in discussions are listed in the next part.

4.2 Interviews

4.2.1 Machining Delivery Unit (MDU)

Results from the two rounds of interviews were analysed and combined under headlines illustrating points that were seen as the most essential issues in the operations of the departments. Requirements, problems and suggestions are all listed according to the views of the interviewees:

Design readiness

- Design must be ready / frozen in time before the start of the machining process
- Machining programs must be ready in time for machining start.
- Products with add-on machining create challenges in process management – these are not Runner products because of the added workload. Improving the situation in these cases requires their own drawings and Bill of Materials (BoM).
- Design proofing is required, the common base frame designs need to be validated for all configurations before production for avoiding problems.
- Tools and instructions for production must be ready in time.
- Communication / information from the design department has to be on good level.

Scheduling

- Scheduling changes affects capacity planning and machining has the least amount of response time. This makes last minute changes a major problem.
- Allowance for problems will create a realistic and achievable schedule.
- Normal production will suffer if special requests are crammed in at the last minute.
- The current situation with extremely large amount of models and variants results inevitably in mistakes in production scheduling.

Quality

- Quality of castings, bad quality and problems necessitate rework, additional requirements for logistics and working arrangements such as re-scheduling.
- New suppliers of castings requires additional resources in both personnel and time for testing and validation.

4.2.2 Serial Delivery Unit (SDU)

Design readiness

- Design must be ready / frozen at the latest a few weeks before start of assembly (SoA).
- Constant design changes are disruptive, especially the automation and electric systems suffers from this, and software design process should be improved.
- Tools and instructions for production must be ready in time for SoA.
- There are problems with module compatibility, better design compatibility validation is needed.

Quality

- Changes to casted parts (long lead-time components) requires validation of suppliers, machining and component compatibility.

Decision making and Communication

- New product introduction (NPI) – process has generally produced good results but needs better attention to product validation. New materials and structures are still encountered even in products that should be Runners, and SDU participation in decision making / defining process should be increased.
- Better communication and increased role in decision making desirable.
- Limited need in participation, no need for participating in Stranger processes.

Engine type

- Dual Fuel (DF) and Gas Diesel (GD) engine models are difficult to keep in desired throughput times.
- Basic Line (L) engines fastest and easiest to produce.
- Workload in assembly phases not stable, might require reassigning of tasks.

Problematic components and materials

- Power Take Off (PTO)-shaft
- Turbocharger at flywheel end creates problems in throughput times with both Line- and V-engines
- Too many different types of parts and components creates problems with material flows, increased standardization would help in this regard.

4.2.3 Pilot Delivery Unit (PDU) / New Product Introduction (NPI)

Design readiness

- Last minute changes in design are a major problem.
- Making diagrams and up-keeping the Visualization tool would help with compatibility issues in bigger changes and in the assemblies by easier problem recognition.
- Tools and instructions, especially lifting instructions and lifting tools need more attention in new designs and design changes.
- Design changes can result in changes in assembly order and setting / phasing.
- Effects of design changes to assemblies need to be communicated as early as possible.

Communication, roles and responsibilities

- People from NPI should be included / informed as early as possible concerning design changes with information on what has changed from previous / standard models. Good communication and the product categorization will help in this.

- Proper communication will allow time for preparation which helps with issues in scheduling and resourcing. Even projects with plenty of time will be problematic if information is not shared.
- There should be at least one document which contains all the relevant data from the whole project, starting from sales and updated as the project moves forward.
- Discussions and meetings concerning RRS boundaries would generate better results than creating automated formulas.
- Clear definitions of roles and responsibilities will help with communication because everyone would know who to contact when needed.

Scheduling

- Fast projects (requirements are out of normal scope) cause problems because there is no time to prepare, leading to increased need for timely communication.

Quality

- Component compatibility validation, especially when design changes are made.
- Tolerance changes may result in problems with compatibility.

NPI

- Definitions need to be made to differentiate between NSR and NPI cases.
- Change of the standard turbocharger supplier causes a lot of problems with compatibility of components and with lifting tools /instructions.
- Non-standard way of operating (differing procedures, recording etc.) requires a lot of extra work with implications to resourcing / scheduling and to the required information flows.
- Special testing, sensor installing, calibration and weighting certifications requires extra time and resources even in seemingly normal projects.

Pilot DU capacity

- After NPI process is done and validated, product should be SDU ready.
- NSR – evaluation of change scope, not automatic assignment to PDU.
- PDU focus should be on the Strangers.

- EDG (emergency diesel generator for nuclear plants) delivery projects are challenging for the supervisors because of the increased workload.

Special project resourcing

- EDG- process developer might be needed.
- Continued supervisor participation is required in special projects and all the training must be arranged for them also.
- Information flows and communication especially important for PDU, because several simultaneous special projects are difficult to control.

4.2.4 Materials Management (MM)

Interviews with materials management were conducted at managerial level and included the LT-50% process owner. Findings include:

Design readiness

- Essential for supplier contracts and validation.
- Timely information essential with critical components that have long lead times such as castings because these require new casting models etc.

Quantity

- Sales of projects with more than a certain amount engines starts to create problems with long lead-time key components.
- This can make large sales problematic especially in situations when order books aren't full and production slots are available fast.
- Controlling inventory values essential.
- Higher safety stocks required for Runners.
- Component deliveries for Strangers should be through guiding parameters, only project specific orders with assured need to avoid expensive stocks of project specific components.

Scheduling

- Dividing production and deliveries for large sales into smaller batches would help in regards with key component orders. Customer doesn't necessary need the deliveries to happen all at the same time but needs case by case evaluation.

Buffering

- A few engines can be completed rapidly with component buffers, but these are not designed for this purpose so this utilization should be kept to absolute minimum
- Buffers might not be sufficient in all cases and might require increasing.

Communication

- Participation in decision making system for categorization needs important, proper communication will allow time for preparation and controlled introduction of new features etc.
- Forecasting accuracy and analysis about changed components especially important in Strangers leading to need for rapid information flows and pre-arranged communication channels.
- Good communication will enable accurate lead-time definitions and executing the agreed upon timelines.

4.2.5 Delivery Management (DM)

Interviewing DM personnel revealed data about possible parameters and ways of working required for the application of product portfolio categorization to actual operations at the DCV.

