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An analysis to increase the productivity of a surface mounting line

Master Thesis report in Production Engineering

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by

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Abstract

Aros Electronics is a company that develops and produces printed circuit assemblies from printed circuit boards. Recently Aros has made a large investment in a new surface mounting line. To maximize usage of their investment, it is important to analyze and improve the manual work around the machine, in order to make sure that the productivity is high.

This master thesis report aims to analyze and give suggestions to improve the productivity, at a surface mounting line, at Aros Electronics. Most of the gathered data came from a work sampling study of the operators at the line, and from machine logs. Besides the gathered data, observations were also done during the sampling. The data was then analyzed to find the major losses in the system, which were the changeovers, machine stoppages and the breaks. By connecting the observations with the analysis, it was possible to determine that the lack of standardization, was the largest reason to the losses.

To increase the standardization of the changeovers, a division of the work tasks and standardized worksheets were created; in addition, a SMED analysis was done, together these changes reduced the theoretic changeover by 91 %. A work division was created for the manual work besides the changeovers as well, in order to reduce the machine stoppages; however, the impact these changes can only me measured if they are implemented. Therefore no quantified data is available for the improvements of the machine stoppages. By rearranging the breaks, it should be possible to remove their impact completely. By combining the improvement from the changeover and the breaks a theoretical production increase of 84 % was reached.

Keywords. changeover, SMED, productivity, surface mounting technology.

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Fredrick Bergström & Niklas Palmkvist, Göteborg October 19, 2014

Glossary

AOI — Automated optical inspection, an automated inspection of PCAs for component displacements or soldering errors.

ASM — The company which developed and produced the new pick and place machines.

CPH — Components placed by hour.

Data gathering period — 2014-03-05 to 2014-03-25

KPI — Key performance indicators.

Moisture sensitive components — Components which can only be exposed to air for a certain amount of time.

MPU — A way to measure productivity described by Almström and Kinnander (2011).

MTM-SAM — A predetermined time system.

Other stops — Stops in the ASM machines which have not been categorized.

PCA — Printed circuit assembly, a PCB with components on.

PCB — Printed circuit board.

SMED — Singular minute exchange of die, a method developed by Shingo (1985) to reduce changeover times.

SMT — Surface mounting technology, a method of mounting and fastening components to a PCB.

Contents

1 Introduction

The master thesis aims to analyze and give suggestions of improvements on the surface mounting line at Aros Electronics, in order to improve the productivity. This chapter aims to introduce the reader to this master thesis and give a introduction to the subject and the company.

1.1 Company introduction

The analysis was done at Aros Electronics, which is located in Mölndal Sweden. Aros Electronics is a medium sized company that develops and produces printed circuit assemblies (PCA), which is a printed circuit board (PCB) with components added. The main focus for Aros, is to develop and produce customer specific solutions, for motors and drives. Aros has a wide range of customers in areas including vehicle and industry, this also leads Aros to have a large product portfolio of over six hundred products, but less than a hundred products are produced at a regular basis. The goal is to continue to produce at a medium sized quantity, but also to increase the efficiency and output from the production, in order to improve the profitability of the company.

1.2 Background

Aros Electronics has a surface mounting department, which consists of two surface mounting technology (SMT) lines. Recently Aros made one of the largest investments in their history, in new higher capacity pick and place machines, for one of the SMT lines. These are four new ASM pick and place machines, all placed in serial. For the future Aros plan to increase the machine count to six machines, in serial, in order to remove the other line. The reason behind the investment is to keep up with the increasing demand of their products. All products produced at Aros needs to go through the SMT lines, therefore they need to have a high capacity and flexibility, which is what Aros hopes to achieve with this new investment. To use the new investment as efficient as possible, it is important to analyze the manual work procedure and to constantly improve it, in order to have a high productivity in the machines. To reach the goal of having a high capacity and a high flexibility, it is important to have work methods that support these goals while still keep a low cost.

1.3 Project description and purpose

The project will analyze the current situation at the new SMT line, at Aros Electronics, to find production losses. When the losses are found, they will be analyzed to find the underlining problems.

The purpose of this project will therefore be to find solutions for the problems, to ensure that a high productivity is reached at a low cost, and that the lines capacity covers the demand of their products.

1.4 Delimitation

The thesis work will be done during a 20 week period, at Aros Electronics in Mölndal. The analysis will be done on the SMT line and therefore not include any workstation after the automated optical inspection (AOI) station. The description of the current situation is based on data gathered from 2014-03-05 to 2014-03-25 and therefore any changes in the production system past that time will not be considered, for future reference this period will be called the data gathering period.

1.5 Goals

The goal is to present a solution to increase the productivity of the SMT line at Aros Electronics. To reach this goal some sub goals has been constructed to help in the project. These are:

- An analysis of the different work tasks and how the operators spend their days.
- An analysis of the machine data.
- An analysis of the changeover procedure.

1.6 SMT at Aros Electronics

Surface mounting technology is a technique of soldering components on the surface of PCB, instead of through holes in the PCB. This process allows for a higher component density and a lower manufacturing cost(Rob and Bergman, 1999). A screen printer applies solder paste to a PCB, each component is then placed individually onto the PCB, with a pick and place machine. When all components are in place, the PCB is sent into an oven, which melts the solder paste and fastens the components. After the fastening is complete, the PCB (which is now actually a PCA) is sent to the AOI station, which detects if a component has been misplaced, or if a solder joint is insufficiently made. If there is a defect, an operator adjusts it manually at the same station. The flow of products between the stations is illustrated in figure 1.1.

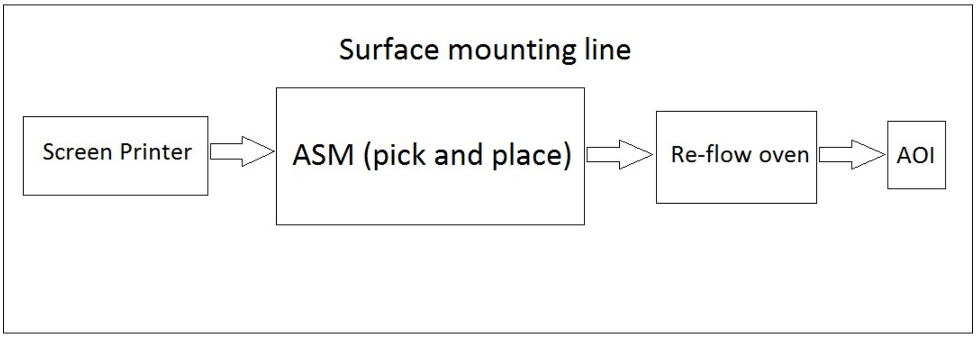

Figure 1.1: Product flow of the surface mounting line

1.6.1 The screen printer

There are different techniques of applying solder paste, Aros uses a screen printer, which applies the paste by smearing it on the PCB through a stencil. The stencil is unique to each type of PCA and ensures that the solder paste is applied only where it is needed. In figure 1.2 the removal of soldering paste in the screen printer is shown.

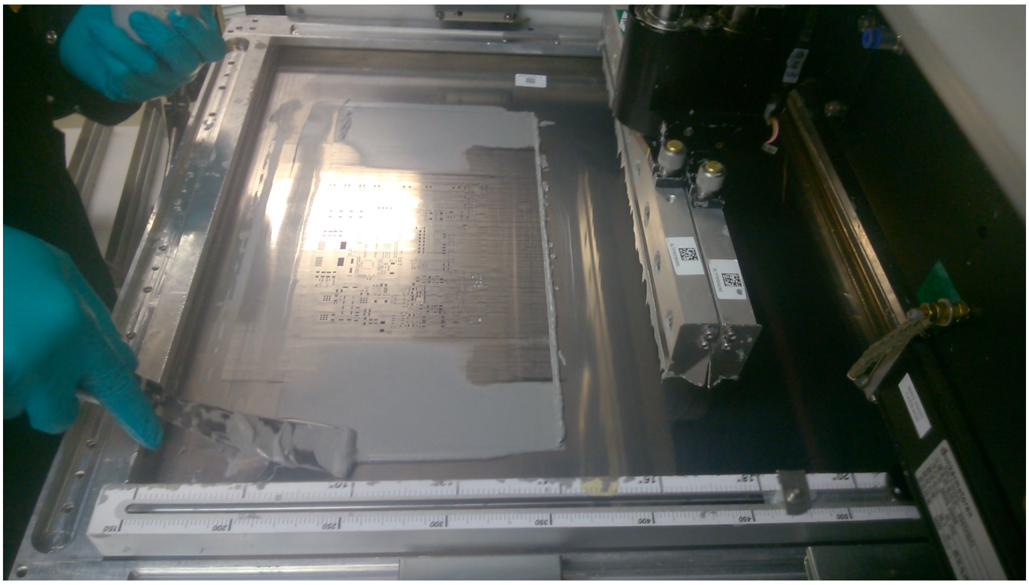

Figure 1.2: Removal of soldering paste from a stencil in the screen printer, during a changeover

1.6.2 The ASM line

The ASM line consists of four pick and place machines, placed in serial. Each machine is loaded with components from two sides, as illustrated in figure 1.3. Most components arrive on rolls; one roll can contain up to 15000 components. In order to load a roll into a

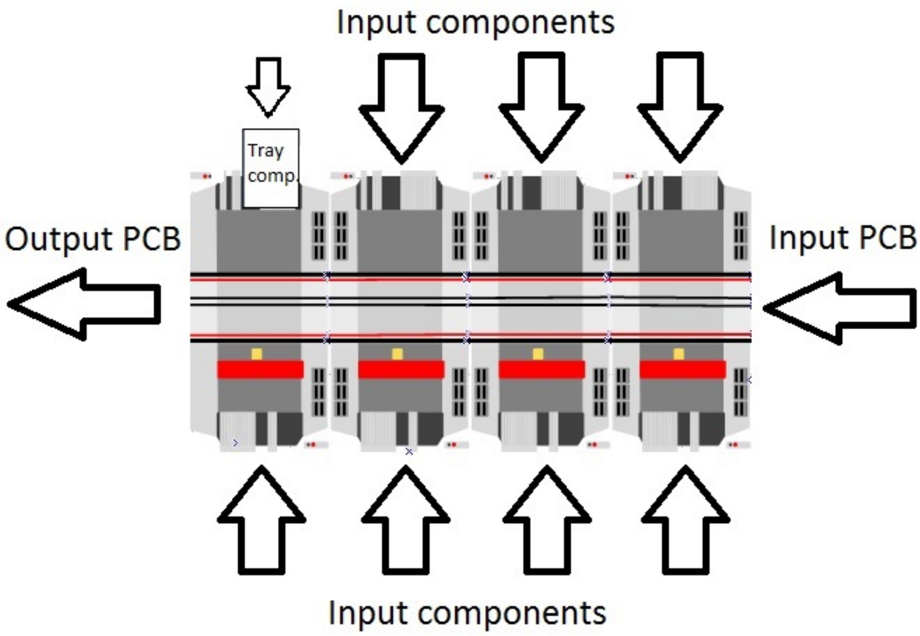

Figure 1.3: Over head view of the ASM line and the material flow

machine, the roll has to be mounted to a feeder, which is then loaded into a trolley, which is loaded into the machine. Because the trolley can contain many feeders, it is possible to change more feeders at same time by changing a trolley, allowing faster changeovers. Figure 1.4 shows an ASM machine loaded with roll components. Components can also be purchased as sticks; one stick do not contain as many components as a roll, which is why sticks are used when only a few components are needed. Special components, such as chip, are loaded into the machine on trays, into a tray elevator which is a small cabinet able to contain several trays during production. Additionally, there are moisture sensitive components, which can only be exposed to air for certain amount of time. Therefore, the moisture sensitive components need to be stored in vacuum, when they are not in use. The first three machines are identical, apart from the components loaded. The last machine is equipped with a picking arm, able to grip larger components; it is also equipped with the tray elevator.

Figure 1.4: One ASM machine with mounted roll components

2 Theory

Every production need a strategy, defining the goals the company and the production are striving towards. Measurements have to be done to support the strategy and from the information gathered by the measurements, improvements can be made. The goal of the theory chapter, is to include a theoretical framework for the most important areas for this thesis.

2.1 Manufacturing Strategy

The process of making changes in a company, is usually slow, regarding the layout, the machines or the organization. Therefore, it is important that all the choices which is made, strives towards the same goal, this is were the manufacturing strategy plays its part (Miltenburg, 2005). By clearly stating a manufacturing strategy, it is possible to make the right choices, at the right time. It is also possible to see if the decisions and choices fit the chosen strategy, if they don't they are probably the wrong choices and should be rethought.

2.1.1 Key performance indicators

The only way to quantify the performance of a production, is to measure different parts of the system, these measurements are called performance indicators and show how well the different parts of the system perform. Based on the strategy, it is possible to determine the most important measurements, these are called the key performance indicators (KPI) (Slack et al., 2007). If measured properly, KPIs show the improvement potential in the different areas, allowing strategic choices to be made. If the KPIs are continuously measured, it is possible to show the effects of changes in the production, and which choices have the desired effect.

One of the most important KPIs for a production is the productivity. Productivity is, according to Hannula (2002), defined as how well a company uses its resources, which can be expressed by the formula 2.1, where the output is the output from the system and the input is all the resources that has been used.

$$Productivity = \frac{Output}{Input} \tag{2.1}$$

A problem with this definition which is formulated by Almström and Kinnander (2011), is the difficulty of measuring the input and that it changes whenever the workforce changes. Therefore, Almström and Kinnander (2011) suggests that productivity and especially productivity increase, should be measured with the formula in 2.2.

$$Productivity = Method * Performance * Utilization \tag{2.2}$$

Where the method is calculated by 2.3 and it represents the frequency of which products leave the system if the tact time is kept. The performance is given by 2.4, it represents the speed that parts are being manufactured. The utilization is calculated according to formula 2.5 and it describes at what ratio a resource is being productive and not.

$$Method = \frac{1}{Tact\,time} \tag{2.3}$$

$$Performance = \frac{Processing\,time}{Tact\,time} \tag{2.4}$$

$$Utilization = \frac{Productive\,time}{Planned\,manufacturing\,time} \tag{2.5}$$

By expressing the productivity in this way it is possible to determine which factor needs improving. To improve the productivity of a line of resources, it is possible to either reduce the tact time (improving the method), increase the speed (improving the performance), or to reduce the nonproductive time (improving the utilization).

2.1.2 Material requirement planing

Material requirement planning (MRP), is a system for planning the production and it can be a part of the manufacturing strategy. By using a MRP system it is possible to reach a feasible production plan. According to Slack et al. (2007), the MRP system requires four different types of inputs: customer orders, forecast demand, inventory and bill of material. In figure 2.1 a flow chart of a MRP system is shown, in this system a master production schedule is created, from the customer orders and the forecasted demand. By combining these it is possible to determine if the production system can produce the decided amount, during the desired period. If the production systems capacity is enough a material requirement list is created, the list is then checked against the available material in the inventory. If there are any material missing and the suppliers can't deliver in time, the master schedule need to be reworked.

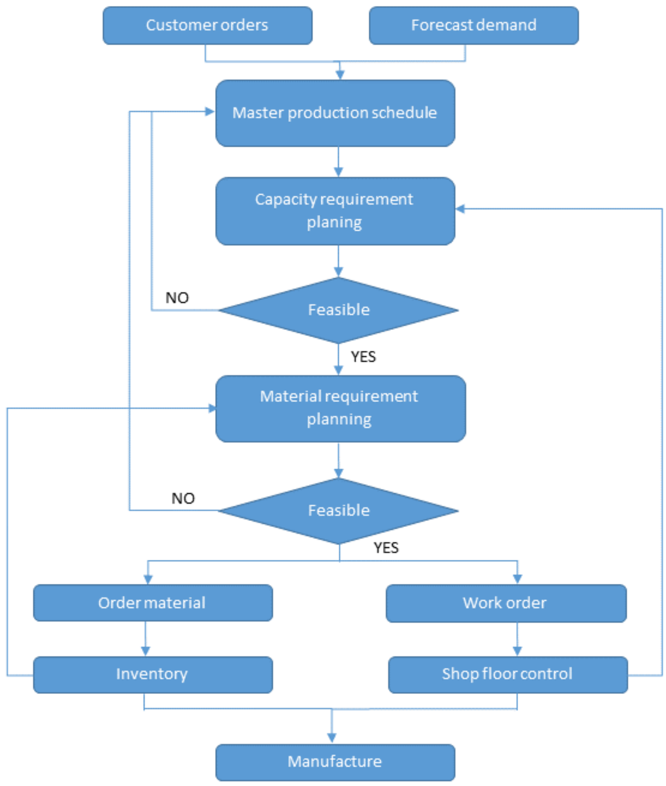

Figure 2.1: A flow chart of a MRP system

2.2 Work Sampling

Work sampling is a method to investigate at which rate different operations occur during a time period, which enables the possibility to determine the amount of time spent on wasteful activities and which activities that consumes the most time. By knowing the distribution of the activities, it is possible to prioritize which activities to improve.

Work sampling can either be done manually or with an automated system. Equation 2.6 is used to calculate the needed samples with a confidence interval level of 95 % and a accepted error of 10 %, p stands for the probability that the operation occur (Robinson, 2010). This makes the choice of how detailed the work sampling will be important, too detailed and there won't be enough samples to be statistically certify. By using the formula it can be calculated that if an operation that occupy a resource for about 10 % of the time, then 3457 samples are needed to ensure it statistically.

$$N = \frac{1.96^2 p(1-p)}{0.1 * p^2} \tag{2.6}$$

2.3 Standardized work

To standardize a work method, is to specify which operations and in which order they should be performed to complete a work task. The reason this is important is that without a standardized work method it is impossible to improve it (Allen et al., 2001). When the method is standardized, it is possible to determine the time it takes to perform the task, making it possible to balance the different work tasks between operators. Another effect of standardized work is a reduction of the variance in both quality and operation time (Maynard and Zandin, 2001).

When implementing standardized work, it is important that the operators are involved when creating and maintaining the standard, since the operators knows the process best and because they are the ones who will be using it (Allen et al., 2001). Also, by involving the operators from the beginning, increases the likelihood that the standard will be followed, and the standard is useless if the operators do not use it.

