Veli-Matti Hakala

Improvement of Production Efficiency by Using Lean Methods

Aidon Oy

Helsinki Metropolia University of Applied Sciences

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This study was commissioned by Aidon, to improve production efficiency by using Lean methods in ACC, Vantaa Finland. The main target of this study was to analyze and improve production efficiency at Aidon Customization Centre.

This study focuses on the production areas, layout, and production process improvements at Aidon Customization Centre by using Lean methods and Six Sigma DMAIC improvement tool. The first step for the improvements was to create a value stream map for old generation process, where process steps were measured, problems such as wastes and bottlenecks were discovered, and improvements in the production process for eliminating those problems were designed and implemented.

In the practical phase, value stream map was created. This visualized problem areas in production. Problems were studied and improvements for the problems were planned by using DMAIC. When correction was clear, the improvements for eliminating problems were carried out and a new analysis was made to see results for the new production method.

The material used in this project was industry literature, online material and interviewing workers and management of the company.

The improvements were implemented. This significantly saves working hours by eliminating unnecessary steps from the process. Also, production speed was increased, inventory space was grown and crossing material movements were decreased between areas.

Keywords	Lean, Process, Improvement

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Tämä automaatiotekniikan insinöörityö tehtiin pohjoismaiden johtavalle älykkäiden energiamittareiden ja verkkotoimintojen toimittajalle Aidon Oy:lle. Työn tarkoituksena on parantaa tuotannon tehokkuutta Aidonin kustomointikeskuksessa (ACC) Lean-menetelmien avulla. Menetelminä käytettiin arvovirtakuvausta (VSM), pohjapiirrustus muunoksia sekä Six Sigma DMAIC -työkalua.

Työn tavoitteena oli luoda arvovirtakaavio vanhasta tuotantoprosessista jossa prosessivaiheet mitattiin, sekä prosessin haitat ja pullonkaulat havaittiin. Tämän jälkeen tuotantoprosessille luotiin parannussuunnitelma, jonka käyttöönotolla poistettiin prosessista löytyneet ongelmat. Uusi arvovirtakaavio luotiin parannellusta tuotantoprosessista jota verrattiin alkuperäiseeen arvovirtakaavioon, jotta parannuksen tuomat hyödyt hahmottuisivat.

Työn lähdemateriaalina käytettiin verkkomateriaaleja, alan kirjallisuutta, sekä johtoryhmän haastatteluja.

Suunnitellut parannukset toteutettiin kustomointikeskuksessa ja nämä mahdollistivat paremman läpimenoajan tuotannossa, suuremman varastotilan eri varastointialueilla, sekä Vähentyneen materiaalin liikuttelun alueiden välillä.

Avainsanat	lean, prosessi, parannus

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Contents

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Consepts

DSO	Distribution Service Operator
ESD	Energy Service Device
MCD	Multi-Connectivity Device
PGM	Power Grid Management
P2P	Point to Point
RF	Radio Frequency
PGM	Power Grid Management
Lean	A concept of maximizing value while minimizing waste, influenced by TPS
DMAIC	Define, Measure, Analyze, Improve, Control
VSM	Value Stream Map
PDCA	Plan-Do-Check-Act
FIFO	First-in-First-out
VA	Value Add
NVA	Non-Value Add

1 Introduction

1.1 Aidon Oy

Aidon Oy is the leading supplier of smart energy metering system and smart grid application in the Nordics. Aidon has already installed over 1.5 million smart energy service devices (ESD) in Finland, and in Norway the company is installing same amount of new generation energy service devices by the end of 2018. This makes Aidon the market leader in Nordic countries. Company was founded 2004 in Jyväskylä, Finland, where Aidon's head office is. Aidon has offices also in Täby, Sweden and in Asker, Norway. All productions happen in two Aidon Customization Centres (ACC) that are located in Vantaa, Finland and in Oslo, Norway.(1.)

1.2 Goal of This Project

The goal of this project is to analyze old production method, efficiency and quality and study possibilities to improve these elements by updating company's layout: re-size warehouse storage space capacity and meter & module production area, design automation possibilities to test cells to increase production speed and quality. Another aim is to analyze new production method and compare it to the old production method to see the benefits of the changes.

2 Aidon Oy

2.1 Business Plan, Customers and Customer Projects

Aidon has more than a hundred customers working and co-operating with each other. Most of the customers are distribution system operators (DSO) who operate, maintain and develop the energy distribution ensuring faultless distribution of electricity to the end users. DSOs use advanced metering management (AMM) to metering, maintaining and billing purposes. Aidon helps customers by providing the complete system of AMM and smart grid system that serves customer needs by sharing and collecting data on

the field. Integrating Power grid management (PGM) to DSOs information system database provides detailed real-time view on the field that shows metering point locations, low voltage network status and supply quality for DSOs. Energy service devices are also working as sensors and collecting information on the field at the same time when meters are metering consumption of electricity. These devices are detecting loads, missing phases, over voltages, under voltages, 0-wire failures and interferences caused by faulty ESD connected to the grid. (2.)

2.2 Smart Energy Service Devices

Aidon has produced two different kind of products: energy service device (ESD) and multi-connectivity device (MCD). About Energy service devices Aidon has produced two different kind of smart meters, 1- and 3-phase smart meters and various different communication modules and accessories. Communication modules offer different kind of communication possibilities for customers to fulfill their needs. Communication principle solution is based on autonomous radio frequency (RF) mesh network. This solution that metering devices use in the field to create micro networks for communication, that will automatically re-route networks when devices detect the new device radio signal. By using this communication solution in field, multiple local smart meters that includes (RF) slave communication modules share information that they have gathered to master meter. Master meter uses 2G/3G/4G connections to communicate with the head-end system that is main part of Power Grid Management (PGM) and works as interface to DSOs information database. (3.)

The main functions that ESD provides:

- Most of meters have integrated circuit breaker that provides possibility to remotely controllability. This will give possibility to cut-off and reconnect current distribution when needed. It also protects smart meter from interferences.

- Real time alerts. Smart meters transmit faults via reading system to DSOs information system database. This provides real-time information of interferences and gives us possibility to avoid greater damage and minimize harms for customer side.

- Large selection of information system modules. Direct Point to Point (P2P) solution for standalone installations by using 2G/3G/4G connection or existing network. Wired RS-485 loop network for apartment houses. Work similarly as RF slave-master connection. New generation solution is RF mesh network that shares information by using radio frequency and gives possibility for wider installations.

- Device different lifespans. In Aidon device, all communication and data transfer happen in system modules. This allows meter and system module to have different lifespans. Communication technology can be updated also when needed without changing meter unit. Only a changing module is enough for changing communication between RF, RS-485 or P2P.

- Using Aidon Head-end system as interface in DSOs database shares metering information as well as logs and status information from smart meters. This is also used for software and configuration changes and updates in smart meters during operation. Upgrading software to smart meters enables new applications and functionalities in smart meters that increase devices lifespans.

- Monitoring distribution transformer stations' loads, will help for predicting device lifespan and it can be noticed for planning next maintenance for device.

Aidon offers multiple different communication technology opinions for DSOs and when customers decide best suitable communication technology for their needs, they have to take into account the following:

- Availability of suitable communications infrastructure
- Density and amount of metering points
- Geographical topology
- Technological and operational requirements
- Initial investment and operational lifecycle costs

Most used communication method that Aidon provides is RF that new generation meters use. It works well in short but also in long range installations and uses only radio

frequency (RF) to share information to master unit. It also updates and re-routes network automatically when detecting new location point. Second one is Point to Point (P2P) method that is used for single location installation, such as in town houses or single houses. This uses direct connection to head-end system via cellular or fiber networks. Third option is wired RS-485 serial communication system that is used in locations where all metering points are located in same space. Meters have been wired all together with RS-485 where all slaves communicate to master, master uses 2G/3G/4G to communicate head-end system in (PGM). (4.)

Multi-Connectivity Device (MCD) is working independently in field extending radio network coverage and/or capacity. MCD is used as master or RF slave unit and it is working without a meter. MCD is also be used to connect other metering devices and sensors to the same Advanced Metering Management (AMM) system. (5.)

Aidon's advanced metering management (AMM) and smart grid technology provides tailored, openness solutions and services for customers when it comes for deployment of new functionalities, as well as new projects or support assistance on systems lifespans. This opens possibility for customers to collect multi-function data from network to get better understand of situations, develop their distribution network and get highest performance on their AMM system.

2.3 Norway and Vantaa Customization Centers

Aidon is producing smart meters in Oslo, Norway, and Vantaa, Finland customization centers. Differences between Norway and Finland production is that Norway uses only RF-technology to produce meters for customers, whereas Finland is using all communication methods to fulfill customer needs. In Finland, Aidon customization center includes five production test cells, module production site and two repair test cells, with eight operators in winter time and fourteen operators in summer time. Norway customization center is three times bigger than Finland and twenty-two operators are working there. It includes nine production test cells, two repair test cells, double sized module production site and huge warehouse storage area.

3 Lean six sigma

3.1 Lean

Lean Manufacturing term became known from the book “The Machine That Changed the World” by James P. Womack and Daniel T. Jones, 1990. Lean philosophy was originally developed from the Toyota Production System (TPS) which means that Toyota’s internal production philosophy has been developed for 100 years. Lean focuses on speed and optimizing the whole process instead of focusing process particular parts. Main idea of Lean is to eliminate and minimize wastes such as non-value added time and maximize value added time that benefits customer and company in production process. Many kinds of production problems can be solved with proper use of Lean. (6).