Runner features

- Design needs to be complete and validated.
- No NSR: s should be allowed in Runner products.

- Features chosen for products in Runner category must have proven demand, otherwise categorization project is useless.
- Purchase agreements done, quality of critical components has been validated and supplier has been consistently able to deliver the products in timely manner.

Ways of working

- Runners must be able to be run through the configurator without extra comments
- Release practise for new products and features should be periodical leading to increased controllability of functions.
- Periodical review required for cost monitoring and validation (Runners can't use really expensive parts even if they are easier to assemble)
- Inputs in a timely manner to DM and process operation according to service level agreement (SLA).

Repeater features

- Design can be open, but only installation dependant components (no long lead time components).
- Repeat projects, but can include document updates.
- Modules cannot require new tools and instructions, discussions will be needed on a case by case basis.
- NSR: s are allowed, but no new features and no design implications for components with long lead-times.

Ways of working

- Design-scope, open modules allowed properties need to be defined.
- Installation dependent design requests.
- Internal Order Specification (IOS) can be commented on (additional features).
- Process operation done according to SLA.

Stranger features

- New design.
- Installation dependant components missing.

- Changes to components with long lead-times, casts etc.
- New cylinder count.
- New design stage.
- New turbocharger.
- Changes in fuel type.
- New classification-, emissions-, IMO-level requirements.

4.2.6 Marine Solutions (MS) Sales

Sales interviews were done to get a clearer picture on the customer needs and how the categorization project could help in answering to these.

Customer demands in MS markets

- Gaining advantage in the Marine markets requires competitive pricing.
- Standardization is difficult in Marine markets because of the nature of product requirements, nevertheless standardization would help in quality, pricing and by making special project resourcing easier leading to increased flexibility. Especially in current difficult market situation added flexibility of deliveries is essential.

How the RRS system could in responding to MS needs

- Better communications, resourcing and clearer design process.
- Product portfolio is too wide and narrowing it down would also help the Sales department.
- Improved communication by assigning roles and responsibilities allows for accurate data to be shared about what the Sales has actually sold. There might be confusion on customer side about their actual requirements which require changes when the delivery process has already started.
- These changing customer demands are difficult to deal with, which is not an internal Wartsila problem but nevertheless affects operations. Better

communication allows for faster reaction to mistakes, changes and IOS updates throughout the DCV organization.

4.2.7 Energy Solutions (ES) Sales

Customer demands in ES markets

- Pricing and delivery times are important, but not the main area to gain competitiveness, because only marginal improvement in ES sales can be gained by improving these factors.
- Main area of advantage to be gained is in engine performance. High performance values in output, heat rate and NoX values are crucial and are the main competitive factors in ES sales. Optimizing the volume products towards these will be essential.
- Quality must be excellent, but this is a basic requirement for remaining competitive.

How the RRS system could respond to ES needs

- Sales projects setups can be very long but when customer decides on the order the engines are needed rapidly, leading to need for engine configurations with rapid delivery times which is exactly what RRS aims to achieve.
- Difficult market situation and customer demands fluctuate monthly, leading to need for rapid responsiveness.
- Product portfolio reduction is a priority to ES Sales too.
- RRS system would improve all around situation by increasing communication throughout the DCV organization.
- Bi-annual RRS review, quarterly is too often.
- Increased standardization.

			PCFI Std/Opt	PCFI Cat	PCFI Relevancy	PCFI Std/Opt	PCFI Cat	PCFI Relevancy
Sys	IOS Feature & Value	Key	W34DF	W34DF	W34DF	W32D	W32D	W32D
1.0 Main data	Application (Marine auxiliary engine)	A_001	Standard	CAT	X			
1.0 Main data	Application (Marine main engine diesel electric)	A_001	Standard	CAT	X			
1.0 Main data	Application (Marine main engine with CP propeller)	A_001	Standard	CAT	X			
1.0 Main data	Application (Power plant base load)	A_001				Standard	CAT	X
1.0 Main data	Automation level (UNIC C1)	A_002				Standard	CAT	X
1.0 Main data	Automation level (UNIC C2)	A_002				Option	CAT	X
1.0 Main data	Automation level (UNIC C3)	A_002	Standard	CAT	X			
1.0 Main data	Cylinder output [kW/cyl.] (410)	A_003	Standard					
1.0 Main data	Cylinder output [kW/cyl.] (435)	A_003	Standard					
1.0 Main data	Cylinder output [kW/cyl.] (450)	A_003	Standard			Standard	CAT	
1.0 Main data	Cylinder output [kW/cyl.] (455)	A_003				Standard	CAT	
1.0 Main data	Cylinder output [kW/cyl.] (460)	A_003				Standard	CAT	
1.0 Main data	Cylinder output [kW/cyl.] (480)	A_003	Standard DFB			Option		
1.0 Main data	Cylinder output [kW/cyl.] (500)	A_003	Standard DFB			Option		
1.0 Main data	Cylinder output [kW/cyl.] (550)	A_003						
1.0 Main data	Cylinder output [kW/cyl.] (580)	A_003						
1.0 Main data	Design stage (A)	A_005	Option	CAT	X			
1.0 Main data	Design stage (A2)	A_005	Option	CAT	X			
1.0 Main data	Design stage (B)	A_005	Standard	CAT	X			
1.0 Main data	Design stage (C)	A_005				NSR	CAT	X
1.0 Main data	Design stage (D)	A_005				Standard	CAT	X
1.0 Main data	Design stage (E)	A_005						
1.0 Main data	Design stage (E2)	A_005						
1.0 Main data	Engine type (W12V32)	A_007				Standard	CAT	X
1.0 Main data	Engine type (W12V34DF)	A_007	Standard	CAT	X			
1.0 Main data	Engine type (W16V32/34)	A_007				Standard	CAT	X
1.0 Main data	Engine type (W16V34DF)	A_007	Standard	CAT	X			
1.0 Main data	Engine type (W18V32)	A_007				Standard	CAT	X
1.0 Main data	Engine type (W20V32/34)	A_007				Standard	CAT	X
1.0 Main data	Engine type (W6L32)	A_007				Standard	CAT	X
1.0 Main data	Engine type (W6L34DF)	A_007	Standard	CAT	X			
1.0 Main data	Engine type (W8L34DF)	A_007	Standard	CAT	X			
1.0 Main data	Engine type (W9L32/34)	A_007				Standard	CAT	X
1.0 Main data	Engine type (W9L34DF)	A_007	Standard	CAT	X			
1.0 Main data	Main fuel type (Crude Oil)	A_009					CAT	X
1.0 Main data	Main fuel type (Gas)	A_009	Option	CAT	X			
1.0 Main data	Main fuel type (Heavy Fuel Oil)	A_009	Standard	CAT	X	Standard	CAT	X
1.0 Main data	Main fuel type (Light Fuel Oil DMB)	A_009	Standard	CAT	X	Standard	CAT	X
1.0 Main data	Main fuel type (Light Fuel Oil DMC)	A_009						
1.0 Main data	Main fuel type (Liquid Bio Fuel)	A_009				Option	CAT	X
1.0 Main data	Optimization (710)	A_011				Standard	CAT	
1.0 Main data	Optimization (780)	A_011				Option		
1.0 Main data	Optimization (900)	A_011				Option		
1.0 Main data	Optimization (Economy (710))	A_011				Option		
1.0 Main data	Optimization (Emission (780))	A_011				Option		

