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1 Introduction

Production Technology is a Bachelor Thesis taken on by five mechanical engineering students from Buskerud University College in Kongsberg.

The Scope is limited to five study credits for the first semester (fall 2011), then 15 study credits for the second semester (spring 2012). This is estimated to 550 work hours per group member. There will be a higher priority on documentation then in a normal industry. This will give a better basis for evaluating the project.

The purpose of this project is to evaluate production models for Kongsberg Protech Systems (KPS). Kongsberg Protech Systems has developed a new product called Protector Medium Caliber that is going into production. To make the production effective they need to develop a specific production model that they can integrate in all their locations, and in different production scale.

The company has other similar products that are already in production. In the existing production there are used several Lean tools to make the production as efficient as possible. The difference between these products and the new one is the size and weight. The existing products are of smaller caliber and therefore smaller in size and easier to handle, than the new Protector Medium Caliber. Due to the size and weight of the product they need to develop a completely new assembly process. The production process is the backbone in the company and it is vital for the company to compete with others.

Our assignment is to make a main study that evaluates different production models and create concepts for the production of Protector Medium Caliber. The production is divided into two cases with different production rate, where Case 1 handles high rate production and Case 2 handles low rate production. For both cases, we will consider the need of cranes, lifts and other equipment to make the assembly as easy and effective as possible. In the production of Protector Medium Caliber there will be a need for a jig or a fixture to hold the product while assembling and testing. This jig will be designed in SolidWorks and integrated in our production model.

To be able to make a good analysis, we need to learn about production technologies and Lean manufacturing. By learning the basics of these subjects, we will ensure effective manufacturing of quality products and a safe and good environment for the workers. To accomplish this, two generic pre-studies will be produced as supporting literature. One study for production technologies and one study for Lean manufacturing. The two studies will be used as a support for arguments for the different choices and conclusions we make in our main study.

This Bachelor Thesis is a theoretical study and takes form of a written report with drawings and illustrations. The sources used are internet, personnel of KPS and literature in form of books. Project expenses are literature and printing of reports and poster.

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1.1 Document Overview

This document is one of many reports in the bachelor Thesis 2012-2.

The Figure below will give an overview and placement of the reports and documents for the Bachelor Thesis 2012-2. The textboxes represents documents and the green box is representing this document. The Appendix documents are not listed.

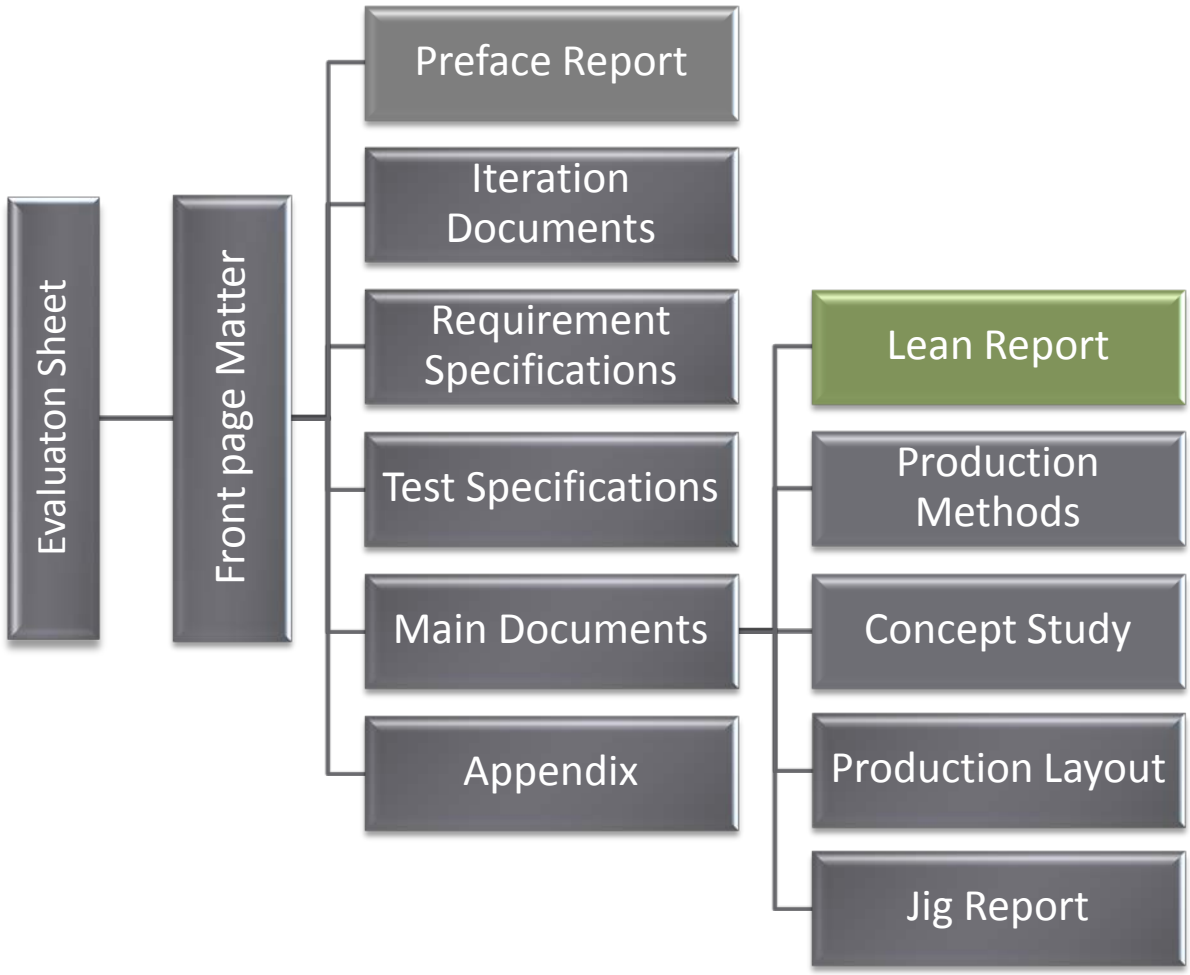

Figure 1 - Document Relation

1.2 Document Purpose

The purpose of this document is to give an introduction to the principals of lean thinking with some of the most used lean tools. These principals will be useful for the reader of this thesis to understand the conclusions we made in the main reports; Production Layout and Jig Report. This document is a result of a study we did to get an understanding of lean thinking, which is not only crucial for our thesis, but also a requirement from KPS and thereby a part of our thesis.