According to Allen et al. (2001), there are several factors that needs to be considered to achieve a standard, these factors are: all the operations required to complete a task, all safety procedures needed in each operation, a visual representation of where each operation takes place, the timing for each operation, and the total tact time.

By using standardized work and constantly improving it, the productivity will be improved, which also leads to reduced costs (Maynard and Zandin, 2001). A maintained standard enables the possibility to distribute the best practice among to operators, it also helps with the introduction of new operators.

2.4 SMED – Single minute exchange of die

SMED is a method for analyzing and reducing setup times. It was originally developed by Shigeo Shingo and it consists of three steps (Shingo, 1985).

1. Separating internal and external setup
   This means separating which actions that could be done while the machine are running (external) and the actions which are necessary to do while the machine are not running (internal).

2. Converting internal to external
   Analyze the internal set up actions and determine if any could be converted to external, allowing less downtime for the machine.

3. Streamlining all aspects of the setup operation
   Analyze and improve each operation both the internal and the external setup work, to make each operation quicker.

The method is an iterative process, which reduces the setup time each iteration.

3 Method

The project method consists of two steps, data gathering and data analysis. The goal of the data gathering was to acquire data, in order to determine the problems of the company; while, the data analysis step was done to find solutions to the problems. In order to gather sufficient data, data gathering methods have been used, these will be presented in this chapter; additionally, the data analysis method will be further explained.

3.1 Data gathering

The data gathered derives mostly from work sampling, machine logs and observations. The quality of the data is important, since bad data may lead to the wrong conclusions in the end; therefore, a significant part of the data gathering was spend to validate the data.

3.1.1 Work sampling

The work sampling was done during the first phase of the project. The focus of the study was the operators involved with the ASM line. During the 14 workdays of the data gathering period, 3400 samples were collected on the main operator. During the same period, 2700 additional samples were collected from other operators, affecting the ASM line. The samples were distributed over the different shift teams, during different parts of the workday, in order to make sure no shift- or time dependent event was missed. The number of collected samples on the main operator is enough to statistically certify tasks occurring more often than 10 % of the time, with a confidence interval of 95 % and a accepted error of 10 %.

3.1.2 Machine data

Each ASM machine, log information such as: each time a product leaves the machine, processing time and when errors occur; based on the logs it generates information regarding: down time, productive time, time starved or blocked. From observations, it was noticed that the automatically generated information was incorrect; it displayed the machine as productive during breaks. Therefore, the machine logs were used to create correct information regarding productive- and down time. Using the logs was also the

Panel ID	Timestamp	Job/Recipe	Board	Setup	Shift	Processing Time	Line Takt
7633	22:43:04, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:18.172	0:01:20.473
7632	22:41:42, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:20.594	0:01:20.473
7631	22:40:18, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:17.812	0:01:20.473
7630	22:38:56, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:21.015	0:01:20.473
7629	22:37:32, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:18.094	0:01:20.473
7628	22:36:10, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:20.891	0:01:20.473
7627	22:34:45, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:18.562	0:01:20.473
7626	22:33:23, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:20.672	0:01:20.473
7625	22:31:59, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:18.141	0:01:20.473
7624	22:30:37, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:20.875	0:01:20.473
7623	22:29:08, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:18.266	0:01:20.473
7622	22:23:31, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:20.938	0:01:20.473
7621	22:20:17, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:18.422	0:01:20.473
7620	22:18:55, 10-mar-2014	1360-102-04	1360-102-04	1068, 1294,1360V10 @ 14-03-06 16:41:28 [39207]	Shift 2	0:01:20.812	0:01:20.473

Figure 3.1: A example of a machine log from a ASM machine

only way to acquire changeover lengths. The logs were collected during the entire data gathering period.

3.1.3 Observations

A positive effect of the work sampling was that about 28 hours were spent at the SMT-line, observing operators and their work tasks. The observations aren't quantifiable as the work sampling and the machine data, but it gives an understanding of the flow of the production and the different problems that arise during a workday. A combination of the sampled data, machine data and the observations gives a coherent image of the whole system.

3.2 Data analysis

In figure 3.1 a small part from a machine log is shown, each row represent a specific PCA. The logs were downloaded in an excel format, where the timestamps were used to determine the time between each product. By comparing the time between each product with the tact time, it was possible to determine if a stop occurred and its length. If the Job/Recipe column changes from one row to another, it is possible to know if a changeover occurred. By categorizing the stops to changeovers, breaks, start-up, end of day resetting and *other stops*, it was possible to determine the impact of each category. The work sampling resulted in samples on 60 different tasks. The tasks were grouped up into larger categories such as, changeover and handle disturbances, in order to determine the time spent on each category.

4 Current Situation

At the current situation the only KPI which is measured on the SMT-lines are components placed per hour (CPH). The target is to place 35 000 CPH, because it is the number of components placed, needed to satisfy the demand. During the data gathering period the average CPH in the ASM-line were 12 400, which is considerably lower than the needed amount.

4.1 Organization in the SMT-line

Aros run two shift teams on the SMT-lines, the morning shift work Monday to Friday 6:00-14:30, while the evening shift work Monday to Thursday 14:00-23:15, the shift teams swap every week. At the shift change from morning to evening, there is a 30 minutes overlap, in order to exchange any needed information. However, between the evening and the morning shift, there is no agreement on how to exchange information; occasionally the operators leave notes to the other shift team. There is no standard for what information the operators are supposed to pass on to one another.

The workforce are uneven divided between the shift teams were one consists of four operators while the other consists of five. The morning shift have one 10 minutes break and a 45 minutes lunch, while the evening shift has a 30 minutes dinner break and two 10 minute brakes, all operators have their break at the same time. During the breaks, all operators leaves the production. Because of safety reasons, PCAs can not be in the oven when unattended, therefore, the flow into the oven has to be turned off, before the break starts.

4.2 Workstations in the SMT-line

Most often the SMT-lines are driven by four main operators, one occupying each of the pick and place machines, one the storage elevator and one at the AOI station in the ASM-line; in addition, up to two flow technicians may aid the production if they are not occupied with other tasks. However, the staffing often differ, due to either sick leave or that a problem have occurred in another division of the production, and therefore require extra personnel. There are occasions when the personnel is temporarily increased as well, due to trainees and practitioners coming and leaving.

There exists a few work task instructions for the old machines; generally, these are not updated or used by the operators. For the newer machines there are no instructions at all yet, neither are there any specific instructions specifying which tasks each operator are supposed to focus on. Figure 4.1 shows the current layout.

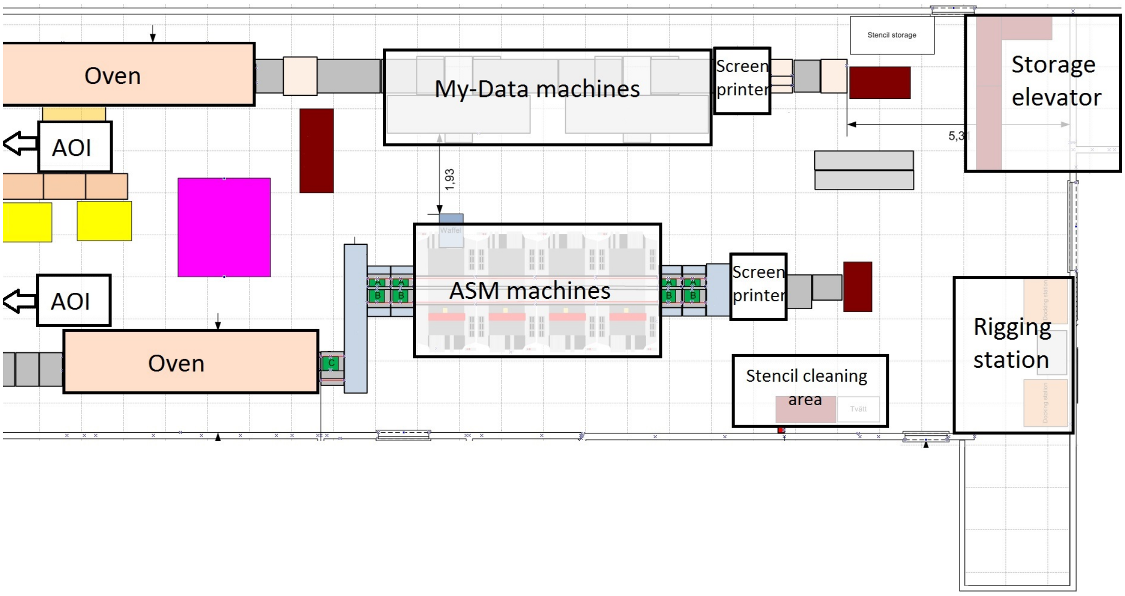

Figure 4.1: Workplace layout with the different workstations

4.2.1 Storage elevator

The goal of the storage elevator workstation, is to supply the My-Data-, the ASM- and the rigging station with components, while also inserting components into the storage elevator. During the gathering period there was often someone absent due to sick leave in the SMT department. Because the storage elevator has the lowest priority, the workstation is not manned full time during that period, since the operator is moved if there is a need elsewhere.

The machine operators are responsible for fetching the components needed during operation, from the storage elevator. In the worst case scenario, three operators need components from the storage at the same time, which lead to queuing.

Many components are not inserted into the storage immediately, this has several reasons, but, the two most common are that the storage is full and that it is not prioritized. Which makes the work station unorganized and it can be hard to find the components. In figure 4.2 a shelf from the storage elevator is shown.

4.2.2 ASM

The ASM station is always manned, the purpose is to make sure that the pick and place machines are continuously producing PCAs, which means, refilling soldering paste in

Figure 4.2: A shelf from the storage elevator with roll components

the screen printer, refilling components in the machines and making sure that no errors occur. When an error do occur, it is also the ASM operators' responsibility to fix the problem as quickly as possible, in order to minimize the stoppage time of the machines. The operator knows if an error has occurred, by watching the ten different light bars or one of the five screens (four on the ASM line and one on the screen printer). The refilling is divided into soldering paste, component rolls, tray components and stick components as well as refilling of PCB into the screen printer. Components on rolls are the most common in the production. When a roll component is about to run out, a new roll of the same type is spliced on the existing one, in order to refill the component without stopping the machine. The operator knows what to refill by observing a screen, which displays the remaining time until each component runs out. During the data gathering, the flow technicians spent much of their time helping the operator at the ASM machine by refiling components and handling disturbances. Figure 4.3 shows the work task distribution of the ASM operator based on the work sampling. The categories, *searching for something* and *wasteful material handling*, derives mostly from disorganization in the work area. The full work sampling results can be found in appendix A.

4.2.3 My-Data

The My-Data line is much slower than the ASM line, which makes it possible for one operator to run the machine and also help-out at the AOI station on the same line. Since this line will be removed in the future, it has not been included in the study.

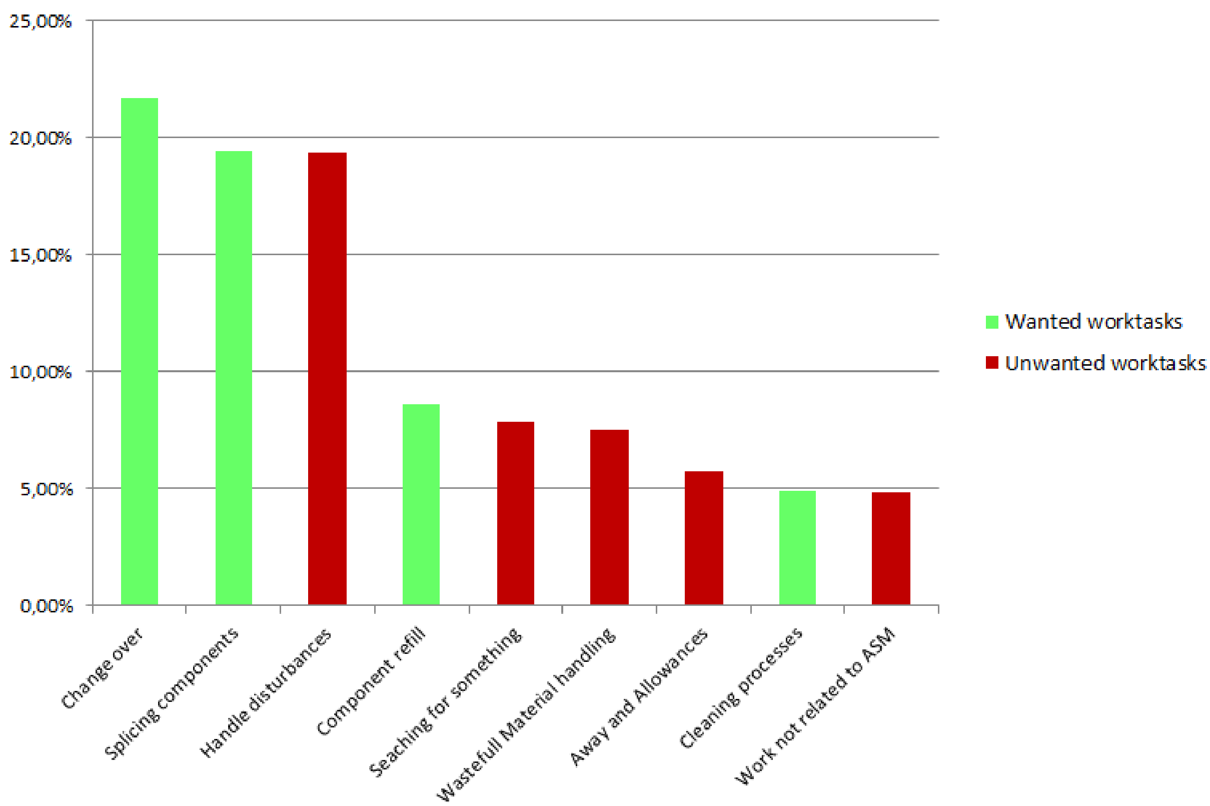

Figure 4.3: Work task distribution for the ASM operator during the data gathering period

4.2.4 Rigging station

At the rigging station, trolleys are loaded with the feeders, which are loaded with the components needed for the next batch, at the ASM line. No personnel were specifically responsible for doing the preparation of the trolleys, and only a few had the knowledge to do it. The trolleys were therefore rarely prepared, before the changeover, which led to unnecessarily long changeovers. In figure 4.4 a trolley is being prepared for the next changeover.

4.2.5 AOI

The AOI on the ASM line is always manned by an operator, while the AOI at the My-Data line operator works on the other AOI station. At the station the soldering is inspected and it is reworked if needed, when they are done the products are inserted into racks for transport for further work.

Figure 4.4: The rigging station

4.3 Changeover procedure

In the machines there are more components slots than required for one product, therefore it is possible to load components for a few products at the same time. In order to utilize the component slots as efficiently as possible and to minimize the number of component changes, similar products are grouped up together into families. Instead of loading the machines with components for one product at the time, Aros loads components for a family. By using this method more preparations are needed for each family but less between each product within the family. In the report a change between product families will be labeled as a family changeover, while a change between products within a family will be labeled as a product changeover. In order to further reduce the number of component changes, four out of the eight trolleys are used for the most common components and are changed more rarely than once a month.

4.3.1 Family changeover

The family changeover can be divided into internal and external changeover. The internal changeover consists of five work tasks, which can be completed simultaneously, these are changing: trolleys, stencil in the screen printer, tray components, conveyor width and the machine program. The external changeover consists of preparing: Trolleys, tray components, PCBs, moisture sensitive components and equipment for screen printer. Since the moisture sensitive components can only be exposed to air for a set amount of time; it is not possible to prepare them other than, right before the changeover. During the observations, it was however never the case that the external part was finished before the internal changeover began. Therefore, the time and the work tasks differed each changeover, depending on how close the preparations where to be complete. Another factor increasing this behavior during the changeovers, was that the work force participating in each changeover differed.

4.3.2 Product changeover

The internal part of a product changeover is similar to a family changeover, with the exception that no trolleys need to be changed. However, the moisture sensitive components needs to be loaded onto the trolleys. Because no trolleys need to be changed, no trolleys need to be prepared; the external part is otherwise the same as with the family changeover.

4.3.3 New products

Whenever a new product is introduced to the ASM line, one PCA is produced and inspected before the rest of the batch is manufactured, in order to ensure that the program has been correctly made. If there is an error, the program is changed and another test PCA is manufactured. When a PCA is approved the rest of the batch is started.

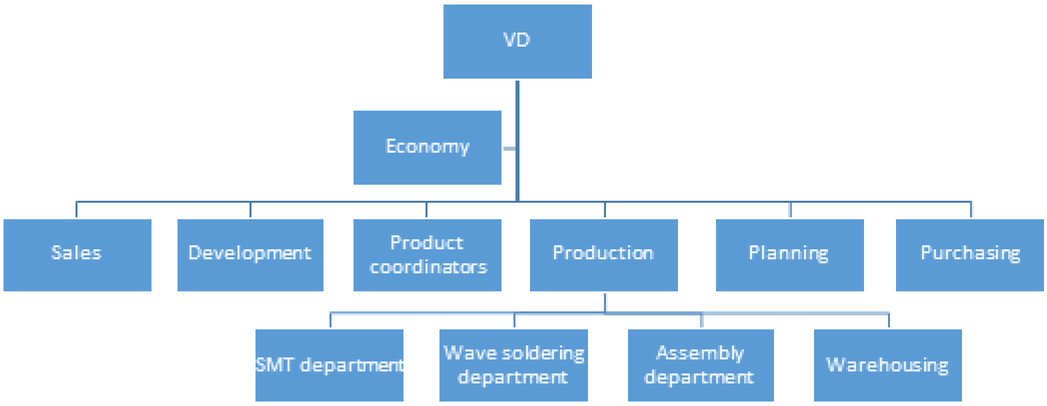

Figure 4.5: The organization structure of Aros

4.4 Organization

Aros consists of several departments, that works together to develop and produce PCAs, the structure is illustrated in figure 4.5. The departments that closely affect the SMT lines are development, purchasing, product coordinators and the planning department. When the developers are done with the development of new products, the products are then handed over to the product coordinators for production.