Table 2: The updated engine type and component / feature RRS categorization chart

4.4 Changing the approach in RRS implementation

Originally the categorization project was intended to be a Delivery Management driven process where the data from interviews in the designated departments is combined with the production data to create clear categories for products. Objective was to create a tool that could be used to find out directly in which categories the available engine configurations are in order to help establishing delivery times and prices which accurately reflect the difficulty and costs of the project. Goal was to work towards increasing the amount of products in Runner-category and then guiding the demand to these in order to create advantages of scale by rationalizing the portfolio.

This approach would have been “sold” to the Sales department by the incentives of lower prices and faster delivery times. Design and implementation process for this approach nevertheless revealed certain issues with the chosen method when the categorization project was proceeding. First problem was that the excel-tool from the production data could be created quite easily, but using it and keeping it up-to-date while performing daily work would be very cumbersome and difficult. Additionally it was useless in taking account many material and immaterial factors that were found in the interviews because it only reflected the past deliveries. Taking account of these multiple factors would require an additional tool that would increase the complexity even further. Another approach would be to continuously hold discussions of the impact of the different factors to the product category assignment thus rendering the project useless.

Second problem was found in the Sales interviews and in the weekly discussions about how the project was proceeding. It became evident that the approach of just superficially including customer needs by interviewing sales personnel and then trying to create product categories which would be attempted to be sold to customers would not resolve the portfolio related issues. All the effort put into categorizing products and attempting to create Runner-products would be useless if the products and features chosen didn't have any real demand in the world markets. After a meeting with Energy Solutions (ES) Sales personnel through a related project concerning these same issues it was found that there was already a plan for ES Sales department to provide a feature-list of components for

the engine types which they see as being in demand in world markets and these could be the designated Runners.

It was immediately apparent that this approach would enable concentrating on products that Sales department saw as the customer needs, and it was decided to scrap the initial approach and rely on this input for the categorization. New approach would skip unnecessary steps and solve the greatest issue which the first iteration had about choosing the features and components which the engine configurations in Runner category would use. Additionally this approach would not create any increased work in categorization process and in the creation of improvements for faster delivery-times and lower costs. The analysis part of the initially designed system could also remain the same in a Sales driven process.

Directly responding to customer needs in this way is exactly what the whole Wartsila strives to achieve at every location and with every service it provides. This approach also clearly conforms to the goal of every improvement project in seeing the customers and their needs as the main focus of operations in every organization. Customer based approach also creates clear focus for the improvement projects because it directly reveals the factors preventing the organization from answering to these. As such it can additionally to be seen as reinforcing the views presented in the literature review of this work and also in the analysis of DCV operations.

Nevertheless the Marine Solutions (MS) projects generally cannot use this Sales driven Runner designation approach because of the nature of the demands in the marine and offshore industry which requires that nearly all products are customized according to the customer needs which precludes standardization in most cases. Nevertheless this is not a handicap in the chosen approach to categorization, because the initial approach was also unable to answer to this problem due to the same reasons. MS projects will nonetheless benefit from the categorization project by the more accurate product assignment in DU's resulting from the project. Further benefits will be gained on all areas by the increased recognition of the different challenges in projects which will allow for more accurate forecasting and scheduling, which allows for general lead-time reductions and improved quality in products.

5. Integrating categorization to DCV processes

5.1 RRS definition process

RRS categorization project is intended as a method for controlling the product portfolio within DCV, and the project was seen from the start as requiring creation of a system for categorization which is constantly updated rather than viewing the project as a onetime event to be executed. This approach originates from the fact that the product portfolio is not a static thing, but a subject which evolves overtime with the introduction of new products and features and with the removal of obsolete products. Constantly evolving nature of product portfolio necessitated the creation of a process for handling the categorization in the future.

Bi-annual or quarterly reviews of RRS status of the portfolio were initially discussed with the decision leaning towards adopting a bi-annual approach according to Sales input. Products with the feature list deemed essential by the Sales departments would be received in an agreed upon manner by the assigned parties within the DCV. This will allow the concerned parties to review their processes in order for identifying the actions needed for achieving the Runner status for the Sales needs. In this way the improvement processes can be focused on the correct areas according to actual customer needs. The RRS meeting will concentrate on reviewing the status of the products and processes in order to find out if the serial production capability is achieved.

Products in the Runner category will require that all processes, features etc. are properly examined and validated because of the aim at the DCV to reduce the lead-times for these deliveries considerably. Repeaters will have the guidelines and lead-times that exist currently for all projects, and the lead-times and costs of Strangers will be analysed in a case-by-case basis but are assumed to be considerably greater than in Repeaters, which aims to be able to better take into account all time and costs of the validation and prototyping required in these deliveries.

RRS process can be combined with the introduction of new features and portfolio management in order to better control the product portfolio. Additionally the system can allow lessening the disruptions of production created by constant design changes by restricting the introduction of new features to pre-designated dates. Set time periods for design releases will allow for more overall control of the design processes. Nevertheless the problems encountered in daily operations of DCV and the input from customers will continue to require design changes to the products already in assembly, so this will only be a partial, but nevertheless a necessary improvement.

