A model for cost-effectively improving production process with respect to material and information handling.
- A case study

En modell för att kostnadseffektivt förbättra produktionsprocessen med hänsyn till material- och informationshanteringen.
- En fallstudie
Sammanfattning

I den här studien framhävdes vikten av ett omfattande material- och informationshanteringssystem och hur det skulle påverka företaget till det bättre om det implementerades. Med olika verktyg analyserades hela produktionsprocessen och dess olika steg för att bevisa effekten av att implementera en sådan förändring och slutligen rekommenderas ett förslag till företaget som bevisligen skulle ge resultat. Resultaten innebär både förbättringar i liten skala och i större skala, som innebär mer jobb men också ett mer omfattande resultat i slutänden.

Abstract
The purpose of this study is to create a model which will help when working with improvements. The model is based on a Maintenance Function Deployment which helps to highlight the areas within a company that should be improved and focused on in order to make the organization more effective. The model consists of seven steps which in different ways identifies and analyzes the organization and the production process. In the model not only technical aspects are addressed, but aspects related to human resources as well as corporate culture. With two different case companies, manufacturing the same product, this study is investigating how to improve one of them, with the inspiration of the other.

In this study it was highlighted how important the material and information handling systems are and how they would affect the company to the better if they were implemented. With different tools the entire production process and its different steps were analyzed in order to prove the effect of implementing such a change and finally a suggestion for the company is recommended which evidently would give results. The results concerns both smaller changes within the production flow and bigger changes which are more expensive and would mean a lot of more work, although with a greater result.
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Herman Carleke                     Johanna Karlsson
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Abbreviations / Definitions of key terms

Corporate culture - “The collective programming of the mind that distinguishes the members of one organization to another” (Hofstede et al., 2010, pp 344)

Effectiveness - The relationship between actual output and expected output during a determined interval. (Hill, 2005)

Efficiency - Measures how well the plant is utilizing its resources, the lower the input for a given output the more efficient. (Hill, 2005)

Just-in-Time, JIT – A production strategy that refers to reducing in-production inventory by having the right material, at the right time and at the right place. (Womack et al., 1991)

Lead-time - The entire span of time from order to delivery (Ruffa, 2009).

Lean manufacturing - A philosophy that aims to eliminate waste such as unnecessary activities which contribute to the adding of value of the e.g. product. Furthermore, to achieve maximized utilization of resources and time. (Ruffa, 2009)

Process - Bergman and Klefsjö (2010) describes a process to be a number of activities in a repetitive manner to extract value for the customer, both internal and external.

Quality - “The quality of a product is its ability to satisfy, and preferably exceed the needs and expectations of the customers.” (Bergman and Klefsjö, 2010, pp 23)

Radio Frequency Identification, RFID - RFID is a tag not unlike the barcode that can contain information e.g. a product such as design or measurements. The radio waves it emits can be intercepted by a scanner to transfer the tags information to the information system. (Thornton, 2006)

Reject rate: The quantity of scrapped/rejected items in a production during a predetermined interval. (Bergman and Klefsjö, 2010)

Supply chain - The entire route, including mechanisms that enable the movement of material from extraction to the end customer. (Vollman et al., 2005)
**Total Quality management, TQM** - The concept of TQM is to work with involving employees in the continuous improvement of quality. This is made possible by incorporating quality improvement in the corporate culture and working in teams. In order to achieve enhanced quality, activities such as strong leadership, customer analysis and process management is included in the concept. (Bergman and Klefsjö, 2010)

**Vibration-based Maintenance, VBM:** Maintenance strategy based on measuring the vibration emitted from a certain points of a e.g. rolling element to detect early indications of deterioration mechanisms. (Al-Najjar, 2010)
1. **Introduction**  
*This chapter will introduce the thesis to the reader. It will present the problem from discussion, purpose and relevance point of view. Lastly, this chapter will reveal the limitations of the thesis.*

1.1 **Background**  
Global competition and a higher awareness from the customer have in the recent years raised the requirements for achieving high quality products in an effective and efficient way. Continuous improvements and developing the products and the production processes has led to new ideas and concepts, which have become methodologies suitable for a company in order to keep the production process cost-effective, productive and competitive (Bergman & Klefsjö, 2010).

Due to e.g. trends the companies need to find other of ways of meeting or exceeding the customers’ demands often pushes companies to change and adapt the different way of e.g. working or thinking. This change of ways needs to be dealt with by managers due to the reluctant nature to change in organizations (Hayes, 2007) and (Seidmann and Sundararajan, 1997). Methodologies such as TQM and Lean manufacturing have gained confidence at world leading manufacturing companies in order to achieve, improve or maintain a flawless production process at the same time as smaller concepts about management, such as change management and the effects around different management methods is starting to get a foothold (Bergman & Klefsjö, 2010).

While the focus commonly is on quality assurance and maintaining equipment to reduce unnecessary costs, it is easy to neglect the role of logistics. The awareness of how important this area is has increased over the last years and the effects of having an optimized arrangement of the facility layout have been acknowledged as a way to address logistical issues. Facilities planning can be applied in order to minimize costs related to the process flow, such as material logistics, and to speed up the lead-time by reducing unnecessary movements (Tompkins et al., 2010).

1.2 **Problem discussion**  
The importance of logistics is to define the routes of the material and information within the company and the repetitions of the movement or transactions in a production. Reducing e.g. transportation distances can result in shortened lead-time. This could be the way to achieve parts of supply chain excellence. The identifying of the non-value adding activities makes it possible to use the resources more efficient, by reducing or eliminating these activities to free resources (Jonsson, 2008).

It is important to get the organization working as one process instead of sub optimizing the various departments (Jonsson, 2008). In order to achieve this, companies can make use of facilities planning as a strategic tool due to the fact that material handling reaches up 35-70 % of the costs of the production (Chiang & Chiang, 2008). According to
Tompkins et al. (2010) the costs that are related to material handling can be reduced by 10-30% by using a proper facility layout. The strategy refers to the arrangement of the e.g. workstations in a production process. To make use of tools such as activity network chart to aid in designing a new layout which could improve the plants cost-effectiveness by reducing the material handling costs. The creation of a new design is often met with restrictions such as space requirements (Tompkins et al. 2010). In addition, Klein and Rai (2009) emphasize the importance of the infrastructure of information flow within the company and its ability to efficiently communicate with suppliers and customers as a main factor to be able quickly adapt to the changes in the market.

1.3 Presentation of problem
The utilization and productivity of the plant can be greatly improved when addressing the areas material handling and information and material logistics. When identifying and mapping these processes one can see where the production can be improved in terms of losses such as idling and stoppages that will result in reduced cost in the production (Tompkins et al., 2010).

To be able to reach an increased cost-effectiveness, these issues can be evaluated to lastly be improved and allocating resources to the right place to increase the company's competitive edge (Björnland et al., 2003). The problem lies in combining these areas and systematically finding a solution to address these issues that is present in the industry. The problem is that the tools available address different problems or has specific approaches that can neglect other important aspects. Furthermore, by using a combination of the tools available one can evaluate and calculate the relationship between the various departments and identify which issues to focus on (Tompkins et al., 2010). The nature present in the industry that involves employees engaging changes in e.g. work routines with unease and hostility must be dealt with to achieve a successful implementation (Hayes, 2007).

1.4 Problem formulation
“How to increase the cost-effectiveness in a production process with respect to information and material logistics.”

1.5 Purpose
The purpose of this thesis is to develop a model to cost-effectively improve the production process flow with respect to information and material logistics. The model aids companies to eliminate unnecessary movements and transactions of information in order to reduce costs related to logistics.

1.6 Relevance
The importance of facilities planning and material flow is a big area which is acknowledged in a lot of literature. Although it is highlighted that the plant layout will increase or decrease the lead-time based on how the production process flow will run, this information is not being used by all companies, due to e.g. initial cost of a rearrangement
and loss of production. This is where the relevance of our study comes in, to make it easier for companies to improve the internal logistics without rearranging the plant. The company in particular that is the main focus in this thesis to be improved, has a traditional way of thinking and working and is opposing to changes and new modern ways of working. This is common in many manufacturing companies due to their strong cultures and loyal employees (Murthy, 2007). According to Lamond (2005) the management is the bridge between new implementations and the employees’ acceptance. This will be used in the analysis after the model has been created in order to show the importance of motivating management and how it will improve the implementation of a new way of work-method.

By making an analysis of the material and information flow and estimate how different changes may affect the company profitability or quality with concrete numbers we hope to give an insight in how they can improve their business. This can be achieved with the help of different theories about logistics and material handling, such as activity network diagram and other tools to evaluate the different stations in the plant and make an as realistic model as possible that will give the greatest benefits and make the business as cost-effective as possible. According to Tompkins et al. (2007) a company has to, in order to stay competitive, need to be cost-effective and give high customer satisfaction, and the material and information handling can help to achieve this and can keep you from achieving it when it is not used properly or not used at all.

1.7 Limitations/delimitations
During this thesis we will have some limitations that will be restricted to one case company and will take the considerations of their production and a comparison will be made with a similar production in the corporate group. The model developed will only be tested on one case company. Other restrictions are the observations, they could be more extensive in terms of amount and variables such as costs related to damages in production logistics to get more reliable input for the tools, models et cetera. Delimitations of the model to be developed focus on an approach to continuously improve internal logistics in terms of material and information flow. In addition, the comparison of our alternatives will be based on the goals of the specific business. It will not include layout suggestions.
1.8 Timeframe

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Table 1.1. Showing the timeframe of this thesis.
2. Research methodology
This chapter will feature the methodologies present when conducting research. It will reveal the various research perspectives and approaches followed by the reasoning of which ones we use. Lastly, how one can assure that the results are valid, reliable and generalizable.

2.1 Qualitative and quantitative research
The methodology of research is often divided into two categories: qualitative and quantitative methodology. When deciding upon what methodology to use, one need to understand what study that is going to be conducted to properly choose the suitable method. Furthermore, to know which one to choose the researcher has to be aware of what makes them differ.

Qualitative research is when interpretation of the result is present. Collection of data in the norms and values in a corporate culture. The other spectrum is the quantitative and this methodology makes use of e.g. comparison of numbers such as seen in statistics is one of the main focuses of this methodology. This has been stated to be more objective and only account for logic and rationality (Bryman and Bell, 2005).

2.2 Scientific perspective
There are two main scientific perspectives when conducting research and these are called positivism and hermeneutics. The two perspectives differ in terms of e.g. objectivity. The perspectives are briefly presented in the two coming paragraphs.

The perspective derived from the traditional methods used in the area of nature science such as chemistry and physics. Positivism is a perspective which addresses the positivity and objectivity in the data. Subjectivity, on the other hand of the interpretation of the data is not considered as scientific (Bryman and Bell, 2005). According to Bengtsson and Bengtsson (2002) the perspective there are two sources of knowledge 1.) The things we can observe with our senses and 2.) the things we logically can calculate. The results and conclusions should be based on facts and thorough observations by the researcher (Giddens, 2006).

Hermeneutics in contrast to the positivism allows subjectivity and opens up to interpretation and reflection of the data. This perspective can e.g. take human behavior into account which in some cases can be random and hard or impossible to logically calculate. In addition, how we use words in different ways to describe or analyze things. The researchers that are using this perspective is interested in the area as a whole and not in exact numbers. This perspective can be seen when interpreting literature or philosophy (Bryman and Bell, 2005).
2.3 Research approach

2.3.1 Inductive
Approaching a study in an inductive way is to form observations and results connect them to theories. The approach goes from specific observations and is widened to generalization and gives room for uncertainties (Bryman and Bell, 2005). The inductive approach is to discover the area included in the research to form a theoretical framework to generalize the e.g. phenomenon. A risk when using this approach is that the theories may not be general due to the fact that it is based on a specific case (Patel and Davidsson, 2011).

![Figure 2.1 The three main processes of the inductive approach. Source: Bengtsson and Bengtsson (2002).](image)

2.3.2 Deductive
The deductive way of approaching a study is by starting from a set number of theories to use as perspective to view the specific area of the study by creating one or more hypothesis. The theories are then tested to be confirmed or denied by comparing data from the related area. Furthermore, a comparison is made and the theories may be revised if needed. A disadvantage of this approach is that the data collected can differ from the hypothesis (Bryman and Bell 2005). The theories determines what data to collect in the research and how the data should be interpreted, some considered this to be objective due to the absences of bias of the result. Critics say that this way of working can be an obstacle to not finding new results or conclusions (Patel and Davidsson 2011).

2.3.3 Abductive
The abductive research approach can be considered as a combination of the previously mentioned inductive and deductive approaches. The first step is to use the inductive approach to gather data from a specific case to form theoretical framework. The following step is addressing the testing of the formed theories, deductive approach. This leaves the researcher with the choice of testing both ways instead of restricting itself to only one (Patel and Davidsson 2011).

This research will make use of the abductive approach due to the fact that we are going to develop a model based on theory and verifying it by using data gathered at the case company. We will start by gathering relevant theories to form a scope of what is considered important to observe measure etc. to later be applied on the case company.
2.4 Case study
The method of working with a case study aims to focus on a e.g. individual, group, organization or other subject in order to get a deeper understanding within that “case”. The approach is to empirically gather information about the subject to get a more detailed and holistic view over the different relationships and processes (Bryman, 2007).