3.2 Six Sigma

Six Sigma is a business management strategy that was developed by Motorola in the 1980s. Six Sigma is a set of tools and techniques for process improvements and these tools and techniques are used primarily to identify, rectify and define in a manufacturing or business process. Six Sigma focuses on speed and quality and its main goal is to identify variation in the types of data inputs and solve at Root Cause Analysis to determine the source of errors in process. Using Six Sigma Methodologies are expanded to reduce errors and failures according to the company's product marketing and strategic targets. (7.)

3.3 DMAIC Method

The DMAIC is a problem-solving method that provides a systematic way of solving problems and improving a solution for business development. DMAIC works as a roadmap for projects or quality improvements that need to be made. The term DMAIC stands for five main steps in the process and is an acronym for the five steps that make up the process as shown in figure 1. (8.)

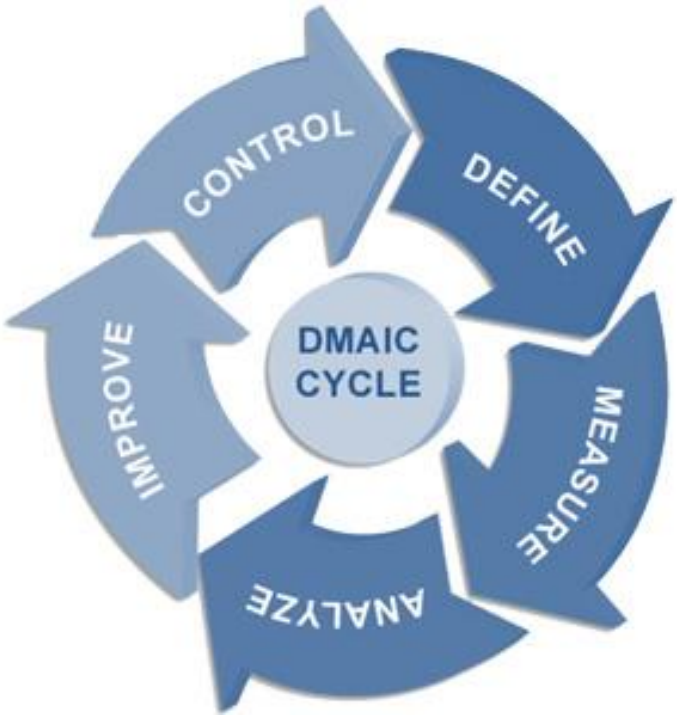


Figure 1. DMAIC problem-solving method. Copied from leansixsigmagroup. (8.)

3.3.1 Define

The Define step is the first step of the DMAIC improvement process. In this phase high-level roadmap is created that helps to understand the process. This is critical phase where problem is identified, limited and also goal has been set for process improvement. (9.)

3.3.2 Measure

The purpose of measure step is to establish current baselines as the basis for process improvement before doing any changes. This is data collecting step with a purpose to establish process performance baselines. The performance metric baseline(s) from the measure phase will be compared to the performance metric at the conclusion of the project and this will determine objectively whether significant improvement has been done. (10.)

3.3.3 Analyze

The purpose of analyze step is to analyze process performance data and identify, validate and select a root cause for elimination. In the process, root causes that are causing problems have been identified using root cause analysis and top 3-4 potential root causes are selected for larger validation. Detailed process map helps to pin-point how process inputs affects process outputs and what the magnitude of contribution of each root cause is. (11.)

3.3.4 Improve

The improve step contains three phases to get best outcome for solving the problem. These phases are identifying-, testing- and implementing phases. First thing is to identify creative solutions to eliminate potential root causes in order to fix and prevent problems in process. Second is to test creative solution on problem using plan-do-check-act (PDCA) cycle to see the result of changes in a process. Third thing is to implement new solution on process based on (PDCA) results, attempt to anticipate any avoidable risks associated with the improvement using the Failure mode and effects analysis (FMEA) and to eliminate key root causes. (12.)

3.3.5 Control

The purpose of control step is to ensure that the obtained gains during Improve phase are standardized, documented and maintained procedures to increase performance in the new process. Monitoring plan is created to follow-up process status and its behavior and for reacting to any problems that arise. (13.)

3.4 Value Stream Map

The Value Stream Map is Lean manufacturing technique that illustrates material and information flow from supplier to customer. Value stream map (VSM) is used to analyze, design, and manage the flow of materials and information required to bring a product to a customer. Value Stream map is effective technique to identify wastes and

it also helps to set the production steps in order to get best outcome in the production flow.

The Value Stream map visualize current state map of production. This map helps to identify and eliminate wastes such as delays, inefficiencies and restrictions and excess inventories in process flow, which gives a working plan to achieve Lean efficiency. Main purpose for VSM is to visually collect information in production flow such as:

- Work and wait times along each step in process
- Individual work steps for operators, including the identification of overtime in process flow.
- Error rates at individual work steps
- Downtime at individual work steps
- Inventory excess or shortfall
- Production or process delays (14.)

3.5 Spaghetti Diagram

The Spaghetti diagram is the visual creation of actual flow in the production process that visualizes movements of operators and materials and draws a map for those movements. This will demonstrate time consuming movements and helps to reorganize layout to eliminate unnecessary movements. (15.)

3.6 Layout Design

A model facility layout is an arrangement of different aspects of manufacturing to achieve desired results in production. Factory layout provides available space, final product, safety of users and facility and convenience of operations in smooth and steady way. Also efficient and effective facility layout will cover following objectives:

- To provide optimum space to organize equipment and facilitate movement of goods and to create safe and comfortable work environment.
- To promote order in production towards a single objective
- To reduce movement of workers, raw material and equipment
- To promote safety of plant as well as its workers
- To facilitate extension or change in the layout to accommodate new product line or technology upgradation

- To increase production capacity of the organization (16.)

4 Depth of the Study

As previously mentioned, the aim for this study was the improvement of production efficiency by using Lean methods. Main issue was to measure and analyze old production method and modify it to support new generation device production (RF-technique). The Lean Six Sigma improvement tool DMAIC was used to find problems and wastes in production and to create solutions for reducing wastes and eliminating problems.

After the improvement plan was implemented, the new production method was analyzed and throughput time was calculated. This new throughput time was compared to old production throughput time to see the results of the improvements on the production method.

5 Research methods

5.1 Research Method for Value Stream Map

The Value Stream Map was used to describe the current process flow steps and give information about the time what is consumed for each phase. This draws perfect map on production state that pinpoints wastes and bottlenecks in production flow that need to be eliminated. Value Stream Map can be seen in Appendix 1.

5.2 Research Method for DMAIC (Define, Measure, Analyze, Improve, Control)

The define step is used to process Value Stream Map and clearly articulate production problem in the production flow. In production flow there are 26 different phases that take different amount of time to produce. Most time consuming and most repeated phases are taken to deeper investigation to improve process flow for revealing wastes,

bottlenecks and other time consuming problem. Also operator workers have been listened to get improvement recommendations in production flow.

The measure step is used to measure how much time all phases needs in production to be completed. All 26 phases are timed and recorded to get real analyze of the state of production.

The analyze step is used to process recorded data and make analyze to reveal problems root causes in production flow. List about potential root causes have been created for bigger investigation.

The improve step purpose is to test and implement new solution for problems. PDCA (Plan, Do, Check, Act) method is used in process to find different creative solution to eliminate root causes in production flow. Improved solution is implemented in VSM with new timed phases to make it better and faster.

The control step is ensuring that new implemented solution in production process is standardized to guarantee root cause execution. New implemented solution is monitored for recording data for success in production

5.3 Research Method for Management

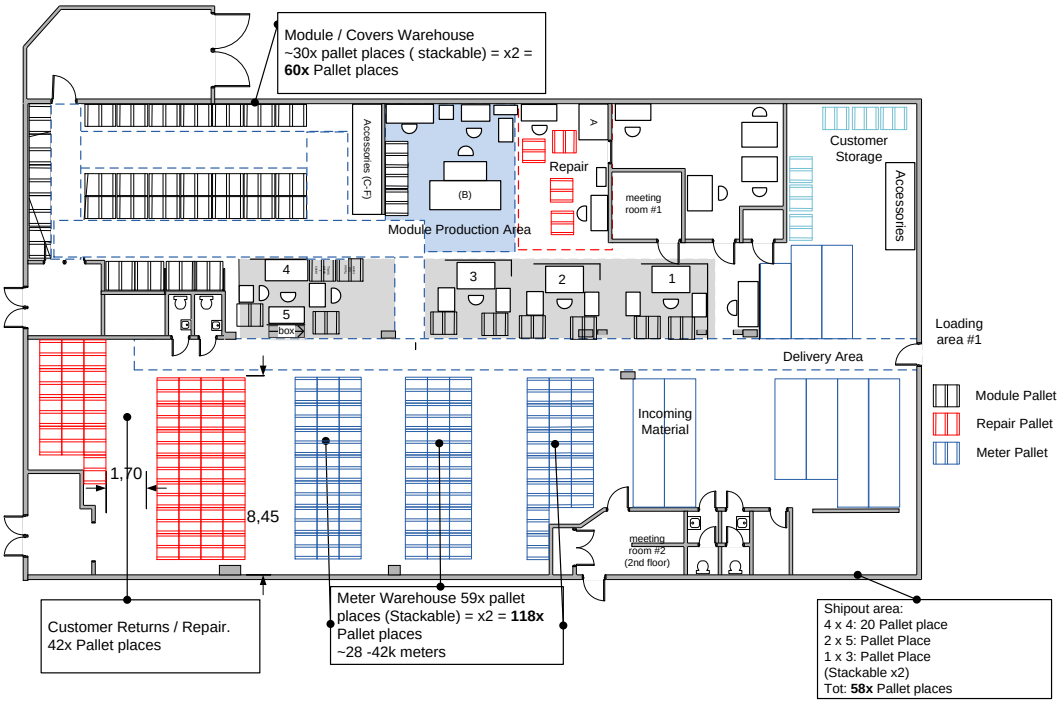
The part of the management who was working in this project was interviewed twice in a month to see results and state of the project, giving guidance in problem cases and moving project forward.