RRS meeting in itself is intended as a higher level definition event and the final definitions will be decided during the product DU assignment as part of the normal operations within the Delivery Management. Data and inputs needed for the RRS meeting are to be gathered beforehand in order to enable the meeting to just concentrate on deciding the new categories for the products based on the acquired facts. Following departments will provide the necessary data for the RRS definition process:

MS / ES Sales

- Customer needs for future Runners and the desired product features.

Delivery Management (DM)

- Phase in / phase out decisions for products, which the delivery management will present in accord with input from senior management. These are mostly “political” decisions but essential in defining the portfolio.
- Production planning tool status.

Research & Development (R&D)

- New product and feature introduction.

New Product Introduction (NPI)

- Product, tools, instructions and method validation status. NPI handles the ramp-up and debugging process for the features and products introduced / demanded by the R&D and Product Engineering.

Materials Management (MM)

- Inventory values, control of these is essential for ensuring a smooth process flow. Inputs from MM are needed in defining the current status and the RRS process outputs are needed for keeping the inventory values in the needed levels when RRS status of the products is updated.
- Larger projects will create challenges in long lead-time components.
- Many special projects / NSR: s will create higher inventory values and difficulties with suppliers. There might not be additional components available in problem / defect cases. This can potentially be a problem even if the assembly phase has nothing special in it.

Supplier Management (SM)

- Supplier validation, includes checking the status of the supplier agreements and the quality / delivery reliability verification of the suppliers.

Production S/P/M DU's

- Technical ability and capacity of DU's. Constraints presented by the premises and facilities of the DU's. Can make it impossible to produce certain engine models in SDU / PDU regardless of product validation and process maturity status.
- Engine cannot be a Runner if the SDU production ability is not verified.
- Familiarization and training status of employees such as supervisors, quality personnel, workers etc.

Project Engineering

- IOS (Internal Order Specification) status.
- Presents the project engineers view on customer requirements.
- Required for creating and validating orders.

Product Engineering

- Engine configuration data + standard register. Non-standard requirements to deliveries.
- Clarifying the missing modules.

- Comparing the data from IOS requirements.

Process charts describing these actions were created in order to visualize the new processes. These were linked to pre-existing processes in order to facilitate their deployment into the regular operations within the Delivery Management.

5.2 Project Delivery Unit assignment process

Integral to the categorization project was the goal of being able to more accurately assign products between the two delivery units (DU's) at the DCV in order to aid in the objective of reducing the lead-times. Current method of utilizing the NPI-process at the PDU for dealing with the difficult, demanding deliveries and with the introduction of new models and features has worked well and introduction of a similar framework for all deliveries was desired.

Formulation of a clear framework for product assignment will help to reduce guesswork and confusion in all cases. Established guidelines on the factors which must be taken into account in order for a new product to be considered serial production ready will help in concentrating improvement efforts on the right areas. Importance of accurate project assignment and its impact in meeting the designated delivery times comes from the fact that the two available DU's at the DCV's premises are configured in fundamentally different ways.

Pilot Delivery Unit (PDU) is arranged as a cell assembly and is therefore capable of building a wider variety of products because delays or changes in production will not disrupt the whole assembly unit. Drawback of this flexibility and also the result of older facilities of PDU is its smaller production capacity compared to SDU. PDU is used for prototype engines and for the more demanding special projects and thus the Stranger-type projects are intended to be assigned to this facility. PDU is also intended to be utilized for the more difficult Repeater-type projects because of its more flexible production facility design, but it can build any engine-type currently in production at DCV. Nevertheless the more general Repeater-type projects and Runner-type projects are only assigned to PDU in situations that demand capacity balancing among the DU's.

Serial Delivery Unit (SDU) is designed as a line assembly with two assembly lines which are intended for mass production of more standardized designs, and because of this the products assigned there need to have proven designs and ways of working. Because of the line configuration this DU is more vulnerable to disruptions and problems at one assembly station can shut down production in a whole line. This precludes the production

of Strangers and Repeaters with more demanding non-standard requests at this DU. Both DU's also have different personnel skillsets, logistics arrangements and capabilities, which combined with the divergent layouts therefore demand accurate product assignment for achieving smooth process flows at the DCV.

Using the designated product categories for DU assignment necessitated the creation of an additional process for evaluating the complexity and challenges of different projects for their assignment in to the DU's. Five main criteria were chosen from the data gathered in interviews and meetings for the purpose of further detailing the product categories and assigning deliveries to DU's. These were chosen because they accurately represent the material and immaterial challenges in production processes at the DCV. Criteria and their effects are presented in *table 3* and *table 4*, *table 5* presents a process that clarifies the process presented in the *table 4* and *table 6* presents this process in an alternate way of viewing the process.

Criteria is directly derived from the same data that is gathered in the initial RRS definition process and are further defined for the DU assignment according to the specific requirements of the deliveries as:

Design engineering Bill of Materials (eBOM) readiness

- Design has to be complete before it can be designated as a Runner. No modifications are allowed, product must have a finalized and executed (project has been done before) eBOM.
- Deliveries requiring new designs are always Strangers.
- Changes to components necessitates compatibility validation, especially with components that have long lead-times such as castings etc.
- New classification-, emissions-, IMO-level requirements.

Non Standard Requests (NSR)

- NSR scope evaluation and impact validation decides assignment and Repeater / Stranger status.
- No NSR: s are allowed in Runner products in order to prevent feature creep.

Supplier validation

- Purchase agreements status, if these are not done in time for the production start the product is a Stranger in all cases.
- Runners must have the supplier agreements done and all items validated.
- Quality of components needs to be validated especially with new suppliers.
- Quantity, larger orders can present problems in delivery times with components that have long lead-times even in standard products.

NPI-process status

- Tools, training & instructions have to be ready and validated for serial production before a product can be a Runner.
- Product validation, 0-series production in Pilot factory is required to validate the parts, settings and the working methods.

Technical ability of DU's

- Status of DU facilities, constraints presented by facilities such as too narrow spaces etc. which can prevent serial production and the Runner status, even if everything else is validated.

Definition process proceeds in these five steps and even one item in Repeater or Stranger categories moves the delivery project into this category. Additionally many Repeater-features in a same product may result in its designation as a Stranger through the evaluation process.