The idea is that the purchasing and planning departments should work closely together. This is done by having the planning department plan production four weeks ahead, so the other departments have time to get the needed components available for production. But, unfortunately the plan is usually changed along the way; there are two reasons behind this. The first is that the SMT- lines are not producing enough PCAs, which makes Aros behind on the deliveries to their customers. The second is that the purchasing department has not been able to acquire the needed components. When the production is behind on schedule, last minute changes in the plan are made to satisfy the customers needs.

4.5 Bottlenecks in the production

Because of the large portfolio there is a difference in the number of components, between the products. This leads to a variation of the cycle time in the ASM machines; the cycle time varies between seven seconds up to over two minutes. The cycle time in the screen printer is about 30 seconds, therefore, the bottleneck alternates between the screen printer and one of the ASM machines, depending on the product. When the cycle time in the ASM machines is lower than 30 seconds, the screen printer is the bottleneck, when it is higher one of the ASM becomes the bottleneck.

5 Analysis

The only KPI from the SMT which is measured is CPH. If the maximum CPH is known, it is a good measurement of the productivity. However, the max capacity of the ASM line is unknown and is varying for each type of PCA. In addition, the CPH measurement does not provide any information about problem areas, which could help improving the system. By instead measuring the productivity as shown in equation 2.2, using method, performance and utilization, it is possible to determine in which category problems occur. In table 5.1, the measured MPU for the ASM line can be found during the data gathering period.

The method value represent the frequency in which it is possible to produce PCAs (1/*tact time*). The tact time for each PCA is determined by an optimization process, which specifies the feeder positions for a family set-up, in the machines. The optimization process is an iterative method which is run for a set amount of time. The method test feeder configurations one by one, and chooses the configuration with the shortest processing time, for the entire set-up. The optimization is run for at least 30 minutes which is recommended by ASM. By running the optimization process longer than 30 minutes or reducing the amount of products in a family, it would be possible to improve the method factor, however, the potential is assumed to be rather small.

Since the speed of the machine is never reduced from it's maximum, the performance factor is 100 %.

In order to identify the utilization of the ASM machines, the productive time was compared to the non productive time, this is shown in figure 5.1. The resulting utilization was determined to be 31.6 %. Therefore, the analysis will focus on the utilization.

Table 5.1: The productivity divided into M, P and U for the data gathering period

Date	M (PCA/Hour)	P (%)	U (%)	M*P*U (PCA/Hour)
2014-03-05	61.54	100	24.4	15.01
2014-03-06	43.29	100	51.02	25.93
2014-03-07	47.37	100	17.88	8.47
2014-03-10	44.73	100	51.19	22.89
2014-03-11	45.58	100	28.11	12.81
2014-03-12	51.55	100	35.86	18.49
2014-03-13	39.24	100	49.67	20.29
2014-03-14	58.04	100	11.15	6.47
2014-03-17	172.44	100	14.15	24.40
2014-03-18	74.86	100	16.88	12.63
2014-03-19	55.88	100	34.65	19.36
2014-03-20	62.27	100	32.11	19.99
2014-03-21	47.08	100	22.99	10.82
2014-03-24	42.82	100	21.25	9.10
2014-03-25	39.01	100	40.86	15.94
Average	52.81	100	31.63	16.70

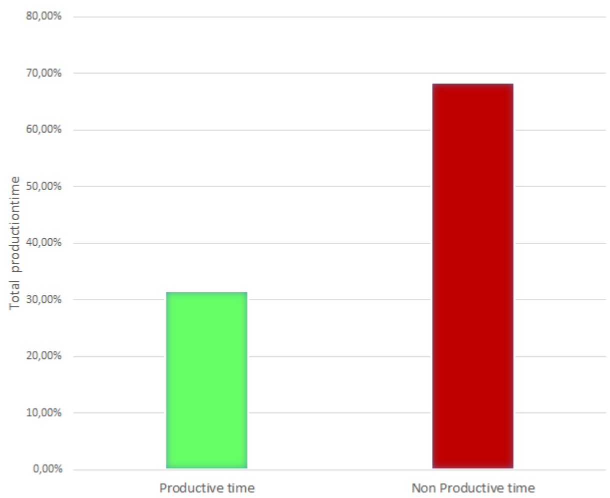

Figure 5.1: Productive and Non productive time in the ASM machine during the data gathering period

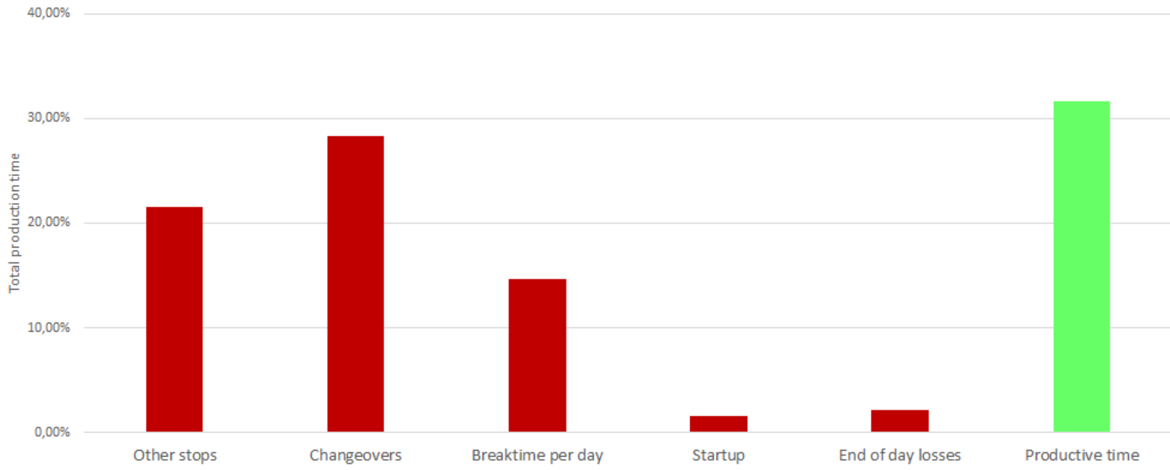

Figure 5.2: Distribution of total production time during the data gathering period

5.1 Losses in production

By analyzing the non productive time, it was possible to divide the it into five different categories: start-up, end of day losses, changeovers, breaks and *other stops*. From figure 5.2, it is possible to determine that changeovers, breaks and *other stops* are the largest time consumers. Start-up and end of day losses consumes about 3,7 % of the total production time, compared to the other losses they are insignificant, which is why the analysis will focus on the remaining three losses, to improve the utilization.

5.1.1 Breaks

During the data gathering period, machine time loss connected to the breaks consumed 14.5 % of the total production time, while the planned loss was 10 %. The difference between the planned and the measured time did not derive from operators having longer breaks, but, from the fact that the flow into the oven has to be stopped 10 minutes before the breaks start. In figure 5.3 the separation between the planned break and the additional lost time is shown. By arranging the breaks so that at least one operator is present in the production during breaks, it is possible to keep the production going, which would increase the theoretical utilization by 37 %.

5.1.2 Changeovers

Changeovers generates more downtime then any other category; about 28 % of the total production time is lost due to changeovers. The changeover can be split into three different categories which are: internal- and external changeover and ramp up, where only the ramp-up and the internal changeover have direct effect on the machines downtime. The distribution between internal- and ramp-up time is shown in figure 5.4. Each changeover differ a lot in time which is shown in table 5.2 and 5.3. From

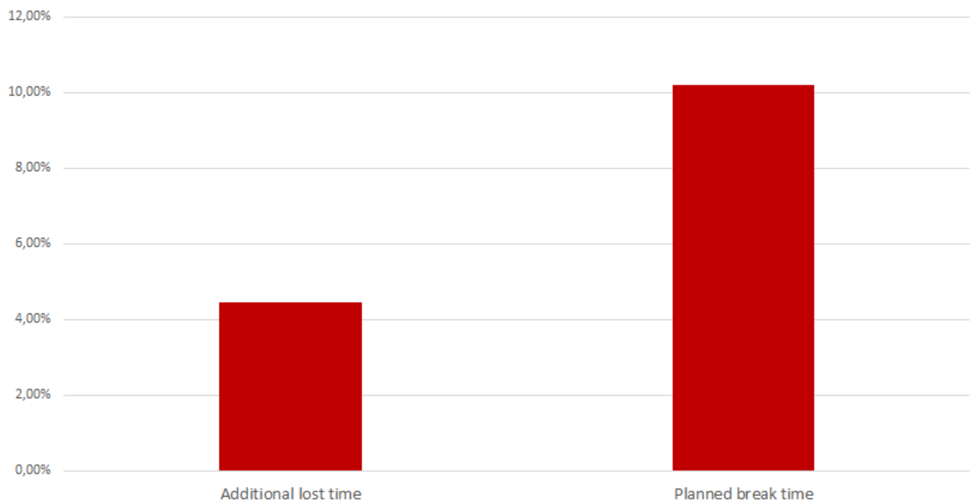

Figure 5.3: The separation between planned breaks and the additional lost time because of them

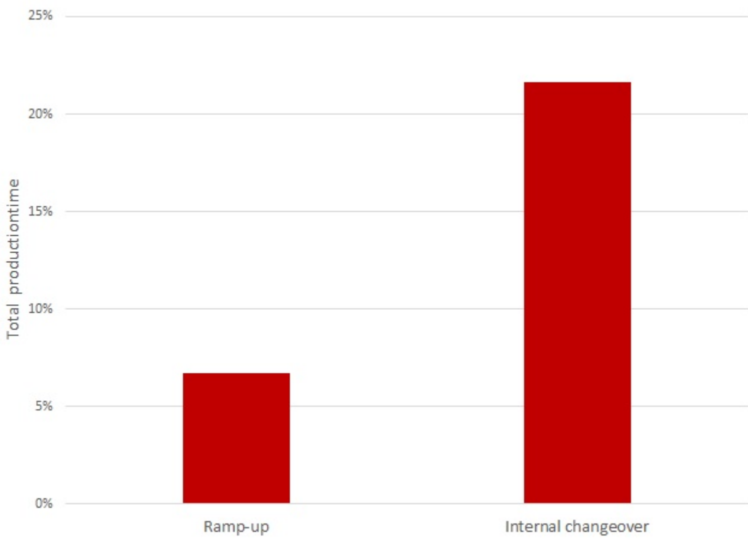

Figure 5.4: Distribution of ramp up and internal changeover

observations, it is possible to determine, that the variations generally originates from the external changeover not being completed on time, thus becoming internal. The fastest family setup performed, was done in 1 hour and 11 minutes, while the average is 3 hours and 17 minutes, which is illustrated in 5.5. Specific times for each changeover during the data gathering period can be found in appendix B and C.

Table 5.2: The average, worst and the best time for 13 family changeovers which occurred during the data gathering period

Family changeover		
	Total time	Ramp up time
Avarage	03:17:13	00:50:20
Worst	06:08:58	02:34:00
Best	01:11:47	00:04:15

Table 5.3: The average, worst and the best time for 19 product changeovers which occurred during the data gathering period

Product changeover		
	Total time	Ramp up time
Avarage	01:38:28	00:28:24
Worst	03:15:18	02:34:00
Best	00:25:49	00:04:15

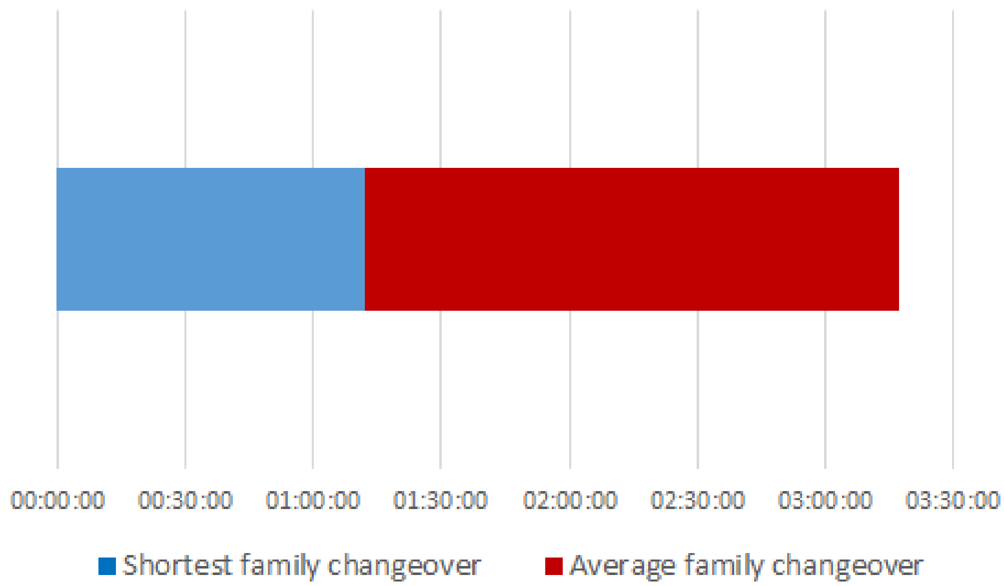

Figure 5.5: Difference between minimum and average setup times

External setup

The SMED method advocates changing internal setup to external (Shingo, 1985), however if the external changeover work cannot be completed on time, this method is rendered useless, since the external becomes internal again, therefore, affecting the utilization directly. The exact time needed for the external setup varies for each family setup, because each type of PCA have a different amount of component. However, shown in appendix D is an approximation based on clocked times, which shows that the time to prepare and reset a family setup, is around 7.1 hours.

During the data gathering period there where 13 family changeovers in total, during the 14 days; an average of less than one changeover each day. With a 17.5 hour long workday and an external work time of 7.1 hours per changeover, it is possible for one operator to complete the external work tasks. Therefore, the reason the external setup is not completed on time, is because it is not prioritized. Appendix D shows that the most time consuming part of the external work, is preparing the trolleys, which is also why the product changeover is considerably shorter than the family changeover.

The key to reduce the changeover times is to minimize the variations caused by the external setup not being complete. As previously mentioned there are no standardized work instructions and thereby no decided responsibilities for an operator, which is, according to Clarke (2005) is a necessity to have, in order to ensure that the preparations will be done. To create standard work instructions, there has to be a fixed number of operators working in the line. If there are problems regarding sick leave, it is possible to create a personnel pool, in order to ensure a stable staffing, however, that is very costly.

Internal setup

The internal changeover is performed differently depending mostly on, how many operators are willing to assist during the changeover and the amount of unfinished external setup work. Therefore, the work tasks differ each changeover and tasks can easily be forgotten. By using a standard, it is possible to divide responsibilities among operators, in order to make sure that no tasks are forgotten. With proper planning, both the flow technicians and the storage elevator operator can be used in the changeover, due to their work tasks not directly affecting the production. Additionally, the AOI operator is usually available, because when the ASM machine is down for setup, no more PCAs arrives to the AOI station. As previously stated it is possible for multiple operators to perform the different setup activities simultaneously, since there are no constraints in which order operations need to be done. Therefore, the most time consuming operation will determine the length of the setup, as long as there are enough personnel working with the setup. From figure 5.6, it can be seen in that the screen printer changeover, is by far the most time consuming setup activity. Therefore, it is the screen printer, which should determine the total changeover time.

The changeover in the screen printer, starts with an operator removing the old soldering paste from the stencil. The stencil is separated from a frame and placed in a washer in an adjacent station. The new stencil is mounted to the frame and moved to

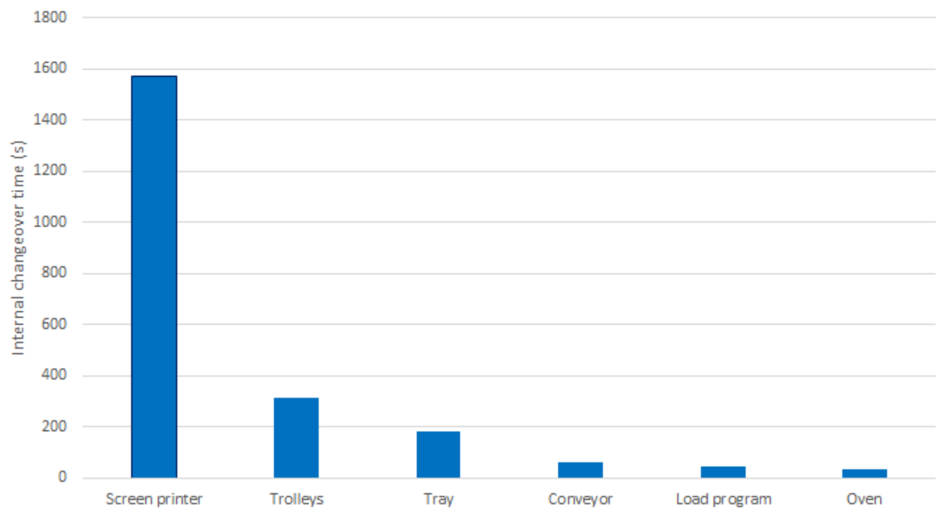

Figure 5.6: Times for internal changeover activities

the screen printer. To make sure that the soldering paste is applied evenly over the PCA, supports are placed within the screen printer. Depending on which type PCA manufactured, the supports are placed differently. The new stencil is loaded into the machine and soldering paste is added. Lastly a PCA is test printed and inspected. This is, a simplified version of the screen printer changeover method, containing only the core activities. To see the complete changeover method see appendix E.

When analyzing the current work method of the screen printer with respect to the first step in the SMED system, internal and external activities was separated, shown in figure 5.7. By placing external work either before or after the setup and having another operator change the conveyor width, a new method which is show in figure 5.8, was developed. The new method reduces the internal setup time from 1570 to 692 second, which is a reduction of about 56 %. By comparing the changeover time using the new method with the average changeover time, a reduction of 94 % should be possible to achieve, which leads to a utilization increase of 47%.

By streamlining all the operations it is possible, according to Shingo (1985), to reduce the changeover even more. This could be done by acquiring better tools to, for example the paste removal process or making a fixture aiding in the placement of the supports.