6 Beginning State in ACC and Problem Identifying

6.1 Old Layout

Aidon has 600m^2 Customization center in Vantaa and this space has been divided in three sectors that are called as production area, repair area and warehouse area. Production area handles meter- and module production. Meter production contains five

test cells that are marked by numbers in layout. Three of test cells are normal size test cells (1, 2 & 3) and last one is called Skyliner where two test cells has been merged as one (4 & 5). Repair area has two smaller repair cells where customer returns are handled. Warehouse is divided in five areas and these are incoming materials area, customer returns area, meter storage area, module storage area and delivery area. Old Layout can be seen in figure 2.



Figure, 2 Old Layout

6.2 Module Production Area Wastage

Module production structure is supporting old generation and is surrounded with tools and test benches that are required to manufacture older module types. Old generation module production is approximately 10 % of all orders and is slowing down mass production dramatically. 90% of orders are supporting new generation (RF-technique) and this module production is main priority to set in order.

Most delays are coming from material transfers between tables and pallets. Module production site is too narrow to be able to make fast productive flow to meter produc-

tion area. Modules are saved in other locations for further actions and are moved back to module production area when needed again. This is creating unwanted material transfers what consumes time and limit storage space. Module production area can be seen in figure 3.

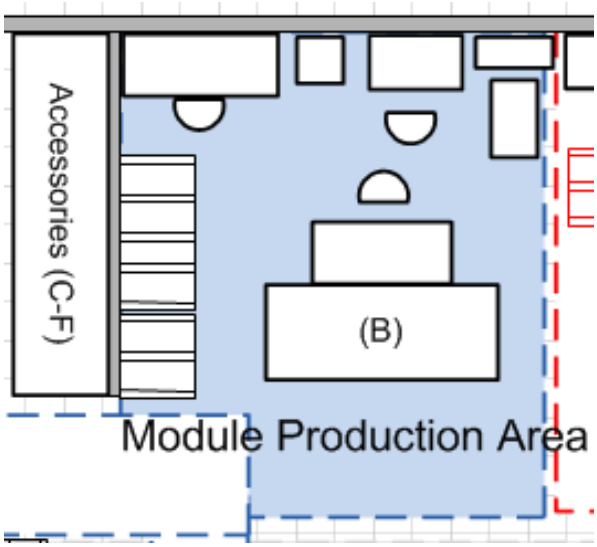


Figure 3, Module Production Area

6.3 Meter Production Area

Meter Production Area contains three normal size test cells and one mass production test cell called Skyliner. Skyliner is built for new generation devices to support RF-technique and make work easier and faster. Skyliner needs three operators to get best outcome where normal size test cell works with two operators.

At this moment Aidon meter production area is supporting old generation meter production method where test times are faster and only one test bench in a fix is capable to get best outcome on production. Now RF-technique is the most wanted data transfer method that customers want and normal size test cells can't offer required actions what RF-technique needs. This causes delays in production tests since test times have been increased and normal size test cells haven't enough meter testing capacity. Meter production area can be seen in figure 4.

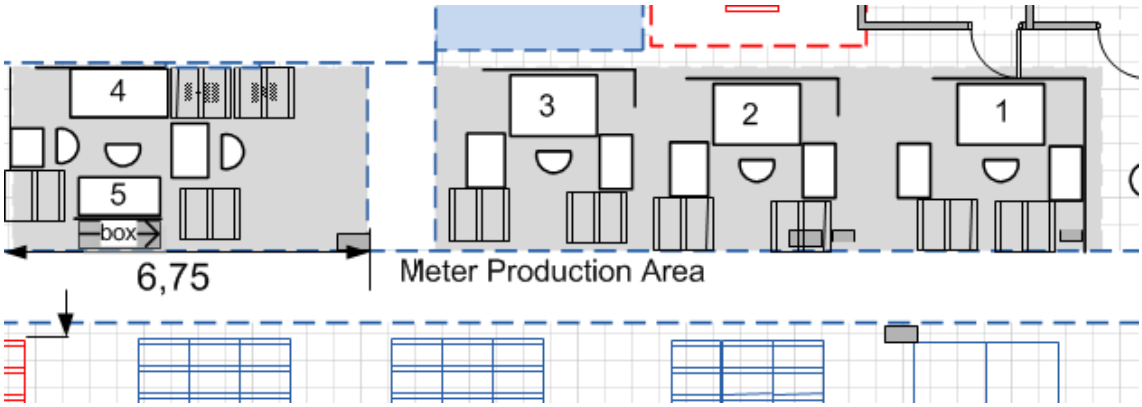


Figure 4, Meter Production Area

6.4 Warehouse Area

Warehouse is capable to handle totally 298 pallets and these pallet places are divided into the following order. Incoming materials has 20 pallet places, Customer return has 42 places, delivery area has 58 pallet places, meter & module storage got 178 pallet places (118 places for meters and 60 places for modules).

Warehouse layout is supporting old meter production where meter pallets were including meters and meter covers. These covers were needed to be disassembled before meters were capable to be tested and this process was consuming 40% more time in production flow.

Now Aidon is receiving pallets where meters and covers are separated from each other. This is saving disassembly phases for us but increases incoming pallets by 300% that makes materials receiving and storing difficult. Warehouse area can be seen in figure 5.

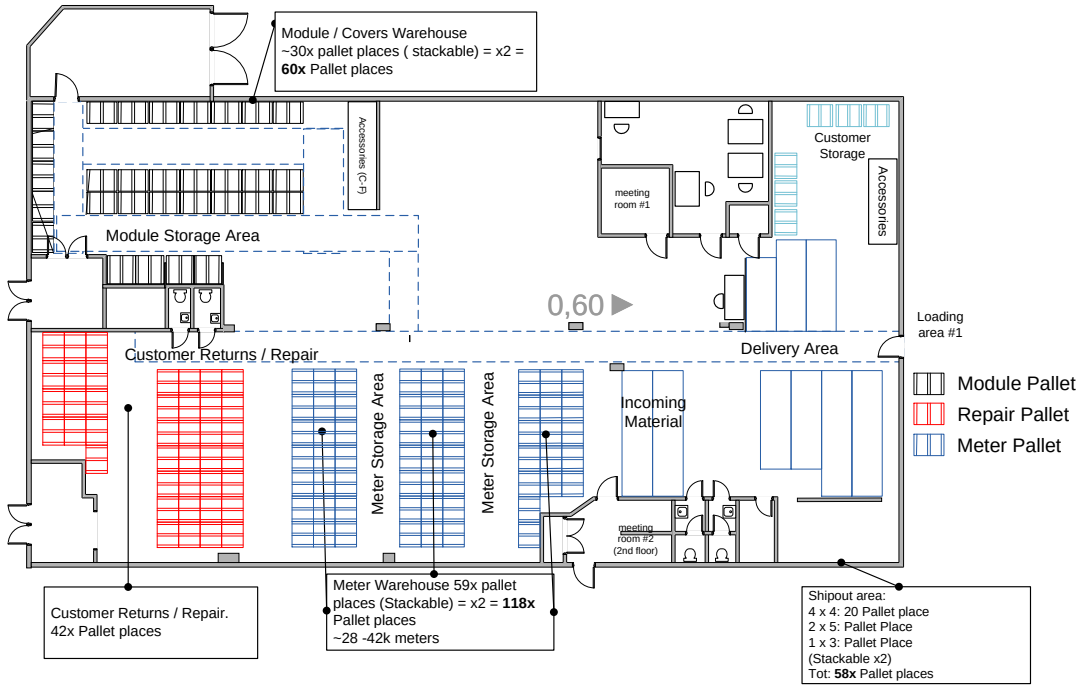


Figure 5, Divided Storage Area

6.5 Repair Area

Repair area is placed between meter and module production. It has two repair cells where operators work with meter and modules what has come back from customers.

Biggest problem in repair site is too crowded area. Repair area is placed too close to meter and module production that causes risk that returned material from customer will be mixed in meter or module production. Also material transferring in and out to repair area is causing difficulties and unnecessary movements between areas. Repair area can be seen in figure 6.