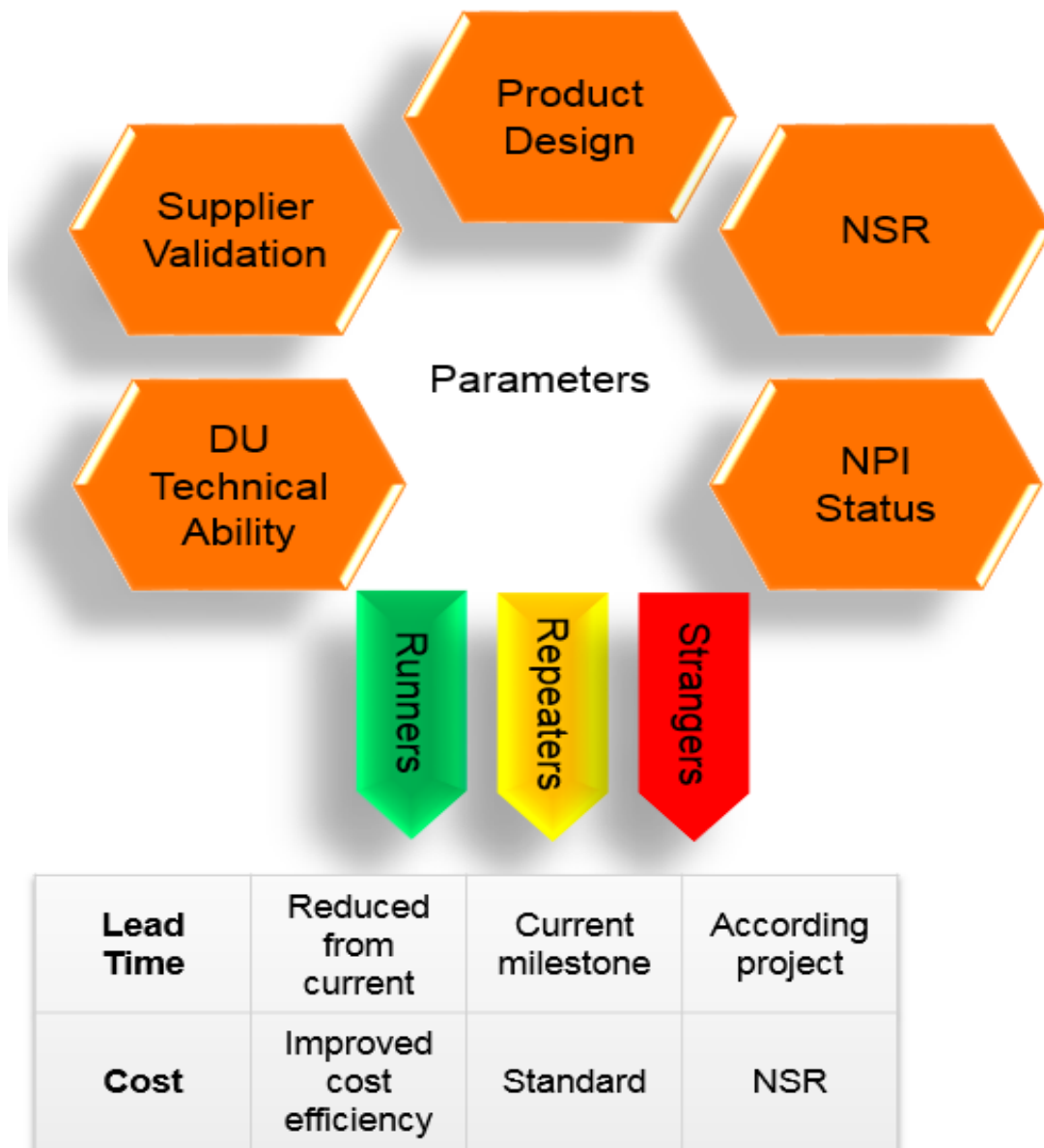


Table 3: Five chosen criteria and lead-time & cost effects of the categories

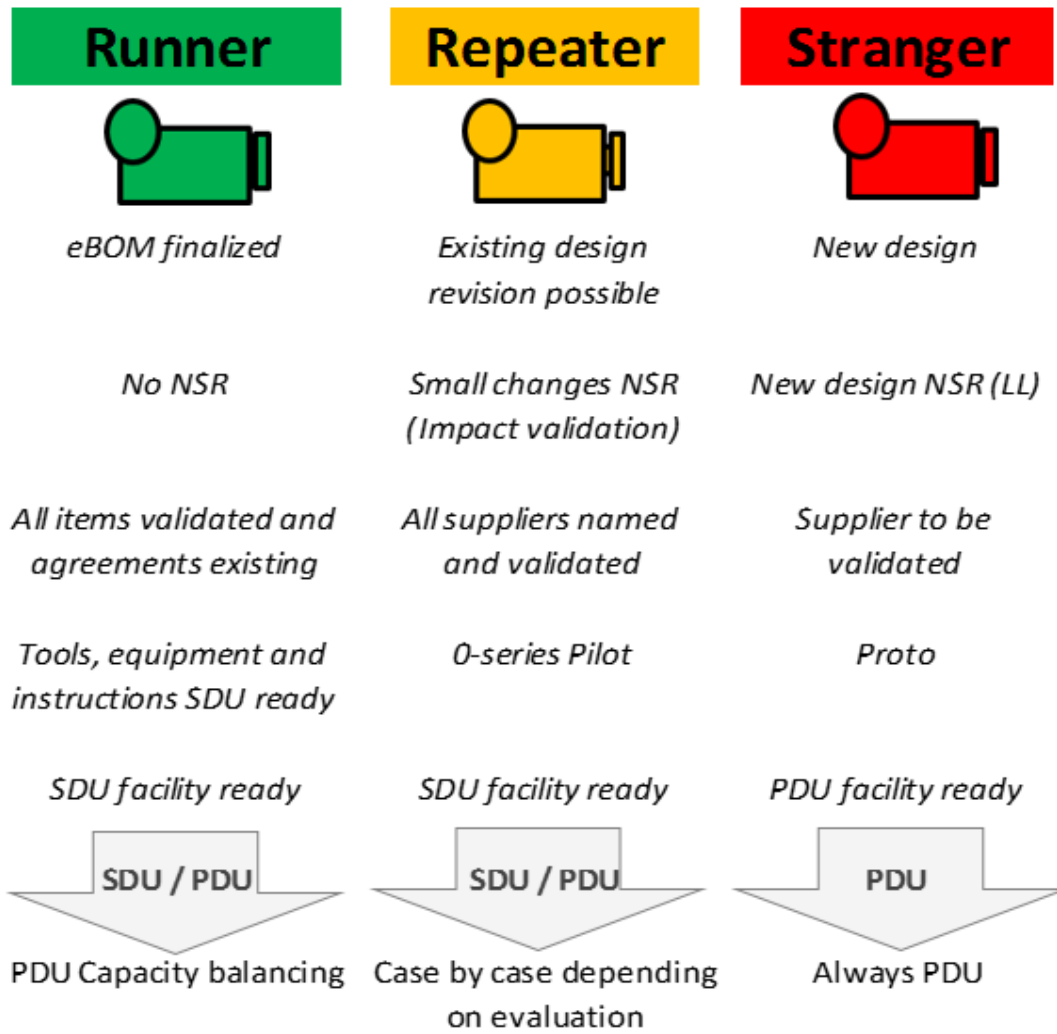


Table 4: Process chart for defining the RRS status and DU assignment

Repeater assignment clarified													
Design revision required	yes	no	no	no	yes	no	no	yes	yes	no	yes	yes	yes
Small changes NSR (Impact validation)	no	yes	no	no	yes	yes	no	no	yes	yes	no	yes	yes
All suppliers not named and validated	no	no	yes	no	no	yes	yes	no	yes	yes	yes	no	yes
0-series Pilot	no	no	no	yes	no	no	yes	yes	no	yes	yes	yes	yes
DU technical ability	Always PDU assignment if SDU lacks capability												
Primary assignment	SDU	SDU	SDU	SDU	SDU	SDU	SDU	SDU	PDU	PDU	PDU	PDU	PDU
	PDU assignment if required by evaluation							Potential Strangers					

Table 5: Process chart clarifying the Repeater assignment and the potential Stranger status

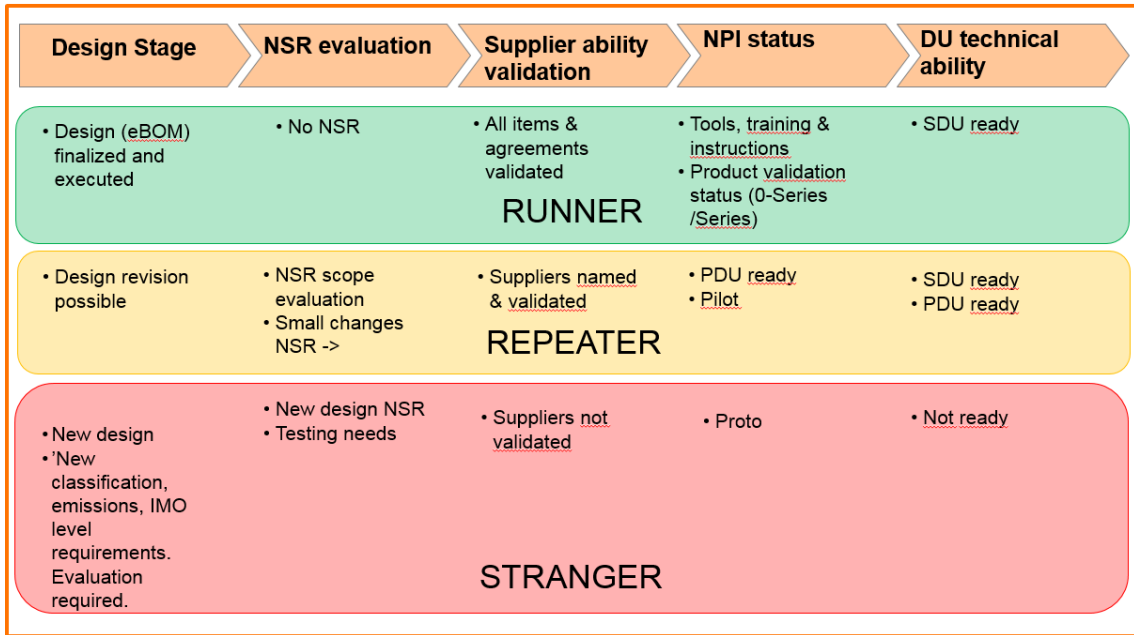


Table 6: Evaluation process chart for project RRS status and DU assignment

6. Applying the new system at DCV

6.1 Implementation plan and communication

The created RRS process will be implemented gradually into the existing processes of the DCV organization starting in 2016 according to a preliminary plan presented in *table 7*. Applying the new system was begun from the Delivery Management (DM) where the Specification Manager is designated as the process owner and every department described in part 5.1 is to be included in the implementation process. An information package about the RRS system was created in order to facilitate the implementation process which will be used to communicate the requirements, facts and goals of the new system to the concerned departments.