In this study we will be working with two different case companies, where we will perform interviews and gather data through observations in order to get a more reliable result. The two companies will be analyzed individually to show how different two similar productions can be although the output is the same and finally one of the cases will be used as inspiration in order to suggest improvements for the other one and vice versa.

2.5 Data collection
The data that will be collected at the case company were gathered in different ways in order to get a holistic view over the production, the management and the strategies.

2.5.1 Observations
Observations are performed in order to get an understanding in how a process works by actually seeing it. The observations can be structured or unstructured. A structured observation means that the researcher has prepared what he is going to observe more structured while the unstructured observations means that just about anything can be observed in order to get a holistic understanding of a process or an area (Bryman, 1997).

By making observations the researcher can see the process of the study in its natural environment being affected by real life factors instead of reading about how it is performed. Observations should be made both when the ones being observed is aware of it and hidden in order to get the most reliable findings since the test people could be affected by the awareness of the observation (Patel & Davidson, 2011).

We will perform observations in two plants, by ourselves and in addition a guided tour with the plant managers. We will make quantitative measurements on the logistics within the plants, individually and then compare these findings according to reliability strategies in order to get realistic and reliable empirical findings.

2.5.2 Interviews
Interviews are performed to gather information by communication between the researcher and a or several individuals connected to the object of the study. The interviews can be structured which means that you ask questions based on a questionnaire or a framework with questions. It could also be unstructured which means that the questions are formulated based on the discussion with the individual you are interviewing and the interview is shaped during the discussion. A survey could also be a sort of interview, here the object of the interview should not discuss anything outside the questions (Bryman, 1997).
We will perform interviews continuously during the project, both structured and unstructured. We have prepared questions for the different companies about the plant business and goals etc. We will also have unstructured interviews during i.e. the guided tour around the plant in order to get a deeper understanding of how they think and work, but also to develop a discussion around problems within the plant and how they have tried to/are going to solve them. No surveys will be done in this study.

2.5.3 Literature review
A literature review is used in studies in order to give the researcher knowledge in a topic, to get understanding and be able to analyze and compare different findings that a researcher may get in a study. It is also used to give the reader of the study an overview of how the different problems within the study were solved and the strengths and weaknesses within the theories (Bryman, 1997).

A literature review is gathered through books, scientific journals, articles and the internet and this should be performed early in the study since it is the base for the entire research. It could also help to narrow down the problem and make it easier to solve by finding sub-problems. One could combine the basic knowledge in books with the edge knowledge in journals and articles in order to get a strong theoretical framework (Patel & Davidson, 2011).

In this study books from the library will be used, combined with articles and scientific journals from the BSP (Business Source Premier) database to get the knowledge needed to solve our problem formulation. E-books from EBRARY will also be used for knowledge as well as previous student thesis from DiVA for inspiration.

2.6 Validity
Validity is a concept within the qualitative research area and it is used to question if your research is measuring what you were intended to measure i.e. the correctness of the measurements and if the results show what they were meant to show (Bryman, 1997). Validity is about determining whether the results of measurements are accurate from the purpose of the researcher, the participants of the research or the readers of the results. When talking about validity words such as trustworthiness and credibility are often used and discussed (Creswell, 2009).

According to Creswell (2009) a researcher should identify and discuss different strategies to ensure the authenticity and the accuracy of the findings. By using different validity strategies the researcher could enhance the possibility of achieving results with high accuracy and also convince the readers of the truth in their research. Examples of different validity strategies are:
○ Using a peer debriefer - finding someone who can review the research and ask questions about it so that it is not only the researcher who resonates about the qualitative study.
○ Using an external auditor - in comparison to the peer debriefer, this person is unfamiliar to the researcher and the project and could provide you with a objective assessment of the study.
○ Triangulation - by triangulating different sources of information one could get closer to the “truth” by combining the data from the different sources. This could help to ensure the precision of the study (Creswell, 2009).

In this study the validity will be ensured with the help of peer debriefers, all familiar to the research. This will be examiner of the study, teachers and other researchers which will read and question the work.

2.7 Reliability
While the validity ensures the accuracy of the findings, the qualitative reliability is about the consistent approach during the research. The reliability ensures that the results will be consistent no matter what the internal and external factors can be, it should not matter who performs the research or how many times it is performed, the result should be the same; it should be reliable (Denzin & Lincoln, 2000).

In order to ensure that the study is reliable, Creswell (2009) suggests that documentation should be performed consistently during the study, such as a detailed documentation of the different steps of the procedure.

According to Patel & Davidson (2011) when working with observations there are two different ways of ensuring the reliability of the findings. These two are called “rater reliability” and “occurrence reliability”. The rater reliability is also called parallel reliability due to the fact that two different observers are performing the research and the results are put in comparison to each other. The occurrence reliability can help to ensure the reliability of interviews, by comparing two researchers notations from the questions asked. If one interviewer have 2 notations on a questions, and the other one has 3 these numbers can easily be divided in order to get a occurrence reliability-number. A high number means high reliability of the observation, in this case it will be 2 / 3 = 0.67 (Patel & Davidson, 2011).

The reliability of the study will be ensured by having both researchers taking notes during the data gathering and comparing the results to make it as accurate as possible. Interviews will not be recorded although when there is a question about a note the company will be contacted again in order to get the correct answers. When making measurements distances and times will be measured multiple times to ensure that the numbers are consistent.
2.8 Generalization
In the world of scientific research it is of great importance to show the ability of the research to be applied on other cases than the case for that specific study. This is done to show that the sample, case, is representative for a population, e.g. industry. If this is possible the researcher can develop grand theories that can be considered in further studies for a certain population (Bryman, 1997).

Generalization consists of two main aspects: empirical and theoretical generalization. Were empirical generalization refers to the conclusion of empirical findings is applicable populations other than the specific sample. The theoretical generalization refers to the widening of a theory, applying it on another population to test generalization (Richie and Lewis, 2003).

The generalization will be ensured by basing the empirical data collection on the model and using the maintenance function deployment to systematically obtain data and information needed. Due to the fact that the model is developed to be able to be applied on producing companies other than the specific case, will also ensure the generalization.
3. **Theory**  
*This section will provide the sufficient theoretical framework for this study. These will determine how the collected data will be processed and analyzed to generate results.*

3.1 Facilities planning  
Facilities planning has under the latest decades proven to be a strategic tool to achieve an improved supply chain. The goal is to achieve integration from all steps from order to delivery, to eliminate the barriers between the departments and making the exchange of information and material as efficient as possible. The planning of the facilities has as objective to e.g. be flexible to meet different types of demands without redesigning the facility and be able to adapt to the change in amount of demand (Tompkins et al., 2010).

Tompkins et al. (2010) describes nine steps to systematically approach the design process of facility planning illustrated in figure 2., starting with defining the objective of the facility to the maintaining of the plan.

![Figure 3.1 Model of the general approach of facilities planning in e.g. manufacturing facilities. Source: Tompkins et al. (2010).](image-url)
3.2 Plant design
The planning of the facility takes material handling system design and interrelationship evaluation to see the interaction of the various departments together with information and material moving throughout the organization. In addition, the process design is a vital step when considering planning the production in a different way. Questions such as: Can this be done in another way, should be asked. To systematically evaluate the processes to continuously improve the effectiveness and efficiency (Tompkins et al. 2010).

These activities could work as a foundation to developing a new layout of the facility to achieve an increased profitability. Tompkins et al. (2010) states that there are a number of traditionally creating the layout of the facility. There are four basic types of layout:, and fixed product layout.

*Process layout groups*, the process e.g. all drilling machines are located in the same department and then sent to the next department where the next process takes place. *Product family layout*, the production is divided into workstations that are producing certain sorts of products. Also known as cellular manufacturing, specializing on certain product families and arranging them accordingly. *Production line product layout*, similar to the product family layout. But here the production is specialized on a particular product that is fairly standardized and has a high demand. The different products of the production have dedicated production lines making only the assigned product. *Fixed production layout*, is fixed due to its restriction to the product it is making. E.g. the production of large products such as aero planes. The restrictions could be e.g. space as in the aero plane case (Tompkins et al. 2010).

3.3 Muther´s Systematic layout planning (SLP) procedure
The development of a layout could be done by using SLP to systematically find the most suitable solution for the specific plant. Muther´s procedure is one of the more commonly used methods in the topic. It provides a number of tools that enables the facility planner to see the relations and requirements of the production. The following chapters will present the tools and charts that are included in SLP. According to Tompkins et al. (2010) the procedure unfolds as in figure 4.1.
3.3.1 Activity Relationship Charts
One of the most critical decision making processes when designing a new plant layout is to evaluate the logistics between the working stations and how important it is for different working stations to be close or far away from each other. Measurements can be made either qualitative or quantitative, which means that the importance of the relationship between the working stations are either judged based on e.g. factors that may affect the quality of the product, or by how large amount of material which is being transported between two different stations. This is later used to calculate the most effective arrangement of the plant (Tompkins et al., 2010).

In the activity relationship tool box there is one quantitative method that is frequently used, the from-to-chart. The chart illustrates the distance between e.g. workstations shown in figure 3.3.
3.3.2 Relationship diagram/Space Relationship Diagram
The next step is to illustrate the relationships of the departments by using a relationship diagram. Showing the flow between the workstations and the next step is to add the space requirements of the various workstations to see the holistic view with both flow and space (Tompkins et al. 2010).

3.4 Maintenance Function Deployment (MFD)
The MFD method is similar to the QFD with four different steps, although it is focused on the production processes and operations instead of the actual product. Al-Najjar (2010) states the different phases within MFD is:

1. Identify the “What”s and “How”s. The “What”s is the output, or what you want to achieve from a working station. Outputs could be for instance high quality of the final product, delivery on time, competitive price, environmental friendly production or having
reliable condition on a machine. These outputs are made possible by the “How”s which is the technical requirements for what is needed to achieve, maintain or improve the output to the wanted condition. The output is important to keep at the wanted quality level in order to reach the company’s strategical goal.

2. In the second phase the tools that are needed to achieve, maintain or improve the “What”s are identified. The “How”s are switched against tools that will make them possible, for example an appropriate maintenance policy, like Condition-based or Preventive maintenance.

3. In phase three the tools used in phase two are used and here you show which activities are needed in order to have an effective utilization of those tools. No matter how much competence you have and no matter how perfectly planned your production is and how reliable the tools that you use to maintain the “What”s are, machines and parts will still deteriorate and age. Therefore it is important to educate your employees to always stay competitive by having the edge knowledge, and the basic knowledge, and to be able to keep your tools and machines available and reliable at all times. Possible tools for having an effective utilization of tools used to maintain the requirements could be for instance education as mentioned earlier, Condition monitoring techniques and a database for information and knowledge.

4. In the fourth and last step the “How”s becomes the “What”s, which means that the activities that were chosen to use to maintain the tools that were needed to achieve, maintain or improve the requirements, becomes the requirements themselves. The “How”s are now the factors which are required to integrate maintenance and its importance into the plant and make it work in order to reach the strategical goals. Factors could be for instance making a plan for integrating the maintenance into the plant business, having a risk capital for this kind of work or the managerial strategies which may be needed in order to motivate this kind of change within the plant.

An implementation of the MFD method could help to determine the importance of maintenance and the impact it has on the strategical goals of the company, and also to improve the profitability of the company and raise their competitiveness by eliminating the losses. By integrating maintenance within the plant business it could also help to eliminate economical losses. MFD is similar to QFD, although it is not a replacement for it, it is more of a support for it. By working with MFD one could get a wider more detailed view of the production process and enhance the QFD.( Al-Najjar 2010)

3.5 Flow analysis

3.5.1 Cross-functional flowchart

Pryzdek and Keller (2010) describes that the cross-functional flowchart is one part of the methodology of six sigma and it is used to illustratively show and document a process,
e.g. a production process. The different phases of the process are shown with differently shaped figures. The start and the end are represented by circles. The direction of the process is mapped out with arrows and the different steps of the process are aligned with chronological consideration. The tasks to be performed in the process are illustrated with squared boxes, the decision making is shown with diamonds. The decision making has two outcomes, yes or no, which will affect the next step of the process. The areas of responsibility in the process can also be shown with intersection of which tasks are performed by which actor (Pryzdek & Keller, 2010). An example is illustrated in figure 3.4.

![Diagram of a cross-functional flowchart]

*Figure 3.4 An example of a cross-functional flowchart. Source: Own example*

**3.5.2 Integration Definition Language 0 (IDEF0)**

The integrated definition language is methodology has as objective to systematically illustrate a manufacturing process with its different functions, information and decisions. IDEF0 is one of the steps in the IDEF-series and is used in the development of a system. The modeling takes four main factors that is related to the main functions or main activities in the process. These four are: Inputs, controls, outputs and mechanisms, illustrated in figure 3.5 (Chin et al. 2006).
**Inputs:** Resources used as input of for the activity e.g. Metal sheet, logs, tubes etc.