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2 Lean Introduction

Lean manufacturing is a method that is used by many companies around the world. It helps them in locating and eliminating things and operations in their production that isn't useful, and wasting time and money.

KPS has used Lean in their production for many years now and are very satisfied with it. This is why they sat a requirement that we should use lean as a tool to develop the production line, (Requirement K02.1). This report gives us a deeper understanding of the subject and we can use it as reference later in our assignment.

Lean is not only a way of thinking but also a set of tools, to put the theory into practice. We have therefore collected and elaborated some of these tools. Lean is not necessary connected to production methods alone, it is also adapted to logistics and distribution, services, retail, healthcare, construction and maintenance. We have not looked at all the tools since not all of them are suited for the production part of the business. We have chosen the tools that are used at KPS and some we thought was relevant to our assignment. This is done in collaboration with KPS. The chosen tools are:

- 5S
- 6S
- Kaizen
- Push-pull
- Kanban
- Poka Yoke
- Value Stream Mapping
- One Piece Flow

In chapter 5 of this document there are a usage matrix, which can be used to find the right lean tool based on the current problem.

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3 History of Lean

Figure 2 - Ford Assembly Line [1]

In the beginning of 1900, Ford Motor Company developed the first assembly line (Figure 2). An assembly line is a process in which parts are added to a product, using optimized logistics to create a finished product, much faster than with hand-crafted methods. The only problem was that this strategy was not very fit for changes. Annually change in models and colors, demanded a more flexible system.

In 1948 some of the employees from Toyota started to study the American production methods, especially the Ford System. They found out that the American systems were built around a single, never changing product. It did not cope well with multiple, or new products. To solve this, the Japanese developed a method called “Toyota Production System”. This system is based on two concepts.

The first is called “Jidoka” which can be loosely translated into “automation with a human touch”, which means that if there is a fault in a product, the machine stops to prevent further damage. This insures good quality in every product (Figure 3).

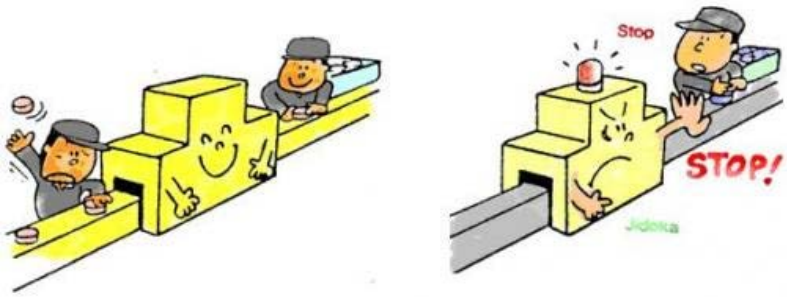

Figure 3 - Jidoka [2]

The other concepts are called “Just-in-Time”, which means, making only what is needed, when it’s needed and in the amount needed. This system makes sure products are produced efficiently and with complete elimination of waste.

This introduced a flexibility that the Americans did not think they needed. But when the Toyota Production System spread to other company’s and the productivity and quality gains became evident, they travelled to Japan to study their system.

In 1990 James Womack, Daniel Roos and Daniel T. Jones wrote a book called “The Machine that changed the World”. This book was a study of automobile manufacturing in America, Japan and Europe. In this book he introduced new phrase called “Lean Manufacturing”. In 1996 Womack and Jones released another book called “Lean Thinking” where they presented these 5 principles:

1. Specify the value desired by the customer.
2. Identify the value stream for each product providing that value and challenge all of the wasted steps (generally nine out of ten) currently necessary to provide it.
3. Make the product flow continuously through the remaining value-added steps.
4. Introduce pull between all steps where continuous flow is possible.
5. Manage toward perfection so that the number of steps and the amount of time and information needed to serve the customer continually falls.

Today Lean continues to spread throughout the world. It is also adapted to logistics and distribution, services, retail, healthcare, construction and maintenance.

[3][4][5]

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4 Lean Tools

The basic of Lean production is elimination of waste in the form of non-profit operations. This gives no profit neither for the costumer nor the owner. For the costumer, it is important to know that the price he paid represent the quality of the product or service. The quality is then not necessary just the final product, but the whole process from A to Z. As of this we understand that it is the costumer view of the system that is a main goal to improve to the best.

From the Lean theology, and other similar production improvement systems, there are some main tasks that we want to consider improving for the reduction of waste. This is referred to as the seven wastes:

1. Too large production rates
2. Unnecessary inventory
3. Movement of workers
4. Movement materials and products
5. Reduction of down-time
6. Unnecessary failures, extra work or rework
7. Unnecessary production methods (improvement of unnecessary work tasks)

To improve production factors like these are not necessary special for lean, but to use the output from analysis of the factors above in a system with new “tools”. This should result in a new way of running the business, a new culture. This is the Principe of lean production.

The above mentioned factors can be split into a lot of subfields. Reduction of movement should not just benefit the workers, but also be a reduction in transportation fields. Every move takes time and cost money. It is also a higher risk for failure or stop in the process due to a lot of handling. If the process can be done in another way to reduce this factor, it will certainly benefit the production system.