Communicating and implementation of the new system will be the responsibility of the Delivery Management, but the input of the designated parties will be essential in further development of the system. Operation of the RRS system is intended to work in a Plan-Do-Check-Act (PDCA) cycle where the lessons of the previous improvement projects are used to continuously refine the processes at the DCV in order to increase the number of products in the rapidly deliverable Runner-category. Continuous nature of the RRS system is further illustrated in the daily functions of the DM where the delivery project list will be constantly reviewed according to the RRS system when additional deliveries are confirmed in the future.

Next review of the categories according to the adopted system of bi-annual RRS meetings and reviews has been preliminarily planned for the September of 2016. Meeting is intended to review the progress on achieving the Runner status of the initial product and feature list that was received from the ES Sales. Further configurations according to the Sales needs will be received in the meeting, but the start of implementation of these is dependent on the progress of the previous improvement projects. Confirming the Runner status is intended to be done in a gradual manner by not clogging up the system with too many simultaneous development projects in a manner where a few validated Runners are seen as more valuable than lots of incomplete projects.

Successfully implementing the RRS system is especially dependent on getting the co-operation of the Sales departments because they are positioned to both understand the customer needs and also to guide them. By showing results of the system it can begin to answer into the needs of the Sales departments’ right from the start. Achieving the Runner-status with at least one important engine configuration and by managing to concentrate efforts into reducing lead-times will illustrate better the benefits of the system to the concerned departments than any presentation.