**Controls:** Measurements, laws, regulations etc.

**Outputs:** Processed input.

**Mechanisms:** Resources used in the activity e.g. hammer, grind, operator.

![Diagram of IDEF0 modeling](image.png)

*Figure 3.5 The functions and notation of IDEF0 modeling. Source: Buede (2009)*

### 3.6 Logistic management

#### 3.6.1 Definition

Logistic is the management of different flows. It is about leading and managing the flow of materials and the information and resources connected to that flow. There are different kinds of logistics, i.e.

- *Transportation logistics* is the physical movement between point A and B and the most common ways of transporting is with; trucks, railroads, boats and airplanes. This kind of transportation happens between supplier and manufacturer or between manufacturer and end-customer.

- *The production logistics* is different since it focuses on the internal actions within a business and how to improve the effectiveness and efficiency, raising the capacity and controlling the lead-times (Larsen et al. 2007).

#### 3.6.2 Information Systems

By integrating information systems or other IT in a supply chain a company can reduce unnecessary inventory and replace it with the information necessary to keep the production flowing without a large inventory. IT allows for monitoring and control of the operations without any boundaries due to the geographical location. Documentation and internal operations routines can be automated with help of different systems, which can lead to processed orders quicker and with less human intervention (Larsen et al. 2007).
The analyzing of information flow throughout the business is important to see the transaction passing from one location to another. Information mapping could be used to visualize and aid to understand the organization. According to Hibberd and Evett (2004) the information mapping can provide certain benefits such as aiding to understand how and by whom information is used, it can reveal by whom as a client the information is ultimate for. Lastly, getting the most of the information inside your organization. A systematic way of mapping the organization is developed by Hibberd and Evett (2004) and consists of a five step approach presented below.

1. Starting with describing the present state of the information flow. E.g. identifying which actors getting information and which that are not.
2. Depict potential alternative clients whom can benefit of using the information.
3. Create a map of the potential clients eventually meaning rerouting of the transaction flow.
4. List the solutions and prioritize them.
5. Creating a information map illustrating the new information flow e.g. for each department involved.

3.6.3 Logistic Information
The logistic information can be divided into different groups based on its characteristics and functions, as shown in figure 3.6. These groups are:

- Transactional information - standard information about individual logistic activities and functions.
- Management control information - About performance measurements.
- Decision Analysis information - This information can help to compare different logistic alternatives and evaluate the strategic and tactical advantages of these.
- Strategic Planning information - information for business planning and for models for decision making (Larsen et al. 2007).
3.6.4 Integration of information systems in operations

Integrating information systems and involving all the different actors within the supply chain is a basic requirement in order to optimize the total supply chain. Different transactions within the supply chain triggers the activation of operations which leads to movement of materials or products. The supply chain can be divided into Supply management which is the flow of materials and products in the production back to the supplier and the Demand management which covers the span from customer order to production, the critical link here is the production scheduling. The production scheduling is the key to a successful production and is performed with the help of approaches such as MRP, basing the production on priority-numbers or getting a optimised schedule with the help of a computer (Larsen et al. 2007).

3.7 Material handling

The material handling refers to the handling and transporting the material internally in a facility. The handling includes e.g. the receiving of goods, internal transportation and packaging. Material handling has to consider a number of different factors when it is designed e.g. the frequency of the movement between two workstations, how long the distance is between them and so on. Certain components and distances may require heavy loads or awkward lifting. To deal with these lifting and transportation there is material handling systems such as robots or lift contraptions. These solutions could make it easier on the operators and improve the throughput time of the material (Jonsson, 2008).
According to Tompkins et al. (2010) the material handling should include nine different criteria’s: Right amount, right time, right material, right condition, right sequence, right orientation, right place, right time, right cost and right method. Theses nine rights should be evaluated to see if your material handling is suitable for your production; to achieve all of these emphases needs to be put on the planning to make the different activities interact seamlessly and with timing.

The designing of the system should be started with asking following questions shown in figure 3.7. The principles starts with defining what that is going to be moved, this refers to the material. Next step is to determine when and where the material should be moved, due to many companies e.g. work with lean manufacturing and JIT which requires timing and planning. Lastly, how and by whom the material is about to be transported and these questions should result in which system to choose or an evaluation of a number of systems. These questions are a part of the material handling system equation (Tompkins et al. 2010)

![Figure 3.7 Source: Tompkins et al. (2010)](image)

The description of the material handling can be presented in a table as shown in table 3.1

<table>
<thead>
<tr>
<th>Step no.</th>
<th>O</th>
<th>T</th>
<th>S</th>
<th>I</th>
<th>Description</th>
<th>Distance</th>
<th>Method of handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Transportation from A to B</td>
<td>X meter</td>
<td>Fork lift, conveyor belt etc.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Waiting for operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>Processing of material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Quality check</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 3.1 Showing the different parts of material handling evaluation*

The first column reveals the number of the activity, in other words, the order of the activities. The second group of columns Operation, Transportation, Storage and Inspection describes what type of activity it is. Next column leaves room to briefly describe the activity. The fourth column describes i meters how long the transportation is followed by what type of material handling it concerns.

3.7.1 Material handling systems
To plan and organize the movement of the physical flow in the production a system could be used to administrate and control the production. There are different methods that can
be applied in a production (Tompkins et al. 2010) According to the institute of transportation research (2002) a major part of in the material handling system includes the equipment for handling and transportation in the production. The equipment should facilitate the operators to handle, store and move material, the movement could be performed by e.g. a forklift or a conveyor belt and a information system could be used to locate and checkout items. Moreover, shelves and pallets are used in many productions to make transportation and storage easier. The system for handling the material could be automated in and make use of information systems that are connected to reduce wear on the operators from heavy lifting or just being able to do it more efficiently (Jonsson, 2005).

3.8 Management strategies
3.8.1 Change management
The changing demands of the market forces the companies to improve or change their e.g. production in order to compete with companies that are agile and adjust to the changes (Hayes, 2007). This is where change management is an important factor to make it possible to successfully implement the changes needed due to the risks that is following a shift in the evolution of e.g. technology and demand. Kotter (1996) states that there are eight common mistakes that is present when change is in organizations:

- The allowance of too much compliancy - To go into the change with ease and not communicating the severity and urgency of the change.
- Insufficient guiding of the managers and leaders - The ones in charge need to be involved and committed to pass the motivation down to the other employees.
- Not seeing the impact of a vision - The vision can be used as a guideline and inspire the people involved in the change.
- The vision is under communicated - Not spreading the vision in an efficient way e.g. when heads of the organization behaves in contradiction to the vision which spreads a feeling of betrayal or hypocrisy among the employees making them lose faith in the change.
- Letting obstacles hinder the vision - E.g. The organization structure is often an obstacle that stands in the way for successful change, if the obstacles are known by employees the change will not be empowered and the change is likely to be negatively affected.
- Not being able to set short-term wins - If the employees can not see the short-term wins of the change they are less willing to dedicate to the long-term win.
- Claim victory before it is finished - many organizations declare that the change is almost complete, but the change is not fully adopted until it is a part of the organizational culture. If this is done old traditions and habits
are likely to emerge in the organization making the change regress into the previous state.

- failing to incorporate the change in the corporate culture - Only making the change at the surface as change of routines or reorganization, not seeing the importance of being the change in contrast to doing the change.

According to Hayes (2007) there are two main types of change, incremental and transformational change. The incremental change is the type that refers to the continuous improvement of an organization, in other words evolution of the organization by enhancing or adding e.g. processes. Transformational change is fundamental changes such as centralizing of an organization.

3.8.2 Process Management
Process management is the discussion about processes and process improvements. According to Bergman & Klefsjö(2010) there are four steps of the process management procedure:

- The first is ‘Organize for improvement’ which means that ownership and a process improvement team should be defined.
- The second step, ‘Understand the process’ is about defining boundaries and investigating who the customers and suppliers are. It documents the flow of the work.
- The third step, ‘Observe the process’ deals with controlling the process. The process manager should establish control points and implement measurements. The process should fulfill the goals that have been set for it.
- In the fourth and final step, ‘Improve the process continuously’, the process owner should use the feedback from the measurement and control system to improve the process.

3.9 5S
This methodology refers to keep the work place organized and tidy. It involves five pillars beginning with S which explains the name The First stands for Sort, which means that only items needed for the operation at that specific workplace should be located at the station, all other should be removed. The second addresses Set in order. Here labeling and arranging of the e.g. tools used in an operation is included. The third, Shine, refers to keeping a clean workplace by. e.g. sweeping the floor. To Standardize is the fourth, this aims to standardize the first three pillars and always work in the same way. The last pillar is Sustain, which is the most difficult part. This means making them a part of the working routine and maintains the proper way of performing the activities described in the four previous pillars (Hirano, 1996).
3.9.1 5S impact on production
As a part of the Lean manufacturing methodology 5s has a positive correlation to increased productivity, quality and increase synergy at the workplace (Kobayashi, 2008), (Bayo-Moriones, 2010) and (Ablanedo-Rosas, 2010). The different pillars serves as a base of improving the production by identifying release resources bound in unnecessary e.g. activities.

By organizing the tools and items amongst other things used at the specific workstation, it could make it easier to find and put back the tools to eliminate time consumed looking for it. This will also make it easier for new co-workers to learn the place for the tools. A relationship to maintenance has been found for companies using 5S (Kobayashi, 2008) and (Hough, 2008), by cleaning the workstation defects can more easily be detected due to removal of e.g. oil from surfaces. In addition, if the cleaning is incorporated to the daily routine the check for damages on wires or lenses on sensors can be performed which can prevent failure from occurring. Furthermore it can lead to preventing quality issues or breakdown of a machine leading to loss of production.

3.10 Maintenance and its impact on production
The conventional view of maintenance is that it is a cost-driver and expenditures need to be decreased in the maintenance department. Recent studies (Al-Najjar and Alsyouf, 2004; Al-Najjar, 2007), on the other hand, reveals by investing in a cost-effective maintenance strategy the business will generate profit. The proper strategy such as VBM can manifest itself in e.g. lower reject rate, improved production logistics and higher availability which will reflect positively on the profit (Al-Najjar and Alsyouf, 2004).

In many companies who lack knowledge about this area, tend to maintain excessively or do not assign maintenance action until an actual breakdown has occurred. Both ways are rendering in unnecessary costs for planned respectively unplanned stoppages for maintenance (Safaei et al. 2010).

3.11 Cost-effectiveness and cost-effective improvement
No matter the business, it all comes down to the fact that you have to be more effective and/or efficient than the ones competing with in order to keep the competitive edge(Neely, 1993). Al-Najjar (2007) presents a formula for cost effectiveness in context of implementation of improvements. The formula states:

$$C_e = 1 - \frac{B_b}{B_a}$$

Where $C_e$ stands for cost effectiveness, $B_a$ is average cost per unit before implementation and $B_b$ average cost per unit after implementation. This means that if $B_b$ is greater than $B_a$ the improvement can be considered cost effective. There are several ways to approach improvement in an organization, from top level strategic decisions to small changes in procedures. Literature provides a vast number of methods and philosophies such as lean
Bayo-Moriones (2010) states that 5S is a starting point for Lean manufacturing in a workplace, due to its rooting in the culture and commitment which is essential for ongoing improvement in a production, as it identifies parts that do not add value to the product, lastly, to be eliminated or reduced. Kans and Ingwald (2008) highlight the importance of common database at a plant, making the information flow of the departments integrated. Moreover, if the measurements of the production can be monitored by the maintenance department will facilitate the decision-making of the maintenance department. The sharing of a database do not only apply to the production-maintenance relationship it will apply to purchase sales as he traceability of material can favor the interaction of the various parts of a company.

3.12 Multi Criteria Decision Making, MCDM

In everyday life we are forced to deal with decision making by weighing on decisions outcome to another, although many decision are taken on the feeling in your gut. This is where decision making tools come in handy for professionals who are determining the future of a company. MCDM is a tool that weighs multiple criteria of various solutions to objectively choose one of the solutions. The criteria are assigned different numbers which represent the importance of that specific factor. The criteria are can e.g. be economical, technical or environmental (Agrell, 1995).

The first step is to determine the goal of the decision and in what context it is in a, followed by choosing the alternatives to be considered. The last step is to determine what criteria relevant to use in the decision making.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Alternatives</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria 1</td>
<td>0,5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Criteria 2</td>
<td>0,3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Criteria 3</td>
<td>0,2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Σ1</td>
<td></td>
<td>ΣX</td>
<td>ΣX</td>
<td>ΣX</td>
<td>ΣX</td>
</tr>
</tbody>
</table>

*Figure 3.8 An example of a MCDM table.*

In the figure 3.8 above (our own figure) three alternatives are compared to each other with three different criteria that are considered important when implementing something new. These criterions are weighted based on how important they are, a higher number means that this criterion is more important. The alternatives are numbered based on how well they fulfill the criteria and then that number is multiplied with the weight of the
criteria to get a result from the alternatives. The alternative with the highest total number is the most suitable alternative.
4. Model development

This chapter will include the development of a model to improve the material and information logistics of the production process. It contains an introduction and a description of the model.