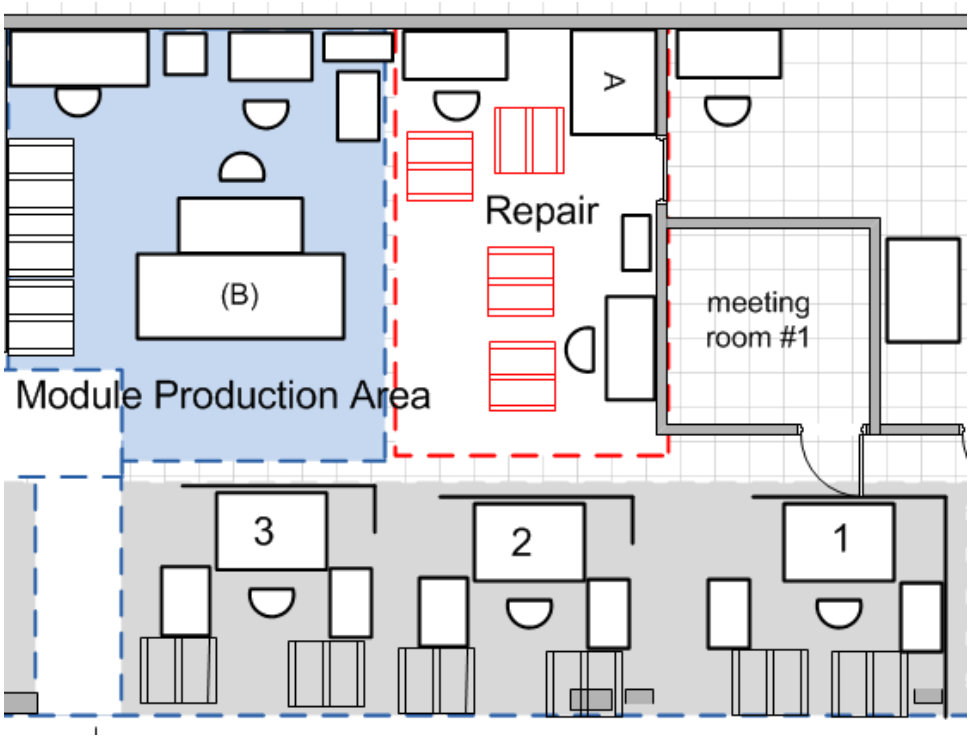


Figure 6, Repair Area between meter and module production

6.6 Production Process Flow

The Value Stream Map describe old layout process flow that includes 26 measurable steps and each of these steps were set in order and timed to get data for better analysis. In production process flow normal size test cells movements are longer compared to Skyliners and rotations are slower what makes waste in material transfers. Production flow also has unwanted step that is possible to handle in manufacturer site.

6.7 Illustrated Movements in Old Layout

Spaghetti Diagram illustrates waste movements in production area. Blue lines shows the movement of a meter production operators, black lines show a module production operators, red line shows repair operators and green line shows packing workers movements. Drawn picture can be seen below in figure 7.

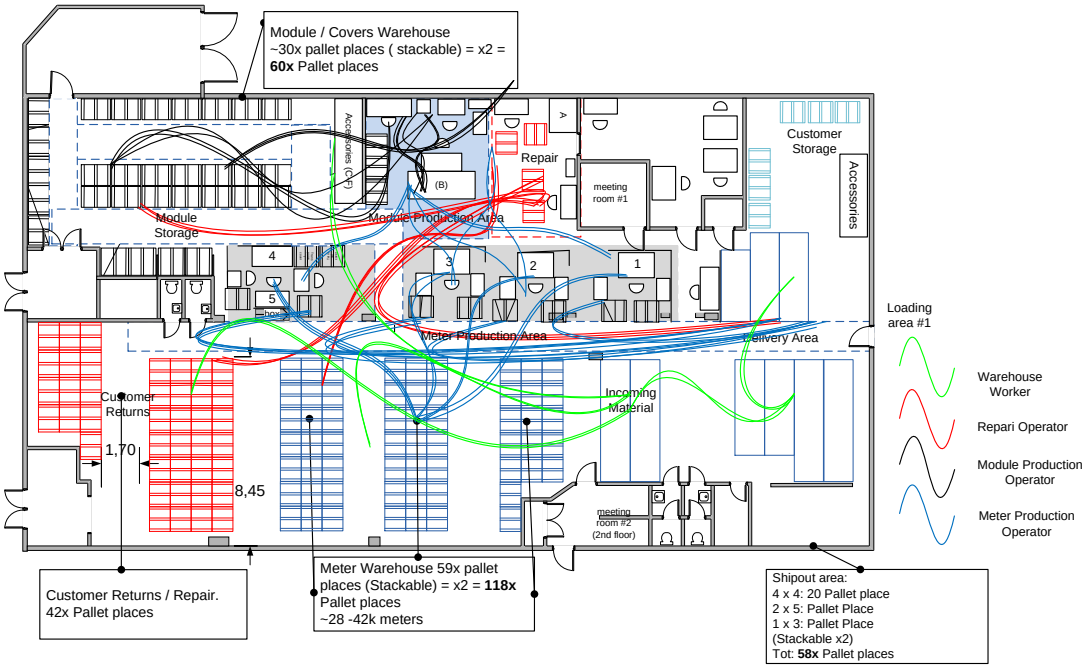


Figure 7, Spaghetti Diagram

6.8 Identified Problems in Production

At the moment, biggest problems that have been identified in old layout is lack of space in all areas, waste movements between areas, old generation tools and techniques are supported in meter and module production, and a risk in a repair area that customer returns will be accidently mixed with production materials.

7 Improvement Plan

7.1 Eliminate Identified Problems

To get improvement plan into action for eliminating identified problems, the first thing is to make layout changes. Module production area will be rebuilt to look wider and extra tables and shelfs will be removed from area. In Meter production area the test cells will be fused to get more productive and faster production line. Repair area will be separated from production area and moved close to Customer return area. This will eliminate

material transferring difficulties between areas and also risk that customer property will be mixed with production. Storage area will be rebuilt and floor markings will be created, also the meter area will be expanded by changing the corridor to meter storage area.

7.2 New Layout

Different layout drawings were made to find the best productive solution with minimal wastes. In version V.1.0 meter and module production areas were changed and storage area was expanded. Old tools and tables were erased from module production and new mass production cell was built. Repair area also get own area in meter production site. First drawing “New Layout V1.0” is displayed below in figure 8.

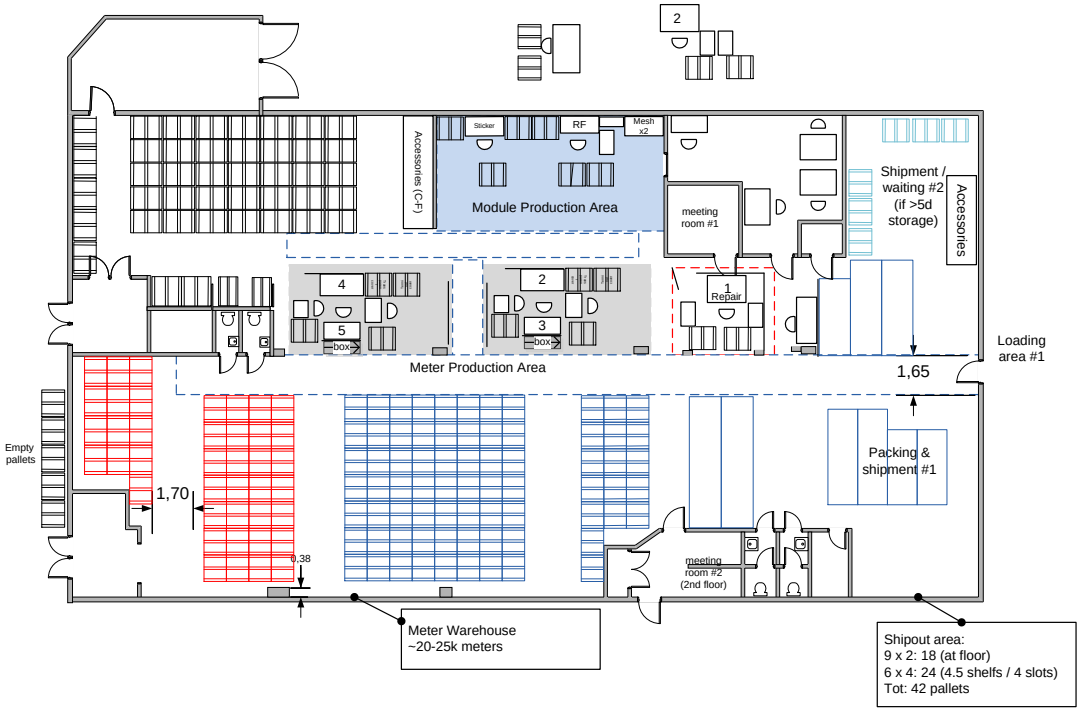


Figure 8, First draw for a new layout V1.0.

After feedback new layout V1.1 was made to eliminate wastes that were revealed in New Layout V.1.0. Especially repair area got feedback, that even when it was m oved away in module production area, it is still too far from customer return site and will

cause unnecessary movements between these areas. Improvements are taken into account in figure 9.