Beginning communicating of the new system in both the ES and MS sales is essential, because by creating understanding in their organizations about the RRS system and beginning to apply its guidelines in the Sales processes it will be possible to gain the benefits from the system. When the Sales personnel and customers understand the boundaries of the categories, and how they consequently affect the delivery times and pricing it will be possible to use these facts to guide the demand to appropriate configurations. System will also enable improved prediction of the lead-times by correct assignment of products into the DU’s, enhanced assessment of challenges in the delivery and the creation of a pricing system which reflects the true costs thus creating advantages to both the customers and the Wartsila DCV.

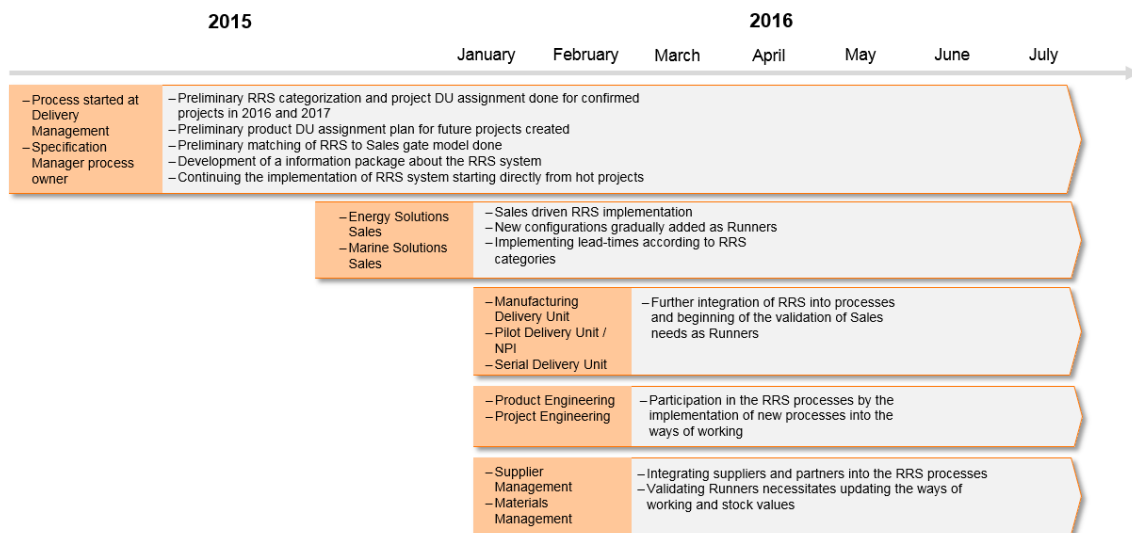


Table 7: RRS implementation plan at the DCV

6.2 Preliminary Delivery Unit assignment of the engine configurations produced at the DCV

Preliminary delivery unit assignments were made for all engine configurations existing in both the ES and MS Sales portfolios in order to clarify the situation at DCV with the coming product introductions and phase-outs. Data acquired in the RRS project was used to create an initial presentation concerning the DU assignment. Results of this initial proposal were then discussed with representatives from the concerned departments in a case by case basis modifying the initial presentation as needed. The results from the meeting were forwarded for further evaluation to concerned parties.

If the products were deemed not to be SDU ready because of different affecting factors, the presentation included the reasons and explanations for the decisions. This was done to clarify the logic of the choices made and to allow easier perception of the developments needed for achieving serial production status for products / engine configurations. Different design stages and products that are assigned to joint-venture (JV) companies were also taken into account in this presentation.

6.3 Delivery project categorization

Existing delivery projects for years 2016 – 2017 with “current order” status were preliminarily categorized and assigned to delivery units by using the data and methods gathered / developed in the RRS process. Assignment process according to the RRS system is shown in the *table 8*.

Example case 1:

Case 1 is an engine delivery project scheduled to begin in the year 2016 with W12V32 engines ordered by a customer in the shipbuilding business. Because of the NSR: s demanded by the customer and considering the design for all components is not yet completed, the details of the delivery resulted in categorizing the project as a Stranger and being assigned to be produced in the Pilot Delivery Unit. Additionally these facts effect also the Supplier and NPI-status illustrating perfectly a more demanding delivery for the DCV.

Example case 2:

Case 2 is an engine delivery project scheduled to begin in the 2016 with W6L20 engines ordered by a customer in the shipbuilding business. Project was categorized as a Repeater because “Installation dependent components” are missing and therefore the certain calculations have to be made in a case-by-case basis. Delivery was assigned to be produced in the Serial Delivery Unit.

This project serves as a good illustration of the “easier” deliveries encountered at the DCV and with some tweaking / further experience this type of delivery could be categorized as a Runner.

	Design stage	NSR evaluation	Supplier ability validation	NPI status	DU technical ability
Case 1	<ul style="list-style-type: none"> Modules missing Missing IOS comments -> IOS not validated Status: Stranger 	<ul style="list-style-type: none"> NSR includes many special requests Status: Stranger 	<ul style="list-style-type: none"> All suppliers named and validated Status: Repeater 	<ul style="list-style-type: none"> Tools, training & instructions Product validation status Status: Repeater 	<ul style="list-style-type: none"> Status of DU facilities Status: SDU ready Runner
	<ul style="list-style-type: none"> Preliminarily categorized as a Stranger and assigned to PDU 				
Case 2	<ul style="list-style-type: none"> Installation dependent components missing Status: Repeater 	<ul style="list-style-type: none"> No active NSR Status: Runner 	<ul style="list-style-type: none"> All items validated and agreements existing Status: Runner 	<ul style="list-style-type: none"> Tools, training & instructions Product validation status Status: Runner 	<ul style="list-style-type: none"> Status of DU facilities Status: SDU ready Runner
	<ul style="list-style-type: none"> Preliminarily categorized as a Repeater and assigned to SDU 				

Table 8: Definition process for the Case 1 and Case 2 projects and the factors affecting the categorization and assignment.

6.4 RRS interaction with the Sales processes

Implementing RRS into the DCV: s processes needs to take into account how the new processes interact with the existing processes of different departments and how these can be integrated. Especially important to successful adoption of the new system are the Sales department's processes, because they are most directly in contact with the customers and their needs. Therefore it was examined how the RRS system can be linked to existing Sales processes in order to fully implement the new system at the DCV.