4.1 Introduction

The model can be a representation of an idea or phenomenon, to facilitate the understanding of it. Development of models can look in a variety of ways depending on what purpose the model has in its creating or developing (Ornek, 2008). This paragraph will describe the model development, explaining what existing models that are available and how we will fill the knowledge gap not included in the existing ones. One of the most recognized models of a systematic approach of the topic is SLP-procedure. Moreover, some elements will be taken from the SLP model and be complemented with models or tools such as MFD and MCDM. MFD is used to systematically find out what necessary steps to take. The MCDM is used due to its ability to compare different alternatives in terms of the various criteria identified as important for the comparison.

The SLP model is a fairly big project which demands capital for the high initial costs such as loss of production due to the rearranging of the plant. It is a very comprehensive model for layout planning and includes tools that systematically reveal information necessary for improving the plant layout. The gaps of the model lie in the absence of managerial actions such as motivating and engaging the staff. In addition, due to the cost of running this project it can with preferably be complemented with a model that can address material and information flow in a way that aids for improving plants cost effectively.

The model is presented in figure 4.1 below and will be described in section 4.2. The model can be useful when starting improving the production logistics.

The reason why we chose to work with the MFD within the model is because of the fact that the functions of the MFD-method is useful when determining the different actions and tools needed to reach the strategical goals. It is also good to emphasize the areas which should be the focus of the company based on their goals, which can lead to a better way of working with improvements. We did not however use the last phase of the MFD, since we did not use the method for implement maintenance. We did use it for the strong functions of identifying activities and tools.
4.2 Model Development

This section will clarify the meaning and order of the steps involved in the model presented in Figure 4.1. In addition, their connection to MFD and the reasoning the chosen tools incorporated in the model and what output they will provide.

**Step 1. Define Business Goal & Strategy**

The initial step of this model is to define the goals and strategy for the specific business. The goal should contain *what* they want to achieve with their business e.g. to deliver products of high quality. The strategy refers to *how* they are going to achieve the goal e.g. using effective maintenance to keep machinery in mint condition. This will serve as input for the MFD and will lead as to the next step.

**Step 2. Process mapping - MFD Phase 1**

When the goal and strategy have been set, the process mapping can be started. This step is performed to illustrate the current state of the production and how the flow of material
and which process is contains. The mapping aids in an illustrative way of depicting the production. The flowcharts are used to help to see the order of the production processes and its different decisions. Idef0 is used to identify the inputs, controls, mechanisms and output that is related to the activity to see what is actually needed for a process.

**Step 3. Evaluate Production Process Logistics - MFD phase 2**
The third step involves tools to describe interaction between the different workstations and how information and material is moved between them. This is important to evaluate the system as all different departments interact and how they affect each other. The process mapping, step 2, gives a holistic perspective of the production processes and step 3 gives a more detailed information about the activities. Furthermore, it gives information of what happens in between two processes e.g. the material handling.

**Step 4. Redefine Business Strategy – MFD Phase 3**
The evaluation, step 3, gives a comprehensive view of the factors to depict the current state of the production. This can reveal a need of redefining the strategy and change or improve the current one/ones. If there is a need to redefine the strategy, do this and start again from step one to base the improvement on the new strategy. If the strategy is sufficient as it is, proceed to step number 5.

**Step 5. Pinpoint Issues - MFD Phase 3**
The previous steps has given the answers of what the company want to achieve, how they are going to achieve it and what they are actually doing in the processes and between the processes. This could give an idea of what to be improved in the production process. Examples could be to shorten distances or remove unnecessary procedures

**Step 6. Evaluate Alternatives**
Step 5 reveals issues or areas to improve within the production process logistics. These different issues or areas are compared with each other in accordance with the criterion chosen. The weighting of the criteria is estimated for each specific company as they have unique set of goals and production etc. If a goal is to provide fast delivery it could be of importance to shorten the lead-time and so on.

**Step 7. Implement Improvements**
The last step involves the implementation of the improvements which involves motivating personnel to adapt to the change and welcome it. This step is very important due to the fact that many implementations fail here, as the personnel often is reluctant to changing the way of working.
5. **Empirical Findings**

Chapter five will include the data collected during this study. It will be divided into two parts where the first part is going to address a general aspect and the second a more specific approach of the empirical data

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**Part one - The company will be introduced together with the standard product presented and described in this part. Furthermore, the information has been gathered from observations, interviews and from the company’s website.**

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### 5.1 Company Description

Inwido AB are the market leaders on manufacturing and selling windows and doors in Sweden, Denmark, Norway and Finland and they also have a leading position in Poland, Russia, Great Britain and Ireland in wood based products. Their headquarters is located in Malmö, Sweden and they export to the whole world, like USA, Canada and Japan etc. Inwido AB has production in eight countries since they are aware of the different standards, laws and dimensions in different parts of the world and therefore they find it to be strength to have local production. Totally they have 35 plants and 12 of them are located in Sweden. About 70 percent of the sales are to the consumer market, like retailers in the construction business which in their turn sells the products to private customers. The other 30 percent is to so called industrial customers, entrepreneurs such as PEAB and SKANSKA.

Our two case companies are a part of Inwido AB, **SnickarPer** which is located in Hånger, Värnamo and **Inwido Production Doors AB** which is located in Bankeryd in Sweden. SnickarPer is one of the leaders in Europe in manufacturing doors. With a high focus on quality and crafted products they have during the last 50 years worked with known architectures and designers in order to achieve great quality, innovative design, innovative use of materials and unique details in both the functional and nonfunctional attributes of the door. Inwido Production Doors AB in Bankeryd has the same concept as SnickarPer with a high focus on quality products and customer satisfaction and also the foundation based on handcrafted doors. (Inwido.se)

### 5.2 The product

The product they produce is a variety of doors with different design and features. To be more precise the door is built to be a front door that separates outdoor from inside. The product can be painted with any color on the NCS-scale you want and with a number of different models with various patterns and glass-design. This means that the production could look very different from one day to another as the doors are highly customizable. At the plant in Hånger they work mainly with customized doors, which mean that there aren’t even any standards in size, therefore they can’t have any inventory of finished products. They work purely based on customer orders, in other words after a pull system.
The door has several characteristics that are desired by the customers such as:

- Soundproof
- U-value
- Security
- Construction quality (paint/material, durability etc.)

Their production consists of models from a variety of companies such as Diplomat, Allmoge and SnickarPer which are all a part of the Inwido group.

In figure 5.1 is the standard door and how it is build with the different layers. What differs this door to the door that is manufactured in Hånge is that number 6 (plastic) is replaced by a much thicker and more expensive material which makes the door heavier and more compact.

01. Framesides
02. Threshold
03. HDF-board
04. Aluminium-board
05. Doorblade frame
06. Isolation
07. Aluminium-board
08. HDF-board
09. Decor
10. Glass
11. Lock-case
12. Screws
13. Hinges
14. Security-tin
15. Sealing spline

Figure 5.1 Showing the components of the door.
Part two - This part will include detailed information about the two case companies included in the thesis. It will describe the production process, material handling and management at the plants. The information and data included in this part has been gathered by observations, interviews and measurements. Both researchers have been present when gathering all information to ensure the quality of the data.

5.3 Production process
The product of the two different factories is the same and therefore the methods are quite similar, although the layout of the two different plants differs and affects the production process in different ways.

5.3.1 SnickarPer
Since the production is focused on special and customized doors it is hard to keep a good flow in the production process, since every door needs different parts and different tools for getting the finished door. Therefore there is no standardized process of how its done, there are a lot of different sub-processes based on which door it is. The process looks mainly like this:

1. Material is first gathered from the storage next to the unloading dock (7) and driven with a fork lift and placed next to the press. Two operators handle this material which becomes the doorblade. The material goes directly into the press (number 2) where the base is nailed/glued together. Here four doors are pressed at one time.

2. After the base is pressed together they place them next to the CNC-machine which is in the same room. An operator prepares the program the door will have in the CNC-machine and prints out a barcode which is attached to the door before it is run through the machine. After the CNC-machine it is placed next to it, the operator organizes the doors based on which color the door will have (NCS-color or wooden surface) and then drives them to the polish (11). Every door is polished to get the surface smooth and get rid of uneven edges from the cutting in the CNC-machine.

3. The next phase in the process is to attach the decor, splines etc. This happens in the coating department (number 3). If the splines need any work, like milling or cutting, this is made in the same room as the CNC and the press (number 2).

4. After this the doors go to the painting (number 4) or to the oiling department next to the coating. The base paint is performed by a robot and then it is dried and polished to look for potential cracks, bumps or dirt under the paint. Then it is base painted again, dried and controlled again, and finally the top coat is applied by the robot if it is a standard color or manually if the color is unusual. Between the two layers of base paint the operator paints the bottom of the door by hand, making it more waterproof and tolerable for wear. If water can come inside the layers of paint it is a risk that the entire door will be ruined by the moist.
5. After the door is dry, all the doors are put in racks and driven into the assembly (number 5). One operator is putting together the outer frame which the door is hung in and it is important that this person is ahead of the work by a couple of doors so that the doors can be packed as soon as they are assembled and won’t have to wait for the outer frame. At the same time as the outer frame is being assembled, the door is being assembled as well at three stations with three operators doing one door each at a time. Here the glass and hinges etc. is attached and the door is hung in the outer frame.

6. In the last phase of the process (number 6) the entire door with the outer frame is packed together with handle, lock case etc. and loaded onto pallets and then transported with forklifts from the packaging station to the unloading (number 7) where they are picked up by the trucking company, delivering it to the retailers or private customers.

*Figure 5.2 The layout of the plant and the different stations.*
5.3.2 Inwido Production Doors AB

1. Material is driven from the warehouse to working station 1 with a truck. Here the operator takes the sides and the upper and lower piece and nail them together, creating the frame of the doorblade. A tag is attached which contain a barcode which the computers in the production line can read and get all the information needed about this specific door, for instance the CNC-machine can read which patterns it should have and the painting robot can detect which color it is supposed to be in.

2. The doorframe rides on a conveyor belt to next station where the cellular plastic for isolation is put in place, and DFD-boards and aluminum boards are placed on both sides and glued together. Then they go into the press. Then the doorblades goes down a conveyor belt and are stacked together and rolled in to the grinding machine.

3. In the grinding machine station a robot arm picks up the doors one by one and places them so they can go in to the machine. After that the robot picks them up again and places them on a conveyor belt so they can go to the next station.

4. The next step is the CNC-machine. There are two of those and there is no human intervention so far in the production after the gluing station. The CNC-machine reads the tags for each door and creates the wanted look for the door. Then a robot arm picks up the finished door and stacks them on pallets. These pallets are placed on rolling conveyors and are taken to the next station without any lifting.

5. Now the doors go to the coating department. Here different splines are attached based on which model it is. The doors are rolled on rolling conveyors to a special press which makes the splines attach after being glued. The doors are now stacked on pallets and taken with a fork truck to the painting department.

6. First the doors are polished in order to ensure that the doors are clean before being painted. With the help of a robot, the doors are hanged in a circuit carrier in the roof which will transport the door through all the next steps of the production process. Then they go into the base painting robot where a white base paint is applied. The door then goes to the dryer.

7. Before the door is top-painted in its NCS color, it is controlled by an operator in a special light to ensure that there are no damages on the door. Then the circuit carrier takes the door to the top-painting robot, or back to the polish and base-painting if it is not approved. After the top-paint the door is once again dried and taken to the next station.

8. Here the operator attach hinges and locks to the door. Then it goes to the assembly were the glass and splines are attached.
9. Finally the door is taken to the last station where the door is attached to the frame sides which are attached to the wall. Then it goes on a conveyor belt to the automated packaging station. The door is now taken to the finished products warehouse.

5.4 Material handling and Information handling

5.4.1 SnickarPer
The material handling within the plant is mainly based on the operator transporting it between work stations. Some fully and semi automatic aids are present in the plant such as lifts and robots. The manual transportation consists of wagons, racks and hand trucks, the transportation is also supplemented with forklifts to assist with heavy awkward lifting. There are no outspoken policies or way of what amount to transport or when to do it, the pallets are sometimes filled to its maximum and other times it is just small items on a wagon that is moved.

The doors are put in racks with room for ten in each rack; the racks are equipped with wheels and helps with the storage and transportation. Pallets are frequently used when storing the material in the plant and are used for most of the material storage in production.

The information related handling is basically paper form starting at the order department. They receive an order which is planned and resources are bought to be sufficient for the producing of the order, the order is given to the first step of the process, which may be either the workshop for customized doors or the CNC-machine for the standardized doors. This flow card containing the specifics of the product follows the door from throughout the production process. The information handling is shown in figure 5.3.

![Figure 5.3 Illustrating the information handling of an order.](image)
5.4.2 Inwido Production Doors AB
Inwido works with a highly automated production in terms of material handling. Manual handling is kept to a minimum and only for short distance transportation. One of the strength of the plant lies in the flow provided by the conveyor system mounted in the ceiling. The system is a circuit carrier with a feature that makes it possible to mount the doors to it which reduces the awkward lifting for the personnel and creates a continuous flow towards the next work station and lastly to the loading dock. Robots for lifting the door blades from the loading zone to the machine or work bench. Roller conveyors is also used as transportation within the work stations such as the pressing and CNC-machine. Additional material handling equipment is forklifts and short distance transportation of goods is made by hand truck or wagons. The latter two are fully manual.