Too large production rates leads to an unnecessary large storage of products at the end of the chain. It might also affect other parts of the production line, like too large inventories. It is not necessary to produce anything before the needs occur. It should also be a controlled system, were the inventories at all time consists of the parts needed to complete the product, and nothing more. If the product has a lot of varieties, it should not be more parts in the inventory than the parts needed to complete one of the different product options. When the parts are taken from the inventory, it should be replaced as soon as possible for the next assembly.
The reduction of down-time is an important aspect. Down-time can occur as a result of failure, damages or maintenance. This means that it is not just important to look at failures, and their source, but also improvement of maintenance routines.

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4.1 5S

As mentioned above we need to change the culture in the whole organization. With a change in the culture these factors can be improved continuously and not just after a one-time analysis. To implant this culture we need some tools. A tool developed for this is called “5S”. This is a system for a “clean” production with main goal of orderliness and clarity in the whole system. The fundamental of lean production is that it will result in more effective production. Untidy work areas are not productive. Tidy areas will affect workers in a positive way; naturally they will spend more attention and this result in a higher care of the production. It is not just the cost-savings that is in interest. We also want to develop a safe and cleaner work environment. Untidy work areas are not productive.

The 5 S’s stands for the 5 Japanese words: Seri, Seiton, Seiso, Seiketsu and Shitsuke. This is often referred to as Sort, Straighten, Shine, Standardize and Sustain (Figure 4).

Figure 4 - 5S, Illustration [6]

Seiri - Sort:

The first part of the 5S’s is often referred to as “sort”, “systematization” or “simplify” in English. As the words describe, the principal is to get a good system in each area or at each workstation. Tools or other items that is unnecessary held at a workstation, or is missing from a workstation leads to problems. It is also necessary to define good workstations at several areas of the production (line). One large or several medium sized areas, for tools and other items for the production, is not good in the way of an effective production.

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The reasons might be:

- **Time loss:** Unnecessary use of time in searching for equipment is waste of time. If tools or equipment is missing from the storage, the time consumption is even larger. This can be the case if multiple people are using it at some point of the production.
- **Calibration problems:** If the tools are missing when this routine is preceded, it might be a lack of calibration.
- **Safety problems**: A large area with multiple users might lead to untidiness; this can result in dangerous situations if people are falling over things.
- **Communication problems:** Large areas with equipment make it difficult for people to communicate and move around.

To define good workstations we need to look critical at it. Equipment that is held unnecessary should be removed, so we only got what we need, and nothing else. One way of doing this is to let the users of the equipments write a note each time it is in use. We can then make a simple system at the work station. The most common used items should be more visible with easier access, and the items that are used recently should be removed for a tidier work space. It is no problem if the operator needs to get a short walk to a small, common tool area once a month to pick up a specific tool. Especially if this is a larger tool that make the workstation unsystematic.

Seiton - Stabilize:

This step is a continuing of the above mentioned step, sort. Seiton can be translated to “orderliness”, “stabilize” or “straighten”. After the sort process at the workstations, it is necessary to organize it. As we can see inn Figure 4 it is important to get a good system, such as a good layout of the workbench. One solution can be name tagging, painted racks and painted tools. In this way everyone knows where it belongs. This is though just one part of it. Seiton also includes the standardization of how things should be done, with what equipment and where in the facility. Seiton might lead to relocating of machines and equipment for a smoother and more effective production. Standardization of documentation, drawings etc. are also a way of running more efficient.

Seiso - Shine:

As mentioned earlier a clean work environment results in a happier work environment, which leads to a more productive production. It is therefore important to keep it tidy at all times, this also means that equipment should be cleaned and prepared for the next user after the usage of it. Dirty equipment and work areas could also affect the failure rate for the product. For example if the product reacts of some chemicals at the tool. It is also important for safety and health issues. Breathing in dusty areas is no good for health; neither is getting chemicals directly onto skin because the tools are not well cleaned. To get this routine running, it is important that someone is in charge of it. It should also be clear who is doing it, when and how. Inspections could be a great way of continuously improve this part.

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Seiktsu - Standardize:

This step could be defined as “standardized clean-up” or just “standardization”. This is not the same as the second step, Seiton. The purpose is actually to “control” that the first three steps are in continuously improvement. In cases with implementation of new techniques of running the production it is often a danger in things going back the way they were before. This danger is especially if the management moves on to another field. Seiktsu is techniques to prevent this from happening. These techniques are usually referred to as the “5S job cycle” because the idea is to re-visit all the steps at a regular basis. It is a good advice to use an external controller person, and a predefined “check list” with key criteria. All employers’ needs to know exactly their responsibilities (standardized) to prevent the first 3S’s from failing.

Shitsuke - Sustain:

Shitsuke,”sustain” or ”discipline” is like Seiktsu maintenance of the 5S system. As Seiktsu introduce some kind of program for the employers to follow, a standardized list of responsibilities, the 5 element focus is to make people want to do this. Discipline should then not be considered as some kind of forced set of rules, which will end in penalties if they are not followed. The company needs to do the right things, so the employees will be stimulated to use this system, and not just follow it one way or another, because they have to. This is of course not an easy task, and the right way of doing it depends on several things like culture. There are though some kinds of key points:

- **Communication:** People need to get information like why they are doing this and what purpose it makes.
- **Education:** Everyone needs to understand the system fully.
- **Rewards:** Positive feedback after success (should be measured often) is a way of keeping people interested.
- **Time:** If we want a task to be done, for example a standardized clean up of a machine five minutes before another shift starts. We need to set time for this, and not think we can produce the same amount as before.
- **Structure:** If people don’t know fully their responsibilities and task, misunderstandings can lead to a negative attitude.