Ramp up

When a new type of PCA is introduced, one PCA need to be produced, inspected and tested, before the start of the batch, in order to avoid rework. While the PCA is inspected and tested the machines are non productive. The introduction of new products is the main reason behind the ramp up loss. Each type of PCA only need to be tested once, therefore, as more types of PCA have been introduced to the ASM line, less downtime will be generated this way.

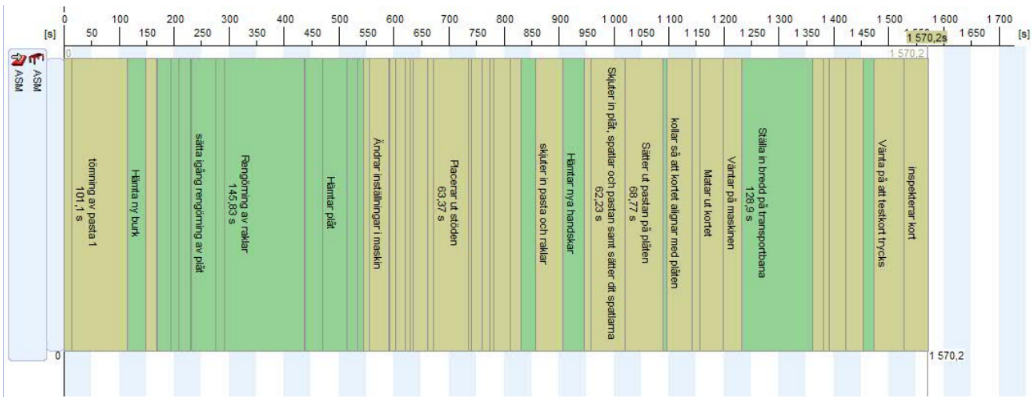

Figure 5.7: Separation and setup categorization of work tasks from screen printer setup

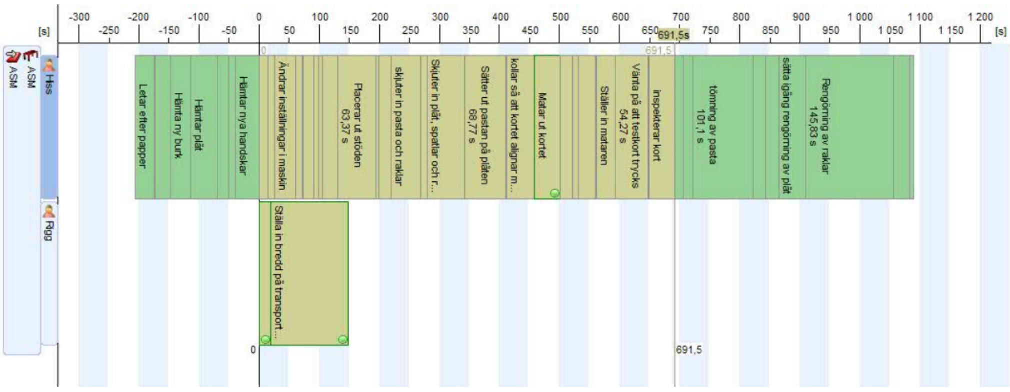

Figure 5.8: New work order assuming minimal investments

Another reason for ramp up time, is that the production is starved before all preparations are complete. The effect is that the machines have to be stopped while the preparations are finished. The underlying reason generating the problem, is that the operators wrongly assumed the preparations to be done, therefore starting the production prematurely. By dividing responsibilities between operators and creating a standard, the problem can be resolved.

5.1.3 Other stops

Other stops represents all the stops in the machines, which are not related to: changeovers, breaks, the start up and the end of the day. The *other stops* consume about 21 % of the total production time. This category of stoppages derives from many different reasons, therefore, a lot of different changes are needed to reduce the stop time. The exact reasons behind each stop and the distribution of each problem, is at this stage, not possible to determine, due to the fact that no data about these stops are gathered. However, much can be said based on observations and the work sampling. In figure 5.9 the *other stops*

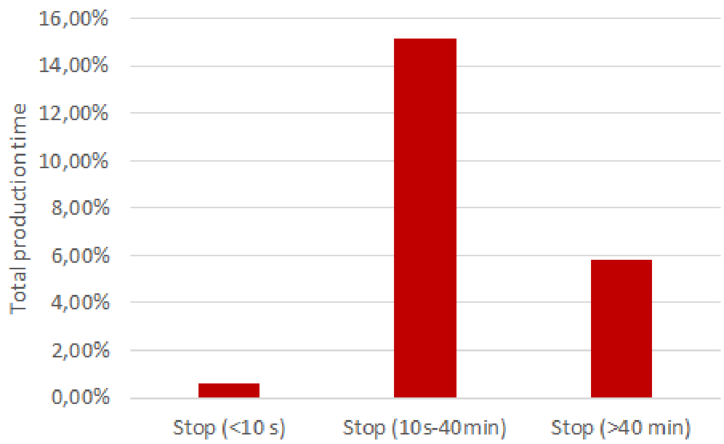

Figure 5.9: The stops separated by their lengths

have been divided by their lengths and added up into the categories, stops less then 10 seconds, stops between 10 seconds and 40 minutes and stops greater then 40 minutes.

Other stops (0s - 10s)

Other stops shorter than 10 seconds, derives mostly from the machines being out of sync to each other, which is a result from the machines being placed in serial. This category consumes less than 1 % of the total production time and will therefore not be analyzed further.

Other stops (40min -)

Stops longer than 40 minutes represents mostly machine breakdowns or complex machine errors. The observed machine breakdowns during the data gathering period, concerned the storage elevator and the AOI, these breakdowns may be reduced with preventive maintenance. Complex machine errors, involves errors that the ASM operator do not know how to solve and help is needed. As the operators gain knowledge, these errors will have a smaller impact. During the data gathering period, 9 *other stops* longer than 40 minutes occurred and represented 6 % of total production time.

Other stops (10s - 40min)

The two most commonly observed reasons for stops in this category, were machine errors and refilling errors. Machine errors are minor faults which stops the machine and require an operator to solve. An example of a machine error, is a pick up failure, where the machine is unable to pick a component successfully. The time to solve a machine error is different for each kind of error, from about 10 seconds to a couple of minutes. Additionally, the time it takes for the operator to realize that an error has occurred, is added to the total stop time.

Refilling errors occurs when a machine run out of components, which originates from different reasons. One reason, is an error in the stock status, which makes the machine display false information to the operator about the time remaining to refill. Another reason, is that all components have not yet been placed in the storage elevator, therefore, the operator has to search for the component in production and this might lead to a machine stop. There are also situations where refilling errors occur, due to the operator not being able to keep up with the work tasks.

The underlying reasons for the stops are different between machine errors and refilling errors, however, they are connected to one another. The more machine errors, the more likely it is that refilling errors occur, since the operator has less time to concentrate on refilling. The same way, refilling errors can increase the length of the machine errors. When an operator is away searching components, machine error can go unnoticed. During the work sampling it was observed that, stops were sometimes left unattended for 10-15 minutes, due to the operator not realizing that an error has occurred. One reason operators miss that stops occur, is the fact that there are 15 different sources of information for handling stops. The sources of information are, five screens and ten light bars, which are directed to one operator alone. Too many sources of information makes it easy to miss information (Bohgard, 2011). Also, data collected during the work sampling show that, the ASM operator spent more than 13 % the time away from the machines, fetching components from the elevator, which is another reason why stops are not noticed immediately.

5.2 Further analysis

The previous analysis has focused on what losses there are and how the SMT department can improve on its own. However, in order to fully utilize the SMT department, it is important that the planning, development and purchasing departments work together with the production. By cooperating with the production, it is possible for planning, development and purchasing to understand how their decisions affect the SMT department. For example, how much extra work and uptime loss, does it generate, by making a planning change in the last second. When this type of information is known, it is possible to make correct decisions.

When observing the system and interviewing operators, components was often an issue in many ways for the production. In some cases there where no components even though the stock status showed it, other times the components was there, however, not located in the storage elevator but instead somewhere in the production. One time an operator spent more than 4 hours in one day to search for one set of components. Lastly, sometimes the components have not arrived on time.

Planning, purchasing and production are very dependent on each other. If components are missing, the plan has to change; if the plan changes, the production has to adapt. The later the change occur, the harder it is for production to complete the external changeover on time. And if the external work cannot be competed, it reduces capacity and creates production backlog. Production backlog makes it harder to both

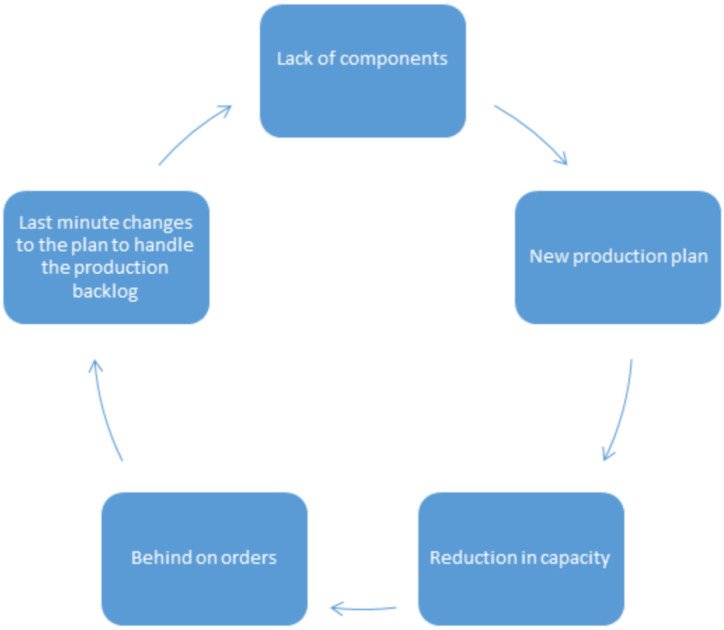

Figure 5.10: Cause and effect diagram of Aros

plan the production and to purchase components, which may lead to a lack of material. This behavior is illustrated in figure 5.10.

It is important that the MRP system is used correctly and no parts are left out, to create a functional production plan. In order to fully utilize the MRP system, the different departments need to communicate and specify exactly which information is needed from one another. For example, the planning department need information from the production, regarding the capacity and changeover times. The planning department also needs to know how far ahead it needs to plan, in order for the purchasing department to get the components on time.

Apart from the purchasing and planning, it is possible for the development department to benefit the production, by implementing design for manufacturing. For example, some types of PCB are too small or too big and cannot be inserted in the machine with the regular procedure, meaning that one operator have to place them one by one manually into the screen printer. In addition some components have a successful pick up rate of less than 20 % in the ASM machines, which leads to machine errors; by not choosing these components in future product developments, it would be possible to reduce the machine errors. Due to other constraints such as customer demands and costs, it may not be possible to redesign products. However, it is still important that information regarding the products in production reaches the developers.

6 Improvements

From the analysis there were two general topics which would aid in reducing all of the three major losses, these are standardization and measurements. Measurements are needed to control the production and also in order to make decisions for future improvements. The standardization should be applied within the entire company, both in the production and in the management areas. By standardizing the management areas and the communication flow between them, it is possible to build a good foundation for the production, with consistently arriving materials and plans, while making sure that newly designed products are customized to fit the production. The standardization of the production will decrease the losses and thereby increase the productivity.

Improvements can be divided into three different categories, organizational improvements, which refer to activities such as planning or standardization, method improvements, which are improvements of the work method, and technical improvements which are investments (Larsson and Rynvall, 2007). The organizational improvements should be carried out primarily, with the motivation that they often hold the largest potential and are cost efficient to carry out. Method improvements are also cost efficient and should therefore be carried out after the organizational improvements. Technical improvements always demand an investment of some kind, therefore should be the last improvement carried out. Since there are a lot of potential in the organizational and method areas the improvements will primarily focus on these categories.

6.1 Breaks

Rearranging the breaks is an organizational improvement which will have a large effect without much effort. Since the shift teams are at least four operators, it should be possible to make an agreement to have breaks in shifts. If this would be possible, the utilization of the machine would be increased by 37 %.

6.2 A standardized work division

A standardized work division will allow the operators to focus on the tasks assigned to them, while making sure that no important tasks are forgotten. By dividing and prioritizing the different work tasks, a standardized work division was created; it was

Figure 6.1: The reduction of changeover time, using the standardized work division

made to prioritize the external changeover, while also keeping a high uptime between the changeovers. The work division is shown in appendix F.

The standardized work division specifies which responsibilities each operator has and how they should be prioritized. Depending on the machine status, the operators responsibilities and priories change. For example, the ASM operator have different responsibilities during a product changeover, than during regular production.

A problem brought up in the analysis, was that the ASM operator left the machine unattended when fetching components, therefore, did not notice errors. The work division, was therefore also designed to relive the ASM operator from fetching components. By making the storage elevator operator, responsible for delivering components to the ASM line, 13 % of the ASM operators time should be freed, to focus on resolving errors. Another positive effect by not having the ASM operator use the elevator, is to minimize the queuing in the elevator.

To reduce the internal changeover, the work tasks are divided among the operators, in order to perform as many tasks as possible, simultaneously. To avoid communication problems, the standardized work division was developed by having same operator responsible for preparation, changing and resetting a specific work task. For example, one operator is responsible for preparing, changing and reseting the trolleys. By using the standardized work division and if enough time is available, the external changeover will not effect the internal, therefore, the changeover time will be controlled by the screen printer, which is according to appendix G is about 26 minutes. Figure 6.1 shows the difference between the average time for family changeovers and the time if the standardized work division would be used.

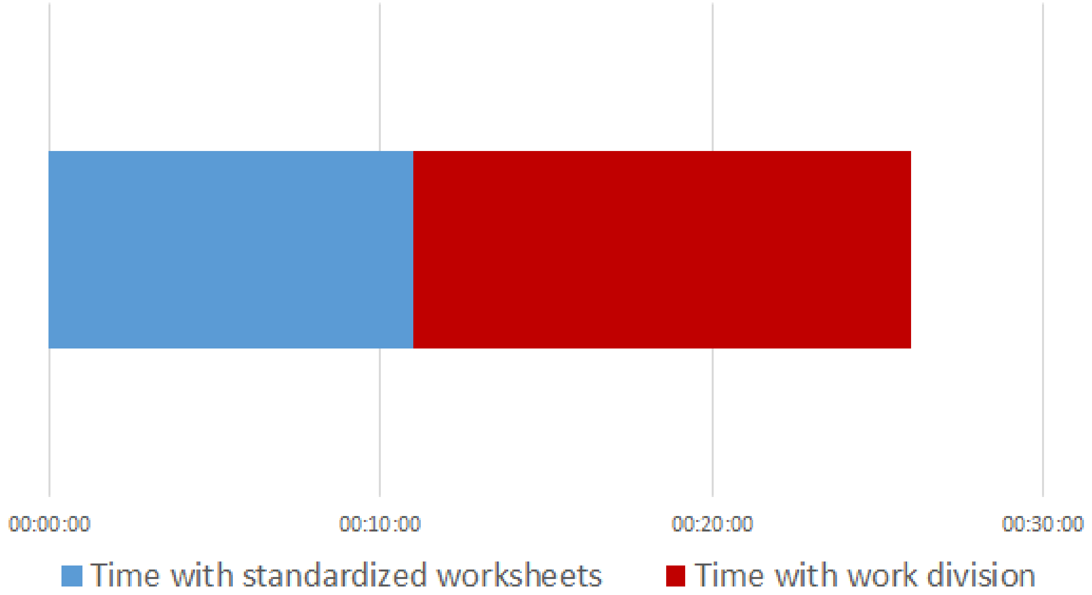

Figure 6.2: The reduction of changeover time, using the standardized worksheets

6.2.1 Standardized worksheets

Standardized worksheets have been created for the changeover, where the work tasks have been divided between four operators. The operations has been separated into work that is done 1 hour before changeover, 10 minutes before changeover, during changeover and resetting. These can be found in appendix I.

The operations which are done 1 hour before changeover, are to load the moisture sensitive components and to check that the external work have been completed. 10 minutes before the internal changeover starts, the trolleys and any other needed material for the changeover is moved into place. During the internal changeover only the necessarily work tasks are done, all other work tasks should be left to after the internal changeover. The resetting operations involves activities such as, move the moister sensitive components to the storage elevator, clean stencils and reset the used trolleys.

The standardized work sheet for the screen printer contains the work order created from the SMED analysis, which reduces the changeover time from 26 minutes to 11 minutes, this is shown in figure 6.2.

6.3 Measurements

Productivity can not be measured with CPH, since the maximum CPH is not known. The recommendation is therefore to use the productivity measurement $Productivity = M * P * U$, by Almström and Kinnander (2011), or a similar measurement system. The M factor can be gathered for each PCA, from the machines data interface. The P factor will be 100 %, unless the speed of the machines are turned down. The U should be measured, by comparing the difference between time stamps with the tact time of each PCA. Additionally it is possible to add a Q factor representing the quality, making the equation $Productivity = M * P * U * Q$.

A large reason for the low utilization, was the category *other stops*; it is needed to document and measure the stops, in order to find the underlying reasons they occur. The suggestion is therefore, to have the operators document the occurring errors. The easiest way to do this, is to create a list of reasons to errors, and have the operators make note on the list, each time an error has occurred. If the operators also note the time of the stops, it would be possible to connect each stop to the times in the machine data. However, it is important that the information gathering is not too time consuming, and does not disturb the operators ordinary work tasks.

Lastly, it is needed to continue to measure internal and external setup times, to keep the planning department updated with correct times.

7 Discussion

When it comes to the project at Aros, there where a lot of possible routes to take as a master thesis; the one we started with, was not the one we ended up with. From the beginning the goals included, optimizing batch sizes and a value stream mapping of the flow before the SMT line. However, after the installation of the line, these goals did not seem as relevant, when the utilization was measured to about 30 %. Because of this, the project changed towards becoming more of a general analysis, in order to assist the company with this problem. Since there were no data available from the production, a lot of effort were put into acquiring machine data, in order to create an accurate picture of the SMT production.

7.1 Data quality

As described in the method, a choice was made to not trust the automatically generated data from the ASM machines, because it showed contradictions to reality. Which is why the data was gathered by the more time consuming method, using the time stamps from the machines. The method used, resulted in data with higher quality, however, the automated generated data from the machines, was not very far of. Therefore, if the data from the machines was used instead, more time could have been spent on analysis.