The plant uses pallets and racks as in-production storage and at loading zones. The storage areas and loading zones are well defined and structured in a systematic manner. The storage for finished products is divided into different sections assigned a letter to aid the location of the items.

The automation of the production is made possible by RFID-tags attached to every door which is scanned to attain the information about the specific item such as design and order number. The tag is scanned and the CNC-machine automatically retrieves the program for the design and starts the operation. The tag also aids the traceability of the products as it gets checked in the system when it is scanned at the different stations.

5.5 Management

5.5.1 SnickarPer
The management of the plant consists of one production manager and two production planners. They are responsible for planning the production from purchasing of resources to scheduling of the production and make sure that the CNC-machine has the programmes required to process the desired design. The departments have coordinators which help with following the production and reporting on the status, if e.g. they are behind schedule.

Due to certain salary regulations they are not assigned responsibility for the personnel, but they experience that they have to take responsibility for the personnel and make up for the extra salary that comes with human resource responsibility. They have no outspoken specific leaders, just the coordinators, manager and planners. This is stated to be an issue when new ideas are brought to the plant and the reluctant view of new thinking blocks the actual gain of the improvement or change.

5.5.2 Inwido Production Doors AB
The management situation in Bankeryd is similar to the one in Hånger. There are one plant manager, one production planner and one economic manager who together plans the weekly outcomes, order resources and deals with other issues related to the production.
On the floor there are two work-leaders, one on each shift. These people are responsible for every department in the production and that everybody is doing what they are supposed to do. There are no work leaders for every working station since they work with a rotating schedule and everybody works at every station based on a schedule. This is to avoid stoppages in the production due to sickness or other absence when only one or two are qualified to work at a certain station. When changes are made the two leaders are the link between the management and the employees.

The management decided to start working with the concept of 5S about six months ago. This project has led to a more structured plant and more organized working areas and working stations. Everybody is supposed to keep their things in the right place and this project has been so far been seen as positive. The project was implemented by the top managers through the shift leaders to reach the employees.

5.6 Data collection
The table 5.1 below shows the different distances the material travels within the plant. These were measured with an instrument during a company visit and the measurements were made several times to ensure the reliability of the study.

<table>
<thead>
<tr>
<th></th>
<th>Bankeryd</th>
<th>Hånger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation within production</td>
<td>73,9 m</td>
<td>159 m</td>
</tr>
<tr>
<td>Transportation between stations</td>
<td>523,5 m</td>
<td>296,6 m</td>
</tr>
<tr>
<td>Manuell transportation</td>
<td>191,2 m</td>
<td>324,4 m</td>
</tr>
<tr>
<td>Automated transportation</td>
<td>406,2 m</td>
<td>0 m</td>
</tr>
<tr>
<td>Total distance</td>
<td>597,4 m</td>
<td>324,4 m</td>
</tr>
<tr>
<td>Distance for getting other parts</td>
<td>26,2 m</td>
<td>17 m</td>
</tr>
<tr>
<td>in the production (such as splines etc.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1 A table of the different distances within the plants.

5.6.1. SnickarPer
SnickarPer’s transportation is mainly manual and a number small storages can be found in many places in the production. These storages can seem to be an issue due to blocking of better suited routes of the production logistics. As table 5.1 shows, the manual transportation is longer than the Bankeryd plant. The lifts used for moving from workstation to in-production storage are semi-manual and requires a operator to move articles from point A to point B. In Hånger the material are first brought in from barns outside the plant. That is a transportation distance of about 100 meters which has not been added to the numbers in table 5.1 since it is not a part of the internal logistics.

The cost for an operator at SnickarPer have been told to 600 kr/h and this sum is calculated on a utilization of 80% the reason why it is not 100% is that sick days etc. is
accounted for resulting in a decrease in utilization of the employees. The rate of production in the plant is approximately 150 doors/week (30 doors/day) but can differ due to the range of customizable products provided by SnickarPer.

The foundation for the use of the MFD can be found in appendix 1, which is the interview that was performed with the plant manager and the production planners. The business goals and strategies were based on the answers from the interview together with their webpage where they have written down some information about the company.

<table>
<thead>
<tr>
<th>Outputs to be achieved, maintained or improved (The What's)</th>
<th>Importance of the What's</th>
<th>Technical Requirements (The How's)</th>
<th>Improving processes and activities</th>
<th>Using high quality material</th>
<th>Effective production process</th>
<th>Effective logistic strategy</th>
<th>High availability on the equipment</th>
<th>High competent staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Quality Products</td>
<td>35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery on time</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased quality rate in production</td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased profit</td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 5.4 The first step of the MFD.*

The first step of the MFD were made together with the company as well as based on information on their webpage. (www.snickarper.se). The strategies were brought up by discussions and ideas from plant managers, production planners and employees within the plant. The weighting is based on comments from the plant manager together with our observations that we have made during our company visits in the plant.

5.6.2 Inwido Production Doors AB

The transportation within the production means that there are no interruptions, such as human intervention in the process. For instance the distance between the press and the CNC-machine is transportation within the production, since it is going on the same
conveyor belt and a robot is doing the movement. The transportation between the stations means for instance transportation between the warehouse and the first station or the transportation on the circuit carrier. The manual transportation is made with human intervention such as forklifts and the automated transportation is purely machines, such as the circuit carrier. The distances for getting material other than the base material for the frame are short since they have strategically placed small inventories for these materials close to the desired workstations. The distances are a bit longer in Bankeryd due to the fact the plant there is bigger than the one in Hânger. In addition, the storage of standard doors is very big and in Hânger it is close to nothing. That leads to the transportation of material in the beginning of the process and the transportation from the packaging to the final storage is long distances and it raises the distances for the plant in Bankeryd.
5.8 Process mapping

5.8.1 Cross-functional flowchart

The cross-functional flowchart in figure 5.5 shows the production process and the different steps and decisions and outcomes within it.

The first step in the order to delivery process is the customer who places an order and the order staff either approves it and sends it to production or rejects it and the customer has to redo the order.

The order is printed and put in production. All the flowcards are printed for each door, which will follow the door throughout the production. The operator now gets the material for a daily batch.

The next decision is if the order is standard or customized, since they will differ in production steps.

The standard process is that the material is put together and glued and pressed. If it is approved the doorblade can go to the CNC-mill. If not, the blade is fixed if possible, or thrown away and a new is put together.

After the CNC-mill the operator makes sure that the door is made according to the flow card. If it is not, it can sometimes be milled again, or it could be placed in the warehouse in case someone orders a door like that later.
The next step is the coating and as well as previous steps the outcome can be customize or standard. Standard splines are in storage and can be attached right away.

The operator attaches the splines and other decor to the door according to the flow card.

The door is polished in a machine and then the surface is controlled. If it is not approved it is polished again. The controls are performed in special light to see all kinds of defects on the surface. Small defects can be adjusted manually.

The door goes to the robot which paints the door with the base coat. The door is dried and painted again. The bottom is painted by hand to ensure that no water or moist could get into the door when it is in a house.

The top paint is made either in the robot or manually depending on what color it is. Standard colors such as white can be made in the robot, while special colors are done manually to reduce work (takes a lot of time to adjust the robot to different colors). After the surface has been approved the door goes to the assembly. If it is not approved it has to be polished again and redone.

*Figure 5.5. Cross-functional flowchart*
5.8.2 IDEF0
In the IDEF0 analysis we have highlighted the production process with respect to the inputs and outputs. This could also be a tool to help with the material handling, since you know what you need and when you need it. Together with tools such as 5S, to keep the materials organized this could be developed to a smooth functioning material handling in the production process.
Figure 5.6. The IDEF0 of the production in Hânger

The arrows coming from the left is different input. The arrows going between the boxes of process steps is the actual door, therefore the door does not have to be addressed as an input in every box. The arrows from above are the different controls that take place, for instance in the beginning the order staff needs to make sure if it is possible to manufacture a door in a certain dimension and check if the customer can get the door in the wanted delivery time. Normal controls are dimension and standards for the model since that is what controls the entire production, the operator has to stick to the measurements of the specific door.

The arrows coming from under are the mechanisms used in that step of the process, for instance machines or tools.
6. **Analysis**

In this chapter the theories will be compared with the empirical data in order to reach a result of the study. The analysis will be performed according to the given methodologies and presented with figures and analyzing text.

This chapter will contain the testing of the model developed in this thesis on the case company. It will describe the seven steps of our improvement model from start to implementation. The source of the data used for the steps can be found in table 6.1:

<table>
<thead>
<tr>
<th>Analysis, Step no.</th>
<th>Source of data, chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>5.1</td>
</tr>
<tr>
<td>Step 2</td>
<td>5.2, 5.3, 5.4 and MFD phase 1</td>
</tr>
<tr>
<td>Step 3</td>
<td>5.2, 5.3, 5.4 and MFD phase 2</td>
</tr>
<tr>
<td>Step 4</td>
<td>Analysis step 1-3</td>
</tr>
<tr>
<td>Step 5</td>
<td>5.2, 5.3, 5.4 and MFD phase 3</td>
</tr>
<tr>
<td>Step 6</td>
<td>Analysis step 1-5</td>
</tr>
<tr>
<td>Step 7</td>
<td>3.7 and analysis step 1-6,</td>
</tr>
</tbody>
</table>

*Table 6.1 Presenting the source of data for the various steps in the model.*

The model that is going to be applies on the case company will look as figure 6.1 shows.

*Figure 6.1 Our model complemented with the tools suitable for the application at the case company.*
6.1 Defining Business goals & Strategy - Step 1
Together with the company we decided upon four main business goals and six main business strategies presented in table 6.2.

<table>
<thead>
<tr>
<th>Goals</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>High quality products</td>
<td>Improving processes and activities</td>
</tr>
<tr>
<td>Delivery on time</td>
<td>Using high quality material</td>
</tr>
<tr>
<td>Increased quality rate in production</td>
<td>Effective production process</td>
</tr>
<tr>
<td>Increased profit</td>
<td>Effective logistics strategy</td>
</tr>
<tr>
<td></td>
<td>High availability on the equipment</td>
</tr>
<tr>
<td></td>
<td>High competence staff</td>
</tr>
</tbody>
</table>

Table 6.2 revealing the business goals and strategies

6.2 MFD
In the first step of the MFD the strategic goals of the company, the what’s, are translated into technical requirements needed to reach these goals. The What’s has been weighted on their importance and the technical requirements has in its turn been weighted based on how much importance that requirement has for the specific goal. All the numbers have been estimated based on our company visits and from comments that the company has made about their strategic goals.

<table>
<thead>
<tr>
<th>Outputs to be achieved, maintained or improved (The What’s)</th>
<th>Importance of the What’s</th>
<th>Technical Requirements (The How’s)</th>
<th>Improving processes and activities</th>
<th>Using high quality material</th>
<th>Effective production process</th>
<th>Effective logistics strategy</th>
<th>High availability on the equipment</th>
<th>High competence staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Quality Products</td>
<td>35%</td>
<td>8%</td>
<td>8%</td>
<td>5%</td>
<td>5%</td>
<td>3%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Delivery on time</td>
<td>25%</td>
<td>4%</td>
<td>2%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Increased quality rate in production</td>
<td>20%</td>
<td>5%</td>
<td>5%</td>
<td>3%</td>
<td>1%</td>
<td>3%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Increased profit</td>
<td>20%</td>
<td>5%</td>
<td>2%</td>
<td>3%</td>
<td>3%</td>
<td>5%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>22%</td>
<td>17%</td>
<td>16%</td>
<td>14%</td>
<td>16%</td>
<td>15%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.2 The first step of the MFD.
The quality of the products is related to all the technical requirements mentioned to reach the strategic goals of the company. The main requirement to reach high quality products is to focus on improving the processes and activities (within the production) and using high quality materials. Having an effective production process and logistic strategy is also important in order to make sure that the products are treated in the right way during the process. The risk for damages during transportation increases if the distances are longer and if there is a lot of unnecessary movement. The competence of the staff is many times an important factor in quality. If the machines are not operated properly it could lead to more damaged products due to damages or failures in the machine. This could also lead to failing in the last technical requirement, high availability on the equipment. If the machines are not functioning as they are supposed to this will lead to lower quality of the output, and lower allover output as well which could lead to delays and decreased profit.

In the second step of the MFD the technical requirements is moved down and becomes the What’s and they are compared against different tools, and in our model also necessary factors, that are needed to preserve the technical requirements. The total importance of the different technical requirements was calculated in the first step of the MFD and is now divided over the different tools.