[7][8][16]

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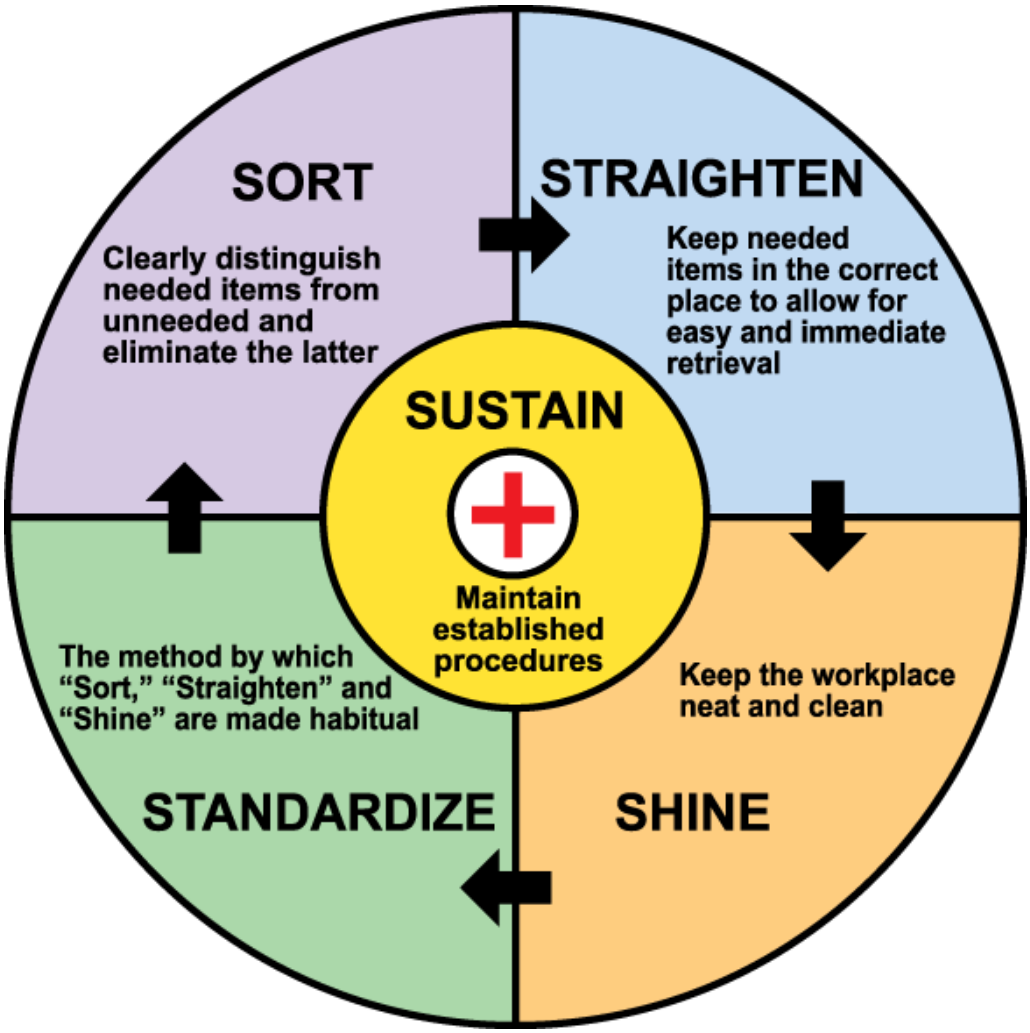

Figure 5 - 5S, Map [9]

4.2 6S

6S is just like 5S with an extra part which is safety. This is something that is implemented in the 5S routine at several companies after 5S is adopted. This part of safety is just the same as the well known term HSE (health, safety and environment). The only difference is that it might be easier to implement safety in the daily routine if it is a part of the 5S system. Safety is everything from accessible fire exits, protection wear to "fool proof"-systems within the production. All safety aspects is basically like Poka Yoke, a system to avoid peoples doing what they are not supposed to do, regardless whether it is due to stress or dumbness. Accidents do occur, and it is the benefit of all that the effects of them are as small as possible.

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4.3 Kaizen

Kaizen is Japanese for «improvement» or «change for the better». Improvement can be the ultimate way of assure good quality. Kaizen is a philosophy that has focus on improving processes in manufacturing, engineering and other types of management. This is a philosophy that involves all employees in the company from the assembly line workers to the CEO. It also applies to purchases and logistics processes.

Kaizen is a daily process, which the purpose goes beyond increasing efficiency. Aside from productivity, it aims to provide a healthy work environment for employees in all levels. This will result in an organized and creative working force that will increase service to the consumers.

In essence the workers will speak up or ask questions if there is something they don't like, are skeptical to or don't want to change. In this way, problems can be discovered before it is too late. This can also make the production easier for the workers and much more efficient.

The cycle of Kaizen activity can be defined as:

- Standardize an operation and activities.
- Measure the standardized operation (find cycle time and amount of in-process inventory).
- Gauge measurements against requirements.
- Innovate to meet requirements and increase productivity.
- Standardize the new, improved operations.
- Continue cycle.

Figure 6 - Kaizen, Change for the Better [10]

[11][12][13]

"One of the ways Toyota has reduced costs in their lean program was commonality of parts," he said. "Well, if that part has a problem, then it affects many more models. If they'd been using a lot of different gas pedals for these models, and they had problems with one, they wouldn't have to shut down the company."That's why humans aren't lean." Blanton said. "It's a Darwinian thing. The purpose of fat is to carry you over periods when you don't have food." Still, most U.S. companies seem to believe the rewards of lean production outweigh the risks.

[14]

4.4 Push - Pull System

The Push – Pull System describes the flow of product and information between the producer and the buyer. In the «Push» you will make a large quantity of your product and place it in a storage facility. This quantity is estimated from long term forecasts, based on past orders. In this way the customer will get his product right away and does not have to wait for it to be produced. The problem with this system is that you will have a lot off expenses in storage and if the demand from the customers fails you will have a lot of products that you already have made that you can't get rid of.

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The pull system is based on a need or demand from the customer. This means that the customer will express his/her need for your company. What he wants and how he wants it made. Then you can produce the product in just the right amount and specification. This will result in a very small storage quantity, no waist and a more Lean production.

[15]

4.5 Kanban

Kanban, in Japanese, means “card”, “billboard”, or “sign”. The term is often used synonymously for the card itself and the material flow system developed by Toyota Production System.