MTM-SAM was used to get standard times for the manual activities in the SMT line. However, many work tasks included extreme precision, which was not possible to account for in MTM-SAM. Therefore, clocked times were used instead. The clocked times for some activities were unreasonably long, because operators explained the work tasks while performing them. Therefore, the work tasks should be able to be performed quicker; this could result in a larger increase of utilization than calculated.

7.2 Results

Since none of the improvements have been tested in the system, the exact effect of them is not known. But by having breaks in shifts and making sure that the external part of the changeover is done in time, it would be possible to increase the utilization of the machine by 84 %; it does not include any improvements to the *other stops* or ramp up, which also should be reduced by using the standardized work division and the standardized worksheets. However, it is not possible to calculate how much.

7.3 Future improvements

Aros makes a lot of different improvement projects, and some are left only partly finished. It is our belief that Aros needs to have a person continuously working with analyzing and improving the production, to drive improvement project from start to end. To utilize the full potential of the created standardized work division and worksheets, it is important to continue with the development. Therefore, this person could be the one responsible for this. Another benefit from adding a person responsible for improvements, is to establish a better contact between the production and the administrative departments.

7.3.1 Work division in the organization

At Aros there are a lot of variations in the production, which all makes it harder to implement a standard. The goal of the organizational departments is to make the productions' job easier. As described in the analysis chapter, one reason behind the variations, is changes in the planning and the lack of materials. How the current planning and component purchasing systems work, is not known by us. However, it has to be improved, in order to maximize the productivity. It is necessary to make sure that the there is a viable plan and that there are components in order to proceed with the plan. This should be able to do by implementing a MRP system.

7.3.2 Technical improvements

The previous parts of the thesis have not focused on technical improvements, since there are a larger improvement potential in the organizational and method categories. However, there are investments which could help the production. By making small investments in the form of better tools for the changeover, such as a bigger bowl and a wider scrape, for used soldering paste, it would be possible to reduce changeover times. Also as explained, there are a lot of different sources of information for the ASM operator to observe. By collecting all the information and displaying it in one place, might make the operator notice stops earlier.

Apart from these changes there are a lot of other ones which possibly could be made. However, it is important that it is proven by actual measurements, that the specific investment is needed, and that the problem is not possible to solve with either method or organizational procedures first.

7.3.3 Implementation

The implementation of the improvements should be carried out with the operators, in order to get them involved in the change process. However, it is equally important that the production management is involved and do not hand over all responsibility to the operators. In the starting stages of the change process, it is important to gather a lot of feedback from the operators and make changes accordingly. It is also important to give the operators enough time and training, to be able to perform the new work methods.

If the operators are left on their own without sufficient support from the production management, the risk is higher that the project fails. When the changes have been implemented, it is important to analyze the results to make certain that the desired effects are reached.

8 Conclusion

This report has tried to raise and solve the problems that exists in the SMT line at Aros Electronics. The problems derive mostly from the lack of standardization and the lack of measurements.

In order to have standardized work methods, the staffing needs to be the same in both shift teams. For the SMT department to reach its full potential, it is important that the rest of the organization also start working with standardization. If the standardized work division and worksheets are used, it should be possible to reduce the changeover from an average of 3.5 hours, to 11 minutes; this reduction of changeover time would increase the productivity by 47 %. If the operators also would have the breaks in shifts, an additional 37 % could be added, leading to a total production increase of 84 %. However, the production increase is only possible if there is a viable production plan and the needed components are available. The new distribution of production time after the changes, is illustrated in figure 8.1.

After the standardization changes, the largest losses remaining are, *other stops* and changeover. The *other stops* depends on the productive time, therefore, they increase as the productive time does. The remaining part of changeovers, derive mostly from ramp

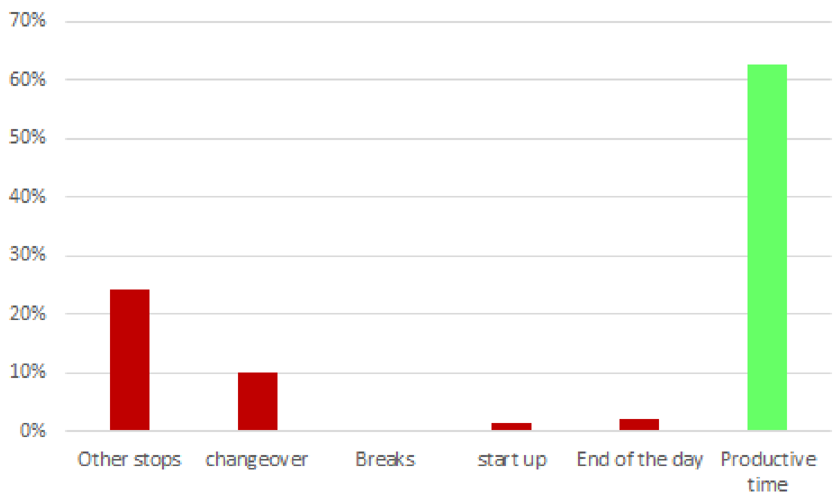

Figure 8.1: Distribution of total production time if the changes are made

up. Both the ramp up time and the *other stops*, should benefit from the standardization changes, however, the effect is not measurable while the changes are not implemented. Therefore, this improvement is not included in the results.

In order to minimize the remaining losses, it is necessary to measure and document the occurring stops, to find the underlying reasons. If the reasons behind the stops are known, it may be possible to prevent them.

There is a large improvement potential at Aros, even after the suggested changes. By continuously improving the standardized work division and updating the standardized worksheets, it is possible for Aros to increase the competitiveness.

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A Work sampling results

The numbers in the table are the percentages of the samples that were gathered during the work sampling.

	ASM	Elevator	AOI	Extra personel	Total
Splicing components	19.4	0.1	0.1	3.9	12.6
Monitoring	4.9	0.1	0.1	2.3	3.9
Refilling the screen press	1	0	0	0	0.5
Refilling the tray elevator	1.4	0	0	1.6	1.6
Changing the ASM	2.1	0.4	0	4.4	3.7
Changeing the screen press	4.9	0.1	0	0.8	3.1
Preparing changeover	0.7	0	0	2.1	1.5
Preparing PCB	7.3	0.4	0	9.7	9.3
Set-up trolleys	4.6	0.4	0	3.2	4.4
Look for materials	0.8	0.8	0.1	0.6	1.2
Look for tools	0.8	0	0	0.2	0.5
Look/read papers	0.2	0.1	0	0.1	0.1
Move material	3.2	0.5	0.1	0.5	2.3
Change side of the ASM	1.3	0.1	0.1	0.2	0.8
Go - Asm to/from Elevator	2.4	0.2	0	0.7	1.8
Allowances	4.6	1.2	1.2	0.8	4.2
Empty trash from machine	2.8	0.7	0	1.1	2.5
Clening	2.1	0	0.1	0.4	1.4
Work with machine disturbance	6.5	0	0.6	2.7	5.3
Singular disturbance	0.4	0	0	2	1.3

	ASM	Elevator	AOI	Extra personel	Total
Method disturbances	2.1	0	0.1	0.4	1.3
Screen press error	0.7	0	0	0.7	0.8
MSL disturbances	0	0	0	0	0.1
Rework	2.1	0	3.9	0	3.2
Gets interuppted by others	3.2	0.5	0.1	0.4	2.2
Other disturbances	0.4	0	0	0.1	0.3
Get components from storage elevator	4.4	3.9	0.1	1.5	5.2
Put components into the storage elevator	0	14.5	0	1.5	8.6
Vacuum-packing MSL components	0.1	0.4	0.4	0.1	0.6
Work that is not linked to ASM	0.7	5.5	0	0	3.4
Reorganization of matrial	0	0.6	0	0	0.3
Sampel equalizer	0	63.6	92.6	55.9	0
Away	1	0	0	0	0.6
Ask for help	0.4	0.3	0	0.1	0.4
Change PCB rack	0.8	0	0	0.2	0.6
Change of roll in the screen press	0.1	0	0	0	0.1
Wait because of method error	0.5	0	0	0	0.3
Before splice	0.1	0	0	0	0.1
Remove MSL	0.1	0	0.7	0.4	0.7
Cleaning the screen press	0.5	0	0	0.1	0.3
Cleaning at the end of the day	0.1	0	0	0.1	0.1
Waiting	0.3	0	0	0.1	0.2
Preparing material for subcontractors	0	4.2	0	0	2.3
Checks among rolls on machine	0.7	0	0	0	0.4
Working on the screen on the machine	0.3	0	0	0	0.2
Writes roll numbers	0.7	0.2	0	0	0.5
Teaching	1.6	0.1	0	0.1	1
Counting components	0	0.1	0	0	0.1
Changing conveyor width	0.6	0	0	0.1	0.4

	ASM	Elevator	AOI	Extra personel	Total
Asking the operator at the elevator for components	0.1	0	0	0	0.1
Start-up machine	0.3	0	0	0.4	0.4
Start-up screen press	0.3	0	0	0	0.2
Helping another operator	2.3	0	0	0	1.2
Running a test card	0.5	0	0	0	0.3
Inspecting card	0.8	0	0	0.5	0.7
Taking done PCB to storage	0	1	0	0	0.6
Looking for person	0	0	0	0	0.1
Go between rigging station and ASM line	0.2	0	0	0.2	0.2
Verify components in machine	0.3	0	0.1	0	0.2
Wait for test card to go through oven	0.7	0	0	0.1	0
Working with order sheet	0.2	0	0	0	0

B Family changeovers

Date	Length(h:mm:ss)
2014-03-05	3:43:41
2014-03-05	2:51:52
2014-03-06	2:27:43
2014-03-10	3:48:37
2014-03-11	4:12:31
2014-03-17	5:24:36
2014-03-17	2:52:32
2014-03-18	2:06:51
2014-03-19	6:08:58
2014-03-20	1:11:47
2014-03-24	1:20:01
2014-03-24	3:50:55
2014-03-25	3:03:48

C Product changeovers

Date	Length(h:mm:ss)
2014-03-07	2:04:39
2014-03-12	2:54:07
2014-03-12	1:39:58
2014-03-12	0:25:49
2014-03-12	2:21:34
2014-03-14	0:42:17
2014-03-17	0:53:01
2014-03-18	2:58:58
2014-03-19	0:54:22
2014-03-19	1:34:26
2014-03-20	1:19:36
2014-03-20	1:02:34
2014-03-20	1:13:43
2014-03-21	1:52:10
2014-03-21	1:17:52
2014-03-24	3:15:18
2014-03-24	1:15:49
2014-03-24	0:40:48
2014-03-25	2:43:49

D External changeover

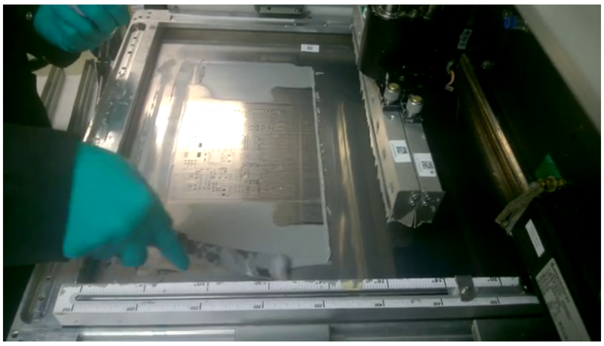
In table D.1 the times for all external activities can be found. The lengths of the activities are from clocked times on operates when the tasks are being done. The only exception is the time for the reseting activity, this since there never were a possibility to measure it. Instead the time for the preparation work for the trolleys were used, that time should be longer then the resetting should take but it is used to be on the safe side. In total the 7.1 hours are calculated fairly high and usually it should be lower.

Table D.1: Time for the external work activities

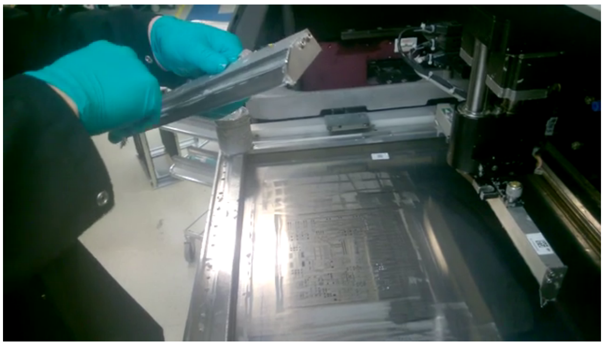
Activities	Time per activity (s)	Number of times	Time (h)
Preparation and finishing	660	5	0.9
Put QR code on PCB	4	50	0.1
Rigging of feeder	60.3	73	1.2
Get PCB from warehouse	204	1	0.1
Get components from storage	46	73	0.8
Open PCB container	19	5	0.1
Get feeder	17	73	0.3
Insert PCB into racks	235	1	0.1
Additional preparations	300	1	0.1
Reseting	2448	5	3.4
Total time			7.1

E Instructions for the changeover in the screen printer

1. Open the protective cover
2. Get protective gloves
3. Remove soldering paste from stencil



4. Remove soldering paste from rakes



5. Move the stencil and rakes to the cleaning area
6. Remove the stencil from the frame

7. Place the stencil in the washing machine
8. Remove the stencil from the frame

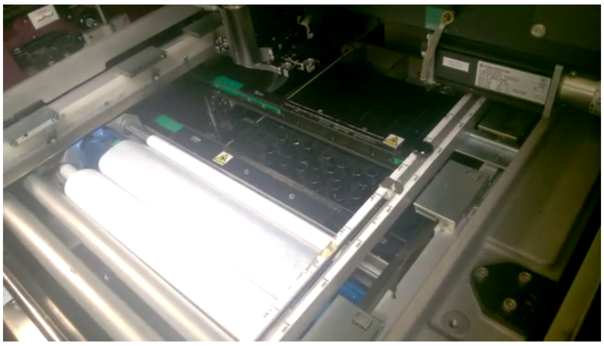
9. Get the wagon, which contain material for the changeover in the screen printer
10. Clean the rakes with alcohol and paper
11. Remove the stencil from the frame

12. Put the rakes onto the wagon
13. Get the new stencil

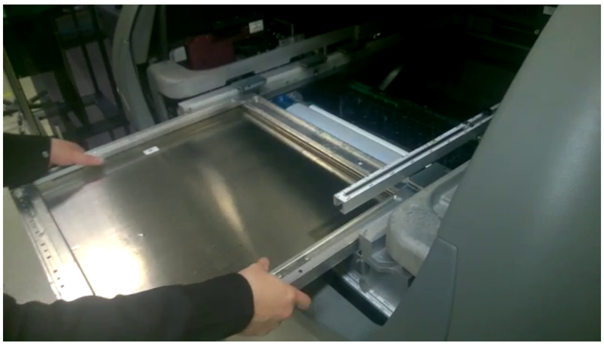
14. Fixate the stencil onto the frame
15. Remove the stencil from the frame

16. Move the stencil and the wagon to the screen printer
17. Type in the password
18. Change which type of PCA that will be produced
19. Remove the PCB rack

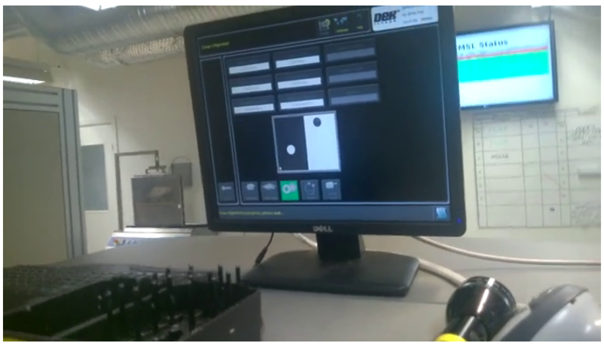
20. Change setting to make the screen printer take PCB manually
21. Type in the password
22. Change machine setting
23. Place supports for the PCB



24. Test if the supports is in the right position
25. Place more supports if needed and test position again
26. Place the frame into the machine

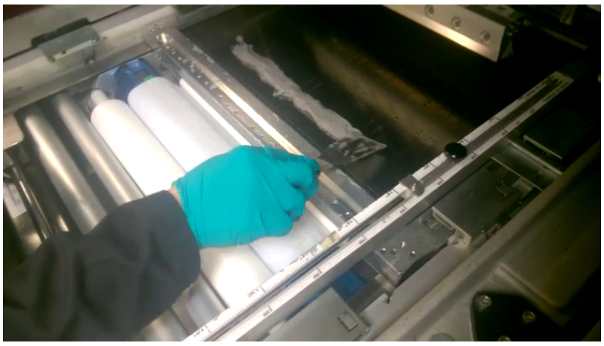


27. close the protective cover
28. Insert a PCB to test that everything aligns



29. Move the PCB out of the screen printer
30. Scan the stencil, soldering paste and rakes

31. Get protective gloves
32. Put soldering paste onto the stencil



33. Throw away gloves
34. change the width of the conveyors after the screen printer
35. Type the password
36. Change the setting so that the screen printer accepts cards from a PCB rack
37. Insert the PCB rack
38. Align the piston that pushes PCBs into the screen printer with the PCBs
39. Stop the conveyors after the screen printer
40. Test print a PCB
41. Inspect the PCB
42. Turn on the conveyors
43. Wait until all other internal changeover is done then out the screen printer to automatic

F Standardized work division

The standardized work division is divided into three different scenarios, which are: machine running, family changeover and product changeover. In each scenario the operators have been given different work tasks, which are also prioritized. Since, the MY-data line will be removed, its operator have been used as a rigging operator in this standardized work division.

F.1 Machine running status

The main purpose when the machine is running is to make sure that it is up at all time, the second priority is to prepare for the next changeover. Therefor the operator's priorities should reflect this.

F.1.1 Operator at the storage elevator

The main focus of the operator is to support the ASM operator and the rigging operator.