<table>
<thead>
<tr>
<th>Technical requirements to achieve, maintain or improve the outputs (The What’s)</th>
<th>Importance of the What’s</th>
<th>Tools and necessary factors needed to preserve the requirements (The How’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving processes and activities</td>
<td>22%</td>
<td>8% 0 0 6% 6% 2%</td>
</tr>
<tr>
<td>Using high quality materials</td>
<td>17%</td>
<td>0 0 11% 0 3% 3%</td>
</tr>
<tr>
<td>Effective production process</td>
<td>16%</td>
<td>5% 4% 0 2% 4% 1%</td>
</tr>
<tr>
<td>Effective logistic strategy</td>
<td>14%</td>
<td>4% 0 0 4% 5% 1%</td>
</tr>
<tr>
<td>High availability on the equipment</td>
<td>16%</td>
<td>2% 7% 0 1% 2% 4%</td>
</tr>
<tr>
<td>High competenced staff</td>
<td>15%</td>
<td>0 0 0 2% 2% 11%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>19% 11% 11% 15% 22% 22%</td>
</tr>
</tbody>
</table>
Process mapping is the first and most important step in improving processes and activities to get a better holistic view over the production to find flaws and make improvements. A system for information and material handling could also help to improve the different processes and activities since it makes them more standardized and easier since they have some sort of manual to work after. These systems can help to organize the processes and make them more effective and efficient. Education is also a part of improving processes and activities since more edge knowledge can lead to more innovative ideas to improve the production and make changes. Using high quality materials is mainly connected to having a reliable supplier, but also about having a smart material handling system which could reduce damages on the material and on the actual product going around in the production process. The effective production process can be achieved with the help of many different tools, such as process mapping in order to learn more about how the situation looks today and make small improvements for a more effective production. Also a suitable maintenance strategy could make the production more effective due to reduced downtime and higher availability on the equipment. The information and material handling system is an important step here as well, since these two systems can help to make the production process more flowing and make more information more available and quick and easy to access. Having an effective logistic strategy can also be achieved with the help of process mapping to highlight the current situation of the logistics and see new different ways of moving the materials. The information and material handling system could also be of great use to improve the current logistic situation, mainly the material handling system for obvious reasons, but the information handling system could also be used for e.g. documentation which could be used for future improvements. The availability of the equipment is mainly related to the maintenance strategy which will help to reduce the downtime due to damages and failures. It could also be somewhat related to the information handling system since it could be used for documentation in order to prevent reoccurring failures in order to prevent them in the future. The material handling system could help to make the materials flow more evenly and decrease the risk for waiting times due to failed material handling. The last tool mentioned, education, is consistently mentioned throughout every technical requirement since having a good knowledge in what you are working with will many times help to do the job right and to prevent damages and failures. The last technical requirement which is the high competence staff is mainly due to the education, although knowledge in the production process could also be developed and improved by using good systems for handling materials and information.

In the third step of the MFD the tools used in the previous step are moved down and become what’s and they are now compared with the activities needed for effective utilization of the tools. The numbers were calculated into totals based on the previous step and are divided, just like before, over the activities. This will be the last step of the MFD that we perform, which means that we will not perform the last step of the MFD which is to identify the factors needed to implement maintenance since that is not the primary goal of doing this analysis. Our goal of making an MFD is to identify the different strategic
goals of the company, the tools needed to achieve these or maintain and improve them, and which activities could be used, since we are mainly working on the idea of implementing a plan for continuous improvements for the company. This MFD brought up will be the foundation of our model that we present in chapter 4 and have worked as a tool to produce ideas for how to work with continuous improvements based on the strategic goals.

<table>
<thead>
<tr>
<th>Tools needed to preserve the requirements (The What’s)</th>
<th>Importance of the What’s</th>
<th>Activities needed for effective utilization of the tools (The How’s)</th>
<th>Analyzing the production process flow</th>
<th>Analyzing the material and information logistics</th>
<th>Software updates</th>
<th>Training staff in using the information and material handling systems</th>
<th>Documentation of failures</th>
<th>Evaluation of suppliers quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process mapping</td>
<td>19%</td>
<td>10%</td>
<td>9%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maintenance</td>
<td>11%</td>
<td>4%</td>
<td>0</td>
<td>0</td>
<td>2%</td>
<td>5%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reliable supplier</td>
<td>11%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4%</td>
<td>7%</td>
<td>0</td>
</tr>
<tr>
<td>Information handling system</td>
<td>15%</td>
<td>2%</td>
<td>5%</td>
<td>3%</td>
<td>3%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Material handling system</td>
<td>22%</td>
<td>5%</td>
<td>9%</td>
<td>1%</td>
<td>5%</td>
<td>2%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Education</td>
<td>22%</td>
<td>3%</td>
<td>3%</td>
<td>1%</td>
<td>15%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>24%</td>
<td>26%</td>
<td>5%</td>
<td>25%</td>
<td>12%</td>
<td>8%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.4 The third step of the MFD

In this step of the MFD we are now getting detailed information about which activities needs to be performed in order to utilize the tools. The process mapping is related to the analyze of the production process flow and the analyze of the material and information logistics. The maintenance is mainly related to the documentation of failures, but also to analyzing the production process flow to find highly loaded areas which needs to be
prioritized in maintenance to prevent failures. The training of the staff in the new systems is also a part that affects the maintenance, since they are working with the documentation handling within the systems. The reliable supplier can only be achieved with evaluation of previous records, which are related to the documentation of failures. If one supplier is providing materials which often is damaged it could lead to a reduced quality rate in the output. The information handling system is affected by all activities mentioned, so is the material handling system, since all activities will be used together with the systems. The education is a tool that is affected by different activities as well, but mainly the training in the new systems. The education is also a part of the analyze, since the analyze will highlight the production process and its different activities and what is working good and what is not, which could lead to increased knowledge for the staff if they need to perform changes in their work routines.

What the MFD has shown us is the actual goals of the company and how they could work to achieve these. For instance we can see that process mapping is a important part of the continuous improvement plan, and then theories such as activity network diagram and relationship charts can be used. Flowcharts and IDEF0 is also an important step in the process mapping. The MFD also shows that even though the company is focusing on high quality, the supplier is not the right way to go if they want to achieve that. Evaluating the supplier is of course important to ensure the quality of the materials, but it is not the main focus to achieve the strategic goals.
6.3 Process mapping - Step 2.

6.3.1 Cross-functional flowchart
From the Cross-functional flowchart we get information about the different decisions in the production process and what will happen if the expected outcome is not what it should be. It is these kinds of mistakes which can be reduced by having for instance more educated employees, and these kinds of mistakes could lead to delays which could be administered more easily if some kind of information system were available. Thereby the employees in the office could serve the customer smoother and just find the particular door in the process and find if there have been some errors along the production, and how it will affect the customer. This map highlights those mistakes that could occur and could thereby be implemented in the information system so the operator easily could enter the system end type in where and when the error happened. By doing this kind of mapping the company will learn more about their production process by displaying it in detail. It will also show which part of the business unit is responsible for which action.

The cross-functional flowchart which can be shown in chapter 5.8.1 highlights how many steps there are in the production process and gives an understanding in that there will be a lot of logistics. This shows the importance of working with improvements and making the logistics as effective as possible in order to get a cost-effective production. A lot of movement also means a higher risk for damaging the goods between the station, which again shows the importance of having a material handling system which is as effective as possible for this particular production process.

6.3.2 IDEF0
To highlight every step of the production process and its different components will open possibilities to work with continuous improvements. By mapping the processes and the flow it will be easier to discuss and develop the process, not only for outside people doing research, but for the company as well since many years in the same plant can make you blind for improvement possibilities.

The IDEF0 gives us the different inputs and outputs in order to, as a continue on the cross-functional, not only show the importance of effective logistics, but also to highlight what kind of material is in the production flow, where is it and when is it needed. The process mapping is of great use for this study since it has helped to determine what the focus should be on and since this production process has many different steps and many different scenarios where the product can be damaged, there is a need for an effective material handling system as well as a covering information handling system in order to ensure the quality of the products which will gain the company, and to ensure the high quality experience for the customer both product wise and service wise.
6.3.3 Improvements in the production flow

The current situation of the production flow is very much back and forth, with some areas being used a lot more than others when it comes to logistics. As you can see in picture 6.5 the area to the left of the assembly there is a lot of traffic. A small change of a route in the flow could reduce the traffic in this area and also reduce the distance the material is transported.

As you can find in the empirical chapter the material handling is in a very high grade manual work and lifts. This is a problem which could be adjusted with changes in the material handling system, for instance investing in some conveyor belts.

![Figure 6.5 The current production flow of the company.](image1)

That could save time, operators and also be a health and safety issue when reducing heavy lifting.

The main changes that we focused on were reducing distances and reducing high trafficked areas. Without making any large rearrangements of the plant, we found that some routes could be changed in order to reduce distance. Mainly, the route after the first round in the dryer (route 1): The current situation is that it

![Figure 6.6 The production flow with the improvements](image2)
goes around the entire plant where there is the most traffic.

By taking the route “the back way” and taking it past number 14 (the saw) and then in to the control-room they could reduce the traffic in the middle of the plant and also reduce the distance for the door to be transported. See figure 6.6

The other route is after the next round in the dryer (route 2): First it went to the middle section where it was stored on racks and then taken into the assembly area. By moving the storage area and putting it next to the assembly it would reduce distance and it would be easier to get the wanted door to the assembly table for the operator. This change is possible since the area next to the assembly (where we now want to put the storage for the doors) is only filled up with storage of unnecessary materials for the production process, such as racks which are not being used etc. See figure 6.6.

The reduced distances that we have calculated are:

<table>
<thead>
<tr>
<th></th>
<th>Route 1</th>
<th>Route 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current distance</td>
<td>74 m</td>
<td>68 m</td>
</tr>
<tr>
<td>Distance after change</td>
<td>55 m</td>
<td>34 m</td>
</tr>
<tr>
<td>Total gain in distance</td>
<td>19 m</td>
<td>34 m</td>
</tr>
</tbody>
</table>

*Table 6.3 The distances after improvements*

The changes that we have considered in the material handling area are the fact that a couple of stations could be improved by adding conveyor belts and thereby reducing the amount of manual lifting. These changes will be addressed in chapter 6.4 where we evaluate implementing a new material handling system.

**6.4 Evaluation of Production Process Logistics - Step 3**

**6.4.1 Activity Network Diagram**

To evaluate the internal logistics we have used this diagram to show the relationship of the workstations and have estimated the importance of the closeness relation. As the diagram shows there are important relations between some of the workstations that is of greater importance than others. Relation especially important (E) is motivated as follows:

- Loading dock - Warehouse: Due to the fact that incoming and outgoing goods are passing through this area.
- Warehouse - Press/Assembly/Workshop: The Press and the workstation is the first activities in the production process and as there are many products going from/to this area it is considered especially important. The assembly is the last part and is considered especially important for the same reasons.
- CNC - Press/Polishing - The CNC mills the design of the door after the pressing of the door blade is finished. The pressed and milled door blade is shipped to the
polishing department to get ready for painting. A lot of material moving between the stations, therefore considered especially important.

- etc

The only departments that have to be close (absolutely necessary, A) is the painting and dryer due to fact that when the door is painted it will tend to attract dust that will ruin the surface of the paint. Therefore, if the distance between them is as short as possible the risk of ruining the surface will decrease.

The important ones are the ones with a medium relationship, where they are not considered necessary but not unimportant due to factors of e.g. small quantities moving between them. The unimportant (U) is does not have a relation at all to the other workstations.

![Activity network diagram over the plant in Hånger.](image)

### 6.4.2 Material handling

<table>
<thead>
<tr>
<th>Step no.</th>
<th>O</th>
<th>T</th>
<th>S</th>
<th>I</th>
<th>Description</th>
<th>Distance</th>
<th>Method of handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Items in Warehouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Getting material for press</td>
<td>22,8 m</td>
<td>Fork lift</td>
</tr>
<tr>
<td>3</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Waiting for doorblade assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Pressing of doorblade</td>
<td>6,2 m</td>
<td>Semimanual lift device</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Waiting for CNC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>X</td>
<td>Moving pallets/lifting unto CNC-mill</td>
<td>11.9 m</td>
<td>Handtruck/Semimanual lift device.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>X</td>
<td>CNC-milling</td>
<td>17.5 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>X</td>
<td>CNC-Milled products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>X</td>
<td>Transported to coating</td>
<td>70.5 m</td>
<td>Fork lift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>X</td>
<td>Waiting for coating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td>Get splines etc.</td>
<td>2 m</td>
<td>Manual cart</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>X</td>
<td>Attach splines and decor</td>
<td>4.2 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>X</td>
<td>Transport to polishing</td>
<td>14 m</td>
<td>Racks with wheels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>X</td>
<td>First Inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>X</td>
<td>Transport to painting</td>
<td>34.4 m</td>
<td>Racks with wheels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>X</td>
<td>Base-painting in robot</td>
<td>24.5 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>X</td>
<td>Transported to dryer</td>
<td>5 m</td>
<td>Robot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>X</td>
<td>Drying</td>
<td>17.8 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>X</td>
<td>Tranported to Top-painting</td>
<td>74 m</td>
<td>Racks with wheels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>X</td>
<td>Top-painting in robot</td>
<td>24.5 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>X</td>
<td>Tranported to dryer</td>
<td>5 m</td>
<td>Robot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>X</td>
<td>Drying</td>
<td>17.8 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>X</td>
<td>Tranported to assembly</td>
<td>68 m</td>
<td>Racks with wheels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>X</td>
<td>Aseembling the doorblade/frame/etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>X</td>
<td>Waiting for packaging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>X</td>
<td>Packaging</td>
<td>21.8 m</td>
<td>Manual lifting/Conveyour belt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>X</td>
<td>Transport to loading dock</td>
<td>4.2 m</td>
<td>Fork lift</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 6.4 the material handling**

**6.4.3 Relationship diagram**

![Relationship Diagram](image)

**Figure 6.8 showing relationship diagram**


The lines represent the flow of material between the stations. This gives a comprehensible view of the production with clear direction of order and flow.
6.4.3 Information handling
The information handling at the company is something mainly related to the managers as information technology is not a part of the production. The only information technology is by the CNC-mill where design programs are stored and executed. When the orders are released or printed an operator has to collect them at the office instead of having a system sending them directly to the actors it concerns. The traceability of the material or orders is checked at two points: The order release and the finished products. There is no information system for indications or following of the material or order once it is in the production process. This can make it hard to see delays etc. in the production. Statistics of e.g. defect items poorly documented on paper sheet could be inserted in a database for follow up amongst other things.