Kanban is a tool to create a “pull” of material or information in the system. External Kanban regulates the flow from the suppliers or customers and internal Kanban regulates the flow within the factory. Kanban is a signaling system that indicates the need of material. This can be done with signaling cards or with empty boxes. In this way it lets the preceding process know when it withdraws a part, allowing it to reproduce or reorder that part. Parts are not produced or reordered by schedule or by estimates, but only when the Kanban card says to do so. This makes you able to reduce your inventory (See Figure 7).

When a production line is designed and balanced, Kanban is introduced. It’s the last step in the standardization and control of a process and lets the downstream processes withdraw items from the upstream processes. The upstream processes produce only what is withdrawn and makes sure that only defect free products are sent. [16]

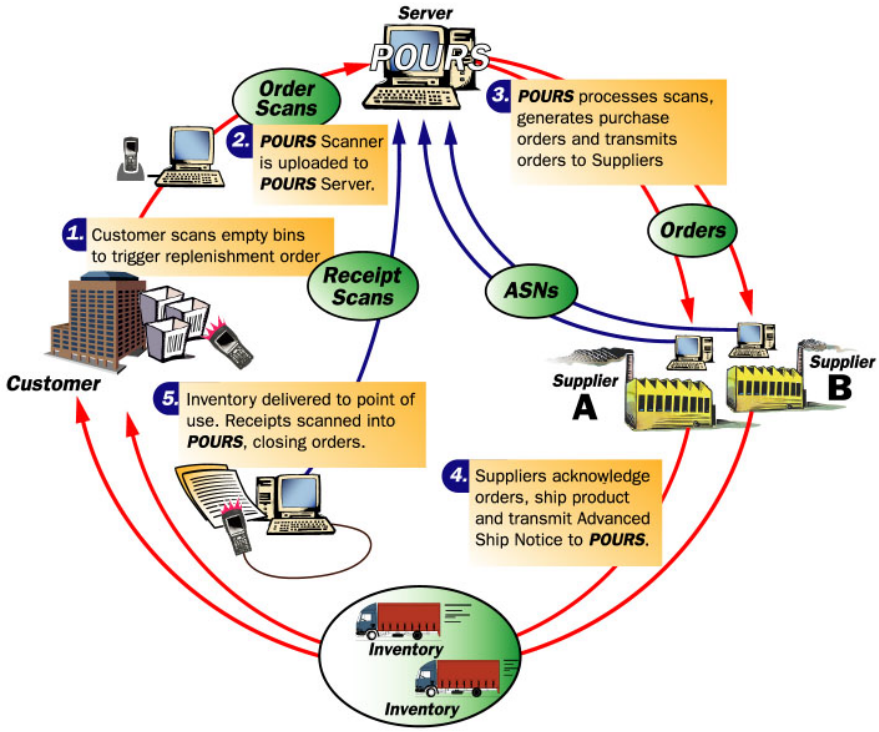

Figure 7 - The Pull of Material in a System [17]

4.6 **Mistake proofing Poka Yoke**

Poka Yoke was developed by Shiego Shingo and is Japanese for “defect proofing” or “error proofing”. A poka yoke is any mechanism that helps an equipment operator avoids mistakes. Its purpose is to eliminate product defects by preventing, correcting or drawing attention to human errors as they occur. This can be done at every step of a process where something can go wrong. Either the operator is alerted when a mistake is about to be made, or the poka yoke device actually prevents the mistake from being made. Examples of this can be to make sure that two parts only fits the right way, have visible signs that shows clearly how the machines are operated, or a warning light when the operator is using the equipment wrong.

There are three types of poka yoke:

1. A contact method identifies product defects by testing the product shape, size and color.
2. A fixed-value method alerts the operator if a certain number of movements are not made.
3. The motion step method determines if the described steps of the process have been followed.

If appropriate poka-yokes are implemented, then mistakes can be caught quickly and prevented from resulting in defects. By eliminating defects at the source, the cost of mistakes within a company is reduced.

Figure 8 - Poka-Yoke, Comic Illustration [18]

[19][20]

4.7 Value Stream Mapping

The main purpose of value stream mapping is to visualize and then eliminate waste connected to the value stream. Waste being any activity that does not add value to the final product. The process itself makes the material and information flow of the product more visual for all personnel involved in the process. In order to this, the Value Stream Mapping method visually maps the flow of materials and information from the time products come in the back door as raw material, through all manufacturing process steps, and off the loading dock as finished products.

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The value-adding steps should be drawn across the centre of the map and the non-value-adding steps be represented in vertical lines at right angles to the value stream. By separating the value-adding steps and non-value-adding steps, the visualization and elimination of waste becomes much easier.

To see all aspects of the flow, the team of personnel making the map should be made up from production, material and quality department. It also important to share the map with everyone connected to the process in the factory, to get as much useful feedback as possible. With a good visualization, it is easier to see the big picture.

Mapping out the activities in the manufacturing process with cycle times, down times, in-process inventory, material movement, information flow paths, helps to visualize the current state of the process activities and guides towards the future desired state.

The process usually includes the physically mapping of the “Current State” while also focusing on where you get to. Another focus is the “Future State” map, which can serve as the foundation for other Lean improvement strategies.