1. Get components from the elevator to the ASM machine.
   Check every 30 minutes what components that are needed to be spliced onto the ASM machine the next 45 minutes. Place these in a box and take it to the machine, while waiting for the elevator preparations of the PCB can be done.
2. Vacuum pack the moist sensitive components and put them into the storage.
3. Prepare PCB cards for the ASM line.
   There should always be a done rack with cards to be inserted into the screen press. Before changeover a rack with the new type of PCB needs to be prepared.
4. Get all the components for the next changeover from the elevator.
   Preparation of PCB can be done while waiting for the elevator.
5. Put the used or the new components into the storage elevator.
   Preparation of PCB can be done while waiting for the elevator.

F.1.2 ASM operator

The main task is to make sure the ASM line is up all the time.

1. Manage machine disturbances.
   Machine three is the prioritized since it's the bottleneck of the tact time is under 30 seconds the screen press is prioritized.

2. Put new soldering past into the screen press.

3. Change PCB rack directly when it is empty.

4. Splice on new components on the machine.

5. Insert new trays in the last machine.

6. Empty the machines of used materials.

7. Monitor the machines
   Important to make sure that there is time to monitor to notice disturbances and to work preventative.

F.1.3 Rigging operator

The main task of the rigging operator is to make sure all the trolley's are done before the next changeover.

1. Prepare the ASM trolley's for the next changeover.
   The operator is responsible to make sure all trolley's are done before the next changeover, get extra help if needed.

2. Empty the used ASM trolley's.

3. Help the other operators if needed.

F.1.4 AOI operator

The task of the AOI operator is to inspect the cards and to help if necessarily.

1. Inspect cards.

2. After assembly.

3. Prepare PCB cards if the other operators don't have time for it.

F.2 Family changeover

The task is to make sure the ASM line is up and running as fast as possible.

F.2.1 Operator at the storage elevator

Its focus is to do the changeover in the screen press.

1. Get all the material needed for the changeover of the screen press.
   This should be done before the changeover starts.

2. Exchange PCB rack when the last card goes into the screen press.

3. Start the changeover of the screen press when the last card is done.

F.2.2 ASM operator

The ASM operators main task is to change the components in the tray elevator

1. Five minutes before the changeover give notice to the other operators so they are ready.

2. Insert new program into the ASM line
   This should be done when the last PCB is through the last machine

3. Change the components in the tray elevator in the last machine.
   The old components needs to be taken to the storage elevator to be vacuum packed and inserted into the storage.

4. Change the width of the conveyors between the ASM machines and the oven.

5. Change the settings in the oven when the last card is done.

F.2.3 Rigging operator

The main task is to change the trolleys and change the width of the conveyors.

1. Exchange the trolley's in the ASM line.

2. Change the width of the first conveyors between the screen press and the ASM machines.

F.2.4 AOI operator

The AOI's responsible to help the rigging operator with the changeover.

1. Help the rigging operator with the change of trolleys.

2. Change the setting in the AOI station when the last card is checked.

F.3 Product changeover

All operators are responsible to make sure the changeover goes as smooth as possible.

F.3.1 Operator at the storage elevator

Its focus is to do the changeover in the screen press.

1. Get all the material needed for the changeover of the screen press.
   This should be done before the changeover starts.

2. Exchange PCB rack when the last card goes into the screen press.

3. Start the changeover of the screen press when the last card is done.

F.3.2 ASM operator

The operators main focus is the change the moisture sensitive components in the tray elevator.

1. Insert new program into the ASM line

2. Change the moist sensitive components in the tray elevator.

3. Change the width of the conveyors between the ASM machines and the oven.

4. Change the settings in the oven when the last card is done.

F.3.3 Rigging operator

Its focus is to change the moisture sensetive components

1. Remove the used moist sensitive components and insert the new moist sensitive components that are needed.
   Take the used components to the storage elevator to be vacuum packed.

2. Change the width of the conveyor between the screen press and the ASM machines.

F.3.4 AOI operator

The operator's main focus is to help the rigging operator operator.

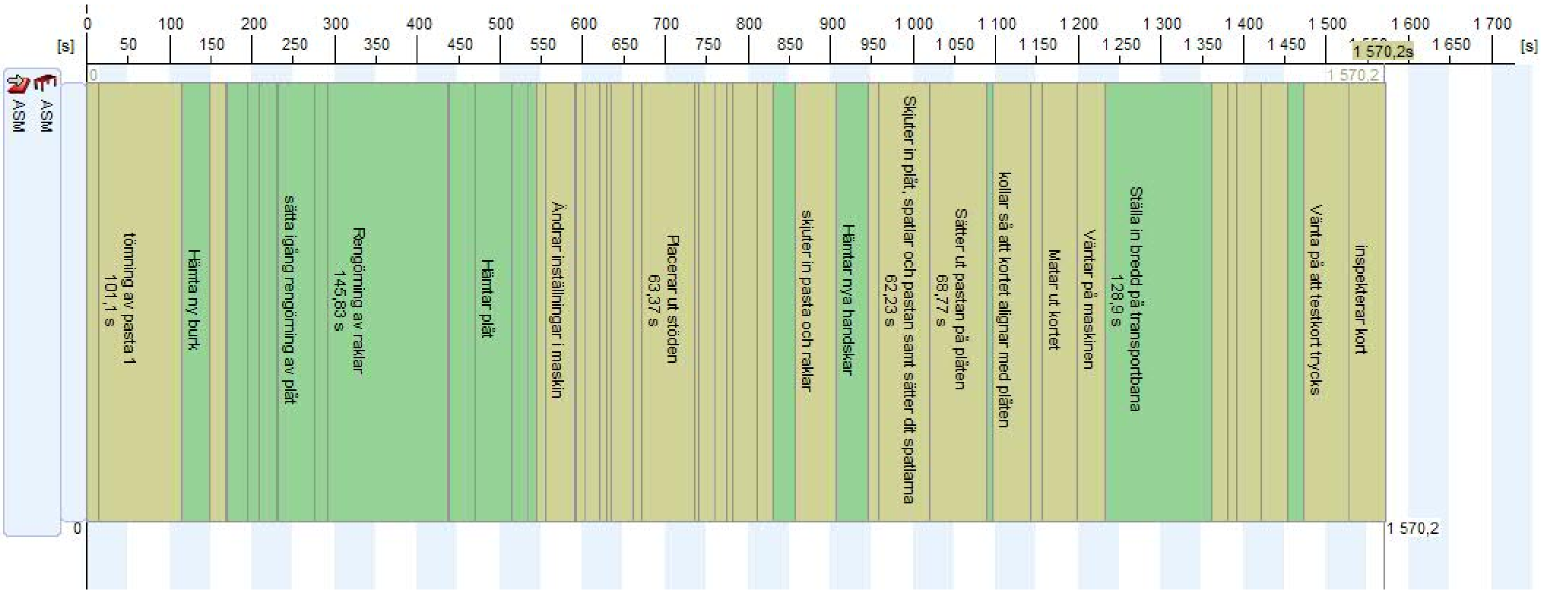
1. Help the rigging operator with changing the moisture sensitive components.

2. Change the setting in the AOI station when the last card is checked.

G Screen press before SMED

Ställinstruktion

Område/Byggnad	Mölndal	**Operatör:**			Yttre arbete
Line:	ASM	Datum för ställ:			Inre arbete
Maskin:	ASM	Variant:	-		Ej klassificerat arbete



Tid för förberedelser:	0,0 s	Använda verktyg
Inre ställtid:	1 570,2 s	
Tid för återställande:	0,0 s	
Dokument:		

Ställinstruktion

Inre arbete					
Line:	ASM	Maskin:	ASM	**Operatör:**	

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-10] Öppna lucka Start: 0,0 s Tid: 14,5 s Stopp: 14,5 s			
	[10-20] tömning av pasta 1 Start: 14,5 s Tid: 101,1 s Stopp: 115,6 s			
	[10-25] Hämta ny burk Start: 115,6 s Tid: 33,1 s Stopp: 148,8 s			
	[10-30] tömning av pasta 2 Start: 148,8 s Tid: 20,1 s Stopp: 168,9 s			
	[10-35] Extra rengörning av raklar Start: 168,9 s Tid: 26,2 s Stopp: 195,1 s			
	[10-40] gå med plåt och ram till rengörningsstationen Start: 195,1 s Tid: 13,8 s Stopp: 209,0 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-50] spänna loss plåt Start: 209,0 s Tid: 21,9 s Stopp: 230,9 s			
	[10-60] sätta igång rengörning av plåt Start: 230,9 s Tid: 45,6 s Stopp: 276,5 s			
	[10-70] hämtning av pasta vagn för rengörning Start: 276,5 s Tid: 15,8 s Stopp: 292,3 s			
	[10-80] Rengörning av raklar Start: 292,3 s Tid: 145,8 s Stopp: 438,1 s			
	[10-90] Letar efter papper Start: 438,1 s Tid: 32,0 s Stopp: 470,1 s			
	[10-100] Hämtar plåt Start: 470,1 s Tid: 45,2 s Stopp: 515,3 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-110] Spänner upp plåt i ram Start: 515,3 s Tid: 18,8 s Stopp: 534,2 s			
	[10-120] Går med plåt till screentryckare Start: 534,2 s Tid: 10,8 s Stopp: 544,9 s			
	[10-140] Skriver in lösenord Start: 544,9 s Tid: 10,8 s Stopp: 555,7 s			
	[10-150] Ändrar inställningar i maskin Start: 555,7 s Tid: 35,9 s Stopp: 591,6 s			
	[10-160] Ta ut rack Start: 591,6 s Tid: 11,9 s Stopp: 603,5 s			
	[10-170] Skriva in lösenord Start: 603,5 s Tid: 17,1 s Stopp: 620,7 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-180] Välja att det matas manuellt Start: 620,7 s Tid: 8,5 s Stopp: 629,2 s			
	[10-190] Skriva in lösenord Start: 629,2 s Tid: 5,7 s Stopp: 634,9 s			
	[10-200] ändrar inställningar Start: 634,9 s Tid: 26,2 s Stopp: 661,0 s			
	[10-210] Kastar handskar Start: 661,0 s Tid: 11,1 s Stopp: 672,1 s			
	[10-220] Placerar ut stöden Start: 672,1 s Tid: 63,4 s Stopp: 735,5 s			
	[10-240] Kollar om stöden är rätt Start: 735,5 s Tid: 4,8 s Stopp: 740,3 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-250] placerar ut fler stöd och kontrollerar igen Start: 740,3 s Tid: 20,4 s Stopp: 760,7 s			
	[10-260] kör in ramen i screentryckaren Start: 760,7 s Tid: 13,4 s Stopp: 774,1 s			
	[10-270] stänger lucka Start: 774,1 s Tid: 7,5 s Stopp: 781,6 s			
	[10-275] omgörning pgr av fel av alignment Start: 781,6 s Tid: 30,6 s Stopp: 812,2 s			
	[10-280] skjuter in plåten Start: 812,2 s Tid: 18,6 s Stopp: 830,8 s			
	[10-290] Hämtar pasta vagn Start: 830,8 s Tid: 25,8 s Stopp: 856,7 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-300] skjuter in pasta och raklar Start: 856,7 s Tid: 49,6 s Stopp: 906,3 s			
	[10-310] Hämtar nya handskar Start: 906,3 s Tid: 39,9 s Stopp: 946,2 s			
	[10-320] kör in ramen i screentryckaren Start: 946,2 s Tid: 11,7 s Stopp: 957,9 s			
	[10-330] Skjuter in plåt, spatlar och pastan samt sätter dit spatlarna Start: 957,9 s Tid: 62,2 s Stopp: 1 020,1 s			
	[10-340] Sätter ut pastan på plåten Start: 1 020,1 s Tid: 68,8 s Stopp: 1 088,9 s			
	[10-350] Kastar handskar Start: 1 088,9 s Tid: 6,5 s Stopp: 1 095,4 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-360] kollar så att kortet alignar med plåten Start: 1 095,4 s Tid: 46,8 s Stopp: 1 142,2 s			
	[10-370] Rework Start: 1 142,2 s Tid: 14,0 s Stopp: 1 156,2 s			
	[10-380] Matar ut kortet Start: 1 156,2 s Tid: 42,3 s Stopp: 1 198,5 s			
	[10-390] Väntar på maskinen Start: 1 198,5 s Tid: 33,2 s Stopp: 1 231,7 s			
	[10-400] Ställa in bredd på transportbana Start: 1 231,7 s Tid: 128,9 s Stopp: 1 360,6 s			
	[10-410] Skriver in lösenord Start: 1 360,6 s Tid: 20,7 s Stopp: 1 381,3 s			

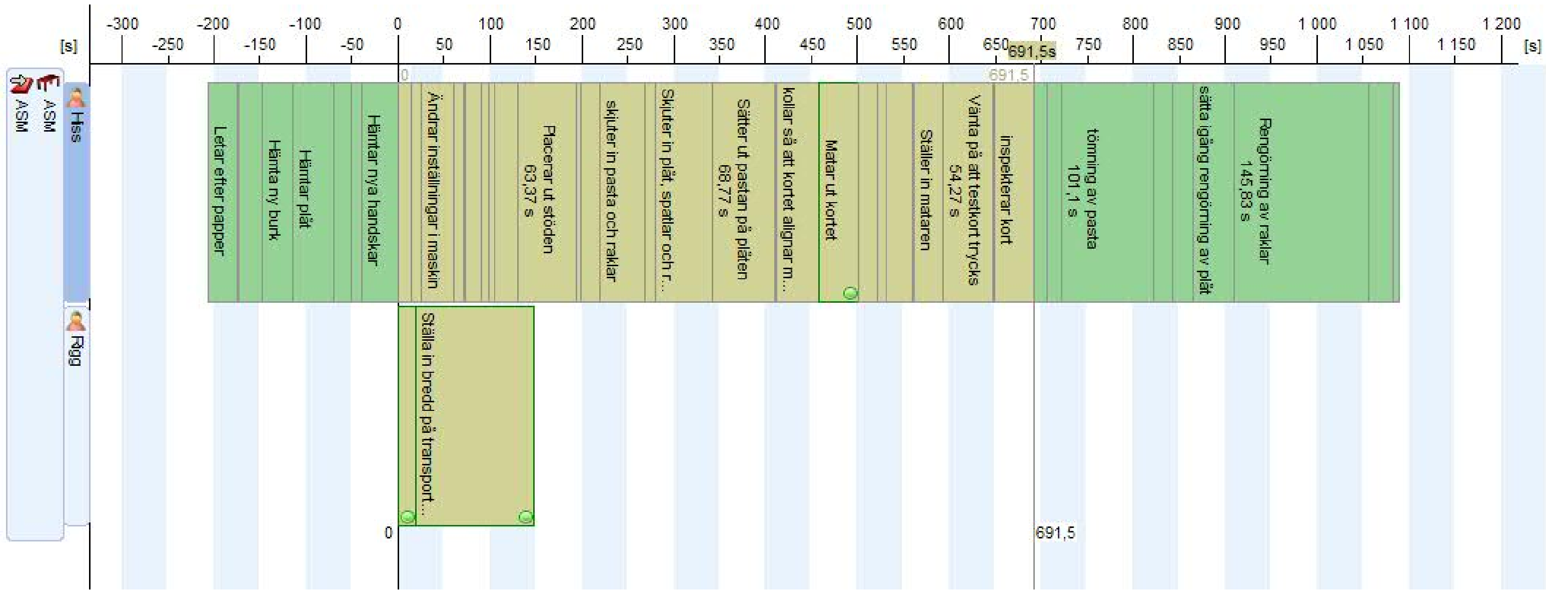
Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-420] Ändrar så att maskinen matas från rack Start: 1 381,3 s Tid: 10,7 s Stopp: 1 391,9 s			
	[10-430] Ställer in rack i maskinen Start: 1 391,9 s Tid: 29,3 s Stopp: 1 421,2 s			
	[10-440] Ställer in mataren Start: 1 421,2 s Tid: 32,6 s Stopp: 1 453,9 s			
	[10-450] pausar transportband Start: 1 453,9 s Tid: 18,8 s Stopp: 1 472,6 s			
	[10-460] Vänta på att testkort trycks Start: 1 472,6 s Tid: 54,3 s Stopp: 1 526,9 s			
	[10-470] inspekterar kort Start: 1 526,9 s Tid: 43,3 s Stopp: 1 570,2 s			

H Screen press After SMED

Ställinstruktion

Område/Byggnad	Mölndal	**Operatör:**	**Hiss**		Yttre arbete
Line:	ASM	Datum för ställ:			Inre arbete
Maskin:	ASM	Variant:	-		Ej klassificerat arbete



Tid för förberedelser:	205,7 s	Använda verktyg
Inre ställtid:	691,5 s	
Tid för återställande:	396,9 s	
Dokument:		

Ställinstruktion

Yttre förberedande arbete					
Line:	ASM	Maskin:	ASM	**Operatör:**	**Hiss**

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-90] Letar efter papper Start: -205,7 s Tid: 32,0 s Stopp: -173,7 s			
	[10-290] Hämtar pasta vagn Start: -173,7 s Tid: 25,8 s Stopp: -147,9 s			
	[10-25] Hämta ny burk Start: -147,9 s Tid: 33,1 s Stopp: -114,7 s			
	[10-100] Hämtar plåt Start: -114,7 s Tid: 45,2 s Stopp: -69,5 s			
	[10-110] Spänner upp plåt i ram Start: -69,5 s Tid: 18,8 s Stopp: -50,7 s			
	[10-120] Går med plåt till screentryckare Start: -50,7 s Tid: 10,8 s Stopp: -39,9 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-310] Hämtar nya handskar Start: -39,9 s Tid: 39,9 s Stopp: 0,0 s			