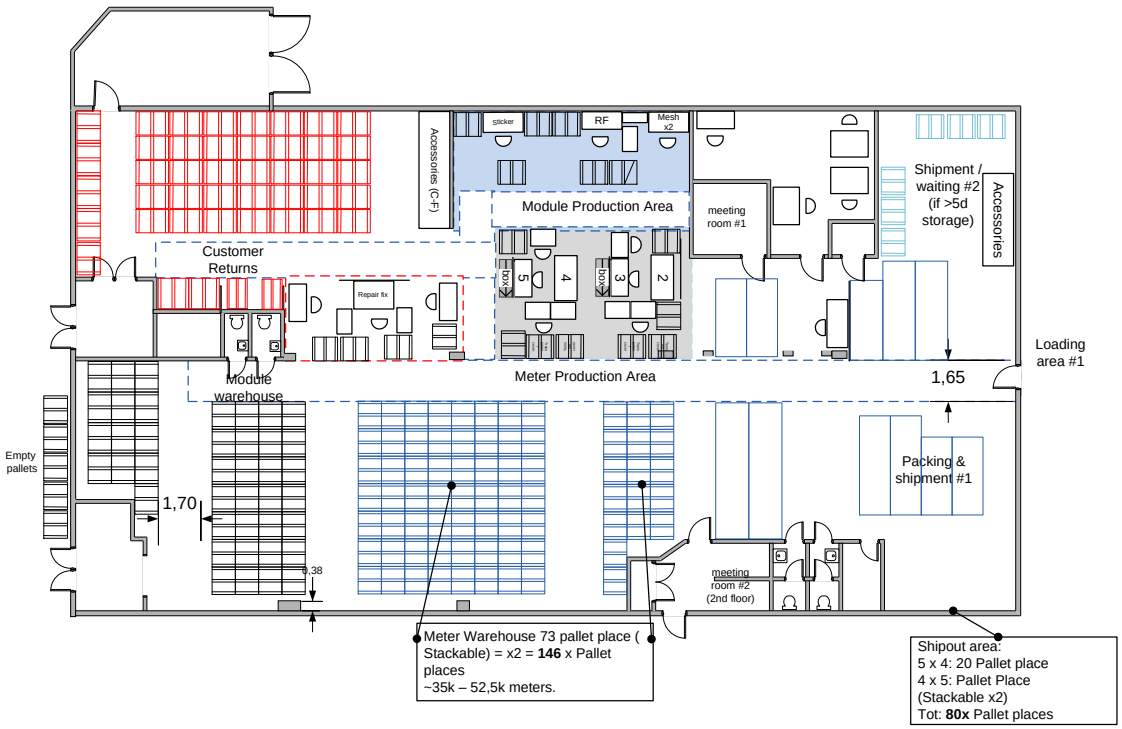


Figure 9, Second draw for a new layout V1.1.

Version 1.1 was done to unite repair area and customer returns area. Also Module area and Customer Returns area changed places in a purpose to clarify material storage places so that raw production material will be saved on bottom side and Customer Returns will be saved on top side.

This layout also got suggestion for improvements that Module area and Meter area should be merged to get best productive production flow without any interruption because of the material transfers between areas. The final layout plan can be seen in figure 10.

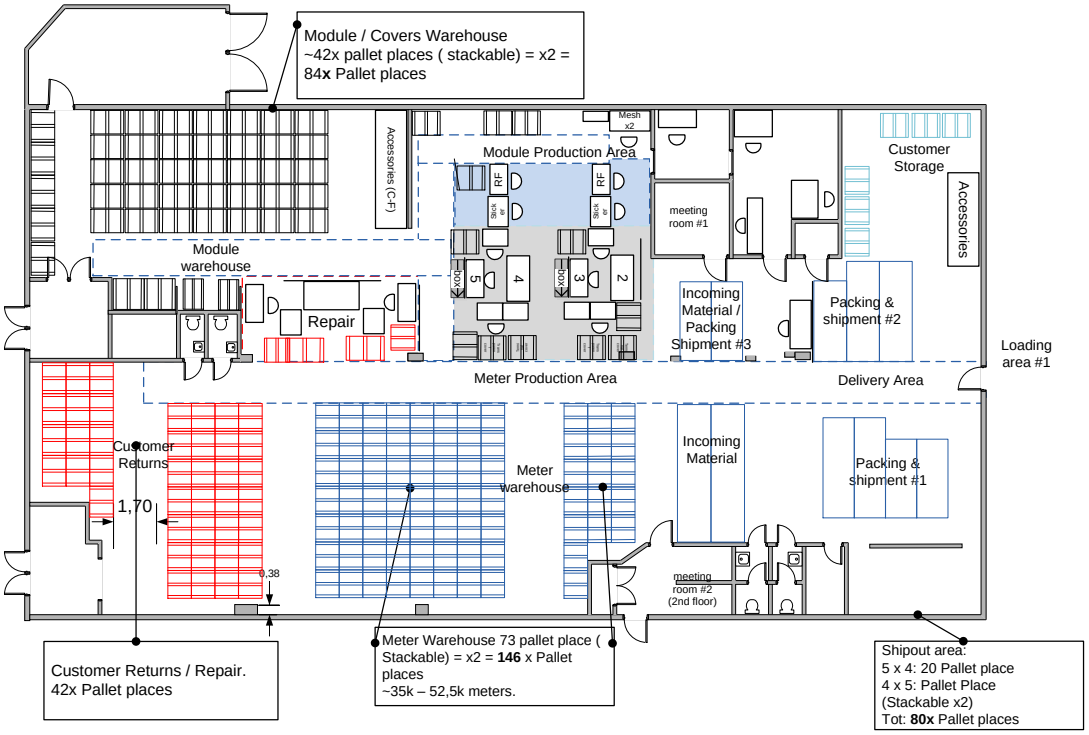


Figure 10, Final layout plan.

Final layout was designed and was accepted by management. Module / accessories area and Customer Return area was restored to the original plan. Meter production area and module production area were merged and modified for new generation devices, Repair area location changed and storage area capacity was increased. Also movements between Areas were decreased. Changes and improvements in layoutV1.2 explained in following sections.

7.3 Module Production Area Changes

Module production area is modified and merged with meter production to support new generation device production. Module production got major update by using automatic printers that attach module stickers on module covers. Also material transfer has become more linear within the update. Now produced modules are moving instantly to meter production without unnecessary movements or storing modules in another location.

Biggest benefits in module production area are wider corridor, spacious production area, and new implemented automatic sticker printers that increased module type sticker labeling speed by 192% and whole throughput time by 92.7%. Changed module production area can be seen in figure 11.

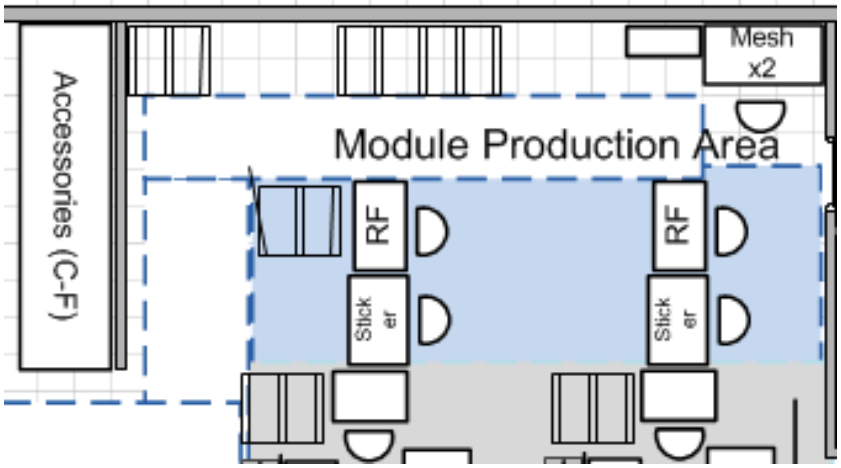


Figure 11, Merged module production area

7.4 Meter Production Area Changes

Meter production area is modified and merged to support new generation device production. Meter production contains two mass production cells that merged with module production. With this combination, production process speed has increased and production flow has come more linear.

Benefits that have been found for merging meter & module production area are improvement capacity speed in production, linear production process where initial product turns to end product by moving through this line without any material interruptions or transfers. Also crossing material transfers between areas have decreased.

Merged meter and module production area has increased throughput time in meter production approximately 30% compared to old production method. This change also eliminated the risk for material to be mixed between work orders and produced module storages has decreased. Changed meter production area can be seen in figure 12.