[16]

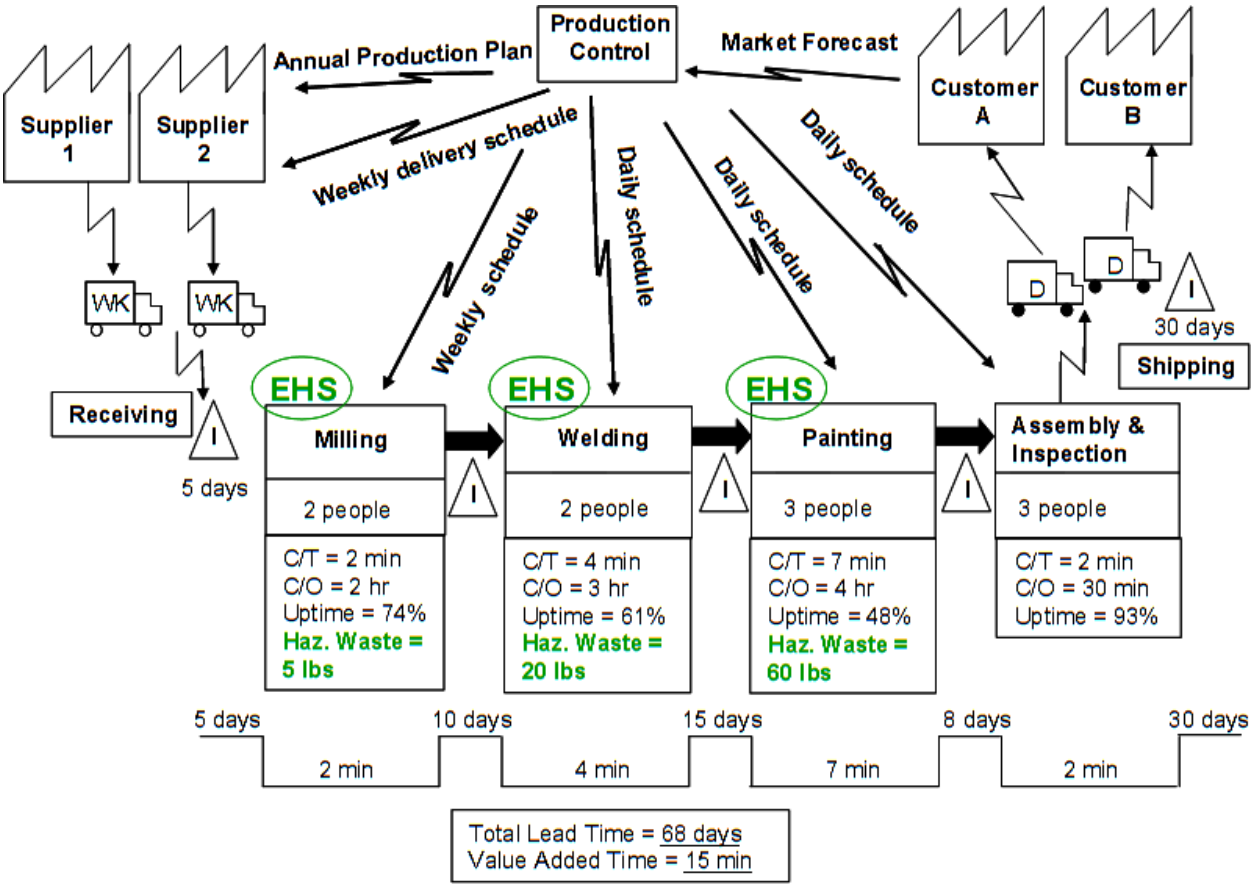

Figure 9 - Value Stream Mapping, Example [22]

4.8 One Piece Flow

One piece flow or continuous flow is all about flow in the production line. This is crucial to get what we call just-in-time manufacturing, which is a pillar of lean production system (or the Toyota production system). This means that the right parts should be finished and available when they are needed and in the right amount for the next step in the production line. It is desirable to avoid any work-in-progress (WIP) between each operation, either with one piece or a small batch at a time. We want a continuous flow with parts being moved step by step. To get a clearer picture of what this really means, we can compare it to a traditional production layout. In a traditional layout the parts are moving from one step to another in batches with little relationship between each manufacturing step. Each step is controlled individually with their own schedule. Therefore two or more products can be made in parallel (see Figure 10).

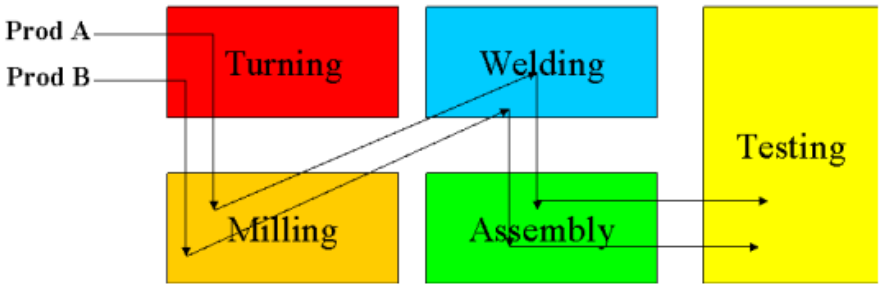

Figure 10 - Functional layout [21]

Functional layout will result in several disadvantages:
- Large amount of waste if a defect is found in the production (whole batch).
- Long manufacturing lead time (time before customer gets his product from ordering it).
- Poor on-time delivery (large batches finished at same time).
- Lots of finished stock items to compensate (buffer of inventory).
- Large amount of WIP (leads to time spent on waiting).

To achieve a one piece flow, we need to connect the flow and make a relationship between each step of the process. This can more easily be achieved with a cellular layout of the production line, where each station has all the necessary equipment within (part of 5S). See Figure 11.