Ställinstruktion

Inre arbete					
Line:	ASM	Maskin:	ASM	**Operatör:**	**Hiss**

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-10] Öppna lucka Start: 0,0 s Tid: 14,5 s Stopp: 14,5 s			
	[10-140] Skriver in lösenord Start: 14,5 s Tid: 10,8 s Stopp: 25,3 s			
	[10-150] Ändrar inställningar i maskin Start: 25,3 s Tid: 35,9 s Stopp: 61,2 s			
	[10-160] Ta ut rack Start: 61,2 s Tid: 11,9 s Stopp: 73,1 s			
	[10-170] Skriva in lösenord Start: 73,1 s Tid: 17,1 s Stopp: 90,3 s			
	[10-180] Välja att det matas manuellt Start: 90,3 s Tid: 8,5 s Stopp: 98,8 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-190] Skriva in lösenord Start: 98,8 s Tid: 5,7 s Stopp: 104,5 s			
	[10-200] ändrar inställningar Start: 104,5 s Tid: 26,2 s Stopp: 130,6 s			
	[10-220] Placerar ut stöden Start: 130,6 s Tid: 63,4 s Stopp: 194,0 s			
	[10-240] Kollar om stöden är rätt Start: 194,0 s Tid: 4,8 s Stopp: 198,8 s			
	[10-250] placerar ut fler stöd och kontrollerar igen Start: 198,8 s Tid: 20,4 s Stopp: 219,2 s			
	[10-300] skjuter in pasta och raklar Start: 219,2 s Tid: 49,6 s Stopp: 268,8 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-320] kör in ramen i screentryckaren Start: 268,8 s Tid: 11,7 s Stopp: 280,5 s			
	[10-330] Skjuter in plåt, spatlar och raklar samt sätter dit spatlarna Start: 280,5 s Tid: 62,2 s Stopp: 342,8 s			
	[10-340] Sätter ut pastan på plåten Start: 342,8 s Tid: 68,8 s Stopp: 411,5 s			
	[10-360] kollar så att kortet alignar med plåten Start: 411,5 s Tid: 46,8 s Stopp: 458,3 s			
	[10-380] Matar ut kortet Start: 458,3 s Tid: 42,3 s Stopp: 500,6 s			Börja efter Ställa in bredd på transportbana Utförs av: Rigg
	[10-410] Skriver in lösenord Start: 500,6 s Tid: 20,7 s Stopp: 521,3 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-420] Ändrar så att maskinen matas från rack Start: 521,3 s Tid: 10,7 s Stopp: 532,0 s			
	[10-430] Ställer in rack i maskinen Start: 532,0 s Tid: 29,3 s Stopp: 561,3 s			
	[10-440] Ställer in mataren Start: 561,3 s Tid: 32,6 s Stopp: 593,9 s			
	[10-460] Vänta på att testkort trycks Start: 593,9 s Tid: 54,3 s Stopp: 648,2 s			
	[10-470] inspekterar kort Start: 648,2 s Tid: 43,3 s Stopp: 691,5 s			

Ställinstruktion

Yttre återställande arbete					
Line:	ASM	Maskin:	ASM	**Operatör:**	**Hiss**

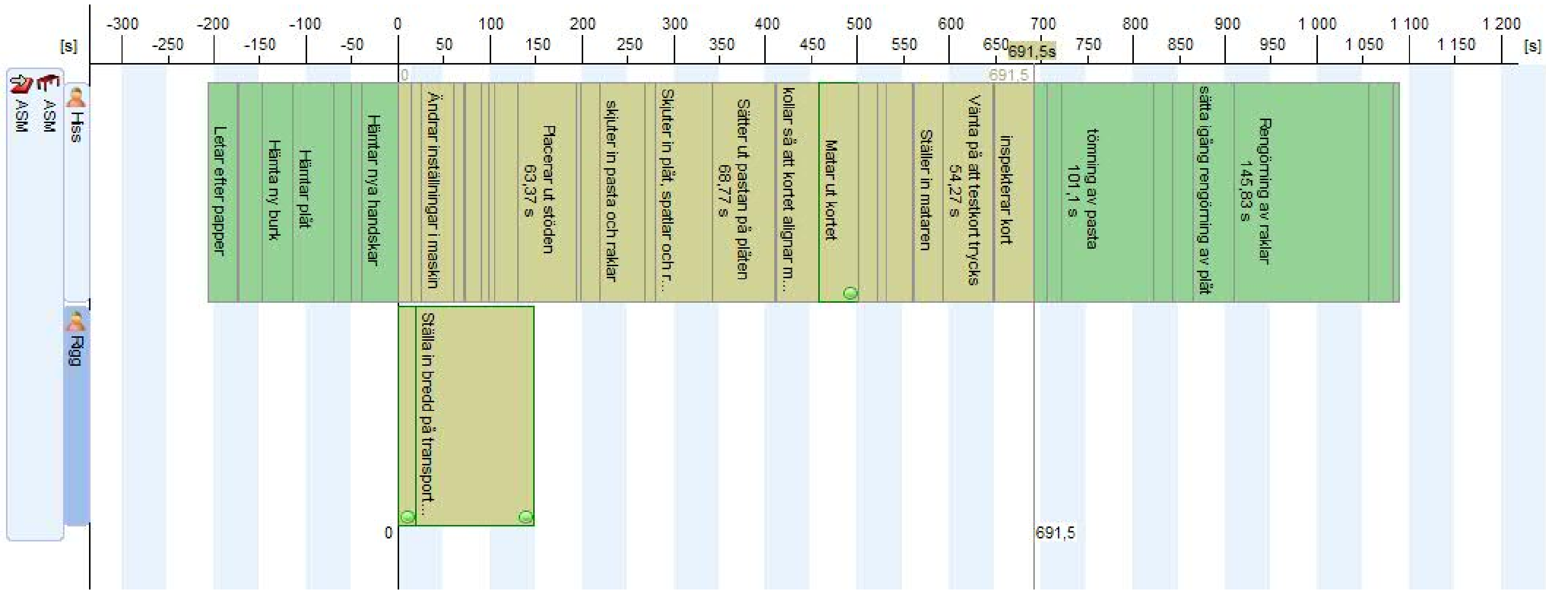
Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-40] gå med plåt och ram till rengörningsstationen Start: 691,5 s Tid: 13,8 s Stopp: 705,3 s			
	[10-70] hämtning av pasta vagn för rengörning Start: 705,3 s Tid: 15,8 s Stopp: 721,1 s			
	[10-20] tömning av pasta Start: 721,1 s Tid: 101,1 s Stopp: 822,2 s			
	[10-30] tömning av pasta Start: 822,2 s Tid: 20,1 s Stopp: 842,4 s			
	[10-50] spänna loss plåt Start: 842,4 s Tid: 21,9 s Stopp: 864,3 s			
	[10-60] sätta igång rengörning av plåt Start: 864,3 s Tid: 45,6 s Stopp: 909,9 s			

Ställinstruktion

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-80] Rengörning av raklar Start: 909,9 s Tid: 145,8 s Stopp: 1 055,7 s			
	[10-35] Extra rengörning av raklar Start: 1 055,7 s Tid: 26,2 s Stopp: 1 082,0 s			
	[10-350] Kastar handskar Start: 1 082,0 s Tid: 6,5 s Stopp: 1 088,4 s			

Ställinstruktion

Område/Byggnad	Mölndal	**Operatör:**	**Rigg**		Yttre arbete
Line:	ASM	Datum för ställ:			Inre arbete
Maskin:	ASM	Variant:	-		Ej klassificerat arbete



Tid för förberedelser:	0,0 s	Använda verktyg
Inre ställtid:	691,5 s	
Tid för återställande:	0,0 s	
Dokument:		

Ställinstruktion

Inre arbete					
Line:	ASM	Maskin:	ASM	**Operatör:**	**Rigg**

Signatur	Tempo Tid	Beskrivning	Bild	Beroenden
	[10-450] pausar transportband Start: 0,0 s Tid: 18,8 s Stopp: 18,8 s			Sluta före Ställa in bredd på transportbana Utförs av: Rigg
	[10-400] Ställa in bredd på transportbana Start: 18,8 s Tid: 128,9 s Stopp: 147,7 s			Sluta före Matar ut kortet Utförs av: Hiss Börja efter pausar transportband Utförs av: Rigg

I Standardized Worksheets

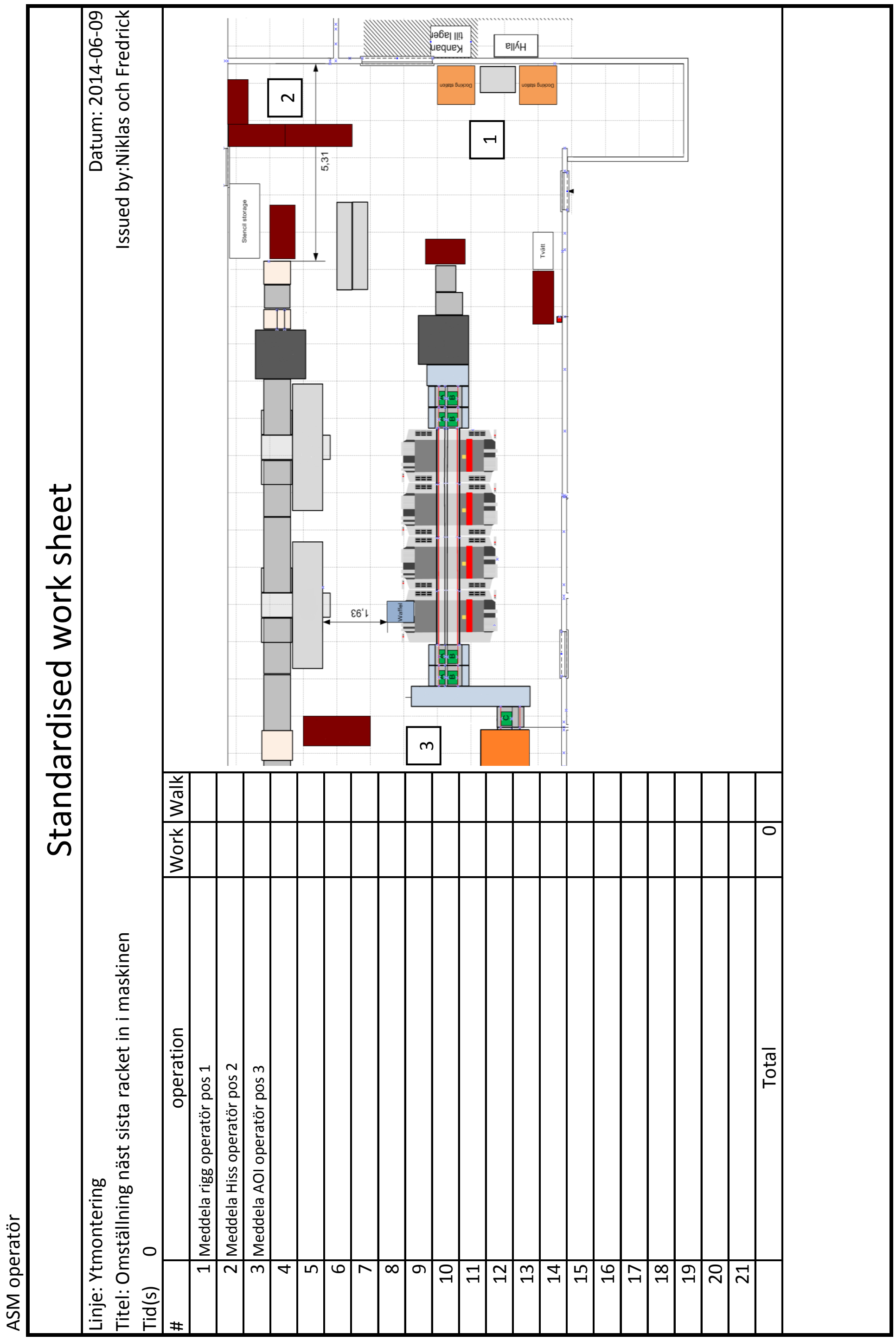


Figure I.1: Standardized worksheet for the ASM operator during the first preparation work before the changeover

ASM operatör

Standardised work sheet

Linje: Ytmontering

Titel: Omställning 10 min innan

Tid(s) 0

Datum: 2014-06-09

Issued by:Niklas och Fredrick

#	operation	Work	Walk
1	Meddela rigg operatör pos 1		
2	Meddela Hiss operatör pos 2		
3	Meddela AOI operatör pos 3		
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	0	

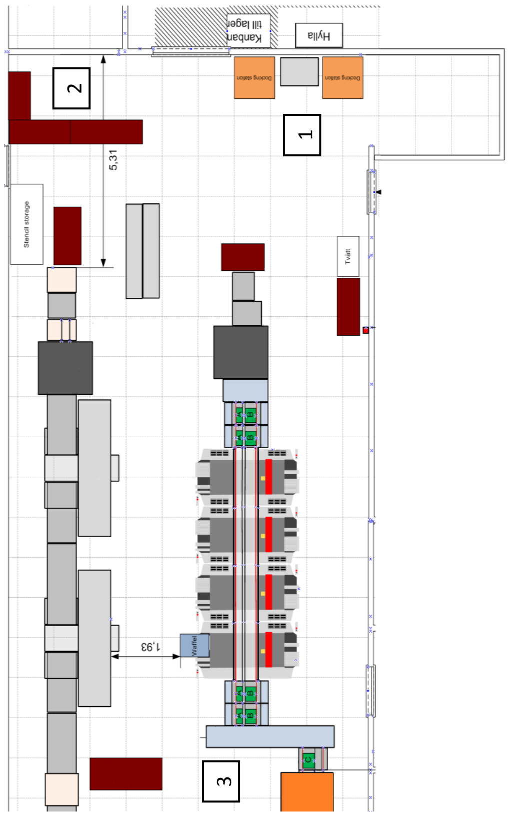
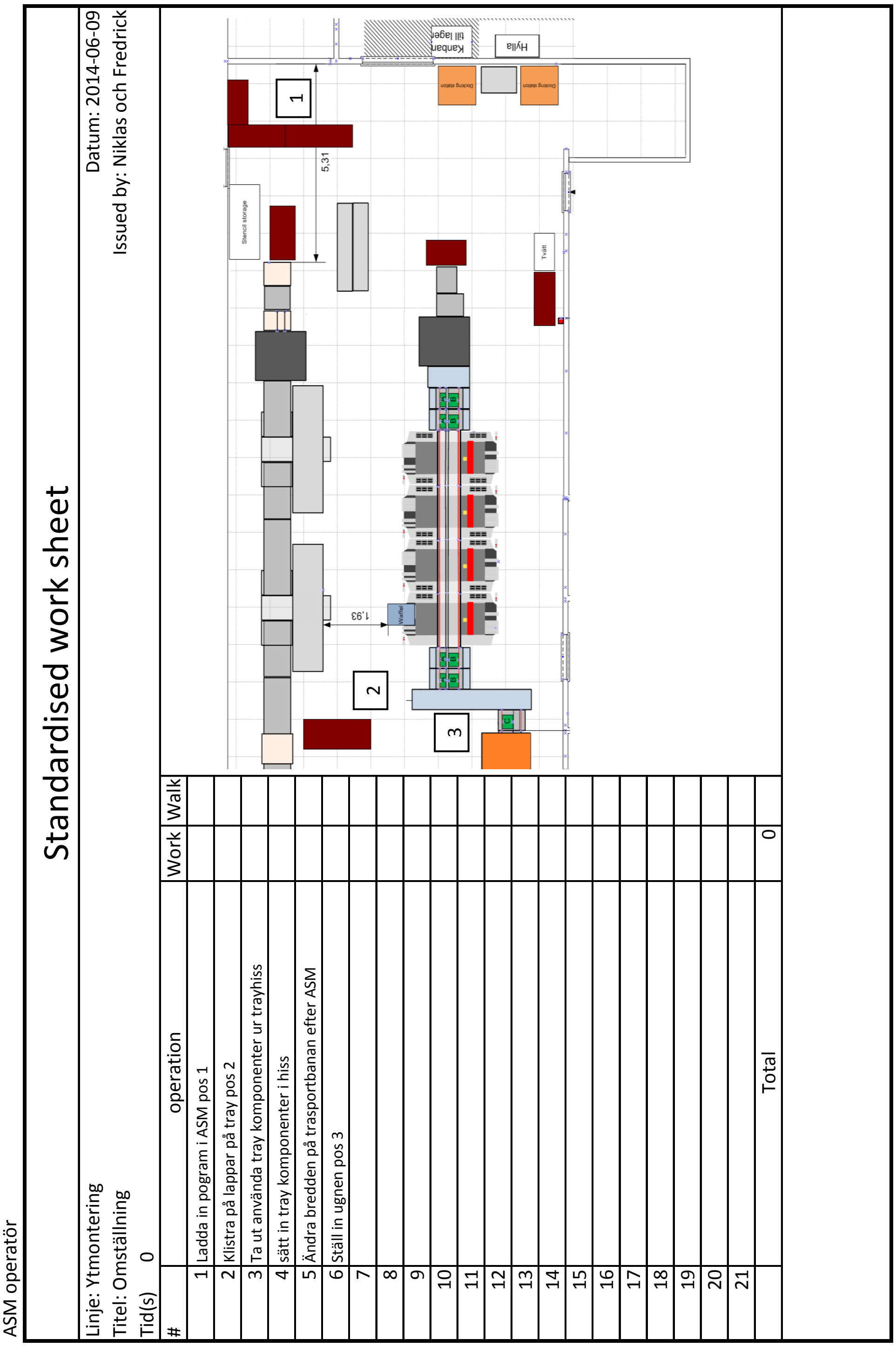


Figure I.2: Standardized worksheet for the ASM operator during the second preparation work before the changeover



ASM operatör

Standardised work sheet

Linje: Ytmontering
Titel: Omställning
Tid(s) 0

Datum: 2014-06-09
Issued by: Niklas och Fredrick

#	operation	Work	Walk
1	Ladda in pogram i ASM pos 1		
2	Klistra på lappar på tray pos 2		
3	Ta ut använda tray komponenter ur trayhiss		
4	sätt in tray komponenter i hiss		
5	Ändra bredden på trasportbanan efter ASM		
6	Ställ in ugnen pos 3		
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	0	

Figure I.3: Standardized worksheet for the ASM operator during the changeover

Hiss operatör

Standardised work sheet

Linje: Ytmontering
Titel: Förberedelse näst sista rack in
Tid(s) 0

Datum:
Issued by:

#	operation	Work	Walk
1	Ta fram traykomponenter från hiss efter lista		
2	Skriva ut etiketter för tray komponenterna		
3	Gå bort med komponenterna till pos 1		
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	0	