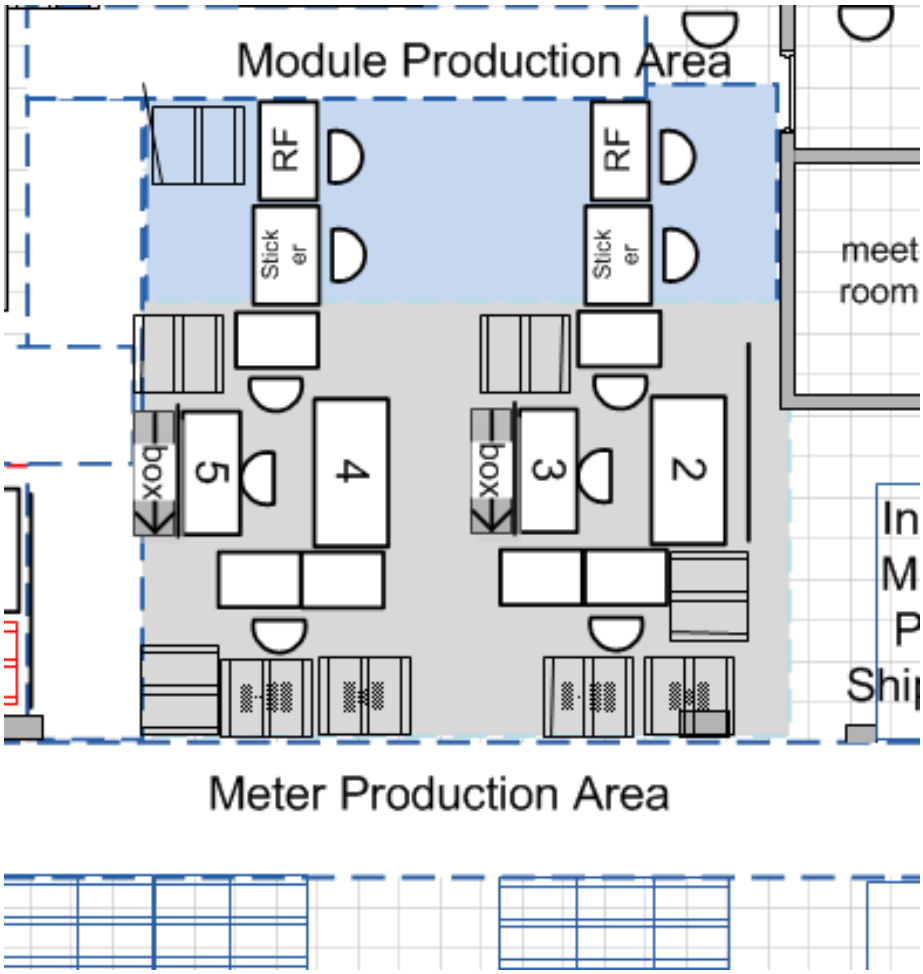


Figure 12, Modified & merged meter production area.

7.5 Warehouse Area Changes

Warehouse area capacity has been increased in all sectors except in customer returns. The storage capacity of the divided areas has increased as follows: Incoming materials and delivery area got an extra common area for storage that contains 6 pallet places. If common area is used to save incoming materials storage capacity, it is increased by 60%. But if it is used for delivery area, the capacity is increased by 15%.

In meter storage area corridor between meter storage lines were filled with meter pallets that increased storage capacity by 24%. Filling a corridor with meters also helps to keep meter storage area in order. Meters types are set in own rows in storage area compared to old warehouse where meter types might have stored on different sides in storage area.

The module storage area capacity was increased by filling second corridor with modules and accessories. This change increased storing capacity in module storage area by 33% and made material storing more rational. All modules and accessories have now own storage rows in area what helps to find certain modules or accessories in area.

Customer return area stayed as original layout showed. Only area boundaries were strengthened. Changed storage area can be seen in figure 13.

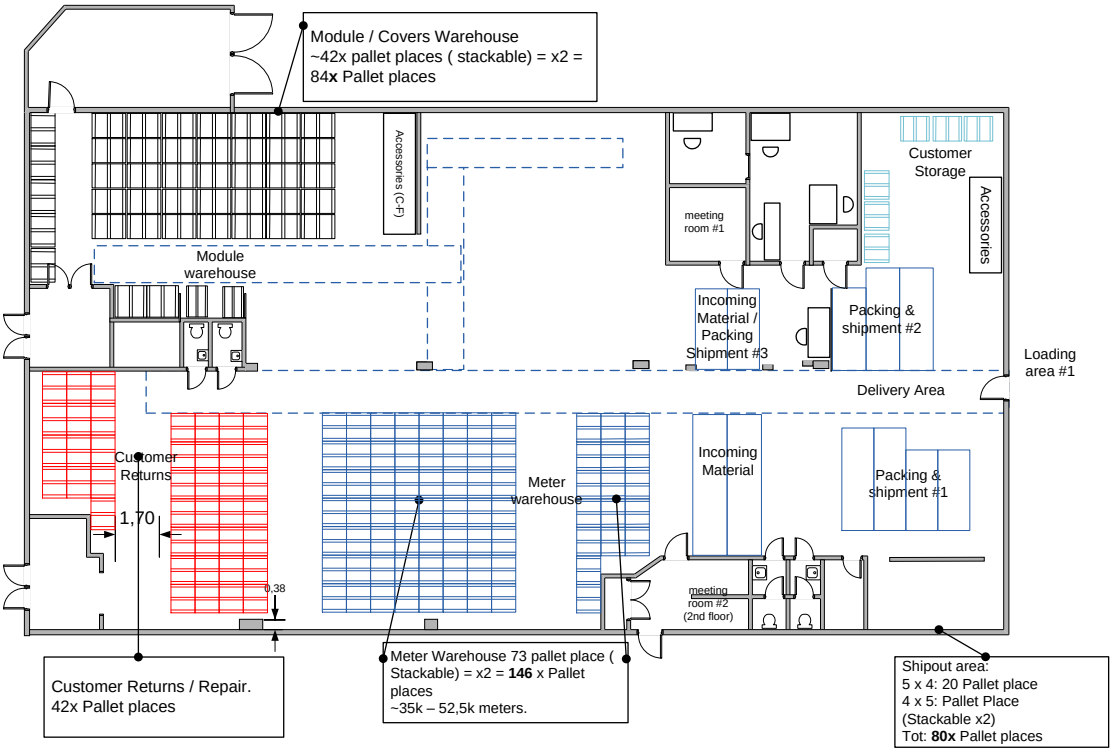


Figure 13, New layout from a divided storage area

7.6 Repair Area Changes

Repair area location has been moved next to the customer return area which separates repair area completely from production area. This modified repair area to be a self-contained area, which increases productivity and made area more spacious. Layout update made material movements to be more linear and also eliminated cross-material movements between areas.

Biggest benefits which the layout update brings are close distance to customer returns area, the elimination of mixing repair and production materials and spacious self-contained area that is separated completely from production. Changed repair area can be seen in figure 14.

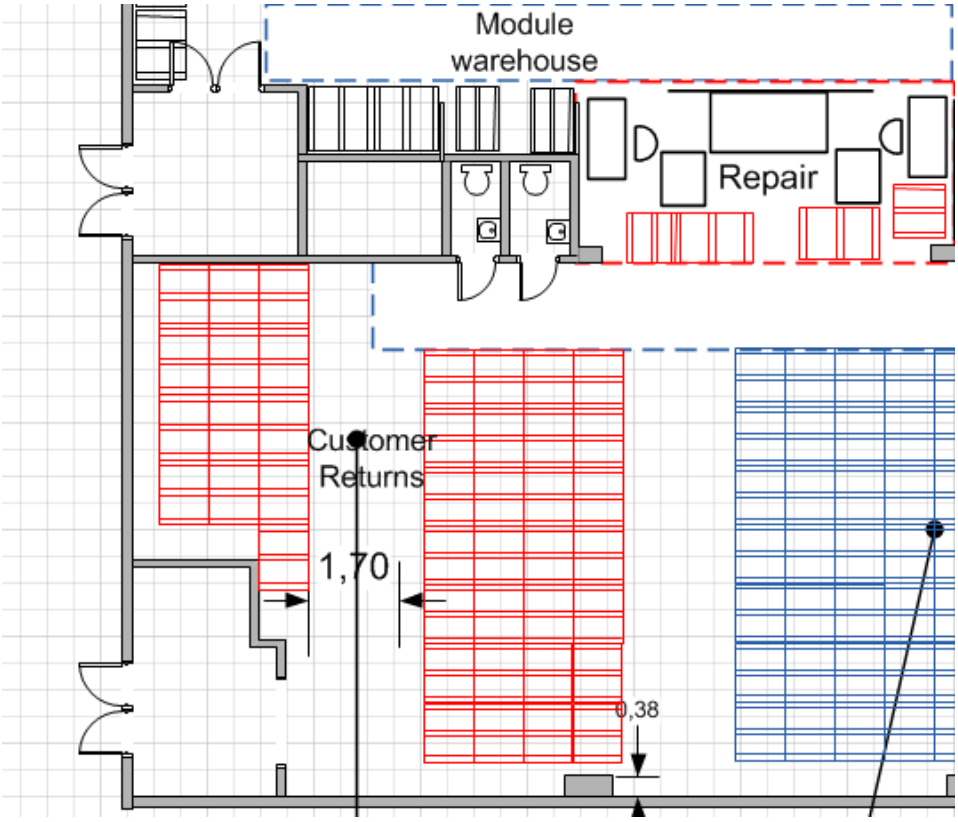


Figure 14, New Repair Area moved close to Customer Returns Area.

7.7 Illustrated Movements in New Layout

When using a new generation production method as reference in calculation, the average profit that is saved in movements would be 70% in module production area, 60% in meter production area, 30 % in packing area and 40% in repair area.

Layout update was approved by management and implemented to get real production data about working methods and movements from all areas. Illustrated movements can be seen below in figure 15.

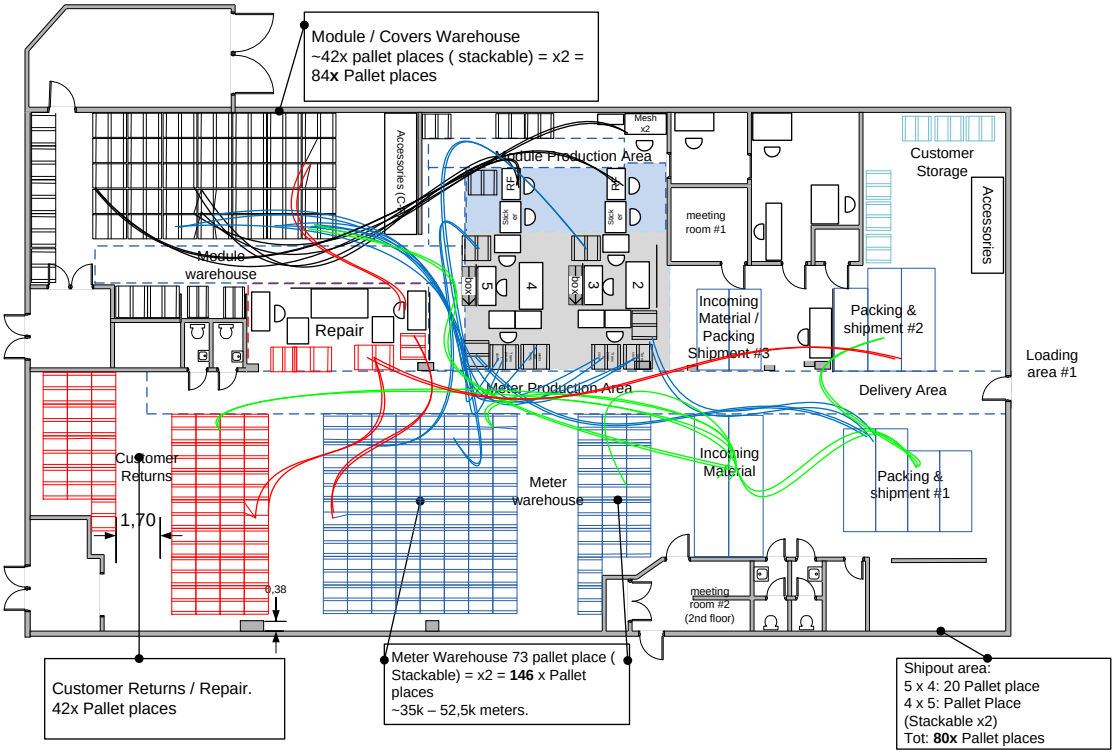


Figure 15, Illustrated movements in new layout

7.8 Effects

The final layout improved productivity in production and repair area and eliminated risk for material mixing. Also warehouse storing capacity increased 15-60 % depending on the area. Enlargement was critical because of the amount of incoming materials to be received is 300% bigger.

The improvements that are implemented in production area are mainly new generation production method for RF-technology devices and merged meter and module production. With these improvements production speed increased and throughput time shortened. RF-slave calculation can be seen in figure 16 and figure 17 and RF-Master calculation can be seen in figure 18 and figure 19.

7.8.1 RF-Slave Production

By using amount of one box as reference in VSM, it gave the best understandable picture of production steps and consumption of time in steps. Figure 16 illustrates chang-

es between old and new production methods. Reason for better value add (VA) ration and throughput time is improved time usage in non-value add (NVA) steps where 27% of NVA time was removed because of the updates.

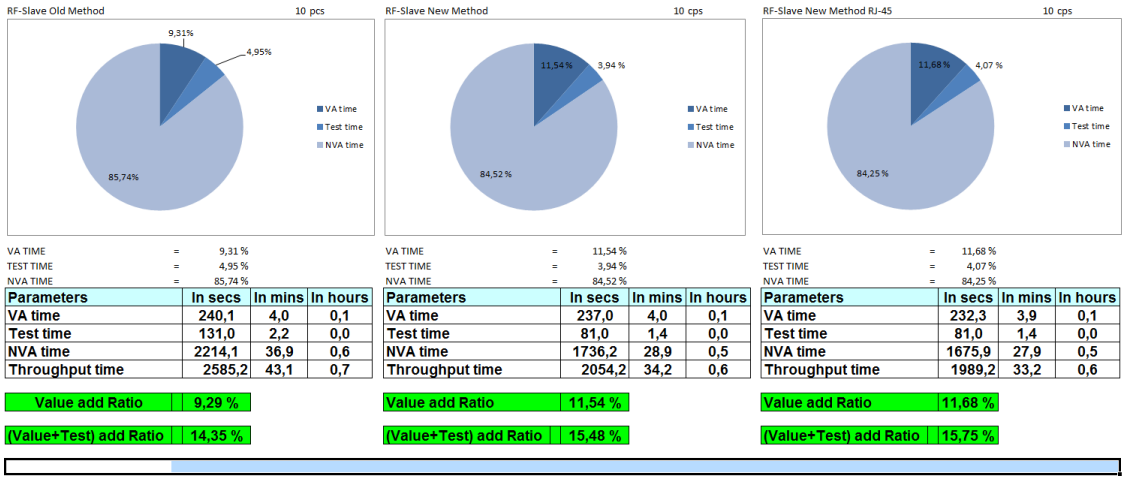


Figure 16, RF-slave old-, new- and future production method calculation for one box.

New production method improved value add ratio by 2.25% and shortened Throughput Time by 26%.

By using amount of one pallet as reference in VSM the NVA time is rising too high and pie chart is mostly illustrating how long materials are waiting before being produced. By using old production method the NVA ratio is 99.22% and in new production method NVA ratio is 99.13%. Differences can be seen in Figure 17.

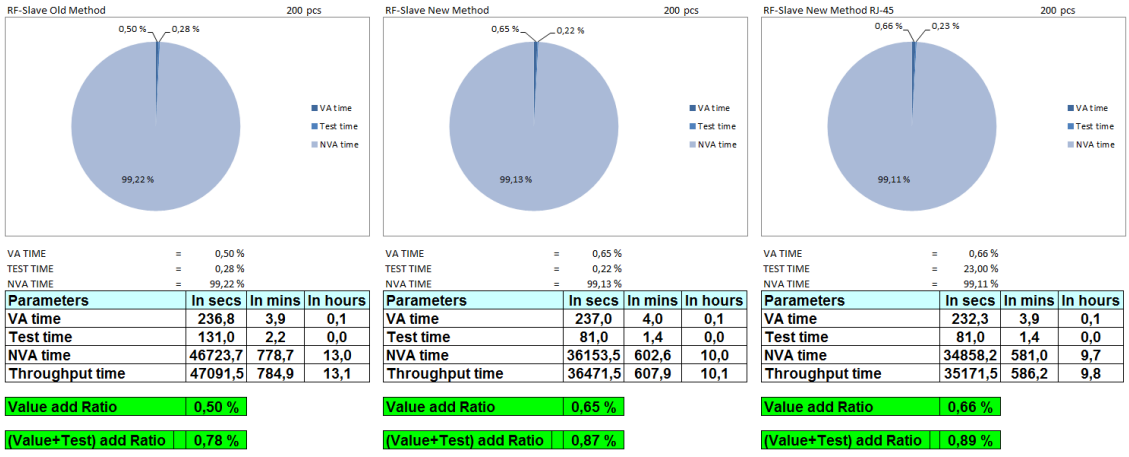


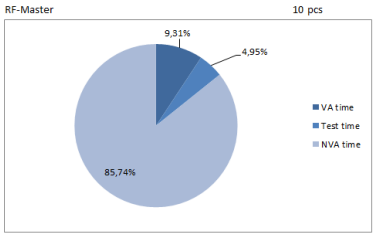
Figure 17, RF-slave old-, new- and future production method calculation for one pallet.

Even when pallet size batch informs in VSM that the production is mainly only containing NVA time and VA ratio is only 0.50% and after update VA is 0.65%, the throughput time has improved greatly. Throughput time improved 29.1% within the update that means three working hours has been saved per pallet per operator in production.

7.8.2 RF-Master Production

RF-master production is taking bit more time in production process because it has step in VSM where master unit was attached to the meter and this makes small differences in VA time, NVA time and Throughput time.

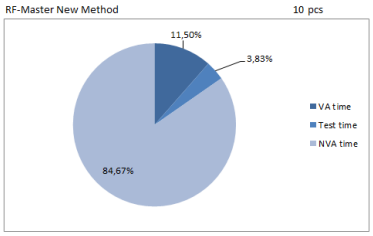
VSM is also done for RF-masters where one box has been reference for calculations. RF-master production pie chart shows the improvements between an old and new production method. Also in RF-master production the biggest benefit is improved time usage in NVA steps that decreases thee wastes by 26.8%. Differences can be seen in Figure 18.



VA TIME	=	9,31 %
TEST TIME	=	4,95 %
NVA TIME	=	84,75 %

Parameters	In secs	In mins	In hours
VA time	246,1	4,1	0,1
Test time	131,0	2,2	0,0
NVA time	2268,1	37,8	0,6
Throughput time	2645,2	44,1	0,7

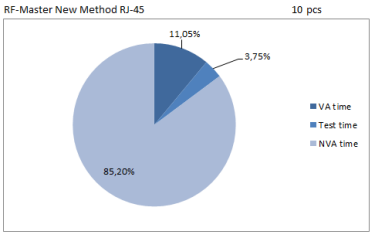
Value add Ratio	9,30 %
(Value+Test) add Ratio	14,26 %



VA TIME	=	11,50 %
TEST TIME	=	3,83 %
NVA TIME	=	84,67 %

Parameters	In secs	In mins	In hours
VA time	243,0	4,1	0,1
Test time	81,0	1,4	0,0
NVA time	1790,2	29,8	0,5
Throughput time	2114,2	35,2	0,6

Value add Ratio	11,49 %
(Value+Test) add Ratio	15,32 %



VA TIME	=	11,05 %
TEST TIME	=	3,75 %
NVA TIME	=	85,20 %

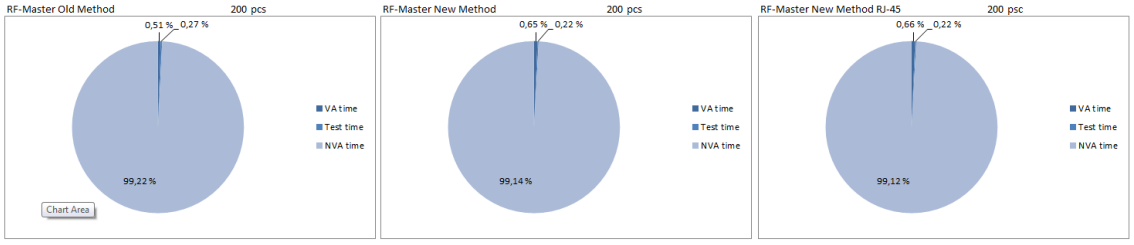
Parameters	In secs	In mins	In hours
VA time	238,3	4,0	0,1
Test time	81,0	1,4	0,0
NVA time	1729,9	28,8	0,5
Throughput time	2049,2	34,2	0,6

Value add Ratio	11,63 %
(Value+Test) add Ratio	15,58 %

Figure 18, RF-Master old-, new- and future production method calculation for one box.

New production method improved value add ration by 2.19% and throughput time by 25.1%.

VSM calculation was also done for RF-masters where reference was one Pallet. By using old production method the NVA ratio was 99.22% and after update the NVA ration changed to be 99.14%. Differences can be seen in figure 19.



VA TIME	=	0,51 %
TEST TIME	=	0,27 %
NVA TIME	=	99,22 %

Parameters	In secs	In mins	In hours
VA time	246,1	4,1	0,1
Test time	131,0	2,2	0,0
NVA time	47914,4	798,6	13,3
Throughput time	48291,5	804,9	13,4

Value add Ratio	0,51 %
(Value+Test) add Ratio	0,78 %

VA TIME	=	0,65 %
TEST TIME	=	0,22 %
NVA TIME	=	99,14 %

Parameters	In secs	In mins	In hours
VA time	243,0	4,1	0,1
Test time	81,0	1,4	0,0
NVA time	37347,5	622,5	10,4
Throughput time	37671,5	627,9	10,5

Value add Ratio	0,65 %
(Value+Test) add Ratio	0,86 %

VA TIME	=	0,66 %
TEST TIME	=	0,22 %
NVA TIME	=	99,12 %

Parameters	In secs	In mins	In hours
VA time	238,3	4,0	0,1
Test time	81,0	1,4	0,0
NVA time	36052,2	600,9	10,0
Throughput time	36371,5	606,2	10,1

Value add Ratio	0,66 %
(Value+Test) add Ratio	0,88 %

Figure 19, RF-Master old-, new- and future production method calculation for one pallet.

Compared to old production method the VA and NVA ratios got a minor improvement. The biggest benefit is throughput time which improved 28.2% within an update. It decreases unnecessary working hours by three and half hours per pallet per operator.

7.9 Results

New layout changes have been taken into use in all locations. New production area where meter and module area is merged increased productivity between 26.8% – 28.2% depending on the product that is produced. Warehouse area storage capacity increased by 15%-60% depending on the area. Repair area has been moved close to customer return area and turned to be the self-contained area. Material mixing between repair and production has been eliminated and unnecessary movements between locations have been decreased to the minimum.

8 Future Improvements

For the future improvements the goals should focus on module production, module software and meter labeling improvements. New production goal that has already started to be investigated is modified RF-module with RJ-45 connector that decreases NVA ration and improves Throughput time. This improvement would also erase two phases totally from VSM measurements and increase operational reliability because

connectors functionality are tested in tests benches, instead of the cables that are out-sourced and sent to customer with modules.

This module update would increase throughput time by 3.9% and if software update would reduce flashing and testing time for modules then throughput time would improve even more.

To improve meter labeling, Aidon should start to use laser marking instead of using printed stickers for products. All meters have their own serial number that is printed on sticker and placed on meter that has the same serial number. Laser marking would help with quality issues with bad printing and also eliminate the risk that sticker with wrong serial number is placed on another meter.

9 Summary

The main target of this study was to improve Aidon Customization Centre layout and production process by using Lean methods and Six Sigma DMAIC improvement tool. The theory part contains information about Lean, Six Sigma and DMAIC philosophy and the basics and practicalities of the methods. With this information it was possible to study the project, plan improvements and later on implement the improvements in layout and in production.

Value stream map was used for old production method that revealed issues such as bottlenecks and wastes in on-going process. A new layout plan was made to reduce wastes and eliminate bottlenecks and Six Sigma DMAIC improvement tool was perfect solution for correcting both of these problems. A new layout merged meter and module production that successfully increased speed, quality and productivity in the merged area, and separated repair area from production area to be self-contained unit. Layout change also reduced material movements on floor and increased warehouse storage capacity.

New layout was successfully implemented in production use and value steam map was done to see results between old and new production method. NVA and VA time were decreased that increased throughput time approximately 30% for products.

As the future improvements, meter and module production should have more automation combined in production methods, that would improve the working environment by helping with quality issues and decrease operator failures in test cells.

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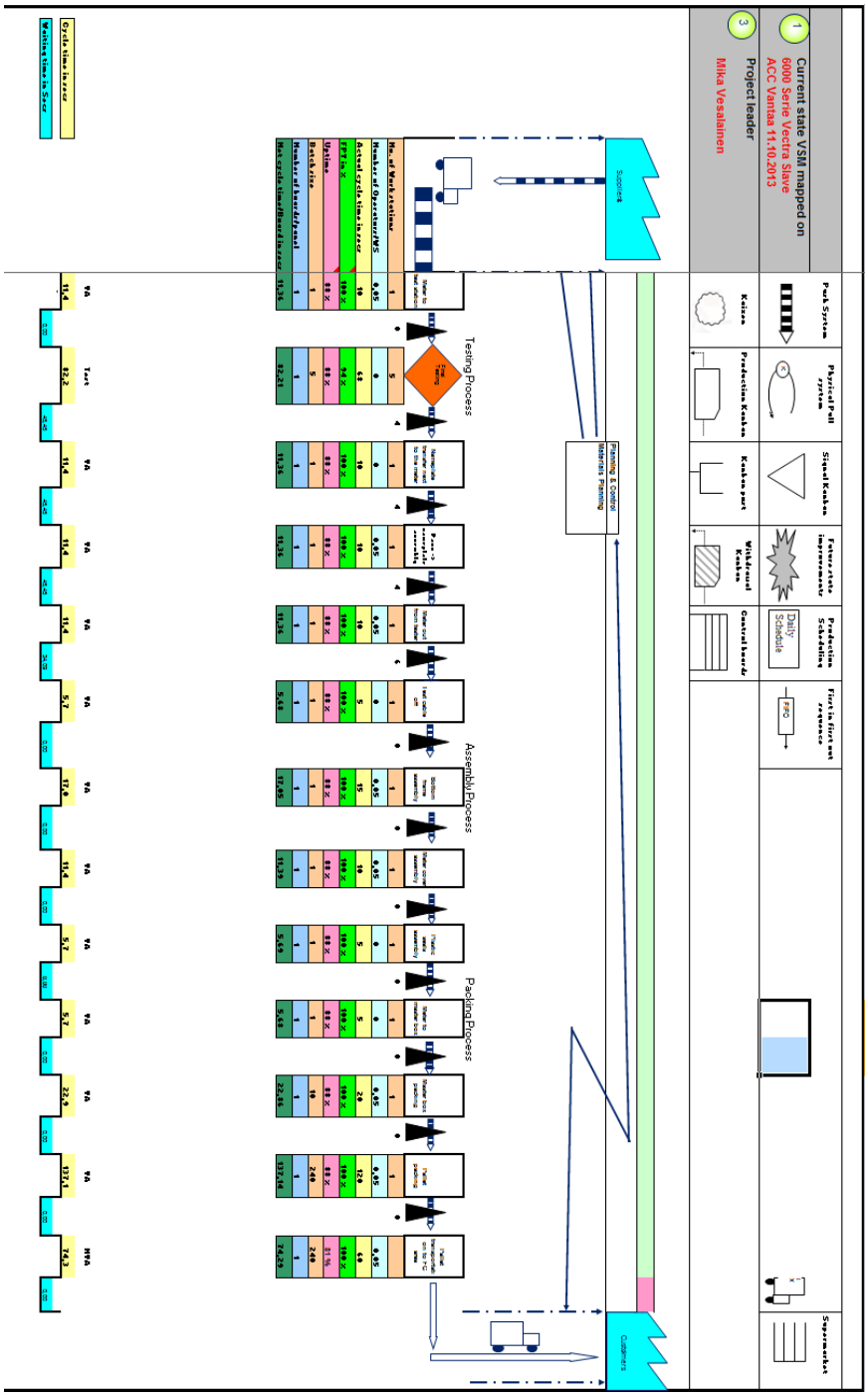
Appendix 1. Value Stream Map with comments/Production Steps



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