The Sales Gate model was cursorily examined in order to find areas that interact with the RRS processes. This was intended to enable the creation of a common understanding from the different views in the departments of the DCV about the whole delivery process from order until customer delivery. Following commonalities with the RRS system in different gates were identified.

Sales initiation uses old production data for initial order definition which is basically the same process that is used in *RRS categorization* event. Further order definition in the Sales process does the evaluation of NSR: s of the delivery, which is done with the RRS operation and does affect both the designated RRS categories and DU assignment which leads to interaction with the *Product design, NSR evaluation, NPI status & Supplier validation* parts of the RRS processes.

Confirmation of the delivery capability of the DCV is done in Sales phase before order confirmation and also in the initial designation of the RRS categories. Data is further used in determining the delivery DU assignment and relates to the *DU technical ability, Supplier ability validation & NPI status* parts of the RRS processes. This part has effects also in the earlier part of the five step RRS process, but they are previously mentioned and are assumed to be clarified already by the time the process has reached this point.

Detailed planning for Sales orders relates to the part of the RRS system where the assignment of deliveries to DU's is finalized, and more generally relates to *Supplier ability validation & DU technical ability* parts of the definition and product assignment process.

Clarifying the RRS process to the Sales departments in this way is essential for the successful implementation of the system at the DCV. Equally important is explaining its significance. By increasing understanding of the consequences in costs and lead-times of the options selected in the Sales phase amongst both the customers and the Sales departments can the system start creating benefits to DCV. Describing the effects such as longer lead-times of the boundaries between different product categories can serve as a powerful incentive in guiding demand towards more standardized products.

Some resistance towards the adoption of the RRS system is expected because it creates boundaries which will conflict with the old way of working where the Sales departments could sell any options without accurate estimates of their effect. This method was clearly detrimental towards standardization and the wholesale process flow, but implementing a new system can be disruptive initially because the possibility of increased costs to customers and longer lead-times in certain cases. The adoption of a Sales needs based approach has also the benefit of lessening this resistance because it allows the whole DCV organization to better answer to the requirements of the world markets creating possibilities to increased orders.

7. Analysis and conclusions

Implementation process for the created RRS processes will be continued in the Delivery Management in 2016, and the other stakeholders will be gradually brought into along into the system according to the presented communication plan. Actions that were already taken in the bounds of the thesis and the initial RRS categorization include:

- Preliminary RRS categorization and project DU assignment done for confirmed projects in the years 2016 and 2017.
- Preliminary product DU assignment plan for future created for all products in the DCV portfolio.
- Preliminary matching of RRS to Sales gate model done in order to facilitate communication between the departments.
- New processes were designed for RRS activities in the Delivery Management and their implementation will continue in 2016.
- Project was concluded by presenting the results to the management team at the DCV.

The RRS system is projected to create advantages for the DCV organization in two ways. Firstly the categories will allow a more accurate view of the challenges with the delivery orders resulting in better evaluation of the delivery times and costs, which will also allow more accurate delivery project assignment into the DU's. Secondly, the system will allow the organization to perceive the issues that prevent the rapid delivery times demanded by the Runner-products and enable the departments to focus on correcting these.

As a major limitation in the RRS system will nevertheless remain the inability to properly standardize the MS projects, but this results from the nature of the customer needs in this market and not from any deficiency in the system. These projects will nonetheless benefit from the more accurate viewing of challenges and from the structure of DU assignment that the RRS system enables.

Theoretical base of the thesis could be successfully linked to the main work by examining how the DCV has utilized these principles in its operations and because of the aim of the RRS system is to create better ability for responding into the customer needs. Further linkage of the theoretical basis to actual work presented in the thesis was created through the fortunate alignment of goals in deciding to adopt a Sales needs based approach to categorization. Also many of the existing and planned improvement programs at the DCV are based on the management of quality and variants of the Lean system which greatly aided in the formulation of the theoretical basis.

Summary

Categorization project was conducted in three phases as planned. Data gathering was done by two rounds of interviews with the personnel in the designated departments. First round of interviews was conducted with the employee level but this was later deemed insufficient because these interviews were felt to be going into too much detail and missing the big picture. For this reason a second round of interviews was conducted at the managerial level in order for getting the big picture of the challenges and needs of the departments. After the initial interviews it became apparent that a more accurate view of the Sales needs was necessary and interviews were conducted at the both ES and MS Sales departments.

In the second phase the data gathered by interviews was combined with the production data to create the initial categories. This initial proposition was done based on the assumption that the categories would be assigned according to a Delivery Management led system. Nevertheless the problems with this approach, especially the difficulties in taking account the actual needs of the customers necessitated a change in approach. By taking into account these problems and the input from other departments it was decided to change the approach into a Sales needs driven process where the Sales departments would present their feature / configuration lists and the rest of the organization would work towards achieving rapid delivery times for these.

Final phase included the clarification of the responsibilities of the RRS system for applying throughout the DCV organization and the process maps illustrating these new processes were created and linked to the existing systems and processes. New processes were used in making a preliminary RRS categorization and project DU assignment for confirmed projects in the years 2016 and 2017. Facts from the interviews were utilized in defining a preliminary product DU assignment plan for all existing, outgoing and incoming products in the DCV portfolio. Lastly the preliminary matching of RRS system to Sales gate model was done in order to begin applying the system throughout the DCV organization.

Schedule for the categorization project was initially set to be from the start of September into the end of year 2015, but because of the market situation it became unavoidable for the DCV to have layoffs in the end of the year which necessitated continuing the RRS project by an additional month into the year 2016. Implementation of the RRS system will be an ongoing process at the DCV in 2016, and it is projected to create advantages to the organization according to initial assumptions which were presented at the beginning of the project. These include:

- By adopting a Sales needs based approach the company can more accurately guide improvement programs towards validating the correct products into Runners and achieving the necessary rapid throughput times.
- Correct categorization and pricing for non-standard products will increase profit margins by better understanding of potential costs and delivery times.
- Increased customer satisfaction resulting from understanding that non-standard products will have much longer lead-times.
- Additionally the product categories can be utilized to more accurately guide projects to the delivery units within the DCV thus lessening the problems with scheduling and incorrect assignment.

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