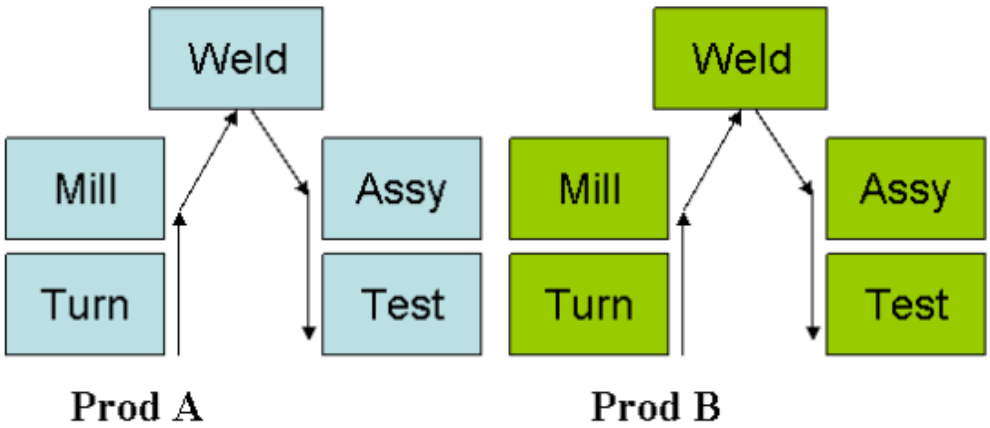

Figure 11 - One Piece Flow [21]

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When implementing a one-piece flow it is important to determine all the work elements and the required time, in detail. Then we should consider if the workstation/cell can meet the takt time, based on the equipment presentable. This should include changeover times, load and unload times and downtime as well. Takt time is net work-time available per shift without breaks, briefing, maintenance, etc. divided on customer demand in units. The next step is to create a good lean layout based on the earlier mentioned 5S tool (remove unnecessary equipment and relocate equipment/materials in an organized way). The space within a cell should be limited to prevent unwanted motion waste and WIP congestion.

U-shaped cells (Figure 11) are preferred, but if the space on factory floor makes it impossible, an S-shape could be a substitute. As a final task, each cell should be standardized (part of 5S) with detailed work-descriptions for each operator. The amount of operators should be determined for each cell, and this might lead to an inconvenient number e.g. 3.6 operators. This can be solved by Kaizen or by relocate operations. By implementing a one piece flow it should be possible to reduce inventory levels, reduce manufacturing lead time, and improve customer service levels.

However, there are some issues that make it difficult to implement a one piece flow:

- Quality issues in product line.
- Much variation in process time.
- Downtime on equipment (it should be close to 100 % uptime).
- Issues by scaling processes to takt time.

A way to improve the flow with one piece flow anyway, is to implement one piece flow in several parts of the whole production line.
[16][21]

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5 Usage Matrix

This usage matrix is used to find the right tool based on the current problem. There exists several matrices today depending on the literature, this matrix is based KPS own matrix.

Lean tool / Area of focus	Kanban	One Piece Flow	5S / 6S	Pull-system	Poka Yoke	Value Stream Mapping	Kaizen
Mapping						x	x
Flow within production	x	x	x	x	x		
Flow within the administration		x	x	x	x		
Cycle time		x		x			
Visual (landskape)			x				x
Reduction of units in production	x	x	x	x			
Reduction of queue	x	x		x			
Reduction of quality cost			x		x		x
Access of goods (units)	x		x	x			
Supplier competence	x		x	x			

Figure 12 - Usage Matrix

6 Lean strategy

This lean report discusses different lean tools, which can be convenient to use in the direct planning of the production layout. On the other hand, it is important to understand the ground principals of lean thinking to use the tools in the right way. It is also important to understand the ground principals to get a lean layout. The tools alone will not result in a lean production layout. To get a better understanding of the lean principals we will start with defining some terms.

Flow units

A flow unit can be one of three things:

1. **Material:** The direct flow of a material can be the flow of units who end up as an assembled product.
2. **Information:** The direct flow of information can be flow of papers from the administration to the production area. For example a status report.
3. **People:** The flow of people can be connected to the flow when a human is given value added activities like a hospital visit where the person is “flowing” through the different departments.

Circulation Rate:
Circulation rate refers to the amount of hours before a flow unit completes one cycle of the planned process. The boundaries of the circulation rate are defined as the time required completing a function, job or task from start to finish.

Value adding activities / not value adding activities:
This is an activity that adds value to the flow unit throughout the process or through the circulation rate. If the flow unit is a person who is going through a process on the hospital, value adding activities can be appointments with the different specialist and the time spent in the waiting area is not value adding activities. For a material a value adding activity can be direct production. Not value adding activities can be lifting, storage or transportation between different areas of production. It is also important to separate between direct and indirect value adding activities.

Direct / indirect value adding activities:
Direct value adding activities is the main purpose of the process, all activities that results in a direct result. For the person at the hospital the direct value adding activities is the result from the test or conducting of the test itself. While the indirect value adding activities can be the experience itself, e.g. the conversation with the doctor. For a material as the flow unit the direct value adding activity can be the assembly process, and the indirect value adding activity can be a feedback to the costumer of where in the process the product is. For a workshop, the repair itself is direct value adding activity for the flow unit, but if the workshop is cleaning the flow unit after the repair, this is an indirect value adding activities.

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Cycle time:
Cycle time is the average time between two units exits the process.

Takt time:
Takt time refers to the tact between two flow units exits the process. This is calculated by dividing net time available to work by number of units.

Flow efficiency:
Flow efficiency defines the amount of time which is value adding in relation to the production time (Circulation rate). Time for transportation and waiting will decrease the efficiency because this is not adding value to the flow unit, but increases the time to produce the product. This can be calculated by dividing the time of value adding activities by circulation rate.

It is not possible to accomplish both 100% flow efficiency and 100% resource efficiency. The variation of the products will also affect the relationship between circulation rate and resource efficiency as we can see in Figure 13 below:

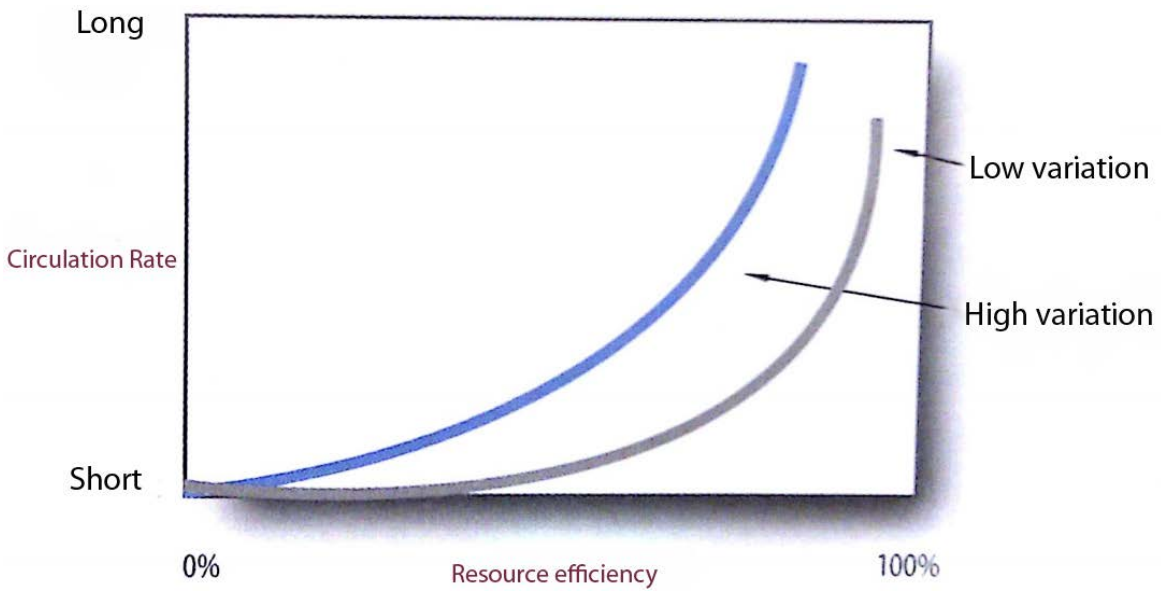

Figure 13 - Circulation rate vs. Resource efficiency

Resource efficiency:
Resource efficiency defines how efficient resources can be used. This means that if every resource is 100 % in use at all time, the resource efficiency is 100 %. If a product is stored at several stages before it will be given a value adding activity to give the worker 100 % up time, and the opportunity to always have a product to work on, the resource efficiency will be 100 %, but the flow efficiency will be lower. Even with good planning to accomplish a great use of resources, the resource efficiency will not be 100 % if the main purpose of the business is to have a low circulation rate. This is because the planning itself is waste of resources that we don't need otherwise, the time spent for each worker to put themselves into a new work situation (or walk between them) will also decrease the resource efficiency.
100 % resource efficiency or 100 % flow efficiency is therefore two different strategies. See Figure 14 below.

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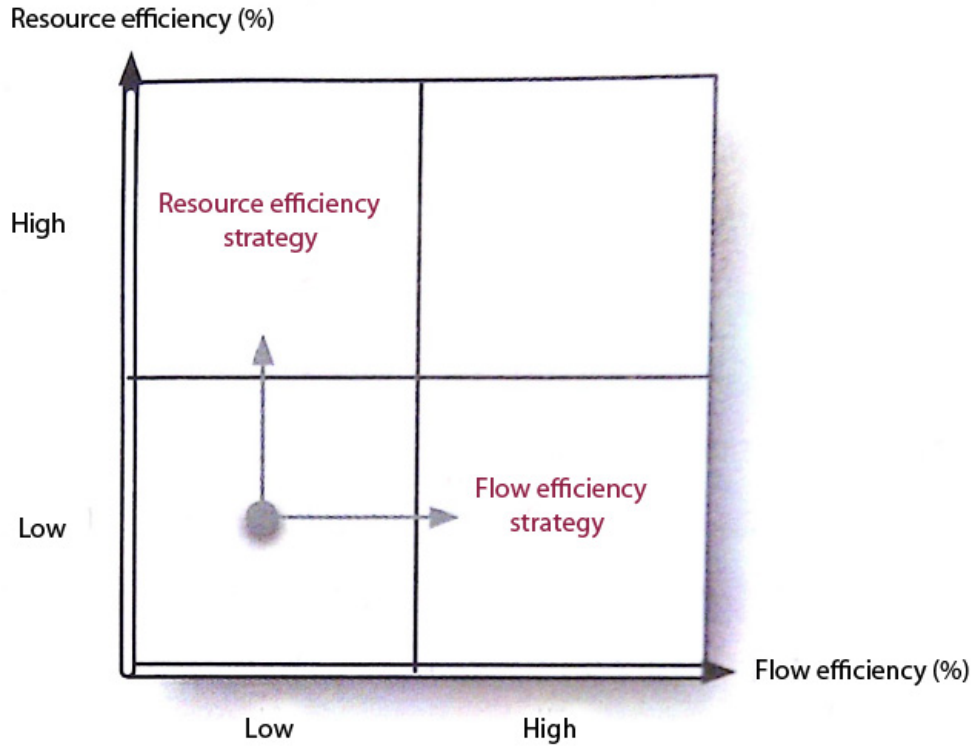

Figure 14 - Efficiency Strategies

Summary:

With these terms we can define lean. Lean is not just a set of tools that can be implemented in the business to achieve a better result. It is a common misunderstanding that everything that is good for the business is lean, and lean is everything good. If this were the case, what is then the alternative? Lean is a business strategy that focuses on 100 % flow efficiency, at the expense of recourse efficiency. With this in mind we can look back at the elimination of seven wastes:

1. Too large production rates
2. Unnecessary inventory
3. Movement of workers
4. Movement materials and products
5. Reduction of down-time
6. Unnecessary failures, extra work or rework
7. Unnecessary production methods (improvement of unnecessary work tasks)

With the right focus on constantly removing waste, as of elimination of time consuming and unnecessary tasks in the process that only increases the circulation rate; the business is having a lean strategy. The above mentioned tools is developed by Toyota Motor Company and are therefore customized for their business model and can therefore not directly be applied to other companies without adopting their specific goal. [23]

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8 Abbreviations

Abbreviation	Description
BUC	Buskerud University College
CEO	Chief Executive officer
KPS	Kongsberg Protech Systems
Rev.	Revision
WIP	Work in Progress

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