6.5 Redefine Business Strategy Step 4
The fourth step in the model is the “Redefine Business Strategy”. After going through the first three steps a couple of new focus areas will have been highlighted. The use of MFD is consistent throughout the model, and in step 4 of the model we use phase 3 in the MFD to show which areas the company should focus on and we will use those to redefine the strategies of the company.

The current situation today is mentioned in 6.1 Defining business goals & strategies and after performing the first three steps of the model we would change the goals and strategies to be more suitable for the current situation of the production and to help the company to develop and improve.

The three most important tools which are highlighted in the MFD phase 3 are “Analyzing the production process flow”, “Analyzing the material and information logistics” and “Training the staff in using the new information and material handling systems”. We will use these tools and translate them into goals and strategies for the company.

The new company goals and strategies look like following:

<table>
<thead>
<tr>
<th>Goals</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>High quality products</td>
<td>Improving processes and activities</td>
</tr>
<tr>
<td>Delivery on time</td>
<td>Using high quality materials</td>
</tr>
<tr>
<td>Increased quality rate in production</td>
<td>Effective production process</td>
</tr>
<tr>
<td>Cost-effective production</td>
<td>Effective logistic strategy</td>
</tr>
<tr>
<td>Continuously improving for competitive advantages</td>
<td>High availability on equipment</td>
</tr>
<tr>
<td>Motivated and engaged employees</td>
<td>Continuous education for core and edge knowledge</td>
</tr>
</tbody>
</table>

*Table 6.5 The new business goals and strategies.*

The changes in the goals are that the “increased profit” has changed to “cost-effective production” since it will lead to a higher profit due to a more effective production process.
and the goal “increased profit” will be easier to reach if it is more defined. We added “continuously improving for competitive advantages” and “Motivated and engaged employees” to the list of goals, since we think that if the company would focus on these they could improve the production process and thereby have a more cost-effective production which will lead to more profit. In the strategies we have covered the goals by adding “continuous education for core and edge knowledge” which could increase the motivation and engagement of the employees. If they get more responsibility due to their knowledge, they will feel more important and also more appreciated.

After redefining the business goals and strategies we continue in the model, and a new MFD based on the new goals and strategies are not necessary to do. A new MFD with these goals and strategies will be made next time the model-cycle starts from the beginning and then new improvement areas will be highlighted and the goals and strategies will once again be updated.

6.6 Pinpoint issues - Step 5
By using the third phase of the MFD following focus areas could be identified to solve issues:

- Analyzing the production process flow
- Analyzing the material and information logistics
- Software updates
- Training staff in using the information and material handling systems
- Documentation of failures
- Evaluation of suppliers quality

The three most important areas are analyzing the production process flow, analyzing the material and information logistics and training staff in using the information and material handling systems according to the MFD calculations. This means that issues which should be focus on are the flow of the production process - it should be improved by improving the material and information handling. Education in the new systems for material and information handling will also be needed to utilize the systems in the most effective way. These are the issues that should be considered to reach the companies strategical goals.

6.7 Evaluate alternatives - Step 6
The evaluation of the alternatives is important as this is where advantages and disadvantages are evaluated and discussed. To be able to compare alternatives, four solutions have been brought forward and will be presented in the coming paragraphs.

Alternative 1 - New material handling system
Alternative 2 - Information system
Alternative 3 - 5S
Alternative 4 – A combination of the first three alternatives

Alternative 1.
The first alternative will be including a new material system. This solution addresses automation of parts of the material handling and minor rerouting of the material flow. The figure 5.2 in the empirical findings shows the material flow and reveals that some routes are unnecessary and be reduced. Measurements of the present material flow and the solution for the future flow together with where new handling systems can be implemented can be seen in table 6.3.

A robot can be installed and complemented with a conveyor belt between the press and the CNC-mill removing movements that require an operator. Same system could be installed between assembly and packing to reduce a lot of heavy lifting. The rerouting of the flow will concern transport between dryer and control along with between drying and assembly, which is addressed in 6.3.3.

Costs related to the investment first of all the cost for the system with design, transportation, mounting etc. Secondly, we have the implementation costs including learning of the system and loss of production due to installation faults which can be a risk. The system will also require safety education due to the automation and education related to basic maintenance actions etc. As the system is up and running it will consume resources such as power, oil and wear and tear parts which will be referred to as operation cost. At certain intervals the system might need maintenance to operate at desirable pace and duration which also will be an expense. The last cost is the disposal cost which is the cost that addresses the demounting and removal of the system when its lifespan has run its course.

Savings the benefits of using this system is the minimizing of manual handling for two main reasons: Operators are free to perform other activities that adds value and the robot and conveyor belt can reduce stress on backs, shoulders etc. on the operators. These changes in material handling will be beneficial in the terms of reduce a small amount of time consumed for these activities and will add up over time to be a reduction of costs operators cost and a possible increase in productivity. It could also help to reduce the damaged goods due to human intervention in for instance lifting.

Alternative 2.
The second alternative will aid the transactions of information in the company. It contains an information system solution that could send e.g. orders from production planning to production, together with CNC-program and other relevant information. An implementation of a RFID-tag could help with traceability checking into two different departments notifying where in the process an order is. The traceability could be used to
see if the production is before or after the set schedule, if the customer might not get in
time amongst other things.

**Costs** connected to this solution are system costs which mean costs for the actual
development or purchase of a suitable system and licenses for using the system. The costs
for purchasing additional hardware such as computers and servers are also included. The
operators need to learn the system to be able to use the benefits of the system. As in
alternative 1 this alternative also consumes resources such as power, the system also
requires support as in updates, service and security.

The **savings** of this solution is the ability to supervise the production together with
making the information exchange more effective. Orders can quickly change priority of
more important customers as a way to reach a higher customer satisfaction. The tag can
also help in inventory making it possible to see how much material they consume to see
when it is time to reorder.

**Alternative 3.**
The third alternative that we have considered is the implementation of 5S. With the
inspiration from the production in Bankeryd, we can see that working with 5S have great
influence on the entire plant, from private work stations to entire storage sections. When
walking into the factory in Bankeryd we can see that everything is neatly placed and the
transportation lines are straight and cleaned so there is nothing in the way when you are
moving materials. The shelves are organized and numbered so material is always easy to
find and the workstations are organized so you can quickly find the tools and materials
you need.

**The costs** for implementing a strategy such as 5S is mainly the time it will take for the
management to try to implement such a cultural change and to convince the employees
that the change is good and will benefit them. Other costs related to this would be some
additional time for organizing and cleaning the plant, and some purchase costs for
material needed such as shelves and boxes for the organization. An implementation of
this kind of strategy is mainly an issue of time, since a cultural change does not happen
overnight.

**The savings** of working with a 5S strategy is the same as the costs, time. The time you
lose when implementing the strategy is time you will gain when the strategy is working as
wanted. The materials and tools you need will always be where you need them, which
will lead to better flow in the production.

**Alternative 4.**
This alternative combines all of the above into a holistic improvement implementation
spanning from culture to technology. The potential gain of using all of these together is
very high, but at the same time risky combining in a massive implementation. The costs and savings are the sum of the three previously mentioned alternatives.

6.7.1 MCDM

The MCDM shown in table 6.4 is filled with various values from 1-5 where 1 is poor and 5 is excellent. The alternatives are evaluated against the redefined goals presented in step 4 to find the most suitable fit for the case company. The weighting is estimated on MFD phase and the discussion in step 4. At the bottom of the table we can see the compiled scores of the different alternatives. This shows that Alt. 4 received the highest score and alt 2. the lowest.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Alt. 1</th>
<th>Alt. 2</th>
<th>Alt. 3</th>
<th>Alt 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>High quality products</td>
<td>0.25</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Delivery on time</td>
<td>0.2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Increased quality rate in production</td>
<td>0.15</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Cost-effective production</td>
<td>0.2</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Continuously improving for advantages</td>
<td>0.1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Motivated and engaged employees</td>
<td>0.1</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.4 MCDM consisting of the comparison of the four alternatives.

Due to the fact that alt.4 is a sum of all advantages of the three it got the highest in all but two criteria: The continuously improving along with motivated and engaged employees. The latter one refers to the major change it would be to implement this solution and might cause a negative effect on the company because the change is overwhelming for the organization. Alt 2. scored the lowest of the alternatives due to its absence in involving quality of the production and quality of the product as well as the others. This solution could have an indirect impact on quality due to statistics, documentation and customer satisfaction resulting in a two instead of one in the high quality products criteria. The criteria that resulted in alt.1 getting lower scores than alt.3 was continuously improving for advantages. The 5S solution has a great potential to improve continuously whereas the improvement in the material system in alt 1. will be an improvement stuck with for a future. The addition of the material handling in the future gave this alternative a 2 instead of 1.

If alt.1 is implemented, the route of transportation for the racks(room for ten doors) is reduced by 54m, which means if they produce 30 doors in a day at an operator's cost of 600 kr/h. using the average walking speed of 4km/h(approx 1.1 m/s). A formula for the cost it will save per day:

\[
54 \times (30/10) \times ((54/1.1)/ 3600) \times 600 = 1325.5 \text{ kr/day}
\]

To translate this into a yearly cost, using the number of working days 224 and 229 per year it would sum up to: 296912-303539.5 kr/year.
The risk in implementing alt.3 and alt.4 needs to be taken into consideration in order to make an accurate assessment. Both solutions involve cultural changes and in alt. 4 as earlier mentioned may have an overwhelming effect on the employees. This will be taken into account in later discussions.

6.8 Implement improvements - Step 7
The management part of the model will contain of two sorts, process management that refers to the more technical and analytical perspective of the improvement. Moreover, change management to be able to get the employees to pull in the same direction as the company or the market.

6.8.1 Process management
The starting point is the process managements four steps described in 3.7.2 in the theory chapter.

- Organize for improvement
  Improvement teams have been assigned but causes for their improvements have not been set. The things to improve are not decided upon e.g. they have no outspoken ways to improve quality.

  Assign teams that will be responsible for improving the production process. The members should have knowledge that span all areas concerned in the improvement work.

- Understand the process
  The knowledge about the process is basically the experience of the operators in the production and no usage of objectivity when looking at the production, e.g. process mapping tools such as flowcharts.

  Make use of the mapping of the processes developed in the second step of the model together with the documentation from step three to fully understand the process. In addition, with the business goal and strategy to understand why and how the process works.

- Observe the process
  The production process include no specific measurements, some efforts related to defective products has been made. These forms are not taken seriously and not filled out truthfully. This makes them useless in the
terms of comparing statistics e.g. before and after changes evaluation if the change is successful can be hard.

The observation of the process refers to defining what to measure and where to measure in order to later on be able to measure the improvements after implementation. E.g. using the cost effectiveness formula shown in 3.11 to compare average cost per unit before and after implementation of improvements.

○ Improve the process continuously

The plant lacks documentation and follow-up of the major parts of the plant, even though some parts are covered they are stored in binders at the office and not further used or analyzed.

During and post implementation the managers need to check the progress and outcome of the implementation. This is important to, first of all, see how it is actually going. If adjustments are needed and actions have to be taken to make sure the implementation is successful. Secondly, to use documentation for a potential future use of the model. To improve where the project did not go according to plans, correcting potential mistakes from happening again. This is done to be able to continuously improve the process.

6.8.2 Change management

The management of the plant has been starting to share the philosophy of the industry “we will work as we always have done”. Or rather an acceptance of this philosophy which can be a factor that makes them lose credibility. Furthermore, if the managers do not fully support the change it is hard to transfer the urge for improvement to the employees. The managers have been gradually used to this climate and they know it exist which need to be changed if the business should be improved.