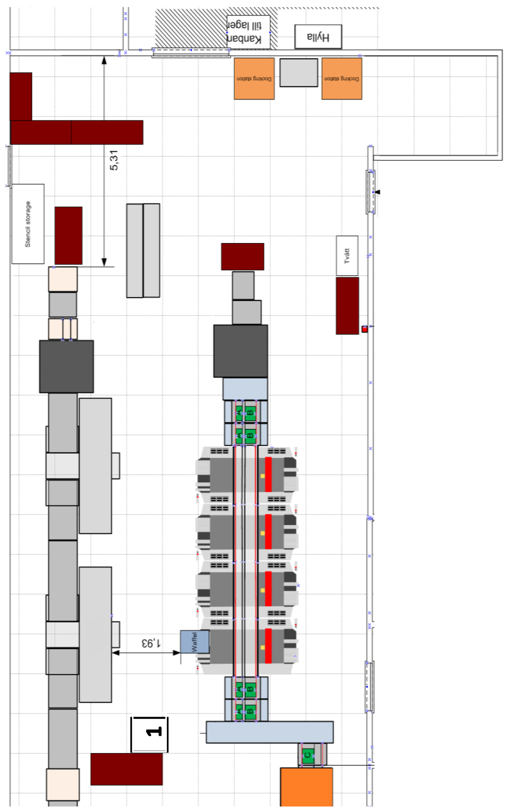


Figure I.4: Standardized worksheet for the operator at the elevator during the first preparation work before the changeover

Hiss operatör

Standardised work sheet

Linje: Ytmontering
Titel:Förberedelse 10 min innan omställning
Tid(s) 194

Datum: 2014-06-05
Issued by: Niklas och Fredrick

#	operation	Work	Walk
1	placera pasta vagn vid pis 2	25	10
2	Kolla om ny burk för pasta rester behövs	10	33
3	Hämta plåt pos 3	46	
4	Hämta handskar pos 3	40	
5	Spänna upp plåt i ram pos 1	19	
6	Gå med plåt och ram till pos 2	11	
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	194	

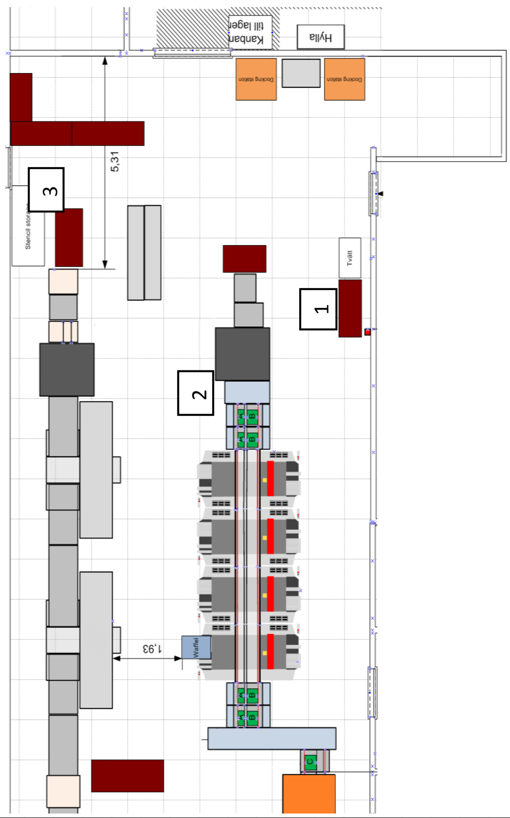


Figure I.5: Standardized worksheet for the operator at the elevator during the second preparation work before the changeover

Hiss operatör

Standardised work sheet

Linje: Ytmontering | Datum: 2014-06-09
Titel: Omställning | Issued by: Niklas och Fredrick
Tid(s) 825

#	operation	Work	Walk
1	Öppna lucka	15	
2	Tömma pasta	121	
3	Ändra inställning kort typ	46	
4	Ta ut rack	12	
5	Ändra så man matar manuellt	25	
6	öppna lucka	30	
7	Placera ut stöden	80	
8	Kontrollera placeringen av stöden	5	
9	Skjut in pasta och spatlar	50	
10	Kör in ramen i screentryckaren	12	
11	skjut in plåt, spatlar, pasta och sätta fast spatlar	62	
12	Smeta ut pasta på plåten	69	
13	kolla så att kortet alignar med plåten	47	
14	Mata ut kortet	43	
15	Ändra så det matas från rack	30	
16	Ställ in rack i maskinen	30	
17	Ställ in mataren	33	
18	Tryck testkort	55	
19	Inspectera kort	45	
20	Sätt tillbaka kortet och kör igång	15	
21			
	Total	825	

Figure I.6: Standardized worksheet for the operator at the elevator during the changeover

Hiss operatör

Standardised work sheet

Linje: Ytmontering
Titel: Efter omställning
Tid(s) 262

Datum: 2014-06-09
Issued by: Niklas och Fredrick

#	operation	Work	Walk
1	Gå med ram samt pasta vagn till pos 1	17	
2	Spänn loss plåt och placera i tvätt	22	
3	Sätt igång tvätten av plåten	46	
4	Rengör spatlar	170	
5	Kasta handskar	7	
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	262	

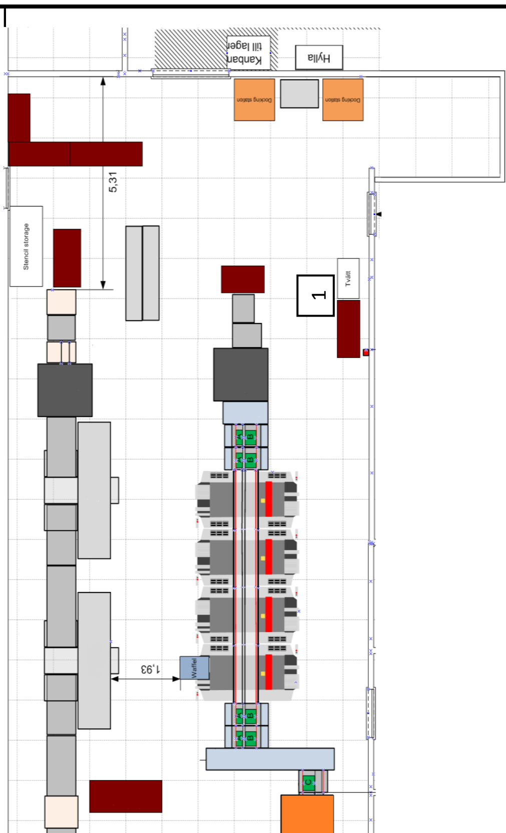


Figure I.7: Standardized worksheet for the operator at the elevator after the changeover

Rigg operatör

Standardised work sheet

Linje: Ytmontering
Titel: Förberedelse då nästsista racket går in
Tid(s)

Datum: 2014-06-05
Issued by: Niklas och Fredrick

#	operation	Antal	Work	Walk
1	Koll rigglista på vagn A2 efter MSL			
2	Rigga alla MSL komponenter			
3	Kolla att alla komponenter sitter på vagnen			
4	Kolla att komponenterna är på rätt plock plats			
5	Gå till vagn B2			
6	Koll rigglista på vagn B2 efter MSL			
7	Rigga alla MSL komponenter			
8	Kolla att alla komponenter sitter på vagnen			
9	Kolla att komponenterna är på rätt plock plats			
10	Gå till vagn C2			
11	Koll rigglista på vagn C2 efter MSL			
12	Rigga alla MSL komponenter			
13	Kolla att alla komponenter sitter på vagnen			
14	Kolla att komponenterna är på rätt plock plats			
15	Gå till vagn D2			
16	Koll rigglista på vagn D2 efter MSL			
17	Rigga alla MSL komponenter			
18	Kolla att alla komponenter sitter på vagnen			
19	Kolla att komponenterna är på rätt plock plats			
20				
21				
	Total			

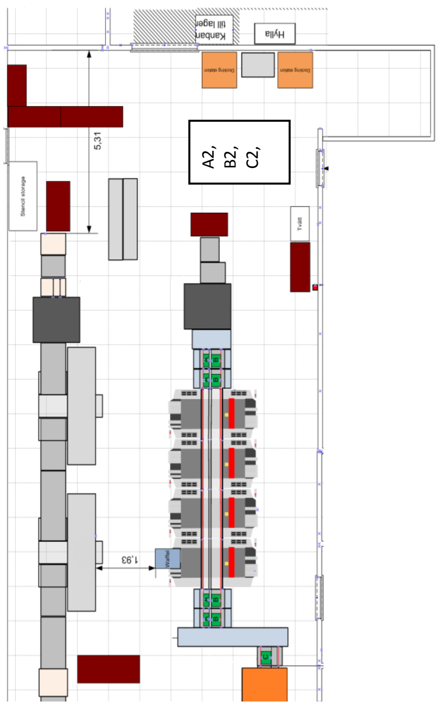


Figure I.8: Standardized worksheet for the Rigging operator during the first preparation work before the changeover

Rigg operatör

Standardised work sheet

Linje: Ytmontering
Datum: 2014-06-05
Titel: Förberedelse 10 min innan omställning
Issued by: Niklas och Fredrick
Tid(s) 91

#	operation	Work	Walk
1	Kör vagn D2 till position 1	20	10
2	Kör vagn C2 till position 2	17	9
3	Kör vagn B2 till position 3	15	8
4	Kör vagn B2 till position 4	12	
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	91	

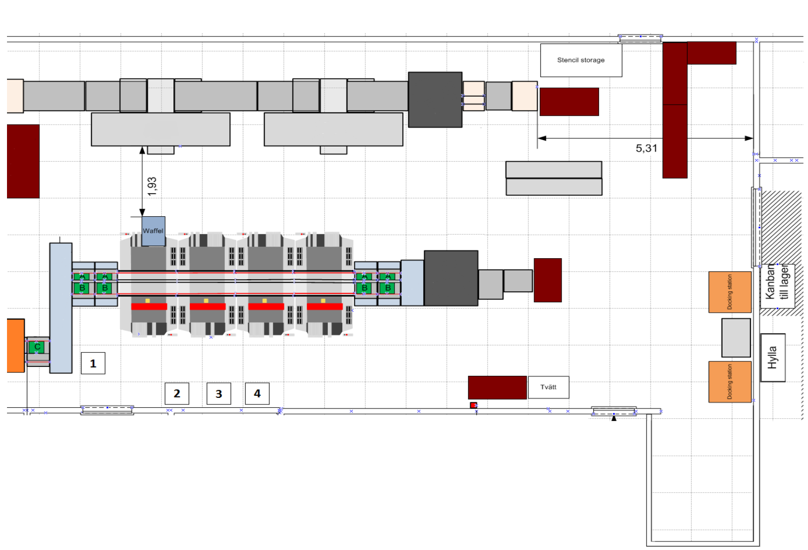


Figure I.9: Standardized worksheet for the Rigging operator during the second preparation work before the changeover

Rigg operatör

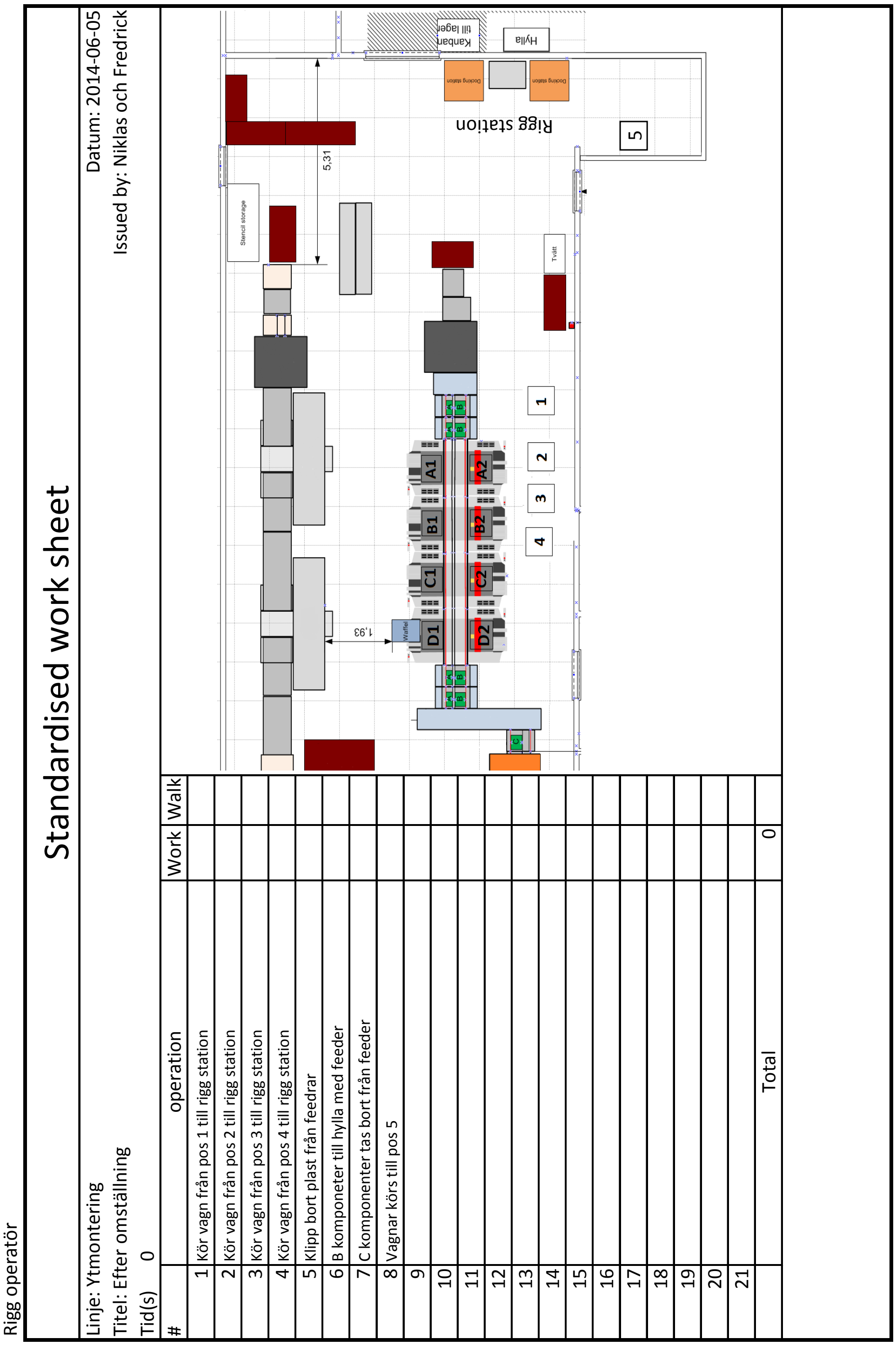
Standardised work sheet

Linje: Ytmontering
Titel: Omställning
Tid(s) 312

Datum: 2014-06-05
Issued by: Niklas och Fredrick

#	operation	Work	Walk
1	Ta ut vagn ur A2 maskinen till pos 1	25	4
2	Sätt in ny vagn i A2 maskinen	35	4
3	Ta ut vagn ur B2 maskinen till pos 2	25	4
4	Sätt in ny vagn i B2 maskinen	35	4
5	Ta ut vagn ur C2 maskinen till pos 3	25	4
6	Sätt in ny vagn i C2 maskinen	35	4
7	Ta ut vagn ur D2 maskinen till pos 4	25	4
8	Sätt in ny vagn i D2 maskinen	35	4
9	Registrera nya vagnen i D2 maskinen	6	4
10	Registrera nya vagnen i C2 maskinen	6	4
11	Registrera nya vagnen i B2 maskinen	6	4
12	Registrera nya vagnen i A2 maskinen	6	4
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	312	

Figure I.10: Standardized worksheet for the Rigging operator during the changeover



Rigg operatör

Standardised work sheet

Linje: Ytmontering
Titel: Efter omställning
Tid(s) 0

Datum: 2014-06-05
Issued by: Niklas och Fredrick

#	operation	Work	Walk
1	Kör vagn från pos 1 till rigg station		
2	Kör vagn från pos 2 till rigg station		
3	Kör vagn från pos 3 till rigg station		
4	Kör vagn från pos 4 till rigg station		
5	Klipp bort plast från feedrar		
6	B komponeter till hylla med feeder		
7	C komponenter tas bort från feeder		
8	Vagnar körs till pos 5		
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	0	

Figure I.11: Standardized worksheet for the Rigging operator after the changeover

AOI operatör

Standardised work sheet

Linje: Ytmontering
Titel:Omställning
Tid(s) 0

Datum: 2014-06-09
Issued by: Niklas och Fredrick

#	operation	Work	Walk
1	Byt vagnar vid pos 1		
2	Hjälp de andra operatörena		
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
	Total	0	

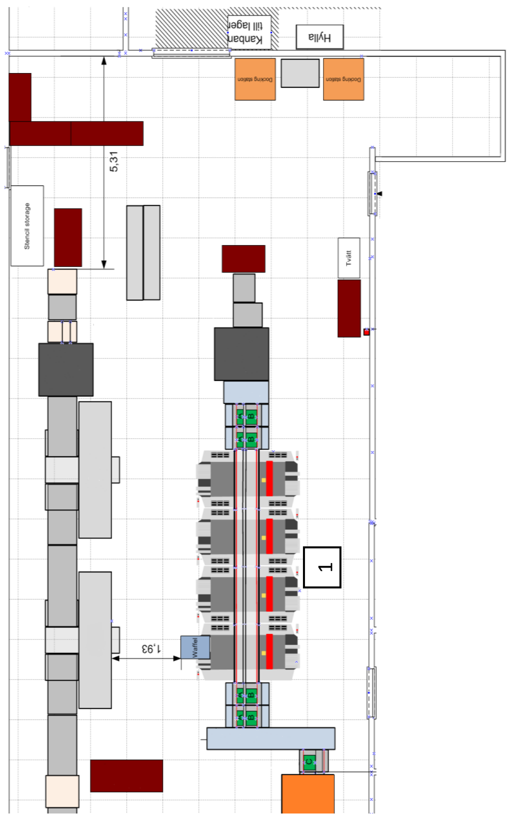


Figure I.12: Standardized worksheet for the AOI operator during the changeover