The first step is to understand where the company is heading, where the company will be when the implementation cycle is completed. Define what the changes will bring and find areas to highlight and bring forward to the once involved. E.g. a message to highlight among the operators could be the reduced lifting due to implementation of a new material handling system. Create a statement or a vision which can guide the entire organization. This vision will be something an employee can rely on to know what to do in the daily routine at work. Before the change officially starts the managers and leaders must be absolutely sure what the change is all about and communicate its importance for the company’s profitability and survival in the competitive market. All obstacles for e.g. communication must be removed making it possible to keep an open dialogue between leaders and employees to enable feedback. The feedback is important to take into
consideration as a change is only as successful as the commitment of the members of the organization.

The part that arguably could be the most important is the culture of the company. If the change is not a part of the culture when the change is “finished” the old habits and routines will soon regress into the previous state.
7. Results of applying the model

In this chapter we will display what we have achieved in this study based on our analysis which we made from the empirical data and the theoretical background. This chapter will describe the results from the different methods used in the analysis.

Making a change in an organization comes with a lot of considerations and aspects which needs to be respected. Factors that need to be considered are not only money, but time, knowledge and other possibilities that may make or break the new change. In the following sections we will give the results from each step in the analysis that was made on the model in previous chapter. We will present the changes that this study supports and the different economical, technical and organizational aspects to why this change has been chosen suitable.

7.1 Model step 1 – Defining the Goal and Strategy

As a first step of the model, we brought forward the business goals & strategies together with the company. The business goals were set to high quality products, delivery on time, increased quality rate in production and increased profit. With these translated into technical requirements (business strategy) we defined what the company is currently focusing on reaching, and how they want to reach it according to the management. The results in the first step of the model are the starting point for the MFD which is the foundation of the entire model.

7.2 Model step 2 – Process Mapping

The next step of the model is the process mapping part. When making an improvement in the production we defined it to be important that the processes and activities are mapped out in order to find improvement areas. The cross-functional flowchart and the IDEF0 together gave us a detailed view of how the current situation is. The process mapping highlights the material flow and the responsible party for the activities. It also brings a detailed picture of where in the production process mistakes can happen, so that when working with changes or improvements these areas could be focused on or implemented in new systems if that is the new investment. These kinds of mapping could be a support for both information and material handling systems, and also when working with 5S since it is important to know what is needed, when it is needed, where it is needed and how much is needed. Based on our observations and calculations we were able to only by rerouting some transportation ways; reduce the distance with 54 m, simple by changing routes. The outcomes of this step are a process flow map which identified...
flaws and the ability to improve the process by rerouting different routes in the production process. The save was just by small adjustments 54 m in distance. By rerouting to our improvement suggestions a yearly cost of hundreds of thousand can be saved.

7.3 Model step 3 – Evaluate Production Process Logistics
The third step in the model is to evaluate the production process logistics. In this step we incorporated phase 2 of the MFD. This is because from the technical requirements different tools were identified which are needed to maintain these requirements. When translating them into activities we identified different methods such as activity network diagram to use for improvement work. By identifying the activities between the work stations we could determine which stations needs to be close and where the most materials are moved. This is not the main focus of our study, since this could mainly be the support for a facilities layout rearrangement, although this will help to identify the logistics and the need for an improved material handling system. A result from this step is that the press and the CNC has a lot of activities and by making that distance more effective, by implementing a conveyor belt and possibly a lifting robot, manual work can be reduced and both time, money and man hours are saved.

7.4 Model step 4 – Redefine Business Strategy
When the first three steps of the model have been completed, we redefined the business strategies based on how the current situation actually looks, and not only based on what the management wants. This led to a change in the business goals as well. The new company goals are now including cost-effective production instead of increased profit, since the company should be focusing more on the actual production than just the profit in order to make profit. The need for motivated and engaged employees is an important factor to reach the goals and to be able to implement changes. This study, mainly by incorporating phase 3 of the MFD showed that the use for education and a motivating management is important and therefore it should be in the business goals.
These are the new business goals and strategies for the company based on the MFD. These are more suitable for the company based on their current situation and by staying updated on how the production actually is working, it will be a lot easier to find improvement areas and implement changes to stay competitive.

7.5 Model step 5 – Pinpoint Issues
Based on the MFD phase 3 which was incorporated into this step we could find the activities that the company should focus on in order to reach their goals.

- Analyzing the production process flow
- Analyzing the material and information logistics
- Software updates
- Training staff in using the information and material handling systems
- Documentation of failures
- Evaluation of suppliers quality

The most important activities are analyzing the production process flow and the material and information logistics, and the training staff in using the information and material handling systems. This shows that in order to reach the business goals, the company must have an effective production process and a functioning material and information handling system could help them reach that. Analyzes of these areas helped to highlight the specific areas where improvements are needed in order to give suggestions for improvements.

7.6 Model step 6 – Evaluate Alternatives
In this step we once again incorporated phase 3 of the MFD in order to get the criteria for the MCDM. The alternatives that we wanted to evaluate were created based on the previous step of the model. The areas the company should focus on improving are the material handling, the information handling and having an effective production process. With these we brought forward the three

<table>
<thead>
<tr>
<th>High quality products</th>
<th>Improving processes and activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery on time</td>
<td>Using high quality materials</td>
</tr>
<tr>
<td>Increased quality rate in production</td>
<td>Effective production process</td>
</tr>
<tr>
<td>Cost-effective production</td>
<td>Effective logistic strategy</td>
</tr>
<tr>
<td>Continuously improving for competitive advantages</td>
<td>High availability on equipment</td>
</tr>
<tr>
<td>Motivated and engaged employees</td>
<td>Continuous education for core and edge knowledge</td>
</tr>
</tbody>
</table>
alternatives: 1. Investing in a new material handling system. 2. Investing in a new information handling system. 3. Implementing 5S. We also suggested a combined alternative, which will cover all the weak parts in the production by implementing all the first three alternatives at the same time. That is an alternative which is more costly, but also more effective in the long run. The MCDM gave us the result that alternative 4, the combined alternative, is the one which will benefit the company the most.

7.7 Model step 7 – Implement improvements
The last step of the model is to implement the improvements. The alternative that we have chosen is the most suitable for the company is alt 4. according to our MCDM. The alternative includes an investment in a new information system, which will provide a more effective way of handling the order from customer order to delivery. This will benefit the company in many ways, since they can now do follow ups, they can trace products, they can document failures etc. By implementing the RFID-tag system they could also be able to make changes during the production process on a product, which could in many cases make the customer more satisfied. The alternative also includes investing in the material handling system, this means that simple changes, such as installing a conveyor belt could be made. 5S is also included in this alternative, and this would help to organize the production process to make it more efficient.
8. Conclusion

8.1 Answer to the problem formulation
“How to increase the cost-effectiveness in a production process with respect to information and material logistics.”

By using the model developed in this thesis, a company can identify various flaws and/or issues in the production logistics. By addressing the information and material logistics a cost-effective production can be reached by reducing the unnecessary movements and transactions within in the production process. The usage of a company’s unique set of goals, the model can systematically find ways to solve the issues standing in the way of reaching their goals. Moreover, the model can also aid in a way that takes the “soft” side of an implementation, the culture and management, into consideration which has been neglected in e.g. the SLP model.

The study showed that the solutions brought forward in step 6 in the analysis can all be beneficially used in the company. The alternative that scored the highest in the MCDM, alt 4, may not be the best fit for our case company. This decision has to be made by the management to make sure the employees are ready for a cultural change, the same goes for alt. 3. If they are not the time and money invested in the implementation would be in vain. Alt.1 and alt. 2 is suitable for the company to be implemented in terms of reaching the goals.

8.2 Recommendation
This chapter will include the recommendations given by using our model and conducting this thesis.

- Our recommendations for the company would be to implement alt.1 and alt. 2 in order to achieve a cost effective production by addressing the production logistics of material and information.

- If the company asses that the employees are ready to adapt to the ways of 5S it will also be a recommended implementation resulting alt 4.

- Use this model at intervals to keep evaluating the internal logistics to find areas to improve.

8.3 Future research
Suggestions of future research will be presented under this heading.

- Apply this method on other companies to increase validity and fill knowledge gaps if possible.
- Procedures for the various steps e.g. creating a procedure or model to address the managerial perspective including in depth change management to deal with changes.
• Develop a model that addresses the corporate culture aspect of a change, how to evaluate the corporate culture and its ability to perform a change.
9. Criticism of the model

Due to restrictions such as time and lack of input data received at the case company some aspects could not be covered. Evaluation of the actual implementation of our solutions brought forward by our model cannot be incorporated in the thesis due to the time frame. Lack of data such as damages due to production logistics et cetera made us leave that out of the application at the company.

Application in other companies could benefit of such information to further evaluation of the production logistics. The model was design to systematically identify evaluate the current situation to later be analyzed. The last steps were to find improvement alternatives to Lastly implement at the company. The implementation of the improvements cannot be observed due to the deadline of the research and therefore cannot be a part of the thesis.

The costs used in model where estimations of our knowledge and the company’s knowledge and weighted in comparison to each other, due to the complexity of calculating the costs for the 4 alternatives. If other aspects is considered more important in e.g. the MCDM where we used the goals of the company. This could be changed for other factors such as life cycle cost, environmental impact and custom satisfaction if needed.

The application at case is to be done, different data will be used and another outcome will be the result. Moreover, the procedure of the model is to be followed using the business goals and MFD to incorporate the core values of the organization.
10. References

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**Internet resources:**

www.inwido.se
Appendix

Appendix I - Interview questions and answers - Hånger

1. *What is transported between the workstations?*
   The material that comprise the door is framesides, threshhold, HDF-board, aluminum-board, isolation, glass, screws, lock cabins, hinges, security tin and sealing splines and this material moves around all of the production. Other things added to the door blade are the frame and glass.

2. *Who is responsible for transporting the material in the production?*
   It is mainly the operator of each department that the material to the next station.

3. *How is the material transported between the workstations?*
   The transportation contains of handtrucks, forklifts and lifting devices to relieve the operators from heavy lifting.

4. *Operator cost*
   They calculate on a utilization of 80% and 600 SEK/hour per operator.

5. *How is the material stored?*
   The material for the frame of the door is first stored in barns outside the plant. When the material is brought in before production is stored in different storage areas within the plant. Splines, glass etc. is stored near the concerned work station. The main storage units are pallets and racks.

6. *How is the information flow from order to delivery?*
   The order is placed by the customer to the order department of the company. They type in the order in the order system which is then printed by the administrative department within the plant. When the orders are printed it is printed as a flow card with the information of the door to the production, this flow card follows the door throughout the production process. When the door is packaged it is registered at the trucking company so it can be traced online.

7. *How does the management situation look like?*
   There are one plant manager in Hånger. Beneath him there are two production planners and on the floor there are two coordinators which help the manager when changes are implemented.
8. **What are your business goals?**
   The goals the company has set are having high quality products, since that is the foundation of our company and our main reputation. We focus on delivery on time for the customer satisfaction as well. Increased profit is always a goal for the company, although not the main one. An increased quality rate in the production is also a goal that we are striving for.

9. **Which are your business strategies to reach these goals?**
   To reach our goals we try to work with improvement teams to improve our processes and activities. We want high quality materials in order to get high quality products. The price is not the main focus, it is the quality. We also try to have an effective logistic strategy and an effective production process. That together with high availability on the equipment and high competence staff should be the strategies to reach our goals.
Appendix II. Interview questions and answers – Bankeryd

1. **What is transported between the workstations?**
The material that comprise the door is framesides, threshold, HDF-board, aluminum-board, isolation, glass, screws, lock cabins, hinges, security tin and sealing splines and this material moves around all of the production. Other things added to the door blade are hinges, lock cabins, splines, the frame and glass.

2. **Who is responsible for transporting the material in the production?**
The major part of the production is automated making use of various transport systems. But where manual transporting is needed it is performed by operator of the workstation.

3. **How is the material transported between the workstations**
There is a circuit carrier that runs throughout the facility which material handling backbone of the production process. This is made possible by the RFID tag that enables it to automatically be scanned to give the machine necessary information about the door and what should be performed on it. Robots are used for lifting articles in place in the machines. Additional methods used for transporting the material are by hand truck, wagons or carts, forklift and roller conveyors.

4. **Operator cost**
An estimation would be 350 kr/hour, not sure about what that includes though.

5. **How is the material stored?**
The storing of material is pallets and shelves around the plant. The material stored in production is located on pallets and the raw material and finished products is stored on shelves.

6. **How is the information flow from order to delivery?**
Once the order is received from the order department the production manager plans the order and sends it to the production who receives information about design etc.. A RFID tag is printed out and placed on the doorblade where it remains throughout the entire production. The RFID is stores information about the ordernr etc. and is scanned at every station and checks in in the information system making it possible to trace the product in the production. When the door is finished the door is checked out of the production which registers that the door is finished for delivery.

7. **How does the management situation look like?**
We have one plant manager, one production planner and a economic planner who plans the production of the week. On the floor there are two work leaders one on each shift. The two work leaders helps the management to execute different e.g. changes in the production. The two work leaders have been useful in the implementation of 5S in the production which started six months ago. As of now the implementation has been a
successful implementation and the employees are satisfied with its outcome together with